# Colville Tribes
# Fish & Wildlife Department
# Anadromous Fish Division

## Okanogan Basin Monitoring & Evaluation Program
## 2008 Report

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## Acknowledgements

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Funding for the Okanogan Basin Monitoring and Evaluation Program is provided by Bonneville Power Administration (BPA). We thank Sarah Branum, Dave Roberts, Christine L. Read, and Kimberly R. St. Hilaire of the BPA, for their support and cooperation with various parts of these projects.

## Executive Summary

The Colville Tribes Anadromous Fisheries Department began designing the Okanogan Basin Monitoring and Evaluation Program (OBMEP) in the spring of 2004 to provide essential information on habitat conditions and fish populations. The collected data has already greatly expanded the level of knowledge being used in planning efforts and for fisheries management in the Okanogan River basin. Information related to the status and trends for all salmon and steelhead within the Okanogan River basin requires long-term vision and commitment to provide answers about population level action effectiveness and this is impossible without a high quality data set that forms a foundation of knowledge.

The Okanogan Basin Monitoring and Evaluation Program is not just another regional monitoring strategy. Rather, this plan draws from the existing strategies (ISAB, Action Agencies/NOAA Fisheries, and WSRFB), guidance from the Monitoring Strategy for the Upper Columbia Basin (Hillman 2006) and is called for in the Upper Columbia salmon Recovery Plan along with the Okanogan River Basin sub-basin plan. The OBMEP approach addresses questions specifically related to the Endangered Species Act for Upper Columbia River steelhead and other salmon recovery efforts within the Upper Columbia Basin and specifically the Okanogan River Basin. This project is also specifically designed to monitor key components of the ecosystem related to anadromous salmonids including biological, physical habitat, and water quality parameters, plus serving to develop baseline research where data are currently unavailable.

We had another productive year in 2008 by completing work elements related to collection of habitat, temperature, spring spawner, adult enumeration, and smolt production data. We catalogued, archived, analyzed, and reported on these data.

Additional cooperative efforts resulted in redd and carcass data collection for summer/fall Chinook, real-time temperature and stream discharge data collection, and international coordination with Canada. All our data and reports are accessible through the World Wide Web and can be accessed through the Okanogan Basin Monitoring and Evaluation Program website, located at: http://nrd.colvilletribes.com/obmep/.

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# Introduction

Federal hydropower projects, private power utility systems, habitat degradation, invasive predatory species, excessive harvest, and human development have negative impacts on anadromous fish that once flourished in the Columbia River basin. A coordinated and comprehensive approach to monitoring and evaluation of status and trends in anadromous salmonid populations and their habitats is needed to support restoration efforts in the Columbia Cascade Province and in the Okanogan sub-basin in particular. Currently, independent research projects and some monitoring activities are conducted by various agencies, tribes, watershed councils, and landowners but there has been no overall framework for coordinating data collection efforts or for the interpretations and synthesis of results prior to 2004.

Fisheries managers implement actions designed to improve the status of fish populations and their habitats within mainstem and tributary systems. Until recently, there was little incentive to monitor such actions to see if they met their desired outcome, but funding agencies are increasingly aware of the need for long-term monitoring and evaluation. Limited funding requires elimination of duplicative or contrary efforts and establishment of a process for universal reporting and strategic planning.

Beginning in 2002, the Upper Columbia Regional Technical Team (RTT) attempted to standardize and improve monitoring by developing the Monitoring Strategy for the Upper Columbia Basin (Hillman 2006). A proposal for funding the Okanogan River portion of this strategy was submitted to the Northwest Power and Conservation Council (NPCC) and received a high priority rating from both the Columbia Basin Fish and Wildlife managers and the Independent Scientific Review Panel (ISRP). Funding for this project was approved in 2003. The Colville Tribes' Anadromous Fisheries Division began implementing this project in the spring of 2004 to provide essential information on habitat threats and fish population viability. The collected data has already greatly expanded the level of knowledge being used in planning efforts and for fisheries management in the Okanogan basin. Information related to status and trends for all salmon and steelhead within the Okanogan River basin requires a long-term vision and commitment to provide answers about population level actions and effectiveness.

The Okanogan Basin Monitoring and Evaluation Program (OBMEP) is not just another regional monitoring strategy. Rather, this plan draws from the existing strategies (ISAB, Action Agencies/NOAA Fisheries, Integrated Status and Effectiveness Monitoring Project (ISEMP), Pacific Northwest Aquatic Monitoring Partnership (PNAMP), and Columbia System-wide Monitoring and Evaluation Project (CSMEP)) and outlines an approach for addressing questions specifically related to anadromous fish management and recovery in the Upper Columbia and more specifically the Okanogan River basins. Therefore, OBMEP is specifically designed to monitor key components of the ecosystem including biological, physical habitat, and water quality parameters. This program also establishes baseline information where data are currently unavailable thus allowing future status and trend analyses to occur.

## Methods

As adapted form Hillman (2006), OBMEP developed a set of specific protocols to allow standardized data collection in a rigorous and scientific manner. Snorkel surveys, water quality monitoring, and physical habitat condition sampling are conducted at sites selected using a random spatially balanced rotating panel design (EMAP sites). These EMAP sites were monitored throughout the Okanogan River sub-basin from March 2007 through February 2008. Migrating adult and emigrating juvenile fish are monitored at fixed sites and redd surveys are conducted using a census approach.

Protocols were developed specifically for OBMEP. The current versions of these protocols can be viewed at our web site:

http://nrd.colvilletribes.com/obmep/.

This report is a synopsis of all data collections and reporting efforts conducted under OBMEP for contract year 2008. Additional information relative to specific data collection activities, or links to previous year's reports can be found at:

http://nrd.colvilletribes.com/obmep/default.htm

or through the BPA web site at:

http://www.efw.bpa.gov/searchpublications/#.

Technical reports or updates completed this year are included in the appendices that follow this report.

## Accomplishments

### Work Element B: Annual Report

Each year OBMEP produces an annual report. Several additional reports were completed as end products for specific deliverables. Some of these reports and conclusions are included in this document under the specific data type and work elements.

## Work Element C: Produce Environmental Compliance Documentation

Permit applications were developed and submitted for operation and collection of fish at our rotary screw trap. All permits were procured before active trapping began. The permits and issuing agencies are as follows:

- Section 10 Incidental Take Permit #1520 NOAA Fisheries
- Hydraulic Project Approval (HPA) #104024-3 WDFW
- Scientific Collection Permit # 08-131 WDFW
- Bridge Attachment Permit #7687B WSDOT
- Shoreline Exemption #1040 City of Okanogan
- Floodplain Development Permit #OKA 05-12 City of Okanogan

In addition to the above permits OBMEP staff worked with BPA to develop compliance with the HIP-BiOp for all other activities.

## Work Element E: Juvenile summer steelhead snorkel surveys at all EMAP sites

The Colville Tribes' Fish and Wildlife Department conducted snorkel surveys in established EMAP sites throughout the Okanogan basin as part of the Okanogan Basin Monitoring and Evaluation Program. The results from the 2008 snorkel surveys were not consistent with data collected in previous years, likely the result of using different observers than were used in the previous surveys. Because of the inconsistent nature of the 2008 survey results relative to other years, the data are considered suspect. As a consequence, the 2008 juvenile summer steelhead snorkel survey efforts will not be reported.

To improve the rigor of the snorkel survey data, future surveys will be conducted by a selected group of experienced snorkelers. This will remove the need to train new observers each year and allow for more consistent methodology within and across years. Additional changes in survey methodology will include the time frame in which the surveys are conducted. Previously, the surveys were all conducted within two weeks of the physical habitat surveys that were performed in those same areas. Instead, all future snorkel surveys will be conducted within a two-week period in August-September in order to develop more consistent survey data sets. Additionally, future efforts will include collecting macro invertebrate data for comparison with juvenile fish population data to determine the best biological indicator for assessing changes in habitat quality.

## Work Element F: Rotary screw trapping for summer/fall Chinook smolt and juvenile steelhead outmigration enumeration at Highway 20 site

The Colville Tribes' Fish and Wildlife Department continued enumerating juvenile salmonids using rotary screw traps in 2008. Anadromous forms of *Oncorhynchus* with verified natural production in the Okanogan basin were targeted for this study, including Chinook (*O. tshawytscha*), sockeye (*O. nerka*), and summer steelhead (*O. mykiss*).

Two rotary screw traps were deployed on the Okanogan River from the Highway 20 Bridge in Okanogan, WA. Traps were operated between 1 April and 19 July 2008. An 8-foot trap was used to sample the main channel of the river for the duration of the study and a 5-foot trap was used to sample lower velocity water near the west bank when discharge levels exceeded 5,000 cfs. The total combined, seasonal salmonid mortality was 2.32%.

Juvenile summer Chinook salmon were the most abundant species trapped in 2008 (12,805 sub-yearlings and 5,785 smolts) followed by sockeye (6,489 smolts), mountain whitefish (2,604), and steelhead (1,572). All sub-yearling Chinook were of wild origin and > 99% of all Chinook smolts were hatchery-reared. A total of six Pacific lamprey were also counted. Salmonid data from smolt trapping operations can be found on the DART website.

Data on sockeye emigration was forwarded to Chelan County PUD on a daily basis to help in the timing and execution of a juvenile sockeye mortality study, and spill timing at Rocky Reach Dam. Scale and DNA samples were collected from natural origin steelhead for analysis by WDFW.

Screw trap operations again received gracious support from the City of Okanogan Public Works Department. The use of a boom truck for trap installation and removal and provision of a secure storage area are greatly appreciated.

A technical report will be prepared using these data once every five years beginning in 2011.

## Work Element G: Adult salmonid enumeration (Video) at Zosel Dam

The OBMEP is using underwater video to collect data on the run timing and abundance of adult salmonids passing into the Canadian portion of the Okanagan River basin. These data provide information that helps establish basin wide and tributary-specific spawner distributions, status and trends of adult returns, and origin information.

Adult Chinook and sockeye salmon passage counts for 2008 are presented based on video data collected 1 January through 31 December. At Zosel Dam, 17 adult spring Chinook salmon and 267 adult summer/fall Chinook salmon were estimated to pass in 2008. Summer/Fall Chinook peaked in daily passage on 5 and 8 October when 28 fish passed the dam. Hourly passage estimates of summer/fall Chinook salmon counts for 2008 at Zosel Dam revealed a slight diel pattern as passage events tended to remain low from 1900 hours to 0600 hours relative to other hours of the day. Summer/fall Chinook salmon showed a slight preference for passing the dam through the west bank video chutes.

A total of 81,260 adult sockeye salmon were estimated passing through Zosel Dam in 2008. After an initial solitary detection in February, the bulk of the sockeye run arrived at Zosel Dam on 26 June. An initial primary mode of passage occurred from 3 through 16 July when 72% of the total sockeye run passed the dam. Smaller pulses of passage occurred from 16 July through 9 August when 25% of the run was observed to pass the dam. Sockeye passage peaked on 11 July with 11,371 fish. Hourly passage estimates of sockeye salmon for 2008 at the dam did not show the strong diel pattern with increased passage during nighttime hours relative to daytime hours observed in 2006 and 2007. Sockeye showed a strong preference for passing Zosel Dam on the east bank (73%) relative to the west bank (27%). Sockeye passage at Wells Dam in 2008 was 165,334 fish (approximately 448% of the 10-year average).

A complete description of the apparatus and methodology for video sampling at Zosel Dam can be found at:

http://nrd.colvilletribes.com/obmep/pdfs/VideoManual070312FinalMR.pdf

Historic results from all years of operation are posted to the Columbia River DART website:

http://www.cbr.washington.edu/dart/adult.html

A complete technical report is currently under review and will be posted shortly to both our web site at: http://nrd.colvilletribes.com/obmep/Reports.htm and uploaded to the BPA web page shortly thereafter.

The complete report is attached as Appendix A.

## Work Element H: Conduct steelhead enumeration in tributary streams using picket weir traps and video counts

The Okanagan Nation Alliance (ONA) conducted a steelhead/rainbow trout enumeration study on Inkaneep Creek using a fish fence and redd surveys in 2008. The fish fence detected migration within the creek beginning 15 April with peak dates occurring between 27 to 29 April and again on 4 May. A total of 59 steelhead/rainbow trout were counted. Of the 59 fish captured, five were adipose clipped and of hatchery origin, with the remaining fish from a wild population. Twenty-two males and 32 females were counted, with eight of unknown gender. Males averaged 46 $\pm$ 11 cm in length whereas females averaged 44 $\pm$ 11 cm in length.

A total of six redds were observed in Canadian Okanagan Basin waters surveyed in the spring of 2008; all in Inkaneep Creek. These redds were observed on 4 and 12 May.

The complete report is attached as Appendix C.

## Work Element I: Conduct steelhead redd counts from throughout the Okanogan River sub-basin

In 2008, 384 redds were observed along the main stem Okanogan and 132 redds in the Similkameen River. Tributaries within the basin that were utilized by anadromous steelhead in 2008 included Salmon, Omak, Bonaparte, Ninemile, and Tunk creeks. Escapement estimates for the entire Okanogan River were between 1,341 and 1,436 summer steelhead and of those, 213 to 266 were likely of natural origin. Escapement into Canada was estimated at 116 (32.67% had an intact adipose fin). Forty-four spring Chinook were collected at the Omak Creek trap. Main stem steelhead redd distributions were highest in the upstream reaches of the Okanogan River and lower section of the Similkameen River, where high quality spawning gravels are common and hatchery releases are focused. Other high density spawning areas included the island section near Tonasket, and near McAlister Rapids, where braided channels and water velocities are favorable for summer steelhead. Annual collection of steelhead spawning data in future years will provide a more comprehensive depiction of spawning distribution and population trends within the Okanogan River basin.

Data on spring spawners can be viewed on our web site at:

http://nrd.colvilletribes.com/obmep/pdfs/200902272008springspawnerFINAL.pdf

The complete report is attached as Appendix B.

## Work Element K: Collection of physical habitat data at EMAP sites in the United States (34) and Canada (16)

Currently, the Colville Tribes are the only organization collecting comprehensive fish habitat data throughout the Okanogan Basin in both the United States and Canada. Cooperation includes the sharing of monitoring responsibilities between the Colville Tribes and the Okanagan Nation Alliance (ONA) , adjusting or changing sampling methods to comport with standardized protocols, and adhering to strict statistical design criteria.

Physical habitat data were collected at 50 EMAP sites (25 panel, 25 rotating panel) consistent with protocols developed by the Colville Tribes. Thirty-four sites were surveyed in the United States portion of the Okanogan Basin by the Colville Tribes and 16 sites were surveyed in the Canadian portion of the Okanagan Basin by the ONA.

Physical habitat data are collected in electronic format on Trimble GPS data loggers. Information collected pertains to: the presence and composition of large woody debris, riparian vegetation structure, canopy cover, human disturbance, substrate composition, stream channel habitat types (pool, riffle, glide, etc.), and channel morphology. All data are compiled on the OBMEP server located at the Colville Tribes', Fish and Wildlife office in Omak, WA. A comprehensive habitat report on all data collected from 2005 through 2009 will be forthcoming in 2010. Specific information requests can be directed to the Colville Tribes, Fish and Wildlife Department, Anadromous Fish Division, 23 Brooks Tracts Road, Omak, WA 98841, (509) 422-7424. Past reports related to habitat data can be downloaded at:

http://nrd.colvilletribes.com/obmep/Reports.htm

## Work Element M: Operate and maintain real-time discharge, water temperature gauging stations in the Okanogan sub-basin

Real time temperature data are collected at three sites on the Okanogan River in the United States at Oroville, Malott and Tonasket by the US Geological Service under contract with the Colville Tribes. An additional site is located on Ninemile Creek. Data have been assimilated into on-going data collection activities within the USGS web sites. These data are available on the Internet to provide transparent public access. Appropriate credit is given to BPA and the Colville Tribes for making these data available. Data links for sites on the Okanogan River:

**Mallot**: http://waterdata.usgs.gov/wa/nwis/dv?referred_module=sw&dd_cd=01%2C02%2C05%2C05%2C05&format=gif&p
**Tonasket**: http://waterdata.usgs.gov/wa/nwis/uv?12445000
**Oroville**: http://waterdat.usgs.gov/wa/nwis/dv/?siteno=12439500&agencycd=USGS
**Ninemile Creek**: http://nwis.waterdata.usgs.gov/nwis/uv?12438900

The Okanogan River watershed, especially the Canadian portion, has several tributaries with unknown discharge or temperature regimes. OBMEP continues to pursue cooperative agreements between the Okanagan Nation Alliance, the Ministry of Environment, Environment Canada, and the Colville Tribes to address these data gaps for Inkaneep, Vaseux, and Shuttleworth creeks. To view data go to:

http://scitech.pyr.ec.gc.ca/waterweb/disclaimerB.asp

1. In the "View all Real Time Stations within" window, select British Columbia and choose Order By: Station name.
2. Scroll down the page and click "I accept".
3. Scroll through the station list and select the station:

INKANEEP CREEK NEAR THE MOUTH (08NM200)
VASEUX CREEK NEAR THE MOUTH (08NM246)
SHUTTLEWORTH CREEK AT THE MOUTH (08NM149)

## Work Element O: Collect water temperature data throughout the Okanogan River basin

The OBMEP program began in May of 2005 deploying Onset® temperature data loggers in streams at all annual and panel tributary sites. The OBMEP also funded real-time temperature data collection at three USGS gauging sites on the Okanogan River: Oroville, Tonasket, and Mallot in the US, and three Environment Canada gauging sites on Inkaneep, Vaseux, and Shuttleworth creeks. Data collection at theses sites began in March of 2005. All Onset temperature data are compiled on the OBMEP server located at the Colville Tribes, Fish and Wildlife office in Omak, WA. Specific information requests can be directed to the Colville Tribes', Fish and Wildlife Department, Anadromous Fish Division, 23 Brooks Tracts Rd., Omak, WA 98841, (509) 422-7424. A report documenting changes in temperature over the last decade is in preparation and is anticipated to be completed within the next year or two.

## Work Element R: Coordination

OBMEP biologists have contacted and coordinated directly with other entities performing M&E related activities throughout the region to ensure compatibility with other regional M&E and salmon recovery efforts. On-going coordination with other monitoring practitioners is critical to the success of the OBMEP's ability to collect useful data that can be easily assimilated to larger spatial scale.

We developed OBMEP under a regional M&E scheme involving coordination with multiple entities through both the Columbia Systemwide Monitoring and Evaluation Project (CSMEP) and the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) to ensure that our project is compatible with efforts spanning the entire Pacific Northwest. Continued coordination with these entities will be necessary as region wide M&E efforts continue to evolve.

At the scale of the Upper Columbia ESU, OBMEP biologists regularly contributed to monthly meetings of the Upper Columbia Regional Technical Team (RTT) and monitoring and data management subcommittees. Data have been shared at these meetings along with field protocols and strategies for field sampling, data archiving, manipulation, and analysis. Ongoing coordination within the Upper Columbia Salmon Recovery Board process is essential to make sure data can be scaled up for ESU related recovery analysis to take place and to measure progress toward recovery of listed salmonid stocks.

Within the Okanogan River sub-basin we have international coordination responsibilities with Canadian entities. To facilitate these relationships we have contracted with Okanagan Nation Alliance and host regular quarterly meetings. Additional meetings are occasionally attended with other agencies and groups that collect monitoring data or have a need or use for the data we are collecting. Regular updates are provided annually at the Bilateral Okanogan Basin Technical Working Group meeting and Lake Osoyoos Board of Control, Fisheries Advisory Group. In addition to providing local groups and agencies with information and updates, many OBMEP survey sites fall within areas of private ownership. Therefore, landowners must be contacted (public outreach) and access granted before field crews can conduct surveys. Biologists and field staff working under OBMEP have made many contacts with landowners throughout the Okanogan basin to gain access to EMAP sampling sites, redd survey sites, and to keep the landowners updated. Most contacts have been positive and access to perform work under this contract would be impossible without cooperation from local landowners.

## Work Element T: Manage and Maintain Database

At the end of the 2006 contract year, OBMEP began using an Access® database developed by Summit Environmental Consultants Ltd to archive our data into relational tables. The OBMEP database and data are contained on the OBMEP server located at the Colville Tribes Fish and Wildlife Department offices in Omak, WA. Summit Environmental Consultants developed protocols for transferring data collected on Trimble® handheld data loggers, data forms and the Internet into the database. The database began functioning as an analytical tool in 2008. Queries have been written by Summit Environmental, BioAnalysts and program biologists that are fully consistent with the needs of the Okanogan basin, Colville Tribes, Upper Columbia ESU, State of Washington, Pacific Northwest, National Marine Fisheries Service, Bonneville Power Administration, and the Northwest Power and Conservation Council. Data collected and queries written are fully consistent with metadata and data management standards developed by the Pacific Northwest Aquatic Monitoring Partnership (PNAMP), Columbia Systemwide Monitoring and Evaluation Project (CSMEP), Stream-Net, and the Northwest Environmental Data workgroup for M&E projects within the Columbia River basin. We have worked closely with NOAA Fisheries as we create similar and compatible database structures through the Integrated Status and Effectiveness Monitoring Project (ISEMP) and Upper Columbia Data Steward. OBMEP is making certain that the database is capable of providing compatible data with all recommended and necessary metadata. A users guide and method for translating data into the OBMEP database has been completed and can be seen at:

http://nrd.colvilletribes.com/obmep/pdfs/6520107OBMEPUsersManualDraftV128-Aug-07.pdf

http://nrd.colvilletribes.com/obmep/pdfs/ProtocalforenteringdataintotheOBMEPdatabaseDraft.pdf

## Conclusions

The OBMEP project completed another year of data collection, coordination, and reporting. All tasks were completed on time and within budget. Some deliverables such as the annual snorkel report, and smolt monitoring report fell behind due to the magnitude of our reporting requirements. In the future, rather than attempting to complete annual reports related to each type of data collection we will instead compile data for five years and report on one subject in each successive year. Annual spring spawning reports have been among the most valued reports to date and will continue to be produced annually. Other reports will be consolidated and produced once every five years beginning with the temperature report in 2009, habitat change and biological response 2004-2009 in 2010, the video enumeration and PIT-tagging report will be compiled from 2005 to 2010 in 2011, Salmon and steelhead smolt outmigration from 2006 to 2011 will be combined and reported in 2012, and then the changes in water quality and quantity report will be updated for the years 2007 through 2012 and reported on in 2013. These technical documents will be compiled into the annual report requirement for BPA and posted on the OBMEP and BPA web sites for public access. Interim access to OBMEP data will be handled through the Upper Columbia Salmon Recovery Board data steward, Integrated Status and Effectiveness Monitoring Project (ISEMP) through the STEM Databank, the Columbia Basin Fish and Wildlife Authorities state of the resource report, Fish Passage Center, US Geologic Survey, and the Columbia River Data Access in Real Time (DART), Stream-net or by contacting us directly.

This program has grown from a few simple data collection activities to a large multifaceted program. OBMEP continues to improve the program by using the latest in technology and scientific knowledge. The video monitoring project will be expanded to include multiple tributaries and PIT tag technology will be integrated over the next several years is additional funding can be secured. Novel ways to view and analyze habitat data are being considered in order to consolidate a multitude of variables into a habitat condition composite tool that can measure status and trends using EDT models already widely utilized across the Columbia River basin. As these efforts mature, the OBMEP staff hopes to contribute to improved data collection and status and trend monitoring throughout the entire Columbia River basin while in turn learning from other project developments.

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# Appendix A. *Enumeration of Salmonids in the Okanogan Basin Using Underwater Video in 2008*

**COLVILLE TRIBES/AF-2009-02** **October 2009**


## Confederated Tribes of the Colville Reservation
## Fish & Wildlife Department
**Anadromous Fish Division – Omak Office**
**Okanogan Basin Monitoring & Evaluation Program (OBMEP)**

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# Enumeration of Salmonids in the Okanogan Basin Using Underwater Video in 2008

BPA Project # 200302200

Performance Period: 01 January 2008– 31 December 2008

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# Abstract

The Confederated Tribes of the Colville Reservation (Colville Tribes) are collecting baseline data on adult salmonid populations and threats to their habitat throughout the Okanogan River Basin through the Okanogan Basin Monitoring and Evaluation Program (OBMEP). Adult Chinook and sockeye salmon passage counts for 2008 are presented based on video data collected 1 January through 31 December. Steelhead passage data at Zosel Dam were acquired in 2008 but the results of that component of the video project are discussed in a separate document (Arterburn and Miller 2009). A complete description of the apparatus and methodology can be found in *Fish Enumeration Using Underwater Video Imagery - Operational Protocol* (Nass 2007). Adult counts from all years of operation are posted to the Columbia River DART website: http://www.cbr.washington.edu/dart/adult.html

At Zosel Dam, 17 adult spring Chinook salmon and 267 adult summer/fall Chinook salmon were estimated to pass in 2008. Summer/Fall Chinook peaked in daily passage on 5 and 8 October when 28 fish passed the dam. Hourly passage estimates of summer/fall Chinook salmon counts for 2008 at Zosel Dam revealed a slight diel pattern as passage events tended to remain low from 1900 hours to 0600 hours relative to other hours of the day. Summer/fall Chinook salmon showed a slight preference for passing the dam through the west bank video chutes. Summer/Fall Chinook passage at Wells Dam in 2008 totaled 25,023 fish, approximately 84% of the 10-year average.

A total of 81,260 adult sockeye salmon were estimated passing through Zosel Dam in 2008. After an initial detection in February, the sockeye run arrived at Zosel Dam on 26 June. An initial primary mode of passage occurred from 3 through 16 July when 72% of the total sockeye run passed the dam. Smaller pulses of passage occurred from 16 July through 9 August when 25% of the run was observed to pass the dam. Sockeye passage peaked on 11 July with 11,371 fish. Hourly passage estimates of sockeye salmon counts for 2008 at the dam did not show the strong diel pattern with increased passage during nighttime hours relative to daytime hours observed in 2006 and 2007. Sockeye showed a strong preference for passing Zosel Dam on the east bank (73%) relative to the west bank (27%). Sockeye passage at Wells Dam in 2008 was 165,334 fish (approximately 448% of the 10-year average).

# Introduction

Salmon recovery in the Pacific Northwest region has become a focal point within the Columbia River Basin. The Colville Tribes are actively participating in a recovery program for salmonids in the Okanogan River Basin which include recent inventories of habitat condition, water quality, and barriers to migration. Currently, there is population information available for spawning fish within the United States portion of the basin (Hillman 2006; Arterburn et al. 2007). However, data are lacking regarding spawner abundance for all anadromous fish (except sockeye) within the Canadian portion of the basin.

Okanogan River steelhead, (*Oncorhynchus mykiss),* were listed as *endangered* under the U.S. Endangered Species Act (NOAA 1997). The combined five-year escapement average for the Methow and Okanogan rivers from 1989 to 1993 was estimated at approximately 2,400 fish; 450 of which were from natural production. From 1997 to 2006, NOAA (2008) estimated the mean abundance of naturally produced summer steelhead in the Okanogan River basin to be 104 wild fish. Arterburn et al. (2007) summarized steelhead data from 2005 through 2007 and estimated overall escapement to range from 779 to 1,492 fish with natural production ranging from 127 to 185 fish. In 2008, between 1.341 and 1,436 summer steelhead returned to the Okanogan River, and of those between 213 and 266 were likely of natural origin (Arterburn and Miller 2009).

Summer/Fall Chinook salmon (*O. tshawytscha*) spawn in the Okanogan River Basin but currently are not listed as either threatened or endangered (NOAA 2008). As of 1998, these fish were classified as having a population of approximately 1,500 with the population increasing at 1%-5% per year (NOAA 1998). The Washington Department of Fish and Wildlife (WDFW) salmonid stock inventory program classified summer Chinook as having a "healthy" status with an average run of 4,346 for 12 years of data (http://wdfw.wa.gov/fish/sasi). The majority of this stock spawns in the Similkameen River below the migration barrier at Enloe Dam. Spring Chinook salmon are listed as *endangered* in the Upper Columbia Evolutionary Significant Unit (ESU). Historically, this run ranged up into the Okanogan River (NOAA 2008) but are now considered to be extirpated from the basin.

Sockeye salmon (*O. nerka*) in the Okanogan River ESU are not listed under the ESA; however the status of Okanogan sockeye salmon is rated as chronically "depressed" by the WDFW (http://wdfw.wa.gov/fish/sasi). This stock is of mutual concern to the United States and Canada as the Okanogan sockeye population is one of only two remaining populations in the Columbia River Basin. The annual escapement of sockeye salmon spawners has varied between a low of 1,600 in 1994, to a high of 60,000 in 2000, and has a 16-year mean of 25,000 (http://wdfw.wa.gov/fish/sasi, as based on counts at Wells Dam). Fisheries and Oceans Canada recommends an escapement of 59,000 for propagation of a healthy population (http://wdfw.wa.gov/fish/sasi).

Chapman et al. (1995) summarized available data on sockeye and illustrated a noticeable discrepancy in counts between returning adult sockeye crossing Wells Dam and the number estimated in spawning areas in Canada. Several hypotheses have been proposed for this discrepancy:

1. Substantial mortality of Okanogan sockeye salmon between Wells Dam and upriver spawning grounds;
2. Considerable error in spawning ground counts based upon visual observations; and
3. Undiscovered spawning areas existing above Wells Dam.

Improved counts of sockeye salmon at Zosel Dam will help answer key questions regarding adult sockeye salmon spawner abundance and the disparity between Wells Dam counts and escapement estimates (Johnson et al. 2008).

The Biological Opinion (BiOp) released in 2008 by NOAA's National Marine Fisheries Service (NMFS) addressed the operation of the federal Columbia River power system. The BiOp defined criteria for acceptable fish population levels to ensure the survival of critical fish stocks. One indicator to ensure survival was the number of naturally spawning adult salmon returning to spawning areas. Therefore, accurate determination of adult salmon spawner abundance is of critical importance to fisheries managers (Faurot and Kucera 2002).

Visually monitoring fish passage at dam fish ladders provides excellent opportunities for enumerating adult fish migrating upstream to spawning areas. However, observer counts based on specimen identification at viewing windows should not be treated as absolute estimates because they are not repeatable and cannot be reviewed for accuracy (Hatch et al. 1994a). Due to these limitations, it was necessary to improve methods for monitoring fish passage.

Fish enumeration programs throughout the Columbia River Basin have shifted to using time-lapse and motion detection video monitoring equipment due to its wide ranging applications (Irvine et al. 1991; Hatch et al. 1994b; Hiebert et al. 2000; Otis and Dickson 2001; Faurot and Kucera 2002; Anderson et al. 2004; Hetrick et al. 2004). Unlike mark/recapture studies, underwater video sampling requires no handling of fish and is a passive, non-invasive process that can potentially operate continuously throughout the year. Digital video images can be reviewed numerous times without degradation, are easily archived, are defensible, and can reduce possible study impacts to the species being observed (Edwards 2005). Images captured with video technology provide a permanent record of fish passage events to obtain accurate specimen and population abundance estimates. Video also permits uninterrupted monitoring of fish passage events allowing for assessment of diurnal movement patterns. Coupled with fish guidance structures, underwater video can be deployed at virtually any location provided there is adequate flow and good visibility. Compared with on-site counting, video monitoring can reduce data gathering costs by approximately 80% while simultaneously increasing data collected by 33% (Hatch et al. 1994a). Unlike other sampling methods such as hydroacoustics and DIDSON systems which require verification of species composition, underwater video provides a way to efficiently collect data describing not only species and natal origin, but in some cases the sex of individual fish.

Zosel Dam has long been considered a desirable location for monitoring adult salmonids by local fisheries managers. Resource managers believed that a counting station placed on the Okanogan River would improve assessments of target salmonid populations entering Canada and better inform future fisheries decision-making. Efforts to count fish at Zosel Dam began with a hydroacoustic study in 1991, but this effort was abandoned due to the difficulty in interpreting the data with any level of certainty (Anglea and Johnson 1991). In 1991 and 1992, Super VHS video equipment was used to estimate sockeye salmon escapement at Zosel Dam (Hatch et al. 1992).

These two years of video estimation of sockeye salmon escapement concluded that:

1. Using underwater video for estimating fish passage was feasible at Zosel Dam;
2. Fish passage only occurred at temperatures below 73°F (23°C); and
3. Most fish passage occurred during overnight hours.

The Colville Tribes recognized the importance of estimating escapement for all anadromous fish species migrating into Canada and solicited funding from the Northwest Power and Conservation Council (NPCC) for project #29008; a video-based, fish counting station at Zosel Dam. The Columbia River Basin Fish & Wildlife Authority (CBFWA) rated this project as a high priority in the 2003-2005 Fish and Wildlife program work plan. Although video enumeration would provide an assessment for the effectiveness of Bonneville Power Authority (BPA) funded projects and other salmon recovery efforts underway in the Okanogan sub basin, funding was not allocated (CBFWA 2002).

However, in 2005, as part of the Okanogan Basin Monitoring and Evaluation Program (OBMEP) to promote the recovery of Pacific salmon and steelhead populations, the Colville Tribes received funding and initiated a project titled "*Design and construction of video detection systems in the Okanogan River Basin to enumerate adult salmon and steelhead*" (hereafter called the OBMEP video project) to provide census counts at strategic locations throughout the Okanogan River Basin. The target species of the OBMEP video project include anadromous forms of *Salmonidae* that have known production in the basin, including summer steelhead, sockeye salmon, and Chinook salmon.

The goal of the OBMEP video project was determining basin- and tributary-specific spawner distributions and evaluating the status and trends of natural salmonid species production in the basin. Target locations were chosen by weighing information regarding current and historic salmonid use, contemporary discharge levels and forecasts, in-stream hydraulic conditions, and access. This project was executed after an initial feasibility assessment exploring the use of video detection systems for enumerating fish passage at potential sites in the Okanogan Basin (Nass and Bocking 2005). The first year implementation of the OBMEP video project occurred in 2006 and the results of that study are discussed in Johnson et al. (2007). The second year of the video project occurred in 2007 and the results of that study are discussed in Johnson et al. (2008).

## *Objectives*

The primary objectives of the 2008 OBMEP video project were to:

1. Install, operate and evaluate a video system at Zosel Dam to enumerate salmonid species; and;

2. Enumerate the number of anadromous fish passing this point, and collect additional data related to origin, species, run timing, and passage patterns.

This report documents the results from operations conducted in 2008 that provides species-specific abundance estimates of anadromous fish using an automated method. Steelhead passage data at Zosel Dam were acquired in 2008 but the results of that component of the video project are not presented here and are discussed in a separate document (Arterburn and Miller 2009).

# Methods

## *Study Area*

The U.S. portion of the Okanogan River is a 74 mile, low gradient waterbody draining a series of natural lakes located in Canada. The Okanogan River flows south through Oroville, Washington, and joins the Columbia River above Wells Dam near Brewster, Washington (Figure 1). Beginning at the outlet of Okanagan Lake in Canada, river discharges are regulated in order to maintain lake heights and supply irrigation water. The elevation of Lake Osoyoos, a transboundary waterbody, is controlled at the outlet by Zosel Dam, located approximately 4 miles south of the US/Canada border.

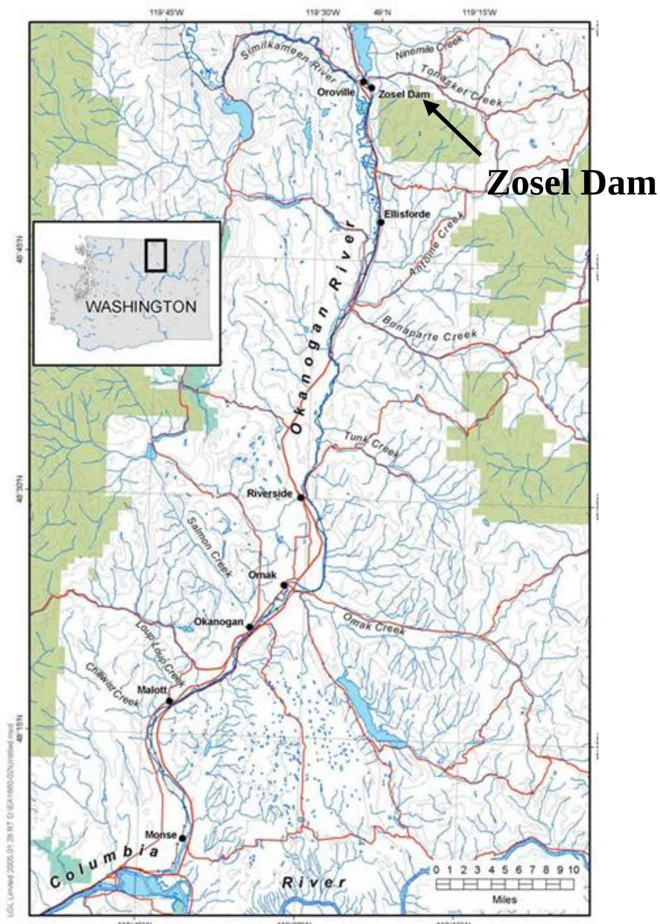


**Figure 1. Map of the Okanogan River Basin. A video monitoring system is deployed at Zosel Dam to enumerate adult salmonid passage.**

## Zosel Dam Site

Zosel Dam (Figure 2) is located at the extreme southern end of Lake Osoyoos and is of prime importance to agricultural interests in the Osoyoos, British Columbia (BC) and Oroville, Washington areas. The lake further serves as a recreational resource and domestic water supply. Zosel Dam has four spillway gates and two pool and weir type adult fish ladders. Zosel Dam is a water control structure and does not have power generation facilities. Construction of the current facility was completed in 1987.

**Figure 2. Aerial photograph of Zosel Dam taken in 2008.**

Roughly one-fourth of the habitat currently accessible to anadromous fish in the Okanogan River Basin is found above Zosel Dam. Lake Osoyoos provides an area for suspended sediment to precipitate before reaching the dam. The flashiness and high turbidity that is characteristic of the lower Okanogan River during the spring freshet can be attributed to the snowmelt-driven Similkameen River which enters the Okanogan River a short distance below Zosel Dam.

Zosel Dam is owned by the Washington State Department of Ecology and operated by the Oroville-Tonasket Irrigation District (OTID) under orders established by the International Joint Commission (IJC). The IJC resolves disputes between the U.S. and Canada under the *1909 Boundary Waters Treaty*. The International Osoyoos Lake Board of Control, consisting of representatives from the BC Ministry of Water, Land and Air Protection, Environment Canada, the Washington Water Science Center, Land & Water BC Inc. and the US Army Corps of Engineers, was established by the IJC to supervise the operation of Zosel Dam in compliance with the IJC's Order of Approval. During normal years the lake elevation is held between a maximum elevation of 911.5 feet and a minimum elevation of 909.0 feet. However, during drought years water may be stored to lake elevations up to 913.0 feet. Zosel Dam effectively controls the elevation of Osoyoos Lake except during periods of very high snowmelt runoff when natural conditions force the lake above the 913.0 foot level. Lake heights are managed primarily to protect recreational properties, irrigation withdrawals and domestic water uses.

*Video Chutes*

The fish ladder exits provide an excellent location for video enumeration stations on the main stem Okanogan River. The Zosel Dam video chutes utilize pre-existing fish guidance structures as they sit at the top of permanent fish ladders and are essentially an extension of the fish ladder.  The fish ladder exits are approximately 24” wide and 78” high, and have a combined flow of approximately 45 cfs at normal operating reservoir elevation (Tom Scott, OTID Secretary/Manager pers. comm.).  Achieving quality imagery is partially dependent upon the clarity of the water.  Under ideal conditions, camera-to-fish distances of 36” are feasible, but the distance decreases substantially under suboptimal water clarity; the frequency of high turbidity conditions requires guiding the fish to within 18” of the camera.  Therefore, narrow chutes (e.g., 12”) are essential for relatively high turbidity conditions.

A basic video chute consists of three components:  fish passage chute, viewing window, and camera housing.  The Zosel Dam system uses eight underwater cameras placed in the two separate counting arrays.  Both the west and east bank arrays were installed and functional by 1 January 2008.  The west bank array was comprised of two separate chutes (Figure 3) and the east bank array was made up of four separate chutes (Figure 4). Cameras 1-4 were located in the west bank unit with cameras 1 and 2 monitoring the top chute and cameras 3 and 4 monitoring the bottom chute (Figure 3).  Cameras 5-8 were installed in each of the four chutes that make up the east bank array and are numbered bottom to top.

**Figure 3.  Photographs of Zosel Dam west bank video chute array prior to (left) and during deployment.**


**Figure 4. Photographs of Zosel Dam east bank video chute array prior to (left) and during deployment.**

Details related to system function and operations can be found in Nass (2007) and Johnson et al. (2007) on the OBMEP web site: http://nrd.colvilletribes.com/obmep/Reports.htm.

## *Monitoring and Maintenance*

Maintaining the video arrays is an ongoing and important component of the video monitoring project. Maintenance visits to Zosel Dam generally occur every three to four days but are seasonally dependant. See Nass (2007) for operational protocols for use with the video systems.

Regular operations and servicing consists of:

1. Daily checks of the Zosel Dam cameras from the office via internet for monitoring system status and image clarity;
2. Frequent chute cleaning to reduce non-target motion triggers resulting from accumulated debris and macrophytes;
3. Frequent removal and cleaning of viewing windows;
4. Cleaning of camera lenses;
5. Monitoring of disk usage and status of underwater lights; and
6. Switching out hard drives when full or when review of previously collected data is complete.

## *Data Collection, Processing and Analysis*

Data are collected on all salmonids passing through the counting chambers across the entire passage season. Therefore, technicians are trained to distinguish characteristics of target species following *Inland Fishes of Washington* (Wydoski and Whitney 2003). Fish counts are grouped into one hour increments. Downstream fish passage events were subtracted from the total hourly net upstream count for each species before entry into the database. All motion clips of Chinook and steelhead were archived by the reviewer. The archive clips were then reviewed by a tribal biologist for quality assurance and quality control of the data. All motion clips collected during the majority of the sockeye run were archived on a dedicated hard drive for future reference.

Numbers of fish that passed during periods in which the video recording system was non-functional were estimated using interpolation. Average daily passage was calculated based on numbers passed during the three days prior to and three days following the missing data period. This average was applied to each full day of lost data. Passage estimates for days in which some hours of data were collected were based on the average daily passage multiplied by the proportion of hours not sampled. For example, if 12 hours of data were collected in a day then the estimated number of missed fish for that day was calculated by multiplying the average daily passage for the time period by 0.5.

Total enumeration estimates include estimated fallback numbers for Chinook and sockeye salmon. For Chinook salmon an estimated fallback proportion of 14% (Bjornn et al. 2000b) was used for both spring and summer/fall run fish. For sockeye salmon, an estimated fallback proportion of 5% was applied (Bjornn et al. 2000b).

All data were collected following OBMEP protocols (Nass 2007). Past reports and representative photographs are available for viewing by all interested parties on the following web page: http://nrd.colvilletribes.com/obmep/Reports.htm.

# Results

## *Physical Variables*

The Okanogan River hydrograph reflects a highly managed discharge pattern. Changes in outflows at Zosel Dam are abrupt and flattened when compared to a more natural system. The pattern of mean daily discharge at Zosel Dam throughout the study period was characterized by peak flows (> 2,000 cfs) occurring on 24 May and 13 June and sustained period of low flows (< 370 cfs) in March, and mid-July through mid-August (Figure 5). Mean daily water temperature at the USGS gauging station in Oroville, WA peaked at 26.2°C on 18 August then gradually declined through the rest of the passage season. Mean daily water temperature exceeded 24°C on several days in July (8-10, 16-28) and August (6-7, 14-19).

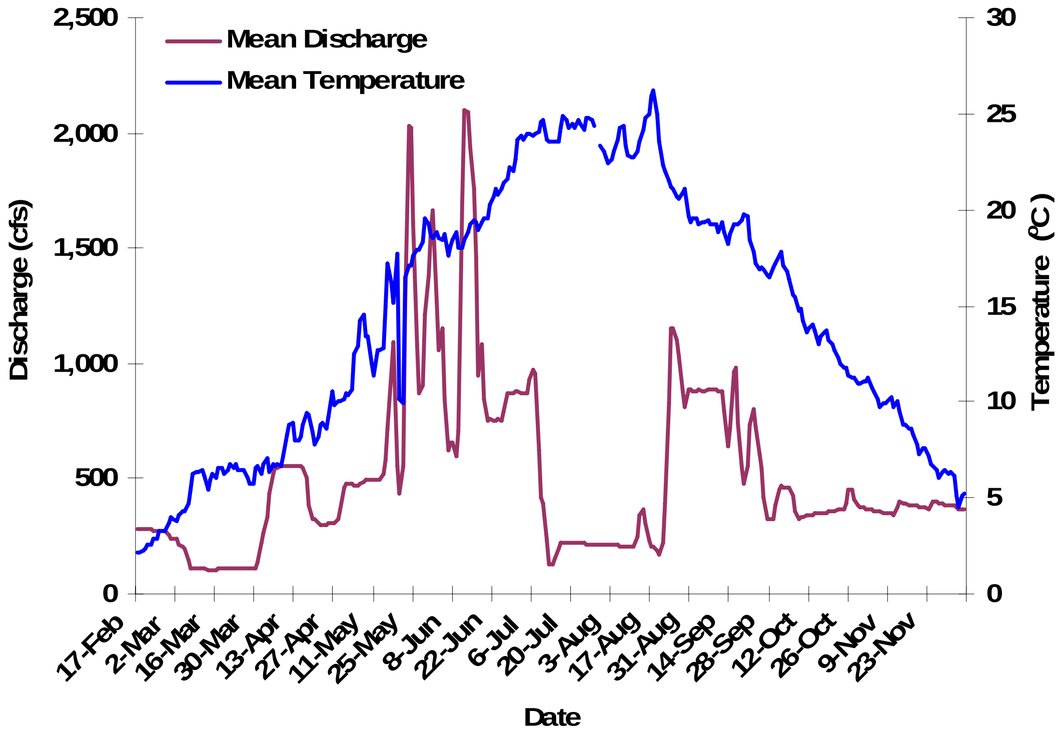


Figure 5. Daily mean temperature and discharge for the Okanogan River below Zosel Dam through the period in which salmon were detected with the video system (17 February through 6 December 2008). Data courtesy of USGS gauge at Oroville, WA. http://waterdata.usgs.gov/wa/nwis

## *Spillway Operations*

In response to the varying water discharge from Canada, Zosel Dam spillway gates were raised and lowered to achieve the target lake levels set forth in the IJC lake level agreement. Throughout the 2008 period in which salmon were detected at Zosel Dam, at least one spillway gate was opened greater than 12" for a limited number of days (a single gate was open for 14 days and two gates were open greater than 12" on three days; Figure 6). The pattern of spillway operations at Zosel Dam throughout the sampling season controlled the pattern of mean daily discharge observed at the USGS gauging station in Oroville.

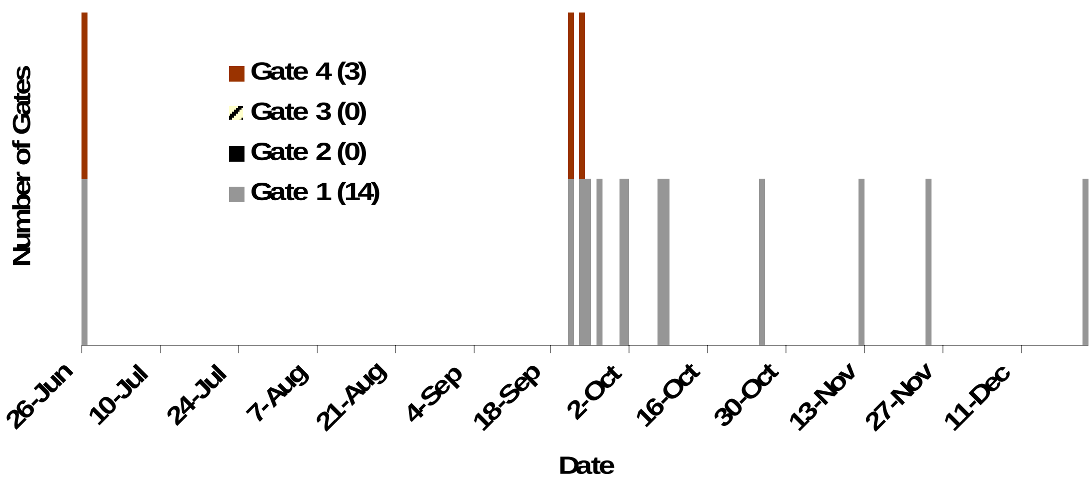


**Figure 6. Dates in which individual spillway gates at Zosel Dam were opened more than 12 inches for the time period of 26 June through 22 December 2008 (time period in which Chinook and sockeye were observed passing Zosel). Numbers in parentheses indicate the number of days in which the gates were opened greater than 12".**

## *Downtime and Missing Data*

There were several instances during the sampling period in which passage data were not collected (Table 1). A total of 342 hours of video data were lost due to corrupt or unformatted hard drives, or unsuccessful swapping of the DVR.

**Table 1. List of time periods in which data collection was interrupted at Zosel Dam in 2008.**

| Time Period | Cameras Affected | Total Hours Affected | Problem |
|---|---|---|---|
| 15 May 12:00 to 20 May 12:00 | All | 120 | Corrupt Hard Drive |
| 17 July 00:00 to 18 July 19:00 | All | 42 | Corrupt Hard Drive |
| 9 Aug 10:00 to 12 Aug 12:00 | All | 74 | Unsuccessful DVR Swap |
| 31 Aug 00:00 to 4 Sep 10:00 | All | 106 | Unformatted Hard Drive |

### *Chinook Salmon*

A total of 284 adult Chinook salmon were estimated to pass upstream through Zosel Dam in 2008 (Table 2). Spring Chinook salmon were estimated at 17 fish and summer/fall Chinook salmon were estimated at 267 fish (all Chinook that passed prior to 25 July were classified as spring run and all Chinook that passed after 24 July were classified as summer/fall run). Enumeration estimates account for the number of estimated fish missed during video system downtime and estimated fallback based on literature values (Bjornn et al. 2000b). About 33 percent of all Chinook were observed to be marked with adipose fin clips.

**Table 2. Total number of adult Chinook and sockeye salmon and bull trout observed based on video counts at Zosel Dam in 2008. Numbers of observed marked and unmarked fish are listed by species. Missed fish were estimated during video system downtime using interpolation. Fallback numbers were estimated from Bjornn et al. (2000b).**

| | Chinook | | Sockeye | Bull Trout |
|---|---|---|---|---|
| | Spring | Summer/Fall | | |
| Unmarked | 13 | 211 | 77,533 | 1 |
| Adipose Clip | 4 | 90 | 0 | 0 |
| Unknown | 1 | 9 | 0 | 0 |
| **Count Subtotal** | **18** | **310** | **77,533** | **1** |
| Est. Missed | 2 | 0 | 8,004 | 0 |
| Est. Fallback | (3) | (43) | (4,277) | (0) |
| **Est. Grand Total** | **17** | **267** | **81,260** | **1** |

Numbers in parentheses ( ) were subtracted from the running total

Summer/Fall Chinook showed a slight preference for the west bank array in 2008 (Table 3), a result not seen in previous years (Figure 7). Almost 80% of Spring Chinook were observed to pass through the east bank array in 2008. Within the chutes, total Chinook passage was recorded exclusively by the deeper cameras in 2008. Similarly, 100% of Chinook detections were observed with deeper cameras in 2006 (Johnson et al. 2007) and 99.6% with deeper cameras in 2007 (Johnson et al. 2008).

**Table 3. Total number and proportion of adult summer/fall Chinook and Sockeye salmon observed by bank location based on video counts at Zosel Dam in 2008.**

| Summer/Fall Chinook | | Sockeye | |
|---|---|---|---|
| Count | Percent | Count | Percent |
| 147 | 47.4 | 56,800 | 73.3 |
| 163 | 52.6 | 20,733 | 26.7 |

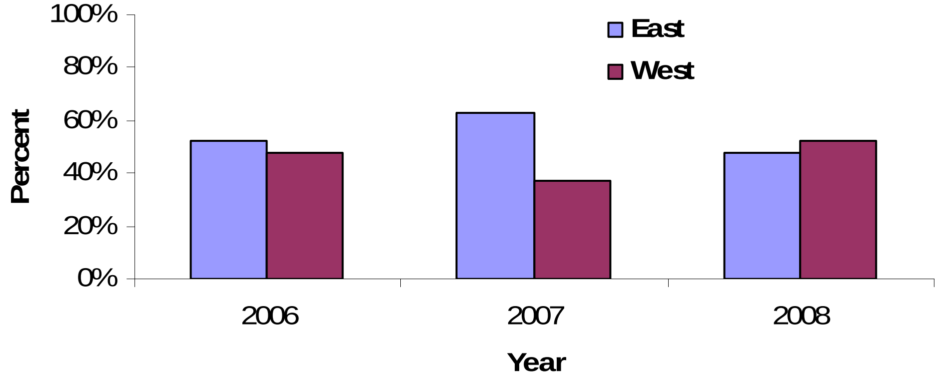


Figure 7. Chinook salmon passage location at Zosel Dam for 2006 through 2008. 2006 data from Johnson et al. (2007) and 2007 data from Johnson et al. (2008).

In 2008, Spring Chinook salmon were initially observed on 30 June (Figure 8) Summer/Fall Chinook salmon were initially observed on 4 August and the last fish was detected on 21 November (Figure 8). The primary mode of passage occurred 4 October through 16 October when almost 69% of the total run passed the dam. Summer/fall Chinook passage peaked with 28 fish observed on both 5 and 8 October.

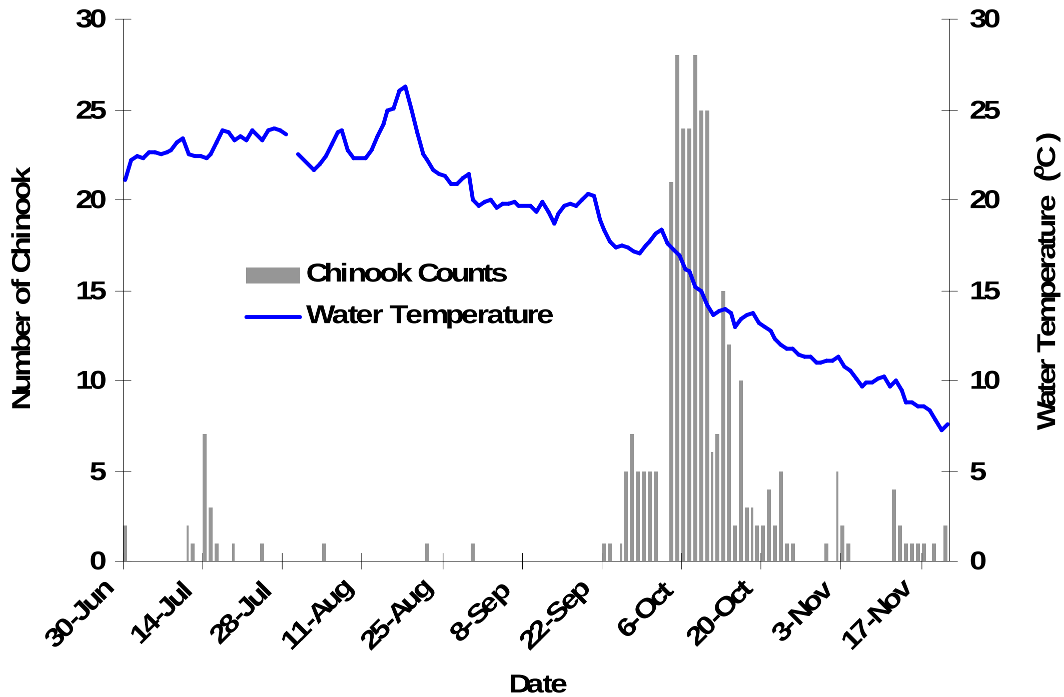


Figure 8. Adult Chinook salmon run timing based on video counts at Zosel Dam from 30 June through 21 November, 2008. Fish passing prior to 25 July were classified as spring run and fish passing after 24 July were classified as summer/fall run. Mean daily water temperature from the USGS gauge at Oroville, WA is also shown.

Hourly passage counts of summer/fall Chinook salmon indicate a slight diel pattern. Summer/fall Chinook passage remained generally low from 1900 to 0600 hours relative to other hours of the day (Figure 9, Table 4). Hourly passage peaked during 0800, and 1600 hours. A two-sample *t* test (Zar 1984) of the hypothesis that the mean number of summer/fall Chinook passing in 2008 during light hours (0700 through 1700) was equal to the mean number of summer/fall Chinook passing during dark hours (2200 through 0500) in the same time period could not be rejected, indicating that there was no significant differences for summer/fall Chinook passage during day and night hours. The pattern of generally higher counts during the day than at night seen in 2008 was also observed in previous years (Figure 9).

**Table 4. Total counts and percent frequency values for hourly data of summer/fall Chinook and sockeye salmon passage based on video counts at Zosel Dam in 2008.**

| | Summmer/Fall Chinook | | Sockeye | |
|---|---|---|---|---|
| Hour | Count | Percent | Count | Percent |
| 6 | 6 | 1.9% | 4,437 | 5.7% |
| 7 | 14 | 4.5% | 3,523 | 4.5% |
| 8 | 25 | 8.1% | 3,604 | 4.6% |
| 9 | 16 | 5.2% | 3,906 | 5.0% |
| 10 | 23 | 7.4% | 4,366 | 5.6% |
| 11 | 18 | 5.8% | 6,586 | 8.5% |
| 12 | 16 | 5.2% | 5,082 | 6.6% |
| 13 | 24 | 7.7% | 3,510 | 4.5% |
| 14 | 24 | 7.7% | 2,717 | 3.5% |
| 15 | 20 | 6.5% | 1,464 | 1.9% |
| 16 | 25 | 8.1% | 1,119 | 1.4% |
| 17 | 10 | 3.2% | 1,074 | 1.4% |
| 18 | 10 | 3.2% | 960 | 1.2% |
| 19 | 5 | 1.6% | 737 | 1.0% |
| 20 | 5 | 1.6% | 577 | 0.7% |
| 21 | 6 | 1.9% | 950 | 1.2% |
| 22 | 4 | 1.3% | 1,481 | 1.9% |
| 23 | 5 | 1.6% | 3,174 | 4.1% |
| 0 | 13 | 4.2% | 3,444 | 4.4% |
| 1 | 5 | 1.6% | 3,864 | 5.0% |
| 2 | 10 | 3.2% | 4,065 | 5.2% |
| 3 | 13 | 4.2% | 3,635 | 4.7% |
| 4 | 7 | 2.3% | 6,297 | 8.1% |
| 5 | 6 | 1.9% | 6,961 | 9.0% |

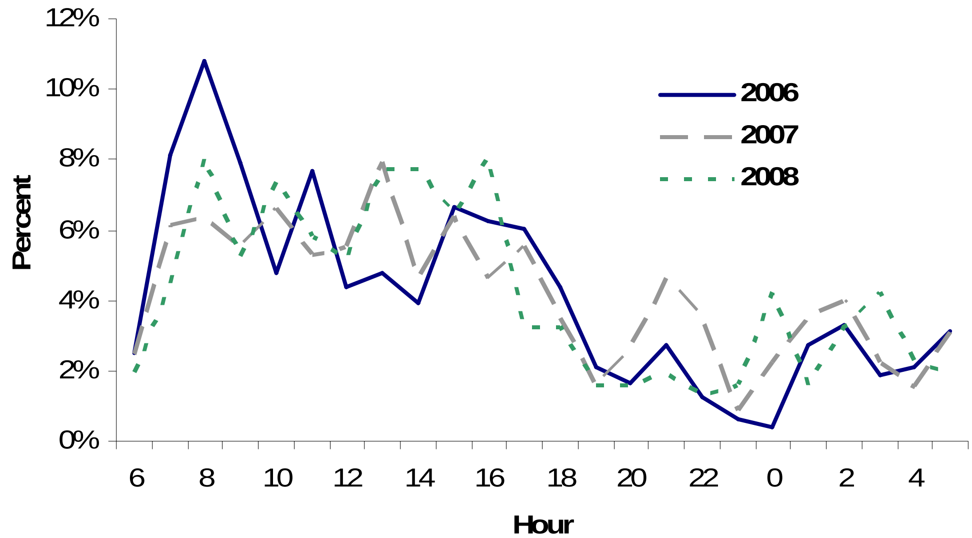


Figure 9. Hourly passage of Chinook salmon at Zosel Dam in 2006 through 2008. 2006 data from Johnson et al. (2007) and 2007 data from Johnson et al. (2008).

## *Sockeye Salmon*

A total of 81,260 adult sockeye salmon were estimated to pass upstream through Zosel Dam in 2008; all observed fish with adipose fins (Table 2). Enumeration estimates account for the number of estimated fish missed during video system downtime and estimated fallback based on literature values (Bjornn et al. 2000b). Sockeye showed a strong preference for passing the dam on the east bank as 73% of all sockeye passage events occurred there (Table 3), a result consistent across the last three years (Figure 10). Deeper deployed cameras detected 99.97% of all sockeye passage events in 2008, which compares well with deeper camera detections of 99.8% in 2006 (Johnson et al. 2007) and 2007 (Johnson et al. 2008).

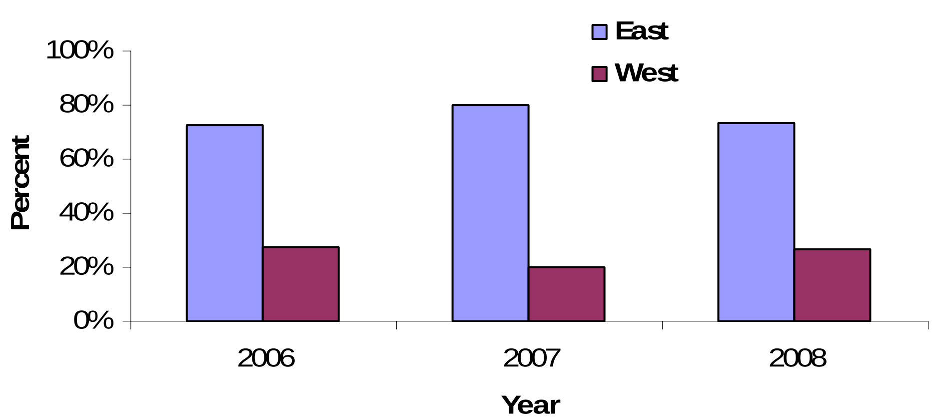


Figure 10. Sockeye salmon passage location at Zosel Dam for 2006 through 2008. 2006 data from Johnson et al. (2007) and 2007 data from Johnson et al. (2008).

Sockeye salmon were first detected at Zosel Dam on 17 February and last observed on 6 December (Figure 11). After the initial detection in February, the sockeye run arrived at Zosel Dam on 26 June. An initial primary mode of passage occurred from 3 through 16 July when 72% of the total sockeye run passed the dam. Smaller pulses of passage occurred from 16 July through 9 August when 25% of the run was observed to pass the dam. Sockeye passage peaked on 11 July with 11,371 fish.

Hourly passage counts of sockeye salmon at Zosel Dam in 2008 indicate increased passage in early and late morning periods relative to other hours of the day (Table 4, Figure 12). A two-sample *t* test of the hypothesis that the mean number of sockeye passing in 2008 during light hours (0700 through 2000) was greater than or equal to the mean number of sockeye passing during dark hours in the same time period (2200 through 0500) could not be rejected indicating no significant difference in sockeye passage during night and day periods. Passage peaked during the 0500 hour, and a secondary peak was observed at 1100; passage was lowest during 1900 and 2000 hours. The hourly pattern of passage observed in 2008 is inconsistent with the trend of increased passage during nighttime hours relative to day time hours observed in 2006 and 2007 (Figure 12).

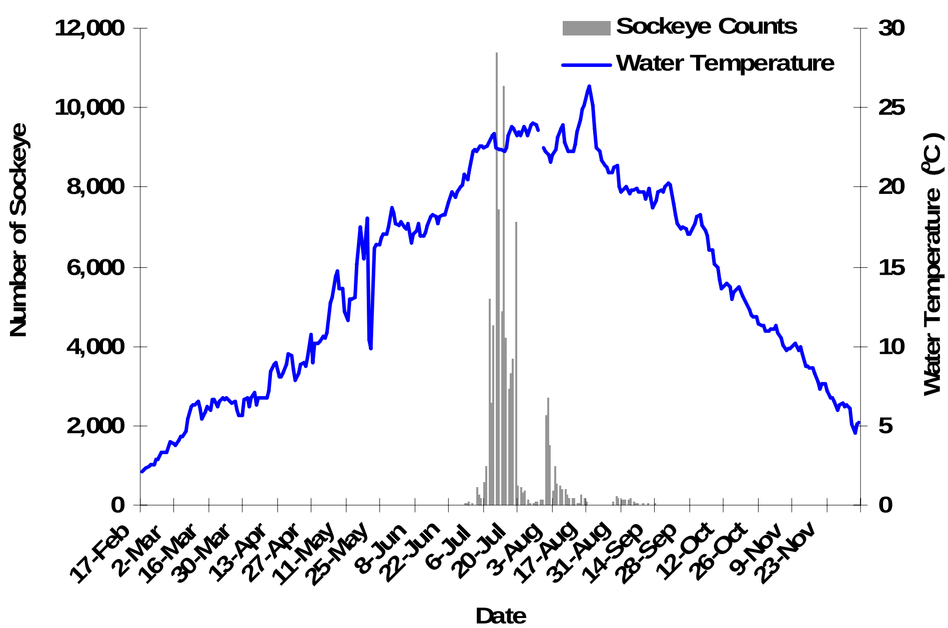


Figure 11. Adult sockeye salmon run timing based on video counts at Zosel Dam from 17 February to 6 December, 2008. Mean daily water temperature from the USGS gauge at Oroville, WA is also shown.

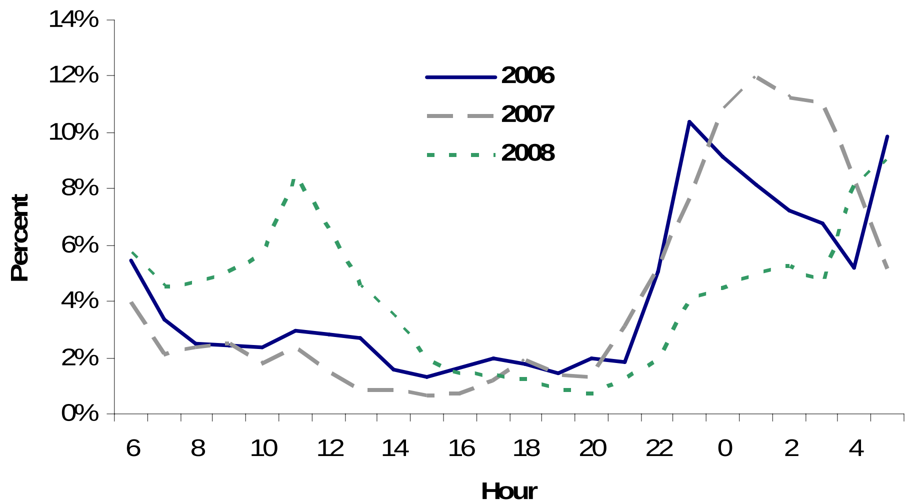


Figure 12. Hourly passage of Sockeye salmon at Zosel Dam in 2006 through 2008. 2006 data from Johnson et al. (2007) and 2007 data from Johnson et al. (2008).

## *Temperature Effects on Fish Passage*

Water temperatures did not appear to negatively impact Chinook passage at Zosel Dam in 2008 as mean daily temperatures ranged between 13 and 17°C during the period of highest passage (Figure 8). Sockeye passage was likely impacted by excessive water temperatures in 2008 as water temperature exceeded 24°C on 23 days during the passage season (Figure 11). The relationship between mean hourly sockeye passage and temperature for the 4 July through 1 August period in which 90% of sockeye passage occurred indicates an inverse trend between temperature and passage (Figure 13).

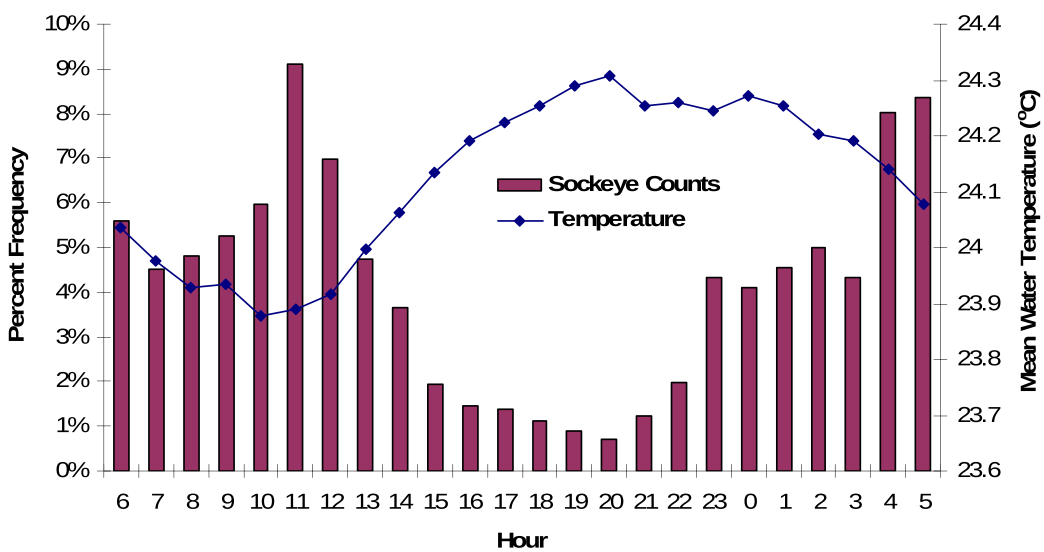


Figure 13. Percent frequency distribution of hourly adult sockeye salmon passage based on video counts at Zosel Dam and mean water temperature in 2008. Data reflect the period 4 July through 1 August.

### *Non-Target Fish*

A total of 21 non-target fish species were observed with the video monitoring system at Zosel Dam in 2008, slightly more species than were seen in 2007 (Table 5). Largemouth bass were the most abundant non-target fish followed by bridgelip suckers and northern pikeminnow in 2008. With the exception of sockeye salmon smolts, largemouth bass was the most abundant non-target species observed in 2007. Similar numbers of steelhead, mountain whitefish, common carp, bluegill, largemouth bass and white crappie were seen in 2007 and 2008. The most disparate counts between species across years were for sockeye salmon smolts (2,931 in 2007 and four in 2008) and bridgelip sucker (one in 2007 and 1,209 in 2008).

**Table 5. List and count of all non-target fish observed at Zosel Dam in 2007 and 2008.**

| Common Name | 2007 | 2008 |
|---|---|---|
| Chinook Salmon (jack) | 12 | 2 |
| Chinook Salmon (smolt) | 6 | 17 |
| Steelhead | 181 | 201 |
| Rainbow Trout | 86 | 14 |
| Cutthroat Trout | 0 | 1 |
| Sockeye Salmon (smolt) | 2,931 | 4 |
| Unknown Adult Salmon | 13 | 9 |
| Brook Trout | 4 | 2 |
| Bull Trout | 1 | 1 |
| Mountain Whitefish | 19 | 16 |
| Yellow Perch | 1 | 7 |
| Brown Bullhead | 6 | 45 |
| Yellow Bullhead | 0 | 20 |
| Unknown Catfish | 2 | 0 |
| Common Carp | 741 | 978 |
| Chiselmouth | 58 | 421 |
| Northern Pikeminnow | 596 | 1,091 |
| Peamouth | 157 | 27 |
| Bluegill | 249 | 344 |
| Largemouth Bass | 1,277 | 1,361 |
| Smallmouth Bass | 18 | 168 |
| White Crappie | 8 | 11 |
| Black Crappie | 0 | 2 |
| Bridgelip Sucker | 1 | 1,209 |
| Largescale Sucker | 0 | 4 |
| Unknown Suckers | 799 | 0 |
| Three-spine Stickleback | 0 | 1 |

# Discussion

## *Run Timing and Relative Abundance*

Comparing the 2008 Zosel Dam passage data with the adult counts at Wells Dam (Fish Passage Center 2009) allows for better understanding of spawner distribution and run timing dynamics in the Upper Columbia and Okanogan River basins. Run timing patterns of Chinook salmon were similar between Wells and Zosel dams (Figure 14). The similarity in run timing pattern and the apparent shift in run timing from Wells Dam to Zosel Dam (22 July to 8 October reflects the time period in which 50% of the run had passed each respective dam) demonstrates that migration delays occur after Chinook pass Wells Dam but before they pass Zosel Dam. Relative abundance of Chinook salmon at Zosel Dam in 2008 comprised 1.1% of the total number observed at Wells Dam, a lower proportion than was observed in 2006 (1.7%) (Johnson et al. 2007) and in 2007 (2.7%) (Johnson et al. 2008). Less than 20 Chinook salmon were observed on spawning grounds in Canadian waters in 2008 (Carla Davis, Okanagan Nation Alliance Fisheries Department, pers. comm.).

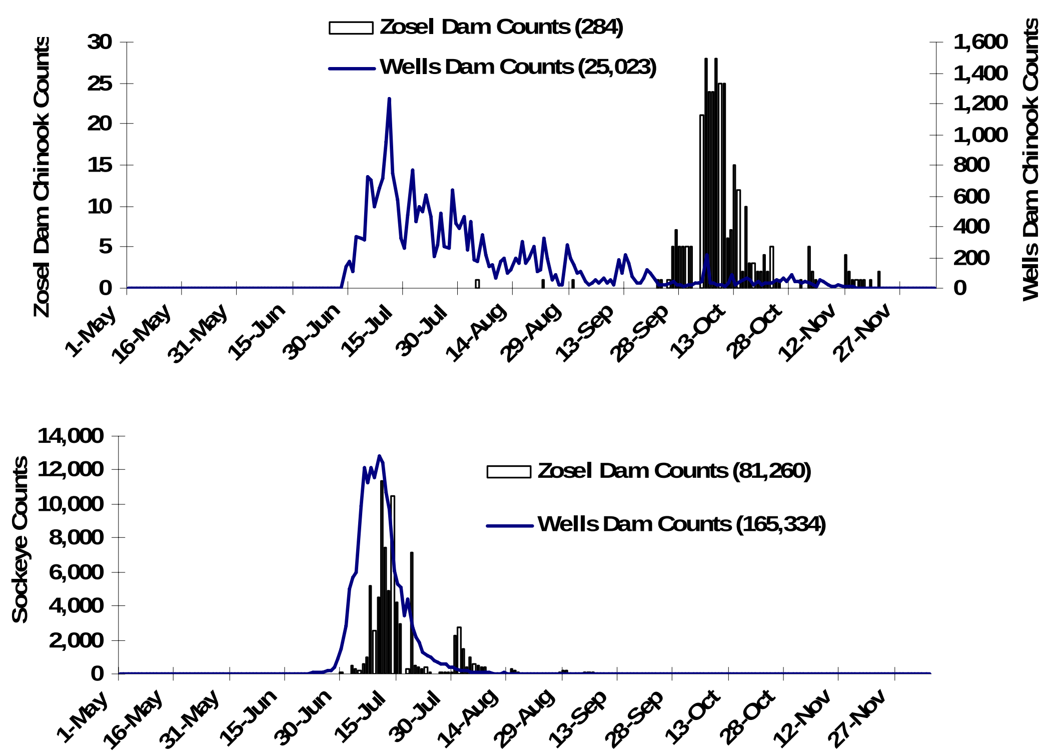


**Figure 14. Run timing of Chinook and sockeye salmon at Zosel Dam on the Okanogan River and Wells Dam on the Columbia River in 2008. Total count estimates at Zosel Dam include estimates for missed fish during video system downtime and fallback. Note that the Chinook counts for Zosel and Wells Dams have different Y-axes. Wells Dam data from Fish Passage Center Website: http://www.fpc.org/.**

Sockeye salmon run timing at Zosel Dam showed two pulses of fish: an initial primary one beginning in the beginning part of July followed by a smaller one in early August (Figure 11). Sockeye passage at Wells Dam was characterized by a bell-shaped run timing pattern centered the second week in July (Figure 14). Peak daily sockeye counts at Zosel Dam did not exceed those observed at Wells Dam, a result contrary to what was observed in 2006 and 2007. A 4-day shift in run timing from Wells to Zosel Dam (10 to 14 July reflects the time period in which 50% of the run had passed the respective dams) occurred. This result indicates major delays in sockeye migration between Wells and Zosel dams did not occur in 2008. Zosel Dam sockeye counts comprised 49% of the total number observed at Wells Dam, a smaller proportion than what was seen in 2006 (87%) and in 2007 (80%). The relative abundance estimate for sockeye passing Zosel Dam compares favorably with the peak live plus dead estimate of 72,598 spawning sockeye based on spawning ground surveys in the Upper Okanagan River in 2008 (Shala Lawrence, Okanagan Nation Alliance Fisheries Department, pers. comm.).

## *Diel Passage*

Patterns of hourly passage at Zosel Dam differed between Chinook and sockeye salmon in 2008. Chinook passage showed a slight but not significant increase in daytime hours relative to nighttime hours in 2008 and in each of the last two years (Figure 9). Sockeye passage did not show the strong pattern of increased passage at night relative to during the day that was observed in each of the last two years (Figures 12 and 13). The increase in sockeye passage during daytime hours relative to previous years may be related to the timing of the sockeye run through Zosel Dam. A majority of the run (98%) passed the dam prior to the occurrence of peak water temperatures in mid August (Figure 11). Mean hourly passage showed an inverse relationship with mean hourly temperature in 2008 (Figure 13), whereas in previous years, highest hourly passage occurred during hours of decreasing water temperature (Johnson et al. 2007; 2008).

Hydroacoustic sampling conducted at Zosel Dam in 1991 indicated that sockeye passage was dissimilar to what was observed in 2008 as sockeye were reported to pass most frequently during the 1900 and 0600 hours, with lows during the mid-morning hours (Anglea and Johnson 1991). Hatch et al. (1992) reported an even more pronounced nighttime trend in sockeye passage at Zosel Dam in 1992 then was observed in 2008 as nighttime (2000 to 0600 hours) passage accounted for 93% of total passage. Also contrary to the results reported here, Hatch et al. (1994b) observed that nighttime passage of sockeye at Tumwater Dam on the Wenatchee River accounted for only 6.7% of total passage. In the Tumwater Dam passage study, Hatch et al. (1994b) reported that nighttime passage for Chinook accounted for 13.6% of total passage, an estimate lower than what are reported for Zosel Dam in 2008. In a video sampling study at Prosser Dam on the Yakima River, Hiebert et al. (2000) found that peak Chinook passage occurred during the 1000 to 1200 hour time period, a result similar to what is reported here.

## *Temperature Effects*

In 2008, negative impacts of water temperature on fish passage were not observed as demonstrated by the lack of large delay between the sockeye passage at Wells and Zosel dams (Figure 14). Only four days separated the timing in which 50% of the run had had passed the respective dams, and peak daily water temperatures occurred after 98% of the sockeye had passed the dam (Figure 11). Mean daily water temperatures were generally cooler when fish were passing Zosel in 2008 as compared with 2007 (Figure 15), when excessive water temperatures likely contributed to delays in migration. This delay in migration in some years is likely the result of the presence of a temporal thermal barrier at the confluence of the Columbia and Okanogan rivers (Duree 1991; Hatch et al. 1992; Alexander et al. 1998).

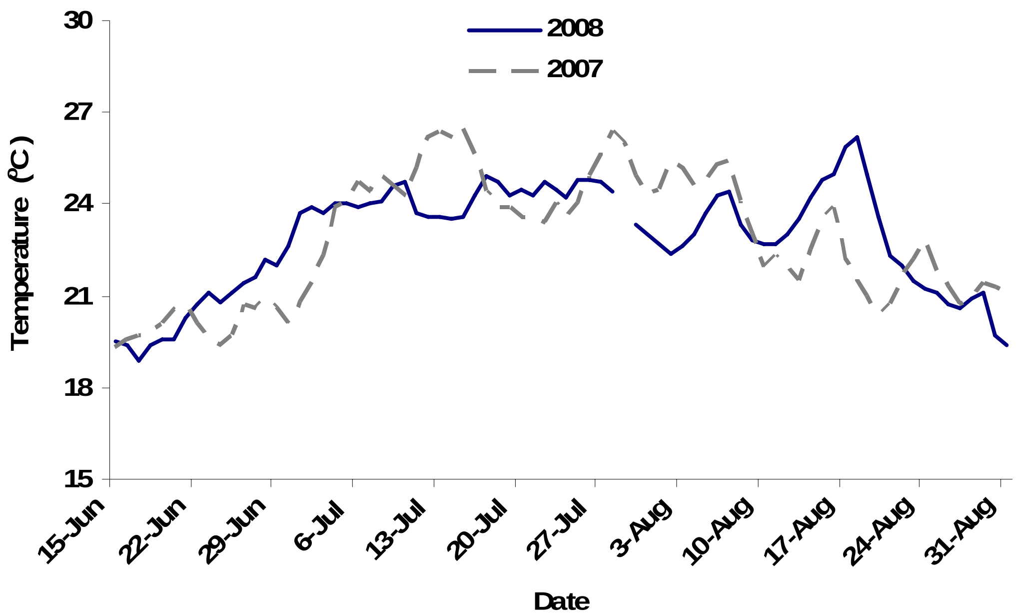


Figure 15. Mean daily water temperature from 15 June through 31 August for 2007 and 2008. Water temperature data from the USGS gauge at Oroville, WA.

## *Lateral and Vertical Passage Distributions*

Sockeye salmon passage was skewed toward the east bank which indicates a preference for passing on the east side of the dam (Table 3). This result is consistent with what was observed in 2006 (Johnson et al. 2007) and in 2007 (Johnson et al. 2008). It is not clear what factors contributed to such a skewed distribution of passage towards the east bank. It may be that fish are distributed along or near the east bank of the river downstream of the dam due to favorable velocity or flow conditions, and that migrants simply pass up through the dam on the east side because they are already distributed to do so. Environmental conditions may then influence lateral passage fate without regard to operating conditions at the dam. Lateral passage fate could be assessed to determine whether downstream flow conditions or chute preference influence migrant passage by releasing groups of radio-tagged fish from both shorelines downstream several miles from the dam. Antennae and receivers located along the river could be used to detect if and when fish change their distributions; if distributions did not change significantly, then it would be reasonable to assume that flow conditions are the prime factors driving passage fate. If distributions showed significant change, especially in the vicinity of the dam, then it would be assumed that operational conditions drive passage fate.

Spill gate opening did not appear to influence lateral passage distributions for Chinook or sockeye salmon in 2008 since the days in which the gates were open greater than 12" were limited during the period in which the majority of fish passage occurred (Figures 6, 8 and 12).

The video monitoring results were also informative regarding vertical distribution of passage since the video chutes are vertically compartmentalized. Passage data strongly indicated that when flow conditions resulted in all levels of the chutes being watered up, the majority of Chinook and sockeye passed the monitoring stations through the deepest portions of the chutes, a similar result to what was observed in previous years (Johnson et al. 2007; 2008). Given the very low proportions of migrants observed with the shallow-deployed cameras, efficiency of the video enumeration program can be increased by removing those cameras and thereby decreasing the amount of labor necessary for video review. In future years, overall video count estimates based only on deeper-deployed cameras could be increased by a very small factor to account for fish that would be observed with the shallow cameras if they were deployed and their data reviewed. A substantial program cost savings in terms of labor would be incurred if this efficiency measure was implemented.

## *Spillway Passage*

Video monitoring arrays at Zosel Dam sampled only the primary passage routes (the pool and weir type fish ladders) in 2008 and in previous years. However, upstream passage by salmon through open spill gates has been documented at Zosel Dam (Major and Mighell 1967; Anglea and Johnson 1991; Hatch et al. 1992). Because no recent monitoring had occurred, an attempt was made to monitor passage through this route using high intensity lights and color cameras on the tailrace side of Gate 1 in 2006. A single spill bay stop log was fitted with cameras and lights and lowered onto the spill apron. This technique was not successful due to the low contrast background, the variable effects of sunlight, and entrained air at the gate edge that made image recognition virtually impossible. As a result, the extent to which upstream occurred over the last several years is unknown. Since spill gates were typically not open more than 12” through the period in which Chinook and sockeye were passing Zosel Dam, it is likely that few, if any fish of these species passed through the spillway on their way upstream in 2008.

## *Non-target Species*

Video counts of non-target fish in 2008 were similar to counts of some species and very different for other species as compared with counts in 2007 (Table 5). Differences in counts across years do not necessarily reflect differences in abundance in resident species. Movement direction is not noted for resident species observations, so it is assumed that many of the counts likely reflect the same individuals moving upstream and downstream through the video chutes. Large differences in counts across years (e.g., bridgelip sucker with one observation in 2007 and 1,209 in 2008) likely suggest an improvement in species identification from 2007 to 2008. In 2007, 799 observations were made of an unidentified sucker species. Based on 2008 counts, these fish were probably bridgelip suckers.

## Recommendations

Based on the ongoing efforts and results from this video-based study and the ones conducted in previous years (Johnson et al. 2007; 2008), we offer the following recommendations to further enhance the effectiveness and reliability of continued assessment of timing and abundance of adult salmonids in the Okanogan River Basin. Following these recommendations will further refine efforts in determining basin and tributary-specific spawner distributions, and evaluating the status and trends of natural salmonid production in the Basin.

### *Optimize Spillway Operation Protocol*

Previous investigators determined that with spillway gate openings less than or equal to 12”, anadromous fish passage up through the spillway gates at Zosel Dam was minimal. Gate openings larger than 12” facilitate passage through the spillway (Hatch et al. 1992). If spillway passage cannot be monitored, then stock abundance estimates for anadromous fish based on video sampling are not census counts but instead are less accurate, relative abundance estimates. Although the frequency of spill gate opening greater than or equal to 12” were fairly low during the passage season, some fish may have escaped detection by passing up through this route. It is important then to minimize spillway passage in order to increase the value and utility of the video counts. To do so, a spillway operation protocol should be put in place and implemented by the dam operators during the fish passage season. As increased discharge warrants the use of spill, the protocol should consist of only opening individual gates a maximum of 10” until all gates are open by that height. This approach would spill the same volume of water as opening a single gate 40” but would minimize unmonitored spillway fish passage compared to the latter approach. It is recognized that during the spring freshet period, the recommended protocol is not usually practical due to the high discharge requirements and few adult salmonids are present anyway.

### *Accounting for Downstream Fish Passage*

Downstream fish passage events in the video chutes at Zosel Dam have not been reported to date. Instead, downstream migrating fish detections were accounted for by modifying the total hourly count for each species before entry into the database. In future monitoring of salmonid passage at Zosel Dam, all instances of downstream movement through the video chutes should be recorded and hourly upstream estimates of fish passage. These data will allow for the assessment of potential trends in downstream movement that would lead to a better understanding of fish passage dynamics at Zosel Dam.

Fallback of adult salmonids occurs to varying degrees across years and locations in the Columbia River system. For example, during the period 1996 through 1998 at The Dalles Dam, fallback rates as high as 12%, 4% and 10% were estimated for summer Chinook, sockeye and steelhead, respectively (Bjornn et al. 2000a). For the same period at John Day Dam, fallback rates as high as 14%, 5%, and 6% were estimated for summer Chinook, sockeye and steelhead, respectively (Bjornn et al. 2000b). Fallback rates at Zosel Dam are unknown. To account for fallback of salmonids at Zosel Dam with respect to total enumeration estimates, literature values of proportional fallback for salmonid species at other Columbia River dams (e.g., Bjornn et al. 2000b) will be applied to total upstream video counts in future monitoring studies.

### *Monitor Tributary Sites*

Monitoring key tributaries in the Okanogan River Basin would broaden the knowledge base regarding the population status and distribution of tributary-specific steelhead stocks. Efforts in 2006 demonstrated the feasibility of monitoring steelhead passage in Bonaparte Creek using a video system (Johnson et al. 2007), but tributary sites were not monitored in 2008. In order to develop a better understanding of the abundance and production of those steelhead stocks, future monitoring efforts should include the following priority list of tributaries for steelhead passage using video monitoring systems: Salmon, Ninemile, Antoine, and Loup Loup creeks. In addition to adult steelhead abundance information, tributary video systems might also be used to provide relative abundance estimates for juvenile steelhead.

### *Assess Temperature Mortality Relationship for Sockeye*

As discussed in Johnson et al. (2008) the disparity between sockeye counts at Zosel Dam and the number of estimated spawners may be explained by mortality that occurs as a consequence of sockeye exposure to lethal water temperatures upstream of the dam. The effects of high water temperatures on fish passage in 2008 did not occur given the relatively moderate water temperatures observed. Nonetheless, to better understand the temperature mortality relationship it is important to continue assessing the factors that contribute to the relationship. Therefore we recommend additional analyses in future years when high water temperatures negatively impact fish passage and a review and synthesis of sockeye passage at Zosel Dam relative to water temperature patterns at Zosel as well as at the mouth of the Okanogan River.

To investigate the occurrence of mortality events and assess the relative magnitude of occurrence, it is essential to estimate the level of sockeye prespawn mortality in the southern basin of Osoyoos Lake. We recommend the use of periodic snorkel and SCUBA surveys throughout the mid July to early September time period to estimate the number of dead sockeye in the lake. Overall yearly mortality estimates could then be analyzed relative to Zosel counts, spawner estimates and water temperatures to better understand the dynamics of sockeye migration mortality.

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# Appendix B. SPRING SPAWNER ESTIMATES FOR THE OKANOGAN RIVER BASIN (2008)

**CCT/AF-2009-1** **February 2009**

## COLVILLE TRIBES
## DEPARTMENT OF FISH AND WILDLIFE


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# SPRING SPAWNER ESTIMATES FOR THE OKANOGAN RIVER BASIN (2008)

Performance Period: March 1, 2008 – February 28, 2009

BPA Project # 200302200

Prepared by

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## February 2009

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## Abstract

Spring spawning surveys were conducted in the Okanogan River basin as part of the Colville Tribes' Okanogan Basin Monitoring and Evaluation Program. In 2008, 384 redds were observed along the mainstem Okanogan and 132 redds in the Similkameen River. Tributaries within the basin that were utilized by anadromous steelhead in 2008 included Salmon, Omak, Bonaparte, Ninemile, and Tunk Creeks. Escapement estimates for the entire Okanogan River were between 1,341 and 1,436 summer steelhead and of those, 213 to 266 were likely of natural origin. Escapement into Canada was estimated at 116 (32.67% had an intact adipose fin). Forty-four spring Chinook were collected at the Omak Creek trap. Mainstem steelhead redd distributions were highest in the upstream reaches of the Okanogan River and lower section of the Similkameen River, where high quality spawning gravels are common and hatchery releases are focused. Other high density spawning areas included the island section near Tonasket, and near McAlister Rapids, where braided channels and water velocities are favorable for summer steelhead. Annual collection of steelhead spawning data in future years will provide a more comprehensive depiction of spawning distribution and population trends within the Okanogan River basin.

## Introduction

The Okanogan Basin Monitoring and Evaluation Program (OBMEP), created in 2004, established a basin wide monitoring program for anadromous fish in the Okanogan River basin. OBMEP fills data gaps particularly associated with endangered summer steelhead through implementing a scientifically rigorous long-term status and trend monitoring design for habitat, water quality, and biological indicators. OBMEP uses protocols derived from the Upper Columbia Strategy (Hillman 2004) that calls for a complete redd census, if possible, or an annual count of the numbers of redds within already-established index areas, or in reaches selected using randomly selected EMAP design. Following the Upper Columbia Strategy's guidance facilitates coordination and standardization with other monitoring and evaluation efforts in the Upper Columbia ESU (Figure 1). In 2004, OBMEP developed the methodologies for implementing redd surveys beginning in 2005 (Arterburn et al. 2004) and these methods were later revised in 2007 (Arterburn et al. 2007c).

In 2005, a complete census of all main stem habitats was conducted within the U.S. for the first time and identified several large areas that contained no redds due to unsuitable habitat for spawning. Eliminating these areas from future surveys reduces program cost without the loss of any biologically important data. A few other areas such as Tunk and Ninemile creeks have limited access due to a lack of land owner permission but these data would be similarly impacted regardless of the monitoring design used. Historic redd survey data collected by the Colville Tribes also provided important information used to establish reference reaches on Omak Creek. Collectively, several recommendations were made and in 2005 that were applied in 2006 (Arterburn and Kistler 2006).

In 2006, we uncovered new information related to summer steelhead spawning in the Okanogan River Basin. First, we were able to estimate escapement into Canada for the first time in 2006 because of the installation of a video counting system at Zosel dam in 2005. Second, we documented spawning areas in four new tributaries; Tonasket, Antoine, Wild Horse Spring, and Loup Loup Creeks. Finally, we added new information related to up-stream barriers for Tonasket, Ninemile, Wild Horse Spring, and Whistler Canyon creeks.

In 2007, stream flows in the main stem Okanogan River exceeded the optimal range conducive for conducting redd surveys but data collected in previous years was sufficient to model results based upon limited data collection opportunities. We also attempted to categorize results into both hatchery and wild fish for the first time.

This is the fourth year of steelhead redd surveys conducted by the Colville Tribes in the Okanogan Basin. An extensive literature review of historic spawning information related to the Okanogan River basin can be found in the 2005 report (Arterburn et al. 2005). This document builds upon previous information and the entirety of these previous survey reports can be accessed through our web-site at:

http://nrd.colvilletribes.com/obmep/Reports.htm

## Methods

Steelhead redd surveys were conducted downstream of identified anadromous fish migration barriers in the main stem and all accessible tributaries of the Okanogan River and Similkameen River drainages (Arterburn et al. 2007a, Walsh and Long 2006). Designated main stem and tributary survey reaches (except reaches of Tunk and Ninemile creeks) have been defined and can be viewed in Table 1. These survey reaches encompass all known spawning habitat currently available in the United States portion of the Okanogan River Basin where summer steelhead are listed as endangered within the Upper Columbia ESU (Figure 1). The area of the Okanogan downstream from Chiliwist Creek is inundated by the Columbia River (Wells Pool/Lake Pateros) and therefore lacks the appropriate velocity and substrate needed for summer steelhead to spawn. Consequently, this lower reach (~ 15 miles) of the Okanogan River has been excluded from surveys or estimates.

Redd surveys were conducted along the main stem Okanogan River between March 17 and April 28, and were conducted up to three times during the spawning period provided discharge levels remained below 3,000 cfs. Single-pass surveys of tributary habitats were conducted starting on April 29 and ending once all tributary reach surveys are completed.

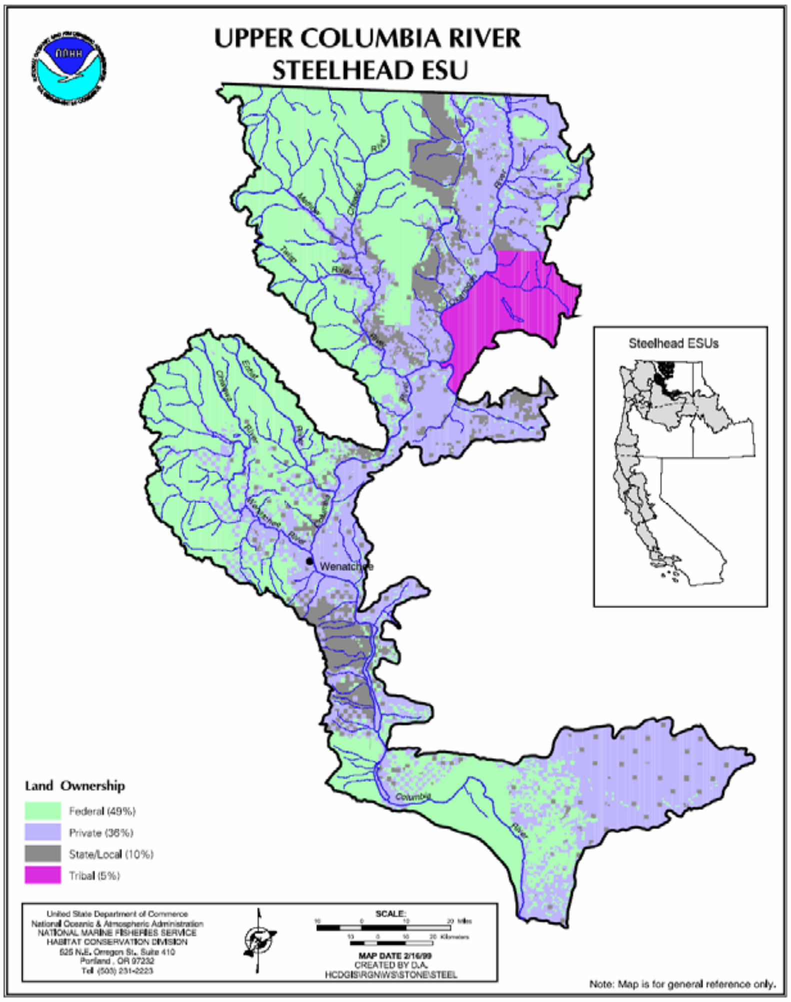


**Figure 5.** The Upper Columbia River summer steelhead evolutionarily significant unit showing land ownership. *Map courtesy of NMFS-HCD* (http://www.nwr.noaa.gov/reference/frn/1997/62FR43937.pdf).

All steelhead redd surveys were conducted, and redds verified, by at least two Colville Tribal fisheries staff members trained in the application of the OBMEP redd survey methodology (Arterburn et al. 2007c). Main stem surveys were conducted by rafts and foot in a downstream progression. All island sections or other main stem areas that could not be floated due to limited access and/or obstacles (e.g. wood debris, braided channels, and diversions) were surveyed by foot. Raft surveys were conducted by a minimum of two people using two, 1-man, 10' Skookum Steelheader model catarafts. Tributary spawning areas were surveyed by foot, walking upstream.

**Table 1.** Designated redd survey reaches in the United States with location description and length in kilometers used by OBMEP in 2008.

| Redd Survey Reaches | Location Description | Reach length(km) |
|---|---|---|
| **S1/S2** | Similkameen/Okanogan Confluence(0) to Enloe Dam (14.6) | 14.6 |
| **O1** | Okanogan River south of Chiliwist Creek(23.7) to Loup Loup Creek(26.7) | 3.0 |
| **O2** | Okanogan River at Salmon Creek(41.4) to the Office(52.3) | 10.9 |
| **O3** | Okanogan River at the office(52.3) to Riverside(66.1) | 13.8 |
| **O4** | Okanogan River at Riverside(66.1) to Janis Bridge(84.6) | 18.5 |
| **O5** | Okanogan River at Janis Bridge(84.6) to Tonasket park(91.4) | 6.8 |
| **O6** | Okanogan River at Horseshoe Lake(112.4) to Confluence with Similkameen River(119.5) | 7.1 |
| **O7** | Okanogan River at confluence(119.5) to Zosel Dam(127.0) | 7.5 |
| **TU1** | Tunk Creek @Okanogan River Confluence (0) to High water mark (0.2) | 0.2 |
| **B1** | Bonaparte Creek/Okanogan River confluence (0) to Bonaparte Falls (1.6) | 1.6 |
| **N1** | Ninemile Creek from Okanogan River confluence(0) to Eder land (1.7) Maximum potential (4.3 km) | 1.7 |
| **TO1** | Tonasket Creek/Okanogan River Confluence(0) to Tonasket Falls (3.5) | 3.5 |
| **A1** | Antoine Creek/Okanogan River Confluence(0) to Antoine Barrier (1.3) | 1.3 |
| **L1** | Loup Loup Creek/Okanogan River Confluence to Loup Loup Creek diversion (2.3) | 2.3 |
| **WS1** | Wild Horse Spring Creek/Okanogan River Confluence to Barrier (1.1) | 1.1 |
| **OM1** | Omak Creek/Okanogan River Confluence(0) to Omak Creek Trap site (2.0) | 2 |
| **OM361** | Above Mission Falls (9.5) to EMAP site 345 (13.3) | 3.8 |
| **OM48** | EMAP site 48 Lower (25) to river kilometer (26) | 1 |
| **SC1** | Salmon Creek confluence with the Okanogan (0) to OID Diversion (7.2) | 7.2 |

Redds were marked by surveyor flagging tied to bushes or trees on the stream-bank adjacent to the area where redds were observed. Individual flags were marked with the survey date, direction and distance from the redd/s, consecutive flag number, total number of redds represented by the flag, and surveyor initials. Incomplete redds or test pits were not flagged or counted. The color of the flagging was changed for each survey, and re-flagged redds were not counted as new redds. Information was collected electronically with the use of a Trimble GeoExplorer XT GPS unit and downloaded into GPS Pathfinder Office® after every survey. The GIS data were reviewed and spatially corrected to accurately display coordinates in a map format. Escapement calculations were made for each main stem reach, sub watershed and the entire Okanogan River population.

We employed the method currently used by Washington Department of Fish and Wildlife (WDFW) in the Upper Columbia Basin to extrapolate escapement estimates using the sex ratio of broodstock collected randomly over the run (Andrew Murdoch, WDFW, Pers. Comm.). For example, if the sex ratio of a random sample of the run is 1.5:1.0, the expansion factor for the run would be 2.5 fish/redd. This method is used for all supplemented stocks within the Upper Columbia Basin. Sex ratio data can be used to provide estimates of total spawner escapement for the population, sub-watershed, or reach.

We expanded population estimates by incorporating sex ratio data generated from several adult traps within several sub-watersheds throughout the Okanogan River basin. Total redd estimates, in combination with spawner escapement where data exists (Omak Creek trap, Bonaparte Creek trap, Inkaneep Creek trap, and Zosel Dam video counts), can be summed to estimate total escapement with a relative high level of accuracy. The sex ratio was determined by counting and sexing all adult fish collected at Wells Dam, Inkaneep Creek, Omak Creek, and Bonaparte Creek traps. The ratio of males to females is used for representative streams. Main stem habitats use values derived from Wells Dam data, medium-sized tributaries in the United States use the sex ratio from the Omak Creek trap, with medium size streams in Canada using the Inkaneep Creek Trap data, and small streams use the sex ratio from the Bonaparte Creek trap. All abundance calculations assume that each female will produce only one redd. For fish collected at the trap on Inkaneep Creek, all *O. mykiss* with a clipped adipose fin or greater than 20 inches in total length were considered steelhead as opposed to an adfluvial rainbow trout.

Estimating redds in tributaries where landowner permission could not be granted presented a hindrance in documentation spawning distribution. The method used to expand estimates to the entire creek was to multiply the density of redds/km of stream in the sampled area by the remaining length of stream accessible by summer steelhead; this method was only utilized for Ninemile, Tunk, and Salmon creeks.

When appropriate, a range of population estimates can be created by manipulating the local sub-watershed sex ratios as described above. Estimates that provide the highest and lowest values represent a reference range in which the likely "true" value would exist.

Range estimates are much more likely to contain the “true” value, when compared to a point estimate, acknowledging the variability within the data collected.

## Results and Discussion

*Sex ratios*

Forty-one summer steelhead were collected at the Omak Creek trap (31 males; 10 females) and a ratio of 3.1 males for each female was observed, resulting in a sex ratio multiplier of 4.1. All 23 summer steelhead (14 male; 9 female) collected at the Bonaparte Creek trap resulted in a sex ratio multiplier of 2.56. At the Inkaneep Creek trap in Canada, 22 summer steelhead meeting our criteria were collected and sexed. Eleven of the 22 fish were females, rendering a male to female sex ratio of 2.0. At Wells Dam, a sample of 333 summer steelhead was examined in order to determine a sex ratio for upstream migrants during 2008. One hundred seventy-one males and 162 females were sexed by Washington Department of Fish and Wildlife personnel (Charles Frady - personal communications). Wells Dam data resulted in a ratio of 1.06:1 males per female or a sex ratio of 2.06.

*Percent wild*

Trap and dam counts provide the basis for determining the natal origin of summer steelhead in the Okanogan River basin. In 2008, WDFW estimated the number of wild summer steelhead that passed Wells Dam at 1,110 or 16.80% of the total escapement. Wells Dam values were based upon fish counts, PIT tags, coded wire tags, scale analysis, harvest, broodstock collection, and stray rates estimated for Wells Hatchery (Charlie Snow, WDFW Pers. Comm.). The proportion of these fish assigned to the Okanogan River was 216 or 12.64% of the Okanogan River summer steelhead population. This percentage was applied to all main stem Okanogan reaches.

The percent of wild summer steelhead returning to Omak Creek was 24.39%. We collected ten summer steelhead at the Omak Creek Trap that had intact adipose fins and no PIT tag or coded wire tag. Ten wild summer steelhead were also collected from Bonaparte Creek representing 43.48% of all steelhead trapped and was based upon the presence or absence of adipose fins and PIT tags. Only five fish with clipped adipose fins were collected at the Inkaneep Trap in Canada, resulting in 77.27% of all steelhead returning to Inkaneep Creek considered wild. At Zosel Dam, 56 summer steelhead had intact adipose fins representing 29.02% of the run passing upriver being classified as natural origin. Removing the 17 of the 22 steelhead collected at Inkaneep Creek resulted in 22.81% of the steelhead passing Zosel Dam to likely build redds in locations other than Inkaneep Creek during 2008. The estimated total number of wild summer steelhead spawning in the Okanogan River subbasin was 225 or 16.23% of the total summer steelhead escapement in 2008. The abundance and percent wild in 2008 was the highest recorded since data collection began in 2005.

*Okanogan and Similkameen River Main-stem*

The Okanogan River was divided into seven segments based on access points and the Similkameen River was surveyed as 2 reaches. These data are later combined into one reach (S1) to maintain consistency with previous reports. All main stem reaches were located upstream of Chiliwist Creek confluence (immediately upriver of the influence of Wells' pool). We used data collected from previous years to initiate surveys on the main stem. In 2008, visibility was excellent during all surveys. The third round of surveys was completed by April 28th and flows did not exceed 3,000 CFS until May 7, 2008 (Figure 2).

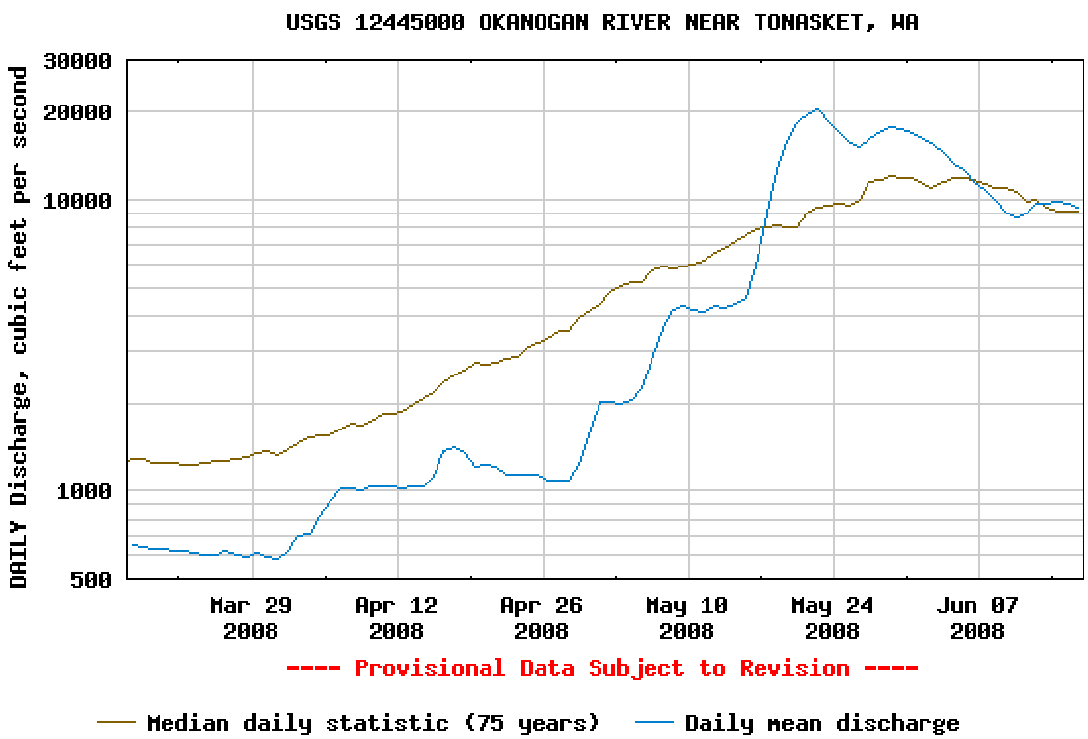


**Figure 6.** Discharge of Okanogan River as measured at Tonasket, WA for the period from March 17th to June 16, 2008 compared to the 75-year historic average (http://waterdata.usgs.gov/wa/nwis/uv?12445000).

The lower most reach on the Okanogan River (O1) was surveyed on March, 17th, 31st, and April 16th (Figure 3). A total of five steelhead redds were observed with one observed during the earliest survey, none during the second survey, and four during the final survey. Previously, summer steelhead in this reach have exhibited a preference for constructing redds on one large, mid-channel gravel bar located a short distance downstream of the confluence with Loup Loup Creek. Redds observed during 2008 represent ten summer steelhead of which one was estimated to be of wild origin. The number of redds observed in 2008 was within the range from previous surveys conducted within this reach (0-17 redds).

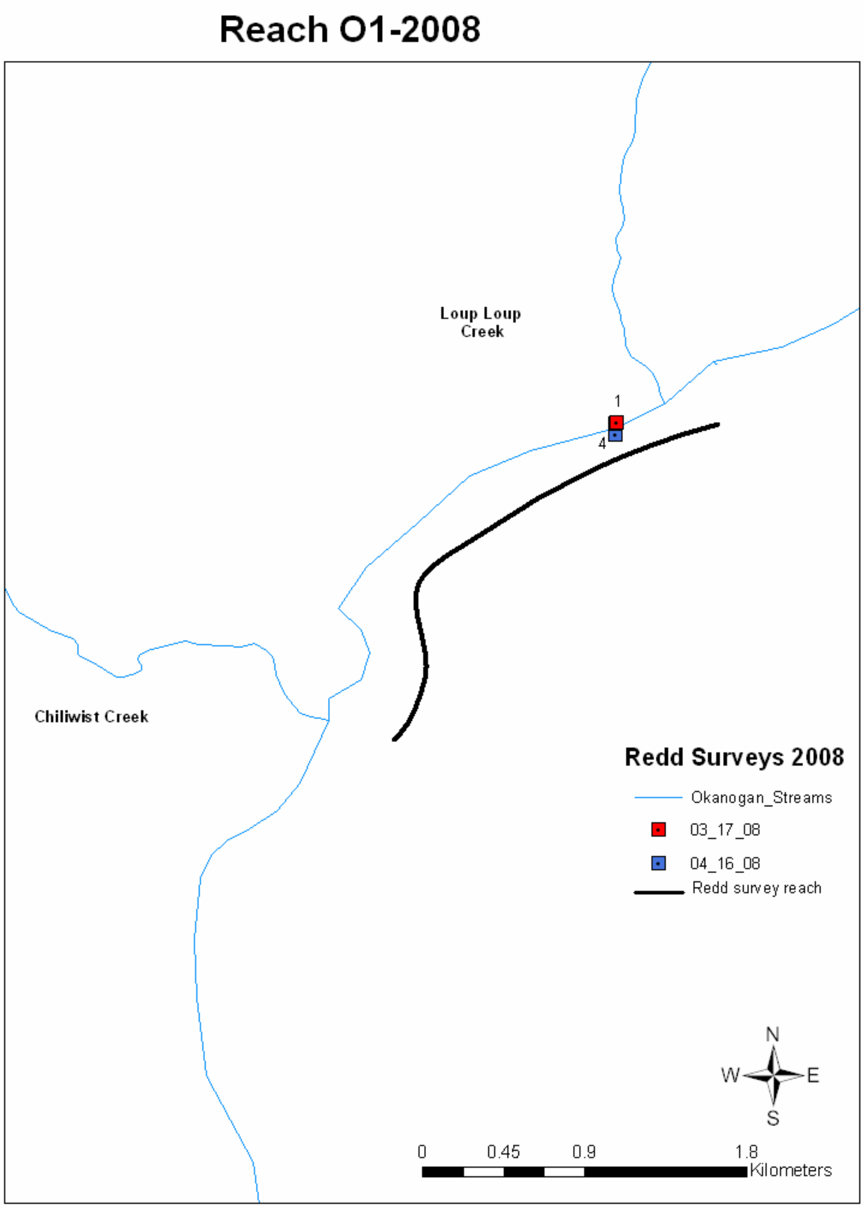


**Figure 7.** Redd distribution observed in 2008 for Okanogan River reach O1 from the confluence of Loup Loup Creek downstream to the confluence of Chiliwist Creek.

Okanogan River Reach O2 was surveyed on March, 18th when five redds were observed, April 8th when five additional redds were observed, and lastly on April 24th when another 38 redds were observed. A total of 48 steelhead redds were identified in 2008. Most of the redds were observed at a mid-channel bar downstream of the mouth of Omak Creek, in the area near the Highway 155 bridge located in Omak, WA, and the island complex upriver Shellrock Point (Figure 4). We calculated that observed redds represented 99 summer steelhead and of these 12 were likely of natural origin. The redd density across the entire reach was calculated to be 4.4 steelhead redds per kilometer. The number of redds observed in 2008 was toward the upper end of the number of redds previously surveyed within this reach (4-56 redds) and this might be because low water levels made it difficult for adult steelhead to enter Omak Creek until late in the spawning season.

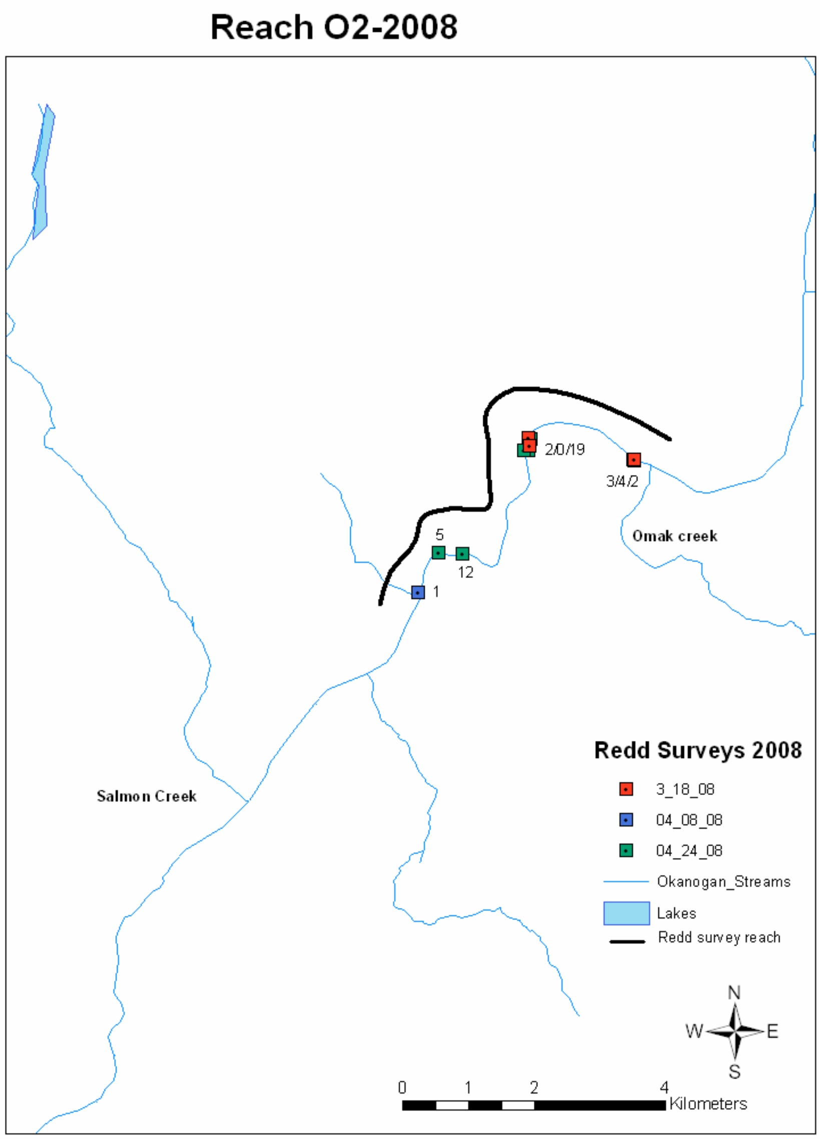


**Figure 8.** Redd distribution observed in 2008 for Okanogan River reach O2 from the confluence of Omak Creek in Omak downstream to Salmon Creek.

Okanogan River Reach O3 was surveyed on March 20th, April 9th, and April 26th. Eight redds were observed on April 9th with no redds counted on the first or last survey. A total of eight steelhead redds were identified. These redds were observed near mid-channel bars located near the center of this reach (Figure 5). We calculated that the number of spawning summer steelhead represented by these redds was 17 and 2 were estimated to be natural origin. The density of steelhead redds in this reach was 0.58 redds per kilometer. The number of redds observed in 2008 was within the range observed during previous surveys (2-10 redds) conducted within this reach.

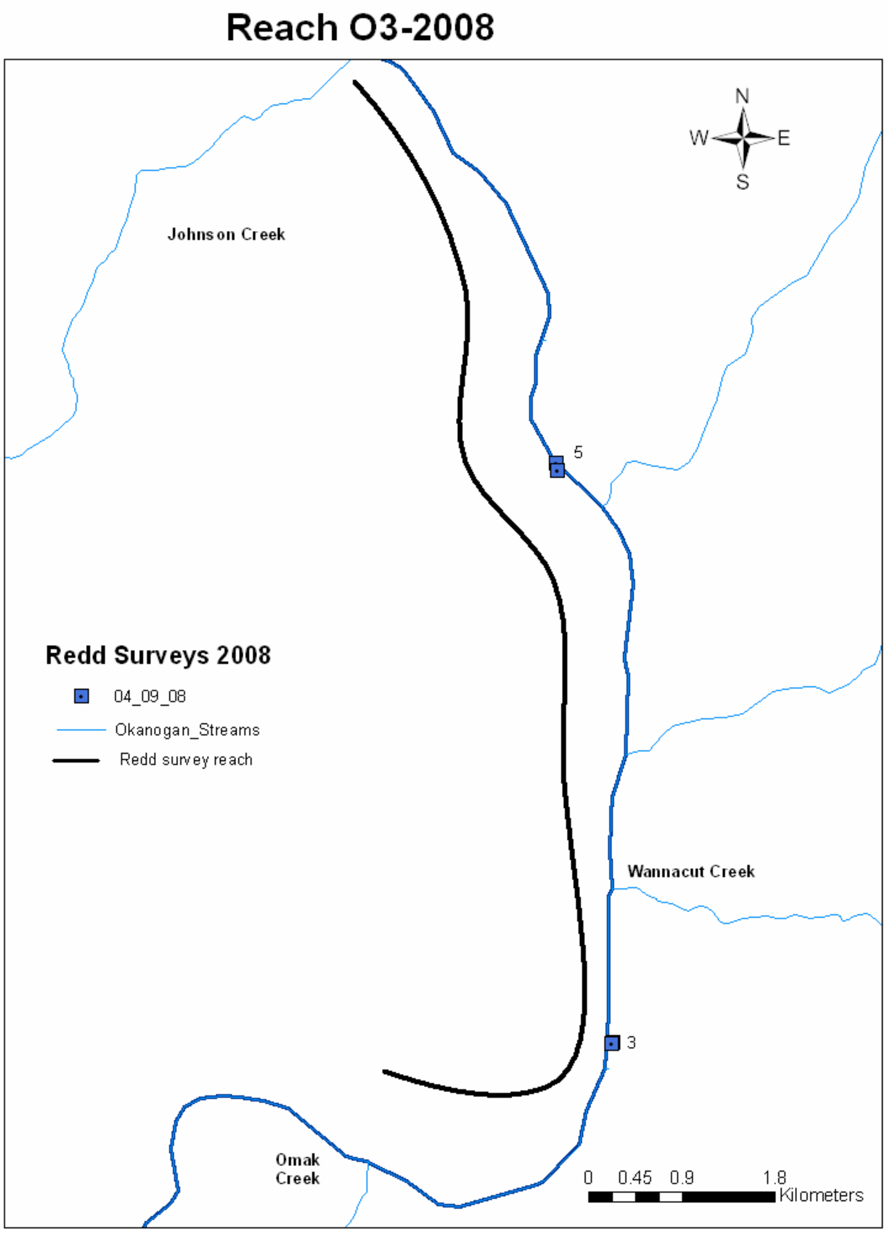


**Figure 9.** Redd distribution observed in 2008 for Okanogan River reach O3 from the town of Riverside, WA downstream to the confluence with Omak Creek in Omak, WA.

Okanogan River Reach O4 was surveyed on March 21st, April 10, and April 24 when 11, 33, and, 11 new redds were identified, respectively. A total of 55 steelhead redds were identified. The majority of these redds were located in two locations, at the lower end of the braided channel below McAllister Rapids near the confluence with Tunk Creek and in the vicinity of Janis Rapids downstream of the confluence with Chewiliken Creek (Figure 6). We estimated the number of summer steelhead spawners using this area to be 111 and the number of natural origin to be 14. Redd density was calculated to be 2.92 steelhead redds/km. The number of redds observed in 2008 was on the upper end of previously observed redds (11-58 redds) within this reach.

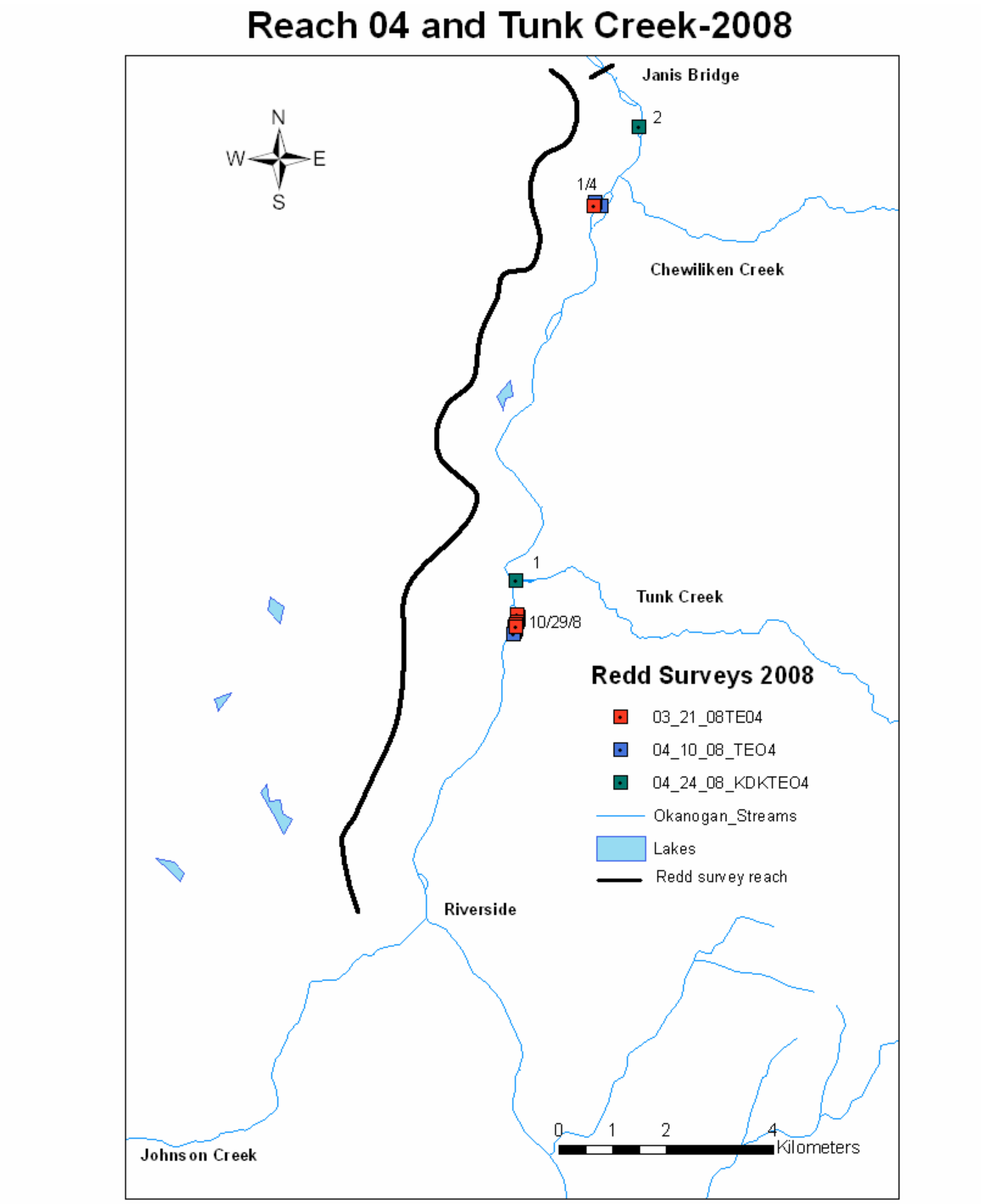


**Figure 10.** Redd distribution observed in 2008 for Okanogan River reach O4 from Janis Bridge downstream to the town of Riverside, WA.

Okanogan River Reach O5 was surveyed on March 24th and April 11th and one new redd was observed on each date. The final survey was completed on April 25th when an additional 17 redds were documented. A total of 19 redds were identified within this reach during 2008 (Figure 7). Most of the steelhead redds were observed in areas with side channels and islands near the town of Tonasket, WA. We calculated that the number of spawners using this reach was 39 summer steelhead including five from natural origin. The total number of redds represent a density of 2.79 steelhead redds per kilometer across the entire reach. The number of redds observed in 2008 was the lowest we have ever recorded within this reach (39-63 redds).

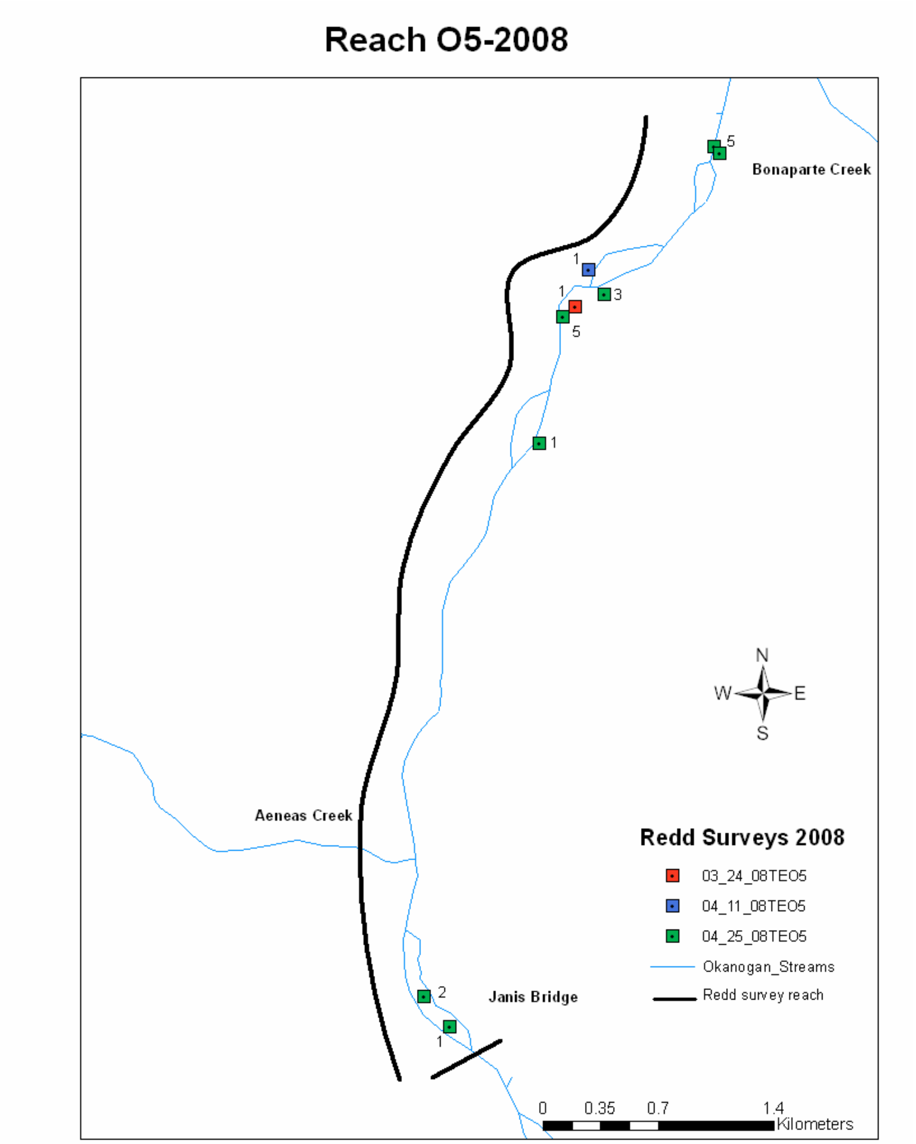


**Figure 11.** Okanogan River redd distribution observed in 2008 within reach O5 from the Chief Tonasket Park located in the town of Tonasket, WA downstream to the Highway 97 Bridge at Janis, WA.

Okanogan River Reach O6 was surveyed three times in 2008 (March 25th, April 14th, and May 1st) and no redds were observed within the area that extends from the Similkameen River confluence downstream to the inlet at Horseshoe Lake. Previous annual surveys identified between 3 and 19 redds within this reach. Zero redds was the lowest number of summer steelhead redds identified in this reach since surveys began. The isolated spawning habitat that exists within this reach is surrounded by habitats that contain mostly sand substrates. Perhaps the quality of the spawning habitat has degraded to the point that it is no longer of a high enough quality to attract adult steelhead spawners. This hypothesis can be tested in future years.

Okanogan River Reach O7 was surveyed three times in 2008 and a total of 249 summer steelhead redds were identified. On April 3rd, one redd was identified, April 17th, 84 redds, and on April 30th, 164 redds were counted. A majority of redds were observed downstream of Zosel Dam but above Driscoll Island in 2008 (Figure 8). Field staff observed numerous steelhead either constructing or adjacent to redds. The number of spawning steelhead estimated using this reach was 513 with an estimated 64 of natural origin. The number of steelhead spawners calculated for this reach was likely conservative in 2008 since the peak number of redds observed occurred during the last survey. It is highly likely that additional steelhead spawned after the last survey. Within this reach, the density was calculated at 33.2 redds per kilometer. The number of redds observed in 2008 was the highest recorded within this reach (141-151 redds). Spawning habitat within this reach is of high quality and hatchery stocking also occurs within this reach therefore high returns are not surprising.

Similkameen River reaches S1 and S2 were each surveyed three times in 2008 and a total of 132 summer steelhead redds were identified:

- (S1) April 2nd (24 redds); April 18th (57 redds); and April 28th (8 redds);
- (S2) April 15th (5 redds), April 29th (20 redds), and April 30th (18 redds).

Most of the steelhead redds were observed downstream of Oroville High School where a braided channel exists (Figure 8). The number of spawning steelhead using this reach was estimated to be 272, of which, 34 were estimated to be of natural origin. Redd densities across the entire reach were calculated to be 9.04 steelhead redds/km. The total number of redds observed in 2008 was the highest recorded but only slightly above the previous range of 98 to 106 since 2005. Runoff was delayed in 2008 resulting in improved spawning conditions (primarily reduced velocity) in this reach and making surveying more productive. However, high flows after eggs have been deposited may reduce spawning success due to bed load movement, resulting in egg damage and reduced survival during peak runoff.

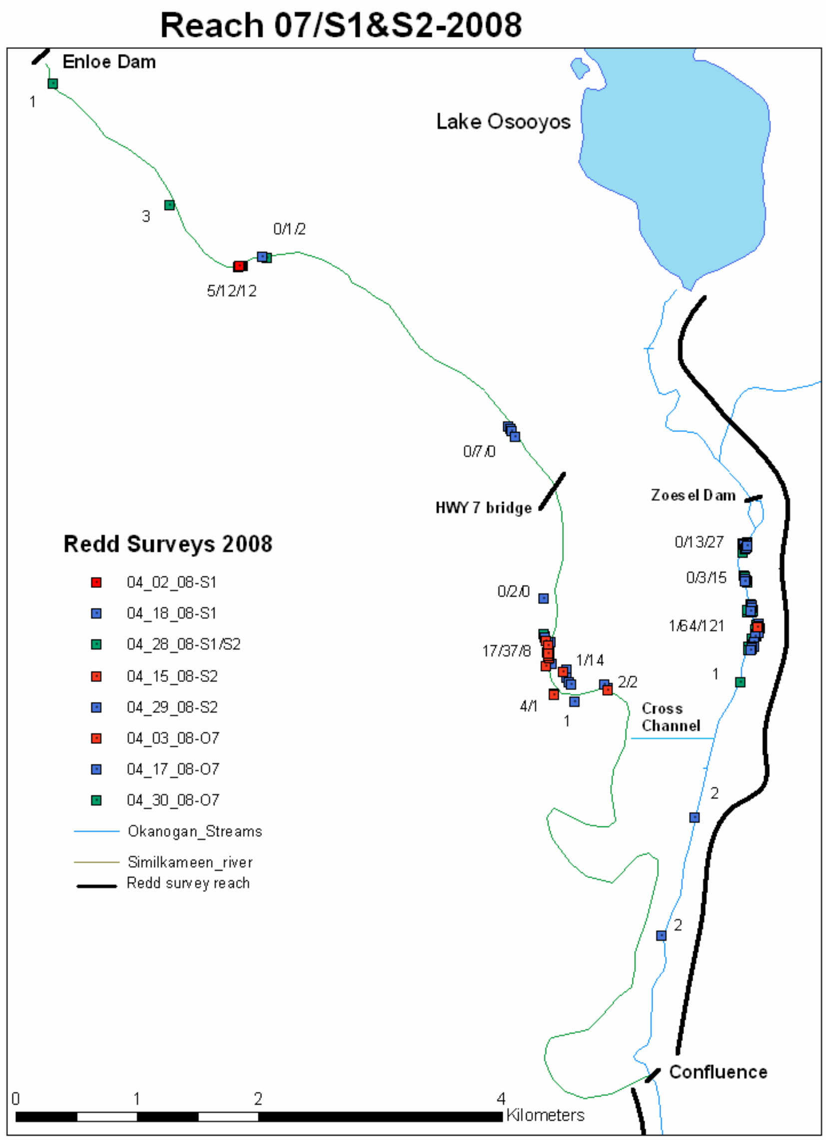


**Figure 12.** Redd distribution observed in 2008 for Okanogan River Reach O7, Similkameen River Reach S1 and Similkameen River Reach S2. Reach O7 extends from Zosel Dam downstream to the confluence with the Similkameen River. Reach S1 extends from the base of Enloe Dam downstream to the water treatment plant in Oroville, WA. Reach S2 extends from the end of Reach S1 to the confluence with the Okanogan River. Any redds observed within the cross channel are considered a part of S2.

### *Tributary redd surveys in the Okanogan River basin*

Tributary habitats were surveyed as water visibility allowed. Varying snow packs and elevations of different sub-watersheds required unique schedules when surveying redds. Smaller, low elevation watersheds became more transparent by the end of May. Omak Creek, a larger watershed with higher elevation was not clear until June 16, 2008.

Steelhead redd surveys within each tributary were conducted beginning on April 29th and ending on June 16th. The extent of each survey was limited by a natural fish passage barrier or access to private land, as described in Arterburn et al. 2007a. Early spring rains in 2008 depleted much of the near average snow pack, creating an earlier than normal peak discharge (Table 2). With little storage in the smaller watersheds and minimal precipitation in April and May, many adult steelhead had difficulty gaining access into tributaries of the Okanogan River (Figure 9). Below-normal discharge in the Okanogan River mainstem further limited access into the tributaries by failing to inundate impassible deltas at the stream mouths (Figure 2).

**Table 2.** Precipitation totals measured by the National Weather Service at Omak Airport. Average precipitation column indicates average precipitation over the last 70 years.
http://www.crh.noaa.gov/product.php?site=NWS&issuedby=OMK&product=CLM&format=CI&version=6&glossary=0

| Month | Inches of precipitation in 2008 | Inches of precipitation in 2007 | Inches of precipitation in 2006 | Inches of precipitation on Average |
|---|---|---|---|---|
| March | 0.73 | 0.08 | 0.81 | 1.00 |
| April | 0.19 | 0.06 | 0.89 | 1.11 |
| May | 0.18 | 0.74 | 1.35 | 1.08 |
| Total | 1.10 | 0.88 | 3.05 | 3.08 |

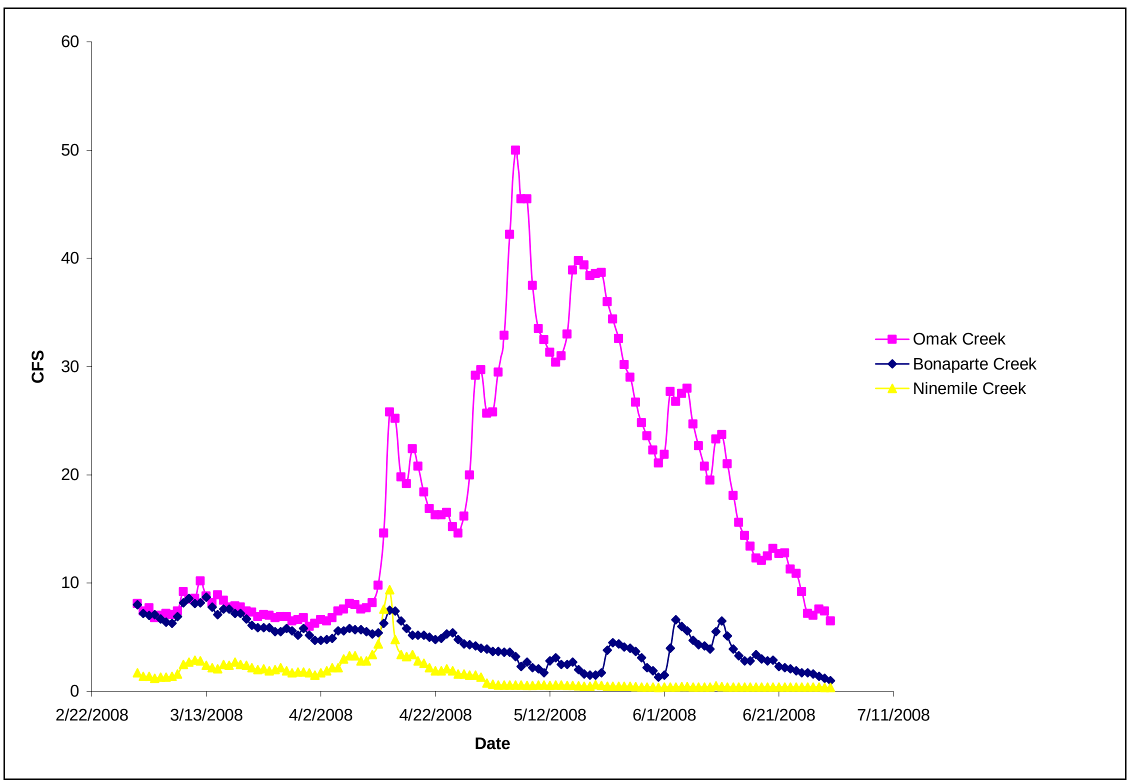


**Figure 13.** Discharge from March through June of 2008 for three tributary streams known to produce summer steelhead in the Okanogan river basin.

*Ninemile Creek*

Lack of access to private lands has been an ongoing problem on Ninemile Creek; therefore, a comprehensive survey of fish passage barriers has not been conducted. However, OBMEP personnel have verified that summer steelhead have access at a minimum of 1.7 km (lower extent of private lands) and a maximum of 4.3 km (impassable falls) of spawning and rearing habitat (Arterburn et al. 2007a). Extrapolating redd surveys is limited to the maximum habitat available, but this evaluation is subject to change as additional habitat information is obtained. Within the lower 1.7 km, 12 redds were identified on May 12th (Figure 10).

We estimated that the range of possible escapement for Ninemile Creek was a minimum of 24 and a maximum of 124. The minimum assumes a sex ratio of 2.0 and habitat is limited to the area surveyed; the maximum assumes a sex ratio of 4.1 and redds are extrapolated over the entire 4.3 km of available habitat. Our best estimate was achieved by extrapolating the observed 12 redds to the entire 4.3km and utilizing the sex ratio of 2.56 from Bonaparte Creek resulting in an estimate of 77 summer steelhead. The redd density was estimated to be 18.07 redds/km. Assuming the spawning escapement into Ninemile Creek was 77 summer steelhead, 18 fish would be of natural origin.

Our estimates for the number of summer steelhead spawning in Ninemile Creek during 2008 were the highest recorded since surveys began in 2005. When standardized across the 4.3km of habitat, past estimates were 52 in 2005, 33 in 2006, and 15 in 2007. An increase in discharge during mid-April (peak spawning) combined with the regulated water level of Lake Osoyoos likely contributed to the large number of redds identified in 2008.

*Tonasket Creek*

Tonasket Creek had reduced discharge water throughout the steelhead spawning season in 2008. There is also a migration barrier of natural falls at 3.5 km (Arterburn et al. 2007a). No redds were observed during the survey conducted on May 12$^{th}$. The number of summer steelhead spawning in Tonasket Creek during 2008 was the lowest recorded since surveys began in 2006. Past summer steelhead spawner escapement estimates for this creek were 8 in 2006 and 17 in 2007. During most years, Tonasket Creek flows intermittently during the spring and by mid-summer is usually dry in the lowermost 3 km. Dewatering of the creek bed likely explains the lack of steelhead observed in 2008

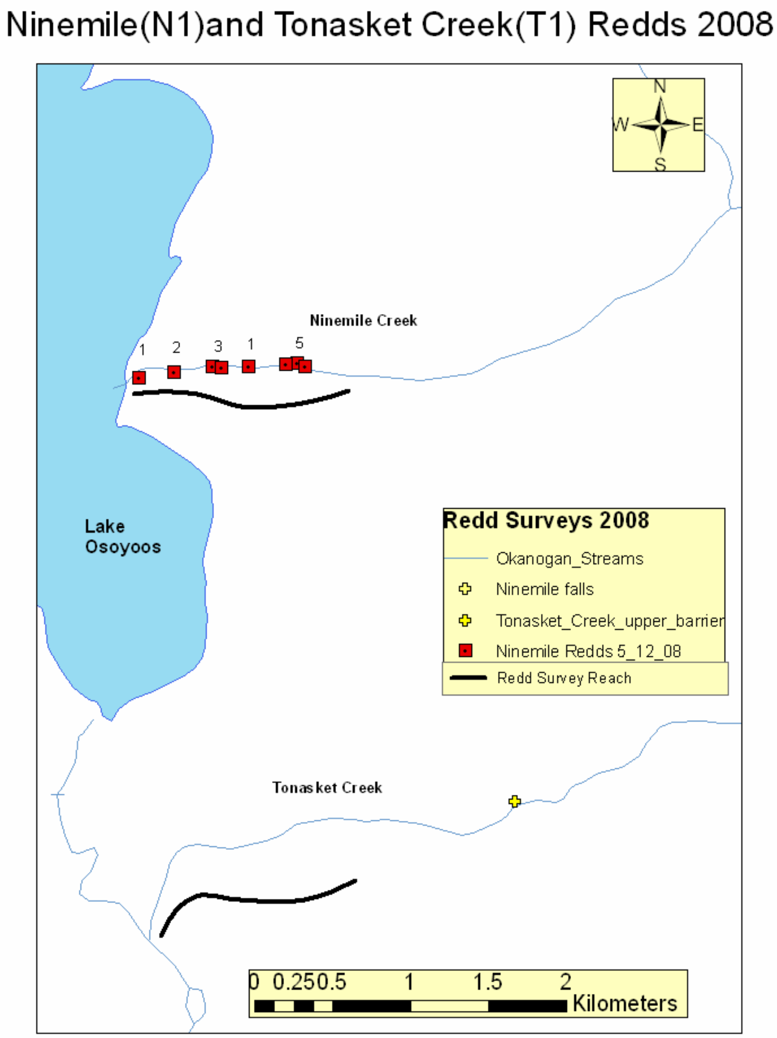


**Figure 14.** Redd distribution observed in 2008 for Ninemile and Tonasket creeks in the lower portions accessible to anadromous fish.

*Wild Horse Spring Creek*

Wild Horse Spring Creek was inaccessible prior to 2006 due to a large beaver dam located near the confluence with the Okanogan River. However, high flows during the spring of 2006 dislodged this dam. With the barrier removed, summer steelhead began utilizing this habitat. In 2006, three redds were observed by OBMEP crews and verified by WDFW biologists. Again in 2007, steelhead redds were observed within the 1.1 km of available habitat. However, no summer steelhead redds were observed in 2008 due to very low flows during the spawning period. Previous surveys estimated spawner escapement at 5 steelhead in 2006, and 12 in 2007.

*Antoine Creek*

Antoine Creek flows perennially, however, minimal spring discharge limited access by adult steelhead throughout the 2008 spawning season. When the stream was surveyed on May 19th, no summer steelhead or redds were observed. A barrier to upstream migration has been located at river kilometer 1.3 where a bedrock feature and irrigation diversion exists (Arterburn et al. 2007a). Although escapement was zero in 2008, snorkel surveys have identified multiple year-classes of both brook trout and *O. mykiss* indicating that favorable rearing conditions exist (Kistler et al. 2006, Kistler and Arterburn 2007). A relatively large delta at the confluence of Antoine Creek makes access difficult for anadromous steelhead and consideration should be given to concentrate flow and improve access during typical flow conditions. To accelerate the reestablishment of summer steelhead in Antoine Creek, approximately 3,000 smolts were released during April of 2008 (Fisher 2008).

*Bonaparte Creek*

A removable picket weir trap has been in operation since 2006 on Bonaparte Creek and was again installed on March 21, 2008. Twenty-three summer steelhead were collected, including 9 females and 14 males with 10 which were of natural origin. These fish had a mean length of approximately 591mm, the delineation between resident and anadromous fish appeared to be 559 mm. Since the weir trap was considered impassable, redd surveys to generate spawner estimates were not necessary. As in 2005 and 2006, redds in 2008 were evenly distributed throughout the 2.2 kilometers of accessible habitat (Arterburn et al. 2005, Arterburn and Kistler 2006, Arterburn et al. 2007).

Redd surveys downstream of the weir were conducted on May 12th after all steelhead were collected at the trap in 2008 (Figure 11). Two summer steelhead redds below the trap site were observed (Figure 12). Based upon the sex ratio generated from adult steelhead collected at the trap, an estimated five summer steelhead spawned downstream. Of the fish enumerated at the trap, 47.5% were of natural origin. An additional two natural-origin steelhead were estimated to have spawned downstream of the trap site. Redd density was calculated at 5.00 redds/km and the total number of summer steelhead spawners was estimated to be 28, 12 of which were of natural origin.

Our estimates for the number of summer steelhead spawning in Bonaparte Creek during 2008 were the lowest recorded since 2006. Past summer steelhead spawner escapement into this creek was 136 in 2005, 18 in 2006, and 204 in 2007. Bonaparte Creek contains only limited spawning and rearing habitat; however, this stream sees a greater proportion of adipose-present fish and contains the highest densities of rearing steelhead compared to all other tributaries within the U.S. portion of the basin. Protecting and restoring high quality habitats within the lowest 1 mile should be a high priority to ensure continued productivity from this stream.

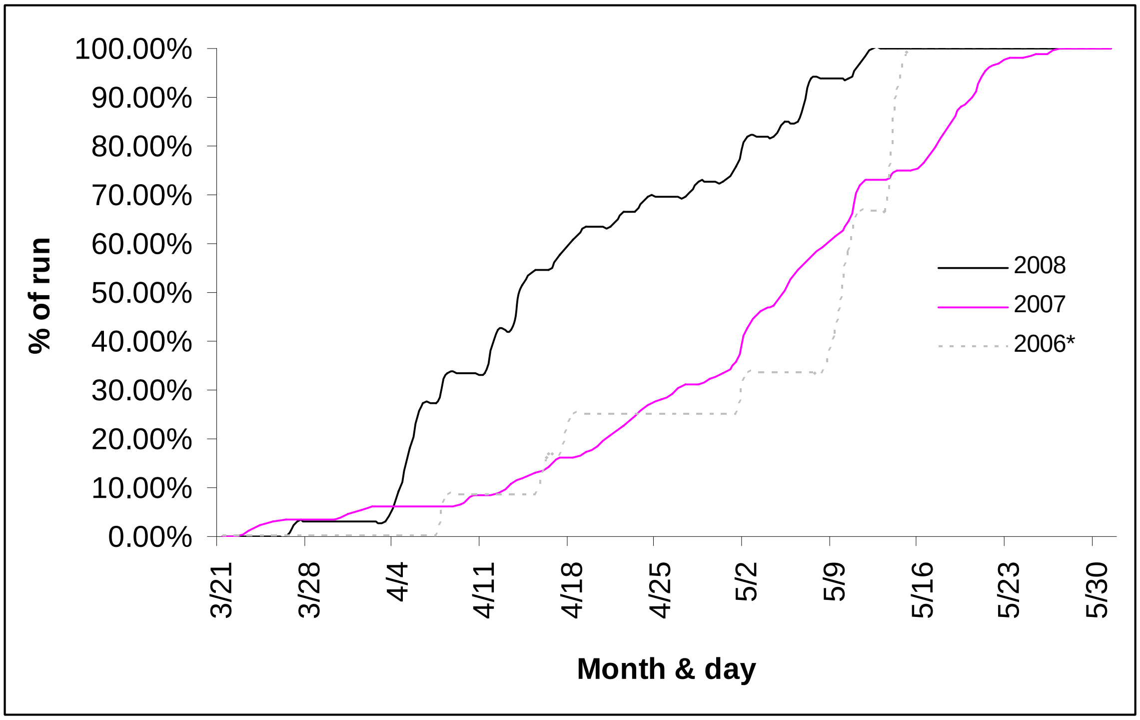


**Figure 15.** The percent of summer steelhead collected for a given date across all years that the Bonaparte Creek Trap has been in operation. The *2006 trap was only operated for part of the season.

*Tunk Creek*

Redd surveys in Tunk Creek have previously been prevented by lack of access on private land. On April 24th, one redd was identified at the confluence. The single redd observed likely represented two summer steelhead of hatchery origin. Although an additional survey was conducted on May 20th after permission was secured from the property owner, no additional redds were observed. One man-made structure was observed just above the confluence and no redds were found above this structure suggesting that it was an impediment to migrating adults at low discharges (Figure 13). Past steelhead spawner escapements at the confluence were seven in 2005, two in 2006, and unknown in 2007. The number in 2008 was the same as in 2006 (Arterburn et al., 2005; Arterburn and Kistler 2006). A section of Tunk Creek approximately ½ mile long was de-watered, probably due to a nearby well (~ 125 ft. from channel) that waters an agricultural field at a rate of 1,000gpm. Dewatering dramatically reduces the productivity of Tunk Creek and until this condition is rectified, few summer steelhead will be likely to be produced from Tunk Creek.

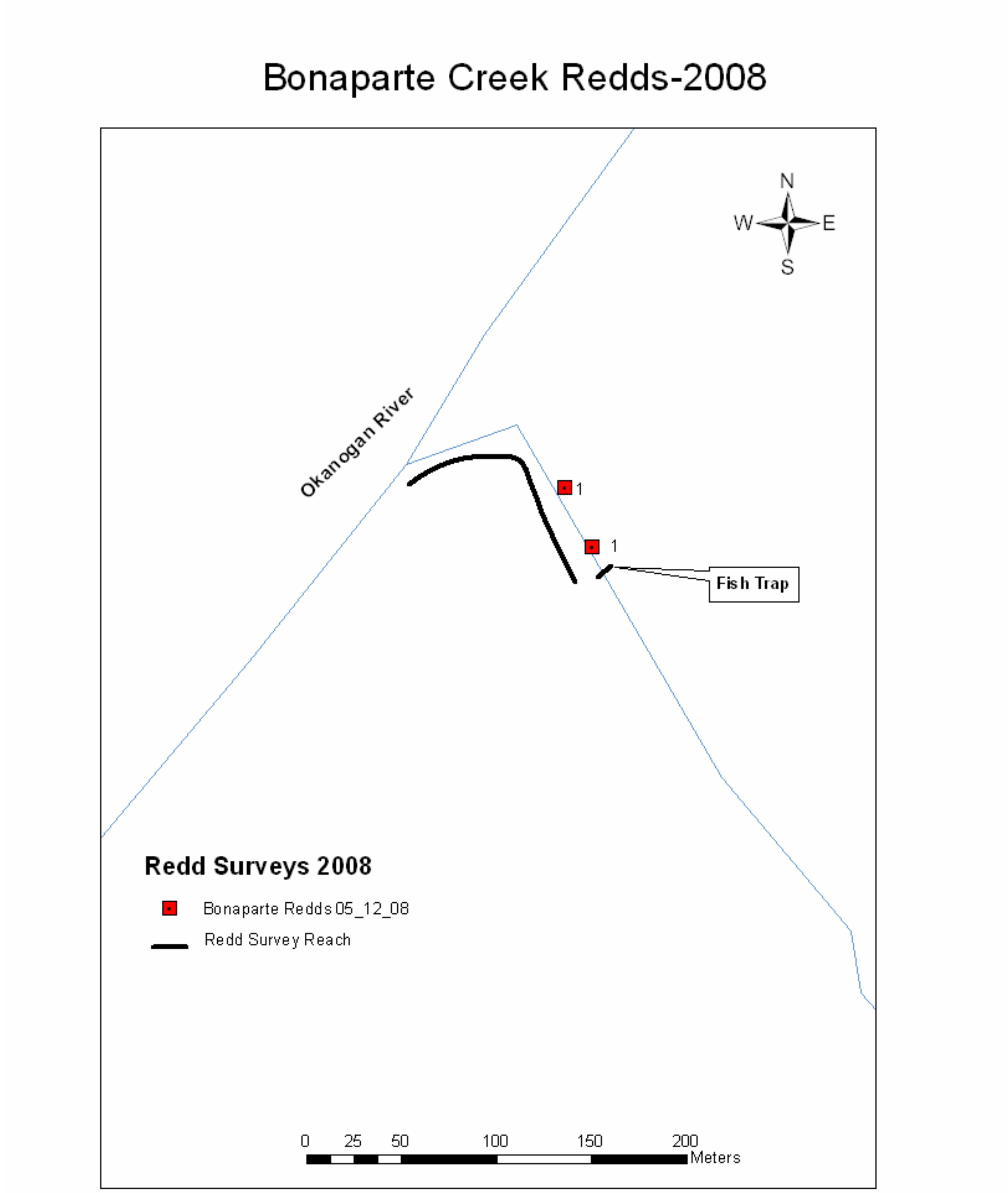


**Figure 16.** The distribution of redds observed in Bonaparte Creek during 2008 from the confluence with the Okanogan River upstream to the Bonaparte weir trap.

**Figure 17.** Passage impediment on lower Tunk Creek discovered during redd surveys in 2008 is located within 0.1km of the confluence with the Okanogan River and is likely an impediment to fish migration during low flow periods. Picture was taken on 4/24/2008.

*Wanacut Creek*

Although Wanacut Creek has a sizeable watershed (roughly 22,000 acres), utilization by summer steelhead is limited to the lower 1 km due to intermittent flows. Habitat accessible to anadromous salmonids was documented at river kilometer 2.64 (Arterburn et al. 2007). During the spring of 2007, Swimptkin Canyon, Pothole Canyon, and Wanacut creeks were flowing to the Okanogan River allowing access by summer steelhead. All three creeks were surveyed multiple times, but only one redd and one adult summer steelhead was observed in Wanacut Creek. During the spring of 2008, water from Wannacut Creek never reached the Okanogan River. Therefore, access to spawning habitat in Wannacut Creek is only available during years when snow pack is above normal.

*Omak Creek*

Fifty-three summer steelhead were collected at the trap from March 21st to May 25th (Figure 14) and 41 of these were released upstream. Six of the 12 steelhead not released above the weir were utilized as brood stock to support the locally-adapted hatchery program and the additional six fish were identified as strays and subsequently released back into the main stem Okanogan River. The average fork length of summer steelhead collected was 628mm. The fork length delineation between resident and anadromous *O. mykiss* was 483mm.

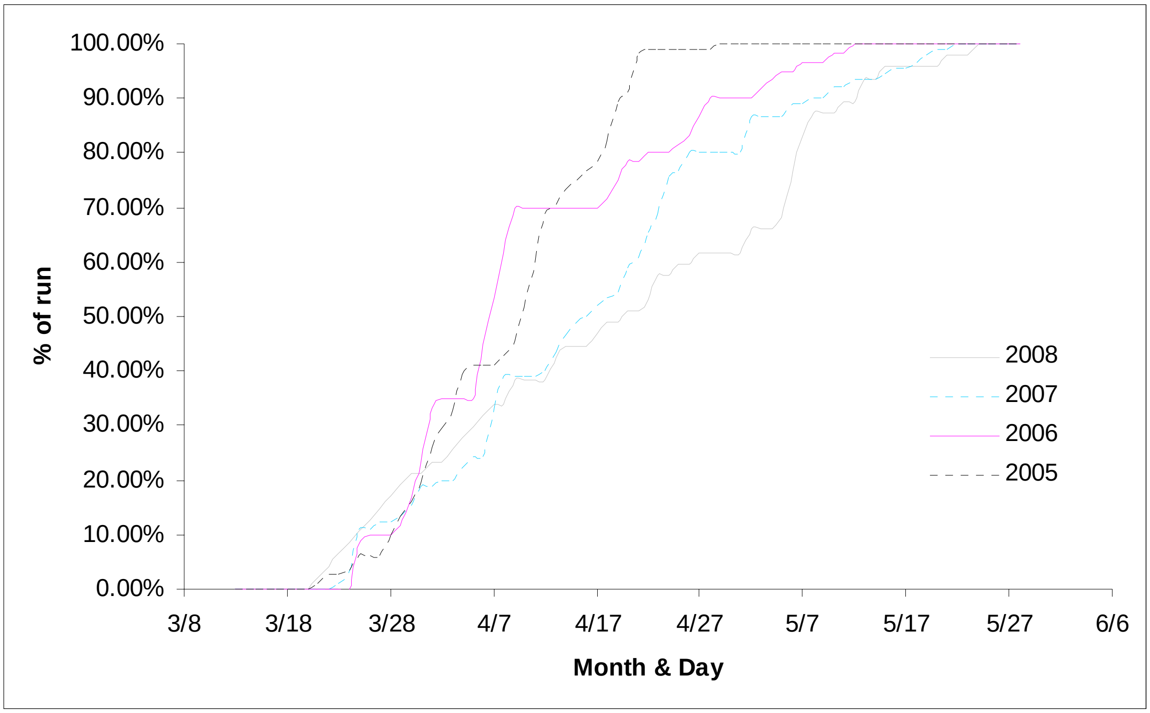


**Figure 18.** The percent of the summer steelhead collected at the Omak Creek trap across the month and days that it was operated since its installation in 2005.

A total of 15 redds were observed downstream of the trap (Figure 15). Nine kilometers of spawning habitat are accessible in Omak Creek downstream of Mission Falls and an additional 22 kilometers exist upstream. In 2008, redd surveys were not conducted between the trap and Mission Falls as spawning areas appear to be rather static over time. Mission Falls remains an impediment, and although summer steelhead attempted to ascend the falls, no redds were observed upstream in 2008.

The skewed steelhead sex ratio was multiplied by redds observed downstream of the trap, which resulted in an estimate of 61 adults. A total of 144 summer steelhead (trap and redd count) returned to Omak Creek in 2008. Of these fish, 102 were allowed to spawn within Omak Creek and 25 were estimated to be of natural origin. The 2008 spawning escapement would be considered average as compared with data from the last six years (Figure 16). Due to the previous investments and the amount of potential habitat available upstream of Mission Falls, investigations to augment passage should continue. As efforts to address passage at Mission Falls continue, so should redd surveys or another means of evaluating passage and enumeration upstream of the falls.

Spring Chinook in 2008 totaled 44 and of these returning adults, 43 were released upstream of the trap. Adult Spring Chinook salmon included 17 males and 26 females with 6 having intact adipose fins and no PIT tags meaning that these fish were either Methow River composite or natural origin recruits. Twelve Chinook salmon redds were identified in Omak Creek (Rhonda Dasher-Colville Tribal Biologists pers. com.). During 2008, more spring Chinook were documented returning to Omak Creek than in any previous year (10 in 2007, 6 in 2006).

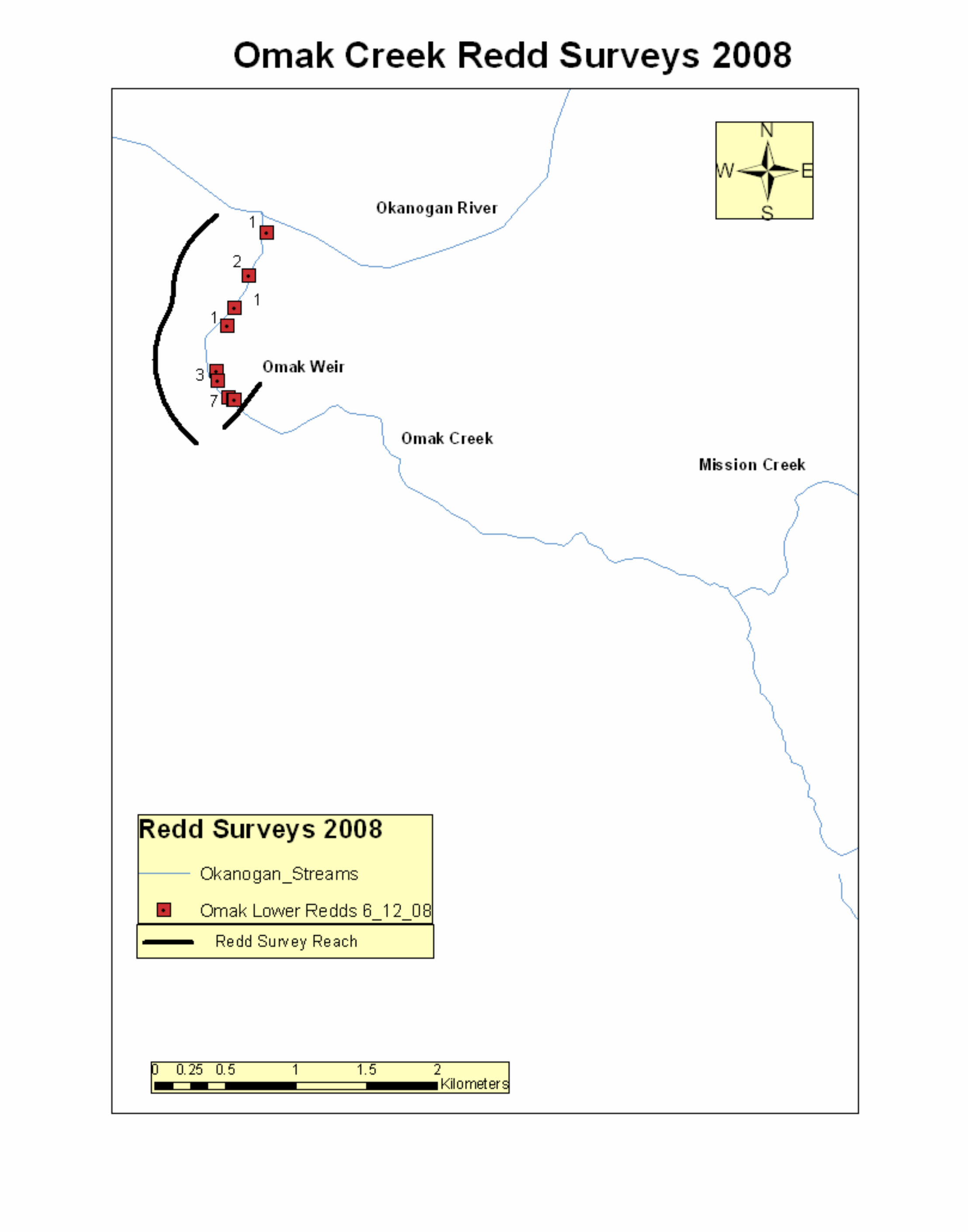


**Figure 19.** Map of summer steelhead redds observed below the Omak Creek trap during the spring of 2008.

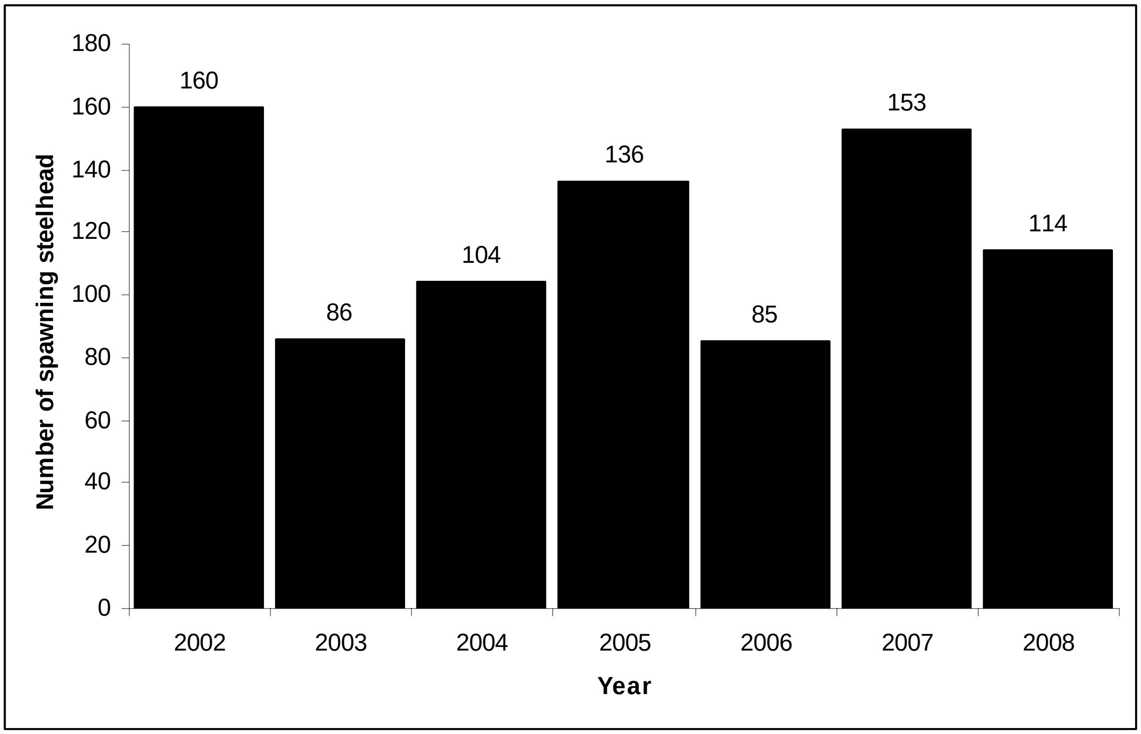

**Figure 16.** Number of summer steelhead spawners returning to Omak Creek from 2002 to 2008.

*Salmon Creek*

Since the early 1900's, Salmon Creek has been entirely diverted for irrigation usage. The resulting dry stream channel extends from the Okanogan Irrigation District (OID) diversion dam (7.2 km) to the confluence with the Okanogan River. Occasionally, uncontrolled spills occur downstream of the OID diversion dam. These spills usually occur after summer steelhead spawn (mid-May to June). However, summer steelhead passage flows were evaluated during a controlled release of 22 cfs from April 1 through April 14, 2003. During this two week period, six redds were constructed within the lower reach of Salmon Creek (Fisher and Arterburn 2003).

As a result of these passage evaluation studies, a long-term water lease was negotiated between the Colville Tribes and the OID that provided sufficient water for smolt releases in 2007 and 2008. In the future, water will be managed in conjunction with a low flow channel (constructed in the fall of 2008) to provide limited access for both adult and smolt steelhead. The controlled releases will likely be initiated in March or April and extend into May.

We observed no redds in the lower 7.2 km of Salmon Creek during 2008, which was anticipated based upon water releases which were timed for smolt out-plants. However, six redds were observed in 2007 and the number of redds extrapolated for the entire watershed was estimated to be 46 summer steelhead. Even though no redds were observed downstream, access upstream of the OID diversion was not permitted due to a lack of landowner permission, thus, redds were unknown in this reach.

Once adult migration flows begin in 2009, spawners will be counted using underwater video equipment that is custom-designed for the fish ladder at the OID diversion (Figure 17). Dramatic increases in steelhead production are anticipated due to flows provided by via a water lease agreement signed between the Colville Tribes and OID, synchronizing water releases to coincide with adult steelhead migration timing, and adult returns from smolt releases (20,260) into Salmon Creek during the spring of 2007.

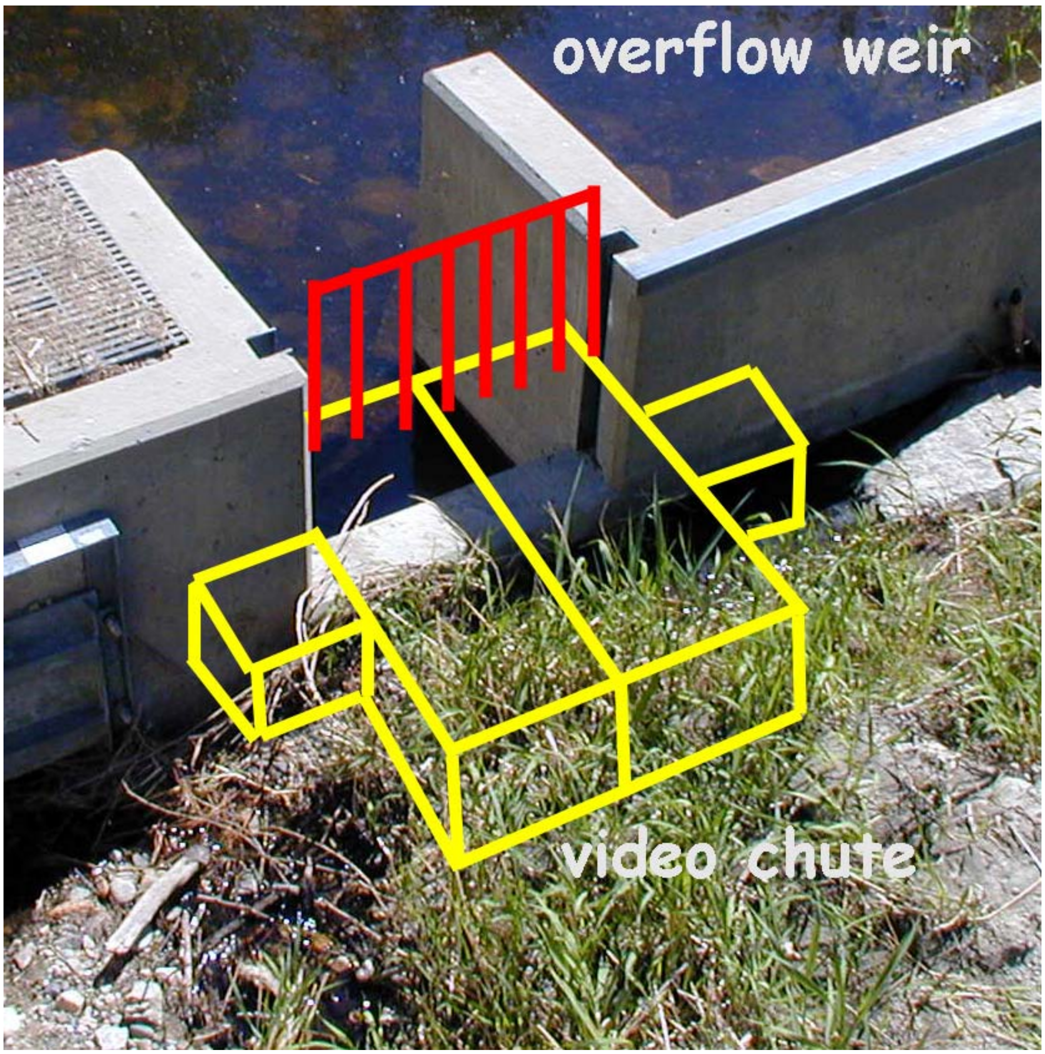


**Figure 17.** Conceptual design of custom built underwater video chute to be installed and operated at the OID diversion fishway on Salmon Creek beginning in 2009.

*Loup Loup Creek*

Loup Loup Creek was surveyed for redds on May 20th and no redds were observed. Low stream flows in 2008 were insufficient to provide passage at the lower most impediment (culvert) located at river kilometer 0.1. This was the second year in the last four that no redds were identified in Loup Loup Creek. When sufficient flows are present to allow passage into Loup Loup Creek, summer steelhead attempt to spawn in this creek but production is limited by instream flow as a result of irrigation diversions (Arterburn et al. 2007b). Past surveys have established that an estimated 12 summer steelhead spawned in this creek in 2006 and another 18 in 2007. Use by spawning steelhead would likely increase substantially if perennial flows were reestablished, passage impediments were removed (culverts), and steelhead were supplemented using locally-adapted hatchery stocks. Steelhead redd surveys will continue in Loup Loup Creek to provide baseline information, and document the effectiveness of habitat rehabilitation projects, once implemented.

*Escapement into Canada*

Since 2005, OBMEP has attempted to conduct redd surveys in Canada to compliment survey data collected in the United States. Although OBMEP redd survey data are very promising in the United States, results haven't been as successful in Canada. To accurately calculate steelhead escapement into Canada, Zosel Dam video counts and a removable trap located on Inkaneep Creek have been utilized.

To calculate the number of spawners entering Canada, the estimated number of spawners that enter Ninemile (77) and Tonasket (0) creeks must be subtracted from the total number counted at Zosel Dam. These two creeks are located upriver of Zosel Dam but south of the international border. During 2008, 193 summer steelhead were counted passing Zosel Dam. Seventy seven were estimated as destined for United States tributaries. Therefore, 116 summer steelhead were expected to spawn in the Canadian portion of the Okanagan Basin.

Wild fish, as determined by the presence of an adipose fin were calculated using a similar procedure. Fifty-six summer steelhead were enumerated at Zosel Dam (Table 3). The estimated number entering Ninemile (18) and Tonasket (0) creeks was subtracted from the total (56). Of the summer steelhead destined for Canada, an estimated 38 were naturally-produced; 32.76% of the total escapement.

**Table 3.** The number of summer steelhead that passed Zosel Dam by month in 2008. Adipose-present fish are designated as Wild; adipose-clipped fish are considered Hatchery.

| Month | Number of Hatchery Adults | Number of Wild Adults | Total |
|---|---|---|---|
| August | 3 | 1 | 4 |
| September | 1 | 2 | 3 |
| October | 6 | 5 | 11 |
| November | 5 | 2 | 7 |
| December | 5 | 1 | 6 |
| January | 4 | 0 | 4 |
| February | 7 | 0 | 7 |
| March | 12 | 11 | 23 |
| April | 94 | 34 | 128 |
| **Total** | **137** | **56** | **193** |

*Inkaneep Trap*

At the trap on Inkaneep Creek, 62 steelhead were collected which includes both anadromous steelhead and resident adfluvial rainbow trout. In an attempt to separate anadromous fish, a fork length of > 500mm was considered a steelhead. A fork length of 500 mm is the threshold used to regulate anglers in Washington State. In 2009, scale samples will be evaluated for exposure to marine environments using radio-isotopes to verify these fork length assumptions. After applying the length criteria, 22 fish were recognized as adult summer steelhead, including all marked fish, known to be summer steelhead as no resident rainbow trout had been marked by clipping the adipose fin. Of the adult steelhead collected at Inkaneep Creek, the average fork length was 546 mm which was the shortest mean length of the three streams where picket-traps were installed. Of the designated steelhead, 11 were male, 11 female and 77.27% were considered natural origin, the highest percentage documented in 2008. No redd survey was conducted downstream of the trap as this short distance of habitat (~ 0.5km) is not considered conducive to spawning.

*Canadian Distribution*

From redd survey data collected in 2006 by the Okanagan Nation Alliance, 90% of the summer steelhead redds were identified in two tributaries; Vaseux Creek (45%) and Inkaneep Creek (45%) with 10% of the redds being observed in the main stem Okanogan River upstream of Lake Osoyoos, but downstream of McIntyre Dam (Long et al. 2006). An approximated distribution can be calculated from these data by taking the number of steelhead entering Canada (estimated to be 116 summer steelhead). Previously, the number of steelhead entering Inkaneep Creek was calculated to be 22 summer steelhead.

The remaining 94 summer steelhead have a distribution that remains undefined. Difficulties associated with collecting data on adult spawners in Canada are in the process of being resolved. Design elements should include the following:
1) development of methodology to measure the abundance of adult steelhead at a sub-watershed scale, 2) harvest of these fish in recreational fisheries at Lake Osoyoos and its

tributaries, which is unknown, 3) pre-spawn mortality as some of the fish pass Zosel Dam many months prior to spawning, 4) steelhead are spawning in areas that have yet to be discovered, as several small streams are accessible to steelhead during spring runoff but are difficult to monitor due to poor visibility, or 5) fallback through Zosel Dam. The last two items can be estimated using methods provided in the literature.

For adult summer steelhead, it has been estimated that a minimum of 94% of steelhead passing main stem Columbia River dams survived to known spawning areas, or remained above the dam (English et al. 2001, 2003). More recent PIT tag data indicates that survival from McNary Dam to Wells Dam averaged 97% per project. Using these values would result in a reduction in Zosel Dam counts of between 6 and 12 summer steelhead.

We estimated that 38 summer steelhead entered Canada. Subtracting the wild steelhead identified at the Inkaneep Trap (17) leaves 21 adipose present summer steelhead with unknown natal streams. Application of potential fallback or mortality factors would account for one of the summer steelhead with unknown distribution.

*Bringing it all together*

In the United States, summer steelhead are listed as “endangered” under the Endangered Species Act in the Upper Columbia River Evolutionary Significant Unit. Detailed percent-wild information for 2008 is provided in this document and every attempt has been made to ensure that these estimates are as accurate as possible. However, these data should be used with caution as definitive methodologies to determine natural origin are not currently possible. Mean values presented in this document represent our best scientific estimate from the best available information, but should not be considered absolute. Thus, high and low estimates are also provided to represent the full range of possible values.

The total escapement estimate for Okanogan River summer steelhead spawners in 2008 was between 1,341 and 1,436 (Table 4). For the first year since OBMEP began collecting data, the WDFW estimate did not fall within our range of potential values. The WDFW estimate was also the highest since we began tracking these values. The WDFW estimates are derived from Wells Dam passage counts modified by subtracting harvest information and divided by river basin through the use of radio telemetry data (English et al. 2001, 2003). The radio telemetry data is over a decade old and perhaps these values need to be revalidated. In 2008, WDFW estimated maximum spawner escapement into the Okanogan River Basin at 1,720 summer steelhead (Charles Frady, WDFW, Personal Communications).

The abundance of wild fish is a subset of the total escapement estimate and the best available information is used to provide an accurate estimate in the Okanogan River Basin. The WDFW escapement estimate was 233 and OBMEP estimated that between 213 and 266 wild summer steelhead likely spawned within the Okanogan River basin in 2008 (Table 5). The WDFW estimate fell within the range of OBMEP values again in

2008 and both agencies had the highest values recorded since data collection began in 2005. The substantial increase in wild fish is at least partially due to incomplete hatchery marking of summer steelhead smolts released into the basin. In 2008, greater attention to other marks and tags resulted in more adipose fin present fish being classified as hatchery fish than in any of the preceding years. Some of this increase may also be attributed to habitat improvement efforts and projects that have been completed over the last 3 to 4 years or more.

A summary of the best available counts and estimates for each reach or sub-watershed throughout the Okanogan River basin is presented in Table 6. Our surveys indicate that main stem spawning is common throughout the Okanogan River but is more heavily focused in the northern portion of the Okanogan and lower Similkameen rivers. The lack of redds in the main stem Okanagan River in Canada is surprising as considerable, high-quality habitat exists. Within the United States portion of the basin, most hatchery steelhead are scatter planted at various locations along the Okanogan and Similkameen rivers; no hatchery stocking occurs in Canada. Therefore, it is highly likely that redd distributions are heavily influenced by the stocking locations used by WDFW. Summer steelhead that spawn in tributary habitats of the Okanogan River are more likely to find suitable environmental conditions and rearing habitats than those spawning in the main stem. If more summer steelhead were stocked into Okanogan basin tributaries, the chances of these tributaries contributing to recovery efforts would be greatly enhanced.

**Table 4.** Total escapement of summer steelhead for the Okanogan River since 2005 including combined hatchery and natural-origin summer steelhead estimates. In 2005 and 2006, only low and high estimates were provided so a simple arithmetic mean was computed for both years. The OBMEP estimate for 2007 was based on estimated main stem data and the 2008 estimate is derived from data presented in Table 6.

| Okanogan River summer steelhead spawner population trend data | | | | |
|---|---|---|---|---|
| Year | WDFW escapement estimate | OBMEP spawner survey estimate | | |
| | | Low | Mean | High |
| 2005 | 1,322 | 1,147 | 1,315 | 1,482 |
| 2006 | 811 | 779 | 855 | 930 |
| 2007 | 1,258 | 1,234 | 1266* | 1,280 |
| 2008 | 1,720 | 1,341 | 1,386 | 1,436 |

* Contains estimated main stem reach data rather than empirical data as in other years.

**Table 5.** Natural origin summer steelhead estimates for the Okanogan River since 2005. The estimates in 2005 and 2006 were calculated by multiplying the average wild percent for the Okanogan River. In 2006 and 2007 various sources data were used, such as trap, video, PIT tags, and coded wire tags were used to develop data for Table 6 at the sub-watershed scale. The WDFW estimate is based upon Wells Dam counts and scale analysis. The OBMEP estimate for 2007 is based on estimated main stem reach data.

| Okanogan River wild summer steelhead spawner population trend data | | | | |
|---|---|---|---|---|
| Year | WDFW escapement estimate | OBMEP spawner survey estimate | | |
| | | Low | Mean | High |
| 2005 | N/A | 143 | 164 | 185 |
| 2006 | 132 | 127 | 139 | 151 |
| 2007 | 116 | 148 | 152* | 155 |
| 2008 | 233 | 213 | 225 | 266 |

* Contains estimated main stem reach data rather than empirical data as in other years.

**Table 6.** Redd counts and spawner counts for each sub-watershed or counting location along with the estimated number of wild summer steelhead represented by each in 2008. The grand total for the entire Okanogan River population is presented with subtotals for tributary and main stem habitat types in the United States and Canada.

| Category | Description/location | 2008 Spawners | Redd count | # wild |
|---|---|---|---|---|
| US Tributary | Spawners placed above Omak trap | 41 | N/A | 10 |
| US Tributary | Spawners below Omak trap | 61 | 15 | 15 |
| US Tributary | Spawners placed above Bonaparte trap | 23 | N/A | 10 |
| US Tributary | Spawners below Bonaparte trap | 5 | 2 | 2 |
| US Tributary | Spawners observed passing Zosel Dam | 193 | N/A | 56 |
| US Tributary | Spawners into Salmon Creek | Unknown | 0 | Unknown |
| US Tributary | Spawners into Wanacut Creek | 0 | 0 | 0 |
| US Tributary | Spawners into Loup Loup Creek | 0 | 0 | 0 |
| US Tributary | Spawners into Antoine Creek | 0 | 0 | 0 |
| US Tributary | Spawners into Tonasket Creek | 0 | 0 | 0 |
| US Tributary | Spawners into Ninemile Creek | 77 | 30 | 18 |
| US Tributary | Spawners into Tunk Creek | 2 | 1 | 0 |
| US Tributary | Spawners into Wild Horse Spring Creek | 0 | 0 | 0 |
| Canada Tributary | Spawners placed above Inkaneep trap | 22 | N/A | 17 |
| Canada Tributary | Spawners below Inkaneep trap | N/D | N/D | N/D |
| Canada Tributary | Spawners into Vaseux Creek | N/D | N/D | N/D |
| Canada Main stem | Spawners into Canadian main stem | N/D | N/D | N/D |
| Canada | Unknown or undefined distribution | 94 | N/D | 38 |
| US Main stem | Spawners into reach O1 | 10 | 5 | 1 |
| US Main stem | Spawners into reach O2 | 99 | 48 | 12 |
| US Main stem | Spawners into reach O3 | 17 | 8 | 2 |
| US Main stem | Spawners into reach O4 | 111 | 55 | 14 |
| US Main stem | Spawners into reach O5 | 39 | 19 | 5 |
| US Main stem | Spawners into reach O6 | 0 | 0 | 0 |
| US Main stem | Spawners into reach O7 | 513 | 249 | 64 |
| US Main stem | Spawners into reach SI/S2 | 272 | 132 | 34 |
| **Subtotals** | **Adult escapement into US main stem** | **1061** | **516** | **132** |
| **Subtotals** | **Adult escapement into US tributaries** | **209** | **N/A** | **55** |
| **Subtotals** | **Adult escapement into Canada** | **116** | **N/D** | **38** |
| **Grand total** | | **1,386** | | **225** |

## Conclusions

Steelhead spawner data clearly show that redd surveys throughout the United States portion of the Okanogan River basin are possible in both tributary and main stem habitats and the distribution of spawning can be effectively quantified. Baseline information for spawning habitat distribution, spawn timing, and spawner escapement have been determined, but additional annual data are necessary to strengthen the body of information for use in trend analysis. Spring spawner data provides a reliable estimate of spawner abundance and slightly less reliable estimates of origin for returning adults. Dependable and reliable estimates such as these are critical for tracking recovery of endangered upper Columbia summer steelhead within the Okanogan River basin. Using a combination of redd surveys, weir traps, video counting chambers, PIT tags, and other marks provides results that are more accurate and precise than would be expected from one methodology alone.

Annual variations in redd distribution can be profound for small tributaries within the Okanogan River basin. Changes in spawner distributions are primarily driven by four factors:

1) The discharge and elevation of the Okanogan River;
2) The discharge of the tributary streams;
3) The timing of runoff that alters the shape of the hydrograph, and most importantly;
4) The stocking location of hatchery smolts.

The first three items are largely part of the natural environmental conditions present in the basin, although they can be altered dramatically by such things as dam releases, irrigation withdrawals, and climate change. These items are inherently difficult for fisheries managers to address. However, the choice of juvenile stocking locations is well within the jurisdiction of fisheries managers to change or modify for the benefit of a given stock. Within the Okanogan River basin, more effort should be given toward developing locally-adapted summer steelhead broodstocks and stocking into tributary habitats that provide the most suitable environmental and rearing conditions. Years such as 2006 and 2008 clearly show how the discharge of the Okanogan River can dramatically alter spawning locations and reduce the number of summer steelhead utilizing tributary streams especially when coupled with a late runoff. Habitat alterations at the mouths of key spawning tributaries can help, provided sufficient discharge is available for adult steelhead to migrate up the tributary stream.

The 2008 data shows similarities with previous surveys; mainstem redd distributions were highest in the upstream reaches of the Okanogan River and lower section of the Similkameen River, where high quality spawning gravels are common and hatchery releases are focused. Other high density spawning areas included the island section near Tonasket, and near McAlister Rapids, where braided channels and increased water velocities maintain clean gravels (1 to 3 inch) preferred by summer steelhead (Smith 1973). Most steelhead redds were observed near Chinook spawning areas or redd mounds or near mid-channel islands. Future habitat improvement efforts should key on providing and sustaining more sites that support a gravel substrate along the main stem

Okanogan River and in close proximity to a cold water refugia to improve egg to fry production for both Chinook and steelhead and over summer juvenile survival for steelhead.

Water availability in the Okanogan River basin approximated normal in 2008, however, much of the snow runoff in the lower elevations occurred prior to steelhead spawning. The remaining snow pack did not melt until late in the spawning period thus many steelhead selected spawning locations along the main stem Okanogan and Similkameen rivers. Many of the small tributaries were either inaccessible due to the low elevation of the Okanogan River or had insufficient discharge for good up stream migration of adult steelhead once they were accessible.

Data collection in previous years and recommendations provided considerable help in 2008; run timing and flows under which we could sample were much better understood. However, data collected in 2008 indicates that over the last four years the timing of redd construction is slowly progressing later each year. In 2009, redd surveys could begin one week later than in years past to help ensure a pre-spawn, peak-spawn, and post-spawn redd surveys get completed. Our main stem redd surveys in 2008 were likely biased low as the post-spawn survey was only slightly lower than the peak spawn survey. Adult spawner counts will be further enhanced in 2009 with the addition of video counting arrays installed on Salmon Creek, Ninemile Creek, and Antoine Creek.

In 2008, we modified the enumeration of summer steelhead at all trap locations by using a length cutoff of roughly 20 inches (500mm). Using this filter helps us differentiate between summer steelhead and adfluvial rainbow trout that occur in both the United States and Canada. The use of this length has been upheld by supplemental DNA data collected in Omak Creek; both DNA and scale data will be evaluated in 2009 to help validate this length for the Inkaneep Creek trap in Canada. Further refinements in distinguishing summer steelhead from other life history forms of *O. mykiss* will continue to evolve in future spring spawner surveys.

Spring spawner data collected over the last four years clearly show that redd surveys are possible and can be enhanced by using underwater video, traps, tags, and marks. However, hatchery activities that do not mark all fish in an easily identifiable way make origin analysis difficult. It is difficult to determine if increasing trends in wild fish are a result of more wild fish production or fewer summer steelhead being marked with an adipose clip. Evaluation of natural production would be enhanced in the future by ensuring that all hatchery summer steelhead are marked by the removal of the adipose fin. Another alternative would be to clip the adipose fin on most but PIT tagging those that are not clipped and expanding the number of PIT tag antennae available for tag interrogation within the Okanogan River basin. Baseline information for spawning habitat distribution, spawn timing, and spawner escapement have been determined but additional years of data are necessary to refine this information and allow for trend analysis.

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# Appendix C. Steelhead Spawner Enumeration in Inkaneep Creek – 2008


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# EXECUTIVE SUMMARY


Steelhead salmon that return to the Canadian Okanagan Basin migrate from the ocean via the Columbia River then into Okanagan River and through Zosel Dam at the outlet of Osoyoos Lake. The video counter at Zosel Dam enumerated 162 adult steelhead (adipose-clipped and unmarked) migrating into Osoyoos Lake between January and May, 2008. Less than this number should be expected to spawn in the Canadian portion of the Okanagan Basin, due to accessible spawning creeks on the American side of Osoyoos Lake North of Zosel Dam. Arterburn and Miller (2008) estimate 116 steelhead spawned in the Canadian Okanagan basin.

The general timing of steelhead/rainbow trout spawning in Inkaneep Creek maintained consistent with 2006 and 2007 to the end of April and 1st week of May. The fish fence on Inkaneep detected migration within the creek beginning April 15 with peak dates between April 27 – 29 and again May 4, 2008. The fish fence enumerated a total of 59 steelhead/rainbow trout.

Of the 59 fish captured, 5 were adipose clipped and of hatchery origin, with the remaining being a wild population. The fish fence caught 22 males and 32 females with 8 undetermined. The sex ratio was slightly lower than witnessed in 2006 at 0.69. Male steelhead/rainbow trout averaged 46 ± 11 cm long compared to the females that averaged 44 ± 11 cm long.

A total of six redds were observed in Canadian Okanagan Basin water-bodies surveyed in the spring of 2008, all in Inkaneep Creek. Redds in Inkaneep Creek were observed on May 4 and May 12.

ACKNOWLEDGEMENTS

We would like to thank the Osoyoos Indian Band, and local landowner Sam Baptiste for allowing access to the survey sites. Funding for this section of the Okanagan Basin Monitoring and Evaluation Program is provided through the Colville Confederated Tribes by the Bonneville Power Administration (BPA).

Disclaimer: Okanagan Nation Alliance Fisheries Department reports frequently contain preliminary data, and conclusions based on these may be subject to change. Please obtain the ONAFD Program manager's permission before citing this work.

Citation: Folks, S., M. Squakin, T. Kozlova., 2008. Steelhead spawner enumeration in Inkaneep Creek – 2008. Within the Okanagan Basin Monitoring and Evaluation Program (OBMEP). Prepared by the Okanagan Nation Alliance Fisheries Department, Westbank, BC.

# 1.0 INTRODUCTION

## *1.1 Project Background*

According to Traditional Ecological Knowledge (TEK) as well as a series of historical accounts, steelhead salmon (*Oncorhynchus mykiss*) were found throughout the Okanagan Basin (Clemens *et al*. 1939; Atkinson 1967; Fulton 1970; Ernst 2000; Rae 2005), a sub-basin of the Columbia Basin. Okanagan steelhead (also known as Upper Columbia summer steelhead) numbers have declined to such an extent that they have been re-listed as an endangered species since 2007 (NOAA 2007). There is limited data about the population size and distribution of steelhead in the Canadian portion of the Okanagan Basin (Rae 2005).

In 2008, the Okanagan Nation Alliance (ONA) working with the Colville Confederated Tribes surveyed the presence and distribution of steelhead spawners in the accessible portions of the Canadian Okanagan Basin as part of the Okanagan Basin Monitoring and Evaluation Program (OBMEP). OBMEP was created to establish a basin wide status and trend monitoring program with a 20 year life-span (Colville Tribes 2003). Within this program an annual estimation of steelhead spawner numbers (redd surveys) is completed to complement habitat surveys (including water quality and quantity surveys) and other biological surveys. This is the fourth year of the OBMEP program, while being the third year of steelhead spawner surveys in the Canadian portion of the Okanagan Basin, of which only two years of the spawner surveys have included a fish fence.

## *1.2 Project Objectives*

To annually enumerate adult steelhead spawners returning to the Okanagan River Basin, a fish fence in Inkaneep Creek was monitored. Also modified redd surveys in Inkaneep Creek were conducted. The end objective is to determine steelhead spawner run – timing and distribution.

Specific objectives for the Inkaneep Creek fish fence include,

- Re-installation and maintenance of the fish fence on the lower reach of Inkaneep Creek throughout the spawner returns (April to May),
- Enumeration of all upstream migrating fish (primarily steelhead and rainbow trout), and
- Collection of biological information including fish length and ratio of male to female trout.

Specific objectives for the redd surveys included:

- Focus redd survey efforts to regions previously determined to have significant numbers of steelhead redds (Long *et al.* 2006; Benson and Squakin, 2007).
- Utilize a fish fence in conjunction with redd surveys to determine run timing, and distribution.

## 1.3 Study Area

The area of the Canadian Okanagan Basin currently accessible to migrating steelhead salmon occurs downstream of McIntyre Dam. McIntyre Dam (24km upstream of Osoyoos Lake on the main stem Okanagan River) was constructed without fish passage in 1920 (Long 2005a). Downstream of McIntyre Dam, two large tributaries flow into the Okanagan system; Vaseux Creek flows into the Okanagan main stem while further downstream Inkaneep Creek flows into the north basin of Osoyoos Lake. Inkaneep Creek was the focus of this year's steelhead spawner surveys conducted in the spring of 2008 based on previous years sampling. In 2006 (Long and Squakin 2006) it was determined that Inkaneep Creek was the most productive of the creeks surveyed. In order to maximize enumeration efficiency, Inkaneep Creek was chosen for the fish fence.

In Inkaneep Creek, 3.7 km of its 23.5 km length is accessible to migrating salmon due to a 6 m high waterfall (Walsh and Long 2005). The entire 3.7 km length of Inkaneep Creek was surveyed for steelhead redds as well as the monitoring of steelhead migrations through a fish fence located 625 m from the mouth of the creek.

In response to the lack of fish passage at McIntyre Dam, the ONAFD and other groups have lobbied to enable fish passage. Currently funding has been secured to install 5 overshot gates at McIntyre Dam which will provide access upriver. These gates are expected to be installed during 2009. Currently, pre overshot gate installation, McIntyre Dam can be operated for short periods of time in the spring freshet in such a way that migration of salmon is possible, thus a main tributary upstream of McIntyre Dam, Shuttleworth Creek may be included in future enumerations.

Steelhead spawning distribution and timing estimates are currently based on redd surveys and fish fence data from Inkaneep Creek (Fig. 1).

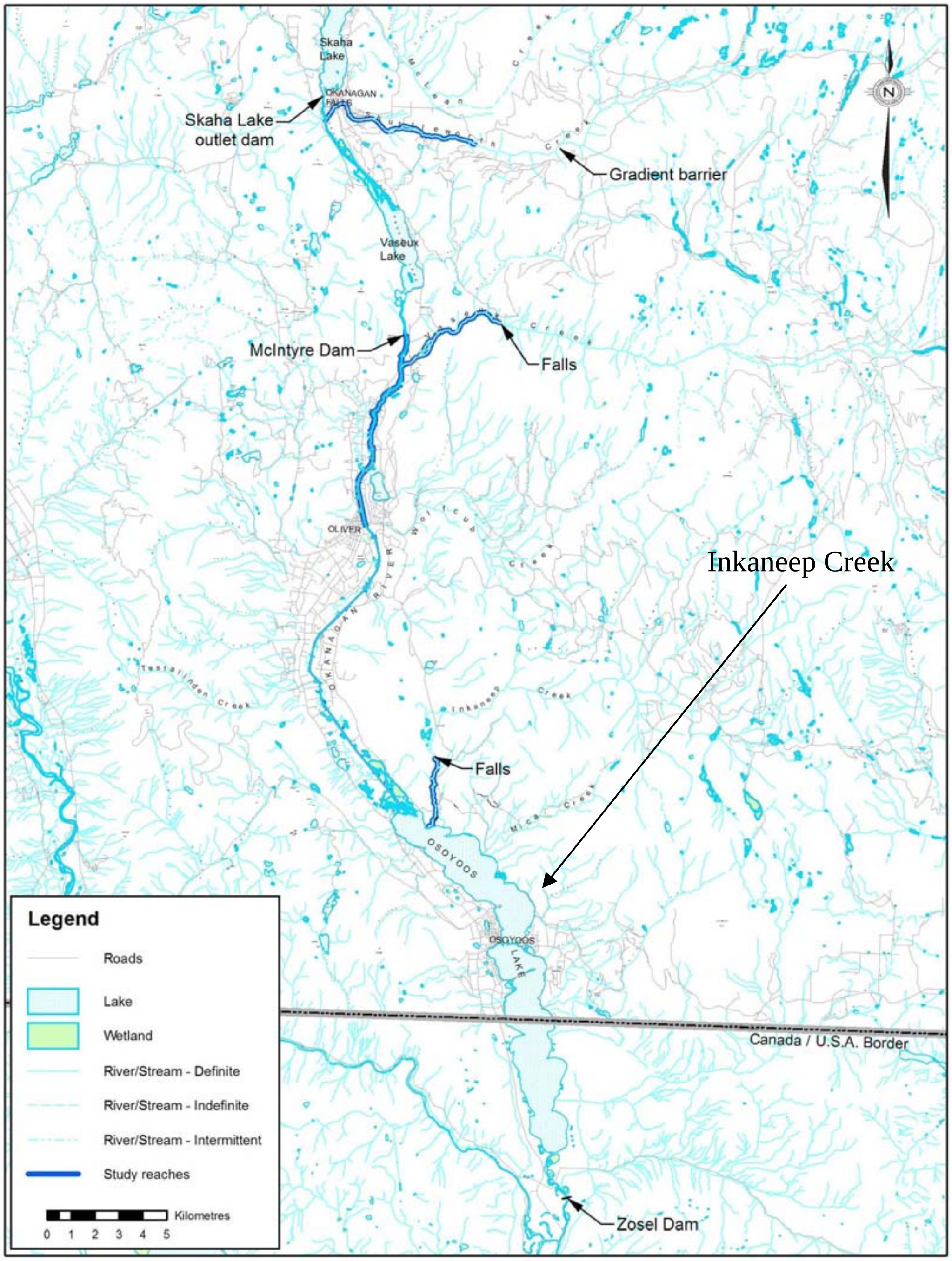


**Figure 20. Canadian Okanagan Basin steelhead/rainbow trout study area**

# 2.0 METHODS

## *2.1 Inkaneep Creek Fish Fence Monitoring*

This is the third year of the steelhead/rainbow spawner monitoring within the Canadian Okanagan Basin, while the second year in which a fish fence has been used on Inkaneep Creek. In 2006 it was determined that a fish fence provided good enumeration results compared to the sampling season in 2007 which relied primarily on redd surveys. The fence was installed on March 31st, 2008 and located 625m from the mouth of Inkaneep Creek (GPS N49.00077220, W119.50360) and later moved (May 5) downstream (N49.07220 and W119.50354) due to freshet flows. The fence was constructed during low flow conditions at mean depths of approximately 1.77m (WSC 2008). Inkaneep Creek typically experiences flash flood flow dynamics where the water levels in the creek are prone to changing over a short time period (Long 2000). In response to this, the fish fence was constructed in the new location 50 m upstream of the previous fish fence site (Long *et al.* 2006) in order to reduce the likelihood of failure. However, despite such efforts the fence was compromised May 5, 6, and 7th, 2008.

As a result of the propensity of the fish fence to become compromised during peak flow periods, the fish fence was removed mid May 2008. This, according to the Water Survey of Canada (WSC), was prior to the peak freshet flow of the spring of 2008 which occurred between May 20th and 25th, 2008 (WSC 2008).

Counts of steelhead/rainbow trout migrating into Inkaneep Creek to spawn were conducted April 7th to May 15th, 2008. Installation of the fish fence occurred before the early steelhead spawners migrated into the system, based on peak dates from previous years sampling (Long *et al.* 2006, Benson and Squakin, 2008). The fence was located at the top of a riffle, where the capture box could sit in the deeper waters of a pool (Fig. 2, Fig. 3). The fence panels were set up across the creek to herd the fish into the capture box.

**Figure 21. Inkaneep Creek fish fence at first location**

**Figure 22 Inkaneep Creek fish fence at second downstream location**

The fish fence was checked daily from April 7th to May 15th, 2008. At each check the sampling box was monitored for fish presence. All fish were noted, irrespective of species, and steelhead/rainbow trout (Figure 4) were bio-sampled. Biological sample data included: nose fork length (cm), sex, adipose presence, fin clip, and scale samples[1]. All diligence was taken in order to minimize both handling and stressing fish. The fish were then released into a pool within close proximity to the sampling box and were monitored during recovery. Additionally daily fence maintenance occurred, insuring there were no breaches in the fence. Lastly it was insured that Wenatchee hatchery (unclipped adipose) fish, indicated by their red dye eye marks, were not released.

**Figure 23. Male steelhead/rainbow trout sampled May 2008**

## *2.2 Redd Surveys*

Based on the failure of previous years surveys (2006, 2007) to significantly detect and quantify steelhead/rainbow spawner redds, the redd survey methodology was modified to include only Inkaneep Creek. Redd detection has previously been difficult within

[1] These samples will be processed in 2009 for aging and stable isotope analysis to determine exposure to marine environments.

Okanagan River tributaries due to high turbidity and high freshet flows. The decision to modify the surveys was made in order to allocate resources to a stream particularly productive in terms of Canadian Okanagan Basin (COB) steelhead/rainbow spawner numbers (Long *et al.* 2006; Benson and Squakin, 2008).

Combined with the fish fence - a method proven to provide good enumeration results, redd surveys were conducted to ameliorate the fence counts whereby distribution within Inkaneep Creek could be assessed. Redd surveys, as mentioned; in previous years have proven difficult to provide for a viable data set with which confident distribution results could be determined. Thus, with improved enumeration in Inkaneep Creek along with continually improving data from Zosel Dam the remaining steelhead spawning distribution can be determined.

Redd surveys were conducted by two ONAFD personal versed in redd survey methodology. The surveys took place concurrently with the fence on two days in early May after fish were observed in the fish fence (Arterburn *et al.* 2007; Benson and Squakin, 2008)[2]. The entire reach accessible to steelhead/rainbow, below the permanent fish barrier on Inkaneep Creek, was surveyed in an upstream manner. The quality of each survey was recorded at the time the enumeration occurred similar to standardized protocols from the ONA sockeye salmon (*Oncorhynchus nerka*) enumerations (Alexis & Wright 2004). Information collected to determine the quality of the counts include;

- water clarity (water depth of visibility),
- weather (cloud cover, brightness, precipitation),
- survey crew,
- start and end time for the survey.

The number and location (GPS) of redds were recorded as well as any note of live or dead fish present and the quality of the survey. Redds were verified by at least two trained crew members. Locations and physical data were entered into a Trimble Geo XT GPS data logger in accordance with Arterburn *et al.* (2007). In order to prevent double-counting of existing redds, confirmed redds were marked with flagging tape tied to a tree or bush on the adjacent stream bank. The flag was marked with survey date, number of redds, and location and distance of the redd from the flag.

[2] Due to budget constraints only two days were spent conducting Redd surveys.

As in past years (Long *et al.* 2006; Benson and Squakin, 2008) the VDS reach was not surveyed due to the limited steelhead/rainbow trout spawning activity (Long 2004; Long 2005b; Audy and Walsh 2006; Long *et al*. 2006; Wodchyc *et al*. 2007).

# 3.0 RESULTS

## *3.1 Inkaneep Fish Fence Monitoring*

The Inkaneep fish fence was monitored for 39 days (April 7 to May 15, 2008) after which the fence was disassembled prior to the peak freshet flow, which in previous years has blown out the fence (Long *et al.* 2006; Benson and Squakin, 2008). During the sampling period of the fish fence a total of 59 steelhead/rainbows were enumerated, while 1 fish was dead and unspawned at time of sampling, and two additional undetermined escapees were also present. Examining the daily migration patterns of steelhead/rainbow trout at the Inkaneep fish fence (Figure 5) indicates that peak migration occurred on April 27-29th, and again May 4th.

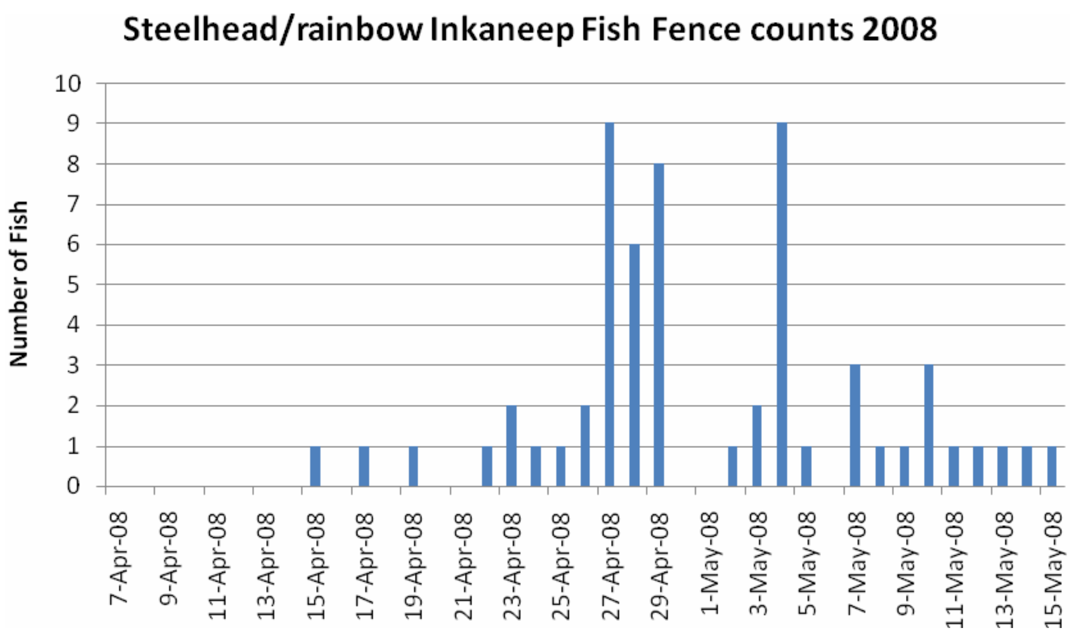


**Figure 24. Daily counts of steelhead/rainbow trout through the Inkaneep fish fence**

Based on data collected by both ONAFD and the Colville Confederated Tribes (CCT) peak steelhead/rainbow trout timing for 2008 has been consistent to the latter half of April and the 1st week of May compared to previous years. Arterburn *et al.* (2007) make mention that this time period is also experienced in Washington State tributaries to the Okanagan River. These peak dates tend to correlate with peak water flows through Inkaneep Creek monitored at the Water Survey of Canada water gauge 08NM200 (Fig. 6). The fish fence was installed during water levels of <1.8m. On the peak migration days (April 27 – 29, and May 4) the water levels and discharge within Inkaneep Creek are rising or have risen (Fig 6.). Also, the small peak of 3 fish noted on April 14, a corresponding increase in streamflow levels also occurred (Fig. 6).

It should be noted that on a number of brief occasions, the fence was compromised by a combination of either flows/vandalism and/or other factors. In each case a section of the fence adjacent to the stream bank was compromised, where a passable hole was present. Fish counts on April 24 and 25 may have been compromised due to intentional removal of a number of the aluminum rods that make up the fish fence. During this time period, pre and post, at most 2 – 3 fish were enumerated per sampling period. Also May 5th, 6th, and 7th there were stability issues with the fish fence. The morning sampling crews note structural alterations to the fence, likely due to stream flow. In response to this, the fence on May 5 was moved downstream approximately 20m and did not cover the stream for approximately 5 midday hours. Figure 6 demonstrates drastic changes in daily flow in Inkaneep Creek. It is possible that during this period there may have been continued peak runs of steelhead, as per Figure 5, in which 9 – 10 fish were observed daily. However, despite brief alterations to the fish fence, the overall count of steelhead/rainbows was a success.

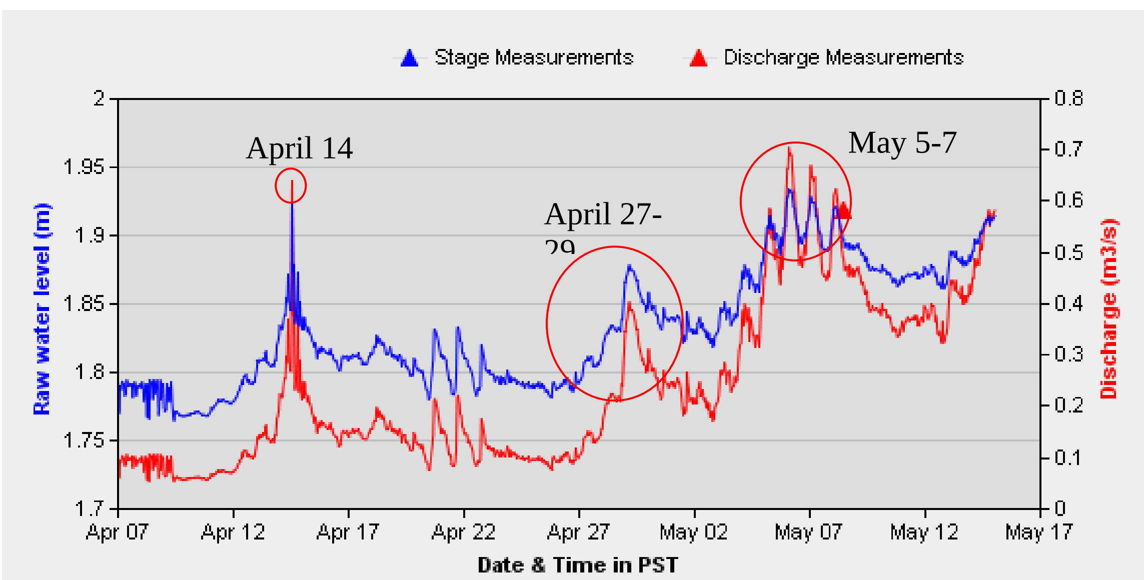


**Figure 25. Water levels (blue) and discharge (red) in Inkaneep Creek at station 08NM200 (WSC 2008).**

The fish fence data from Long *et al.* (2006) corroborates the timing witnessed this season, with peak migration periods broadly during the last week of April into the 1st week of May. In 2006 the fish fence was operated over a longer time period to note pre and post peak spawning events. This time period failed to note additional spawners, safe for 1 fish later May (May 17), outside of the sampling period used this season.

### 3.1.1 Biological Sampling of Inkaneep Creek steelhead/rainbow trout

Of the 59 fish captured, 5 were adipose clipped and of hatchery origin (Appendix A). Therefore the majority (91.53%) of the fish enumerated are most likely a wild population of steelhead/rainbow trout. The fish fence caught 22 males, 32 females, and 5 undetermined (Figure 7). The sex ratio of 0.69 represented a slightly lower than previously witnessed sex ratio of 0.85 (Long *et al.* 2006); however, sex determination of the unknown fish may make up for this variance. Also, Osoyoos Lake is noted has having adfluvial rainbow trout that could be as large as their steelhead counterparts (Long *et al.* 2006). The level of interaction between these adfluvial residents and the adadromous steelhead is unknown.

Male steelhead/rainbow trout averaged 46 ± 11 cm long compared to the females that averaged 44 ± 11 cm long (Table 1). Compared to results collected in 2006 returning numbers to Inkaneep Creek are similar.

**Table 1. Length of Canadian Okanagan Basin male and female steelhead/rainbow trout in 2006 and 2008**

| | Count | | Length | | Std Dev | | Min | | Max | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2006 | 2008 | 2006 | 2008 | 2006 | 2008 | 2006 | 2008 | 2006 | 2008 |
| **Female** | 27 | 32 | 45 | 44 | 9 | 11 | 16 | 16 | 59 | 60 |
| **Male** | 23 | 22 | 49 | 46 | 11 | 11 | 31 | 20 | 76 | 67 |
| **Unknown** | 14 | 5 | | | | | | | | |

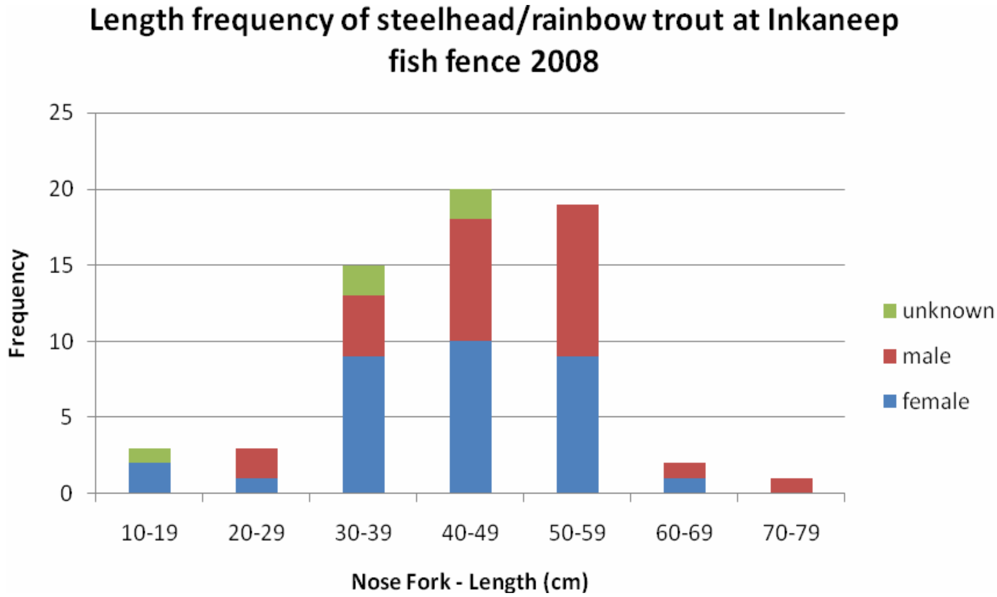


**Figure 26. Length frequency of steelhead/rainbow trout at Inkaneep fish fence 2008**

## *3.2 Redd Survey Results*

Inkaneep Creek was surveyed twice by ONAFD members versed in redd survey methodology. A total of 6 redds were observed in Inkaneep Creek in the spring of 2008 (Table 2).

**Table 2. Inkaneep Creek redd survey data**

| Waterbody | No of redds | GPS | Water clarity | Date | Comments |
|---|---|---|---|---|---|
| Inkaneep Creek | 2 | N 49.07206 W 119.50360 | 10-15cm | 4-May-08 | Cattle crossing present |
| Inkaneep Creek | 4 | Unavailable[3] | 1m | 12-May-08 | |

Based on the number of fish sampled within the fish fence, the observation of 6 redds (Figure 8) speaks to both a lack of sufficient effort to account for all spawning steelhead/rainbow, but also the decreased value of redd surveys in population estimates in the Canadian Okanagan Basin (COB). While Arterburn *et al.* (2007) note that redd surveys in American Okanagan Tributaries (AOT) are well founded, within the COB alternative sampling measures must be considered.

[3] GPS coordinates unavailable due to gear malfunction. These redds were located near (within 100m) the redds indicated on May 4, 2008

Based on previous years sampling, the majority of the redds detected were located in Inkaneep Creek and Vaseux (Table 3). However in 2007 difficult redd survey conditions provided minimal results thus redd surveys for 2008 were conducted in only Inkaneep Creek. Given the presence of redds in Vaseux and Shuttleworth Creeks, and the Okanagan River in previous years it can be assumed that there were redds present within these Creeks for 2008; however, there is insufficient data to produce quantitative estimates for these creeks for this year.

**Table 3. Steelhead Redd surveys in the Canadian Okanagan Basin**

| Redd Locations | 2006 | 2007 | 2008 |
|---|---|---|---|
| Inkaneep | 10 | 2 | 6 |
| Vaseux | 10 | 1 | |
| Okanagan | 2 | | |
| Shuttleworth | | 1 | |

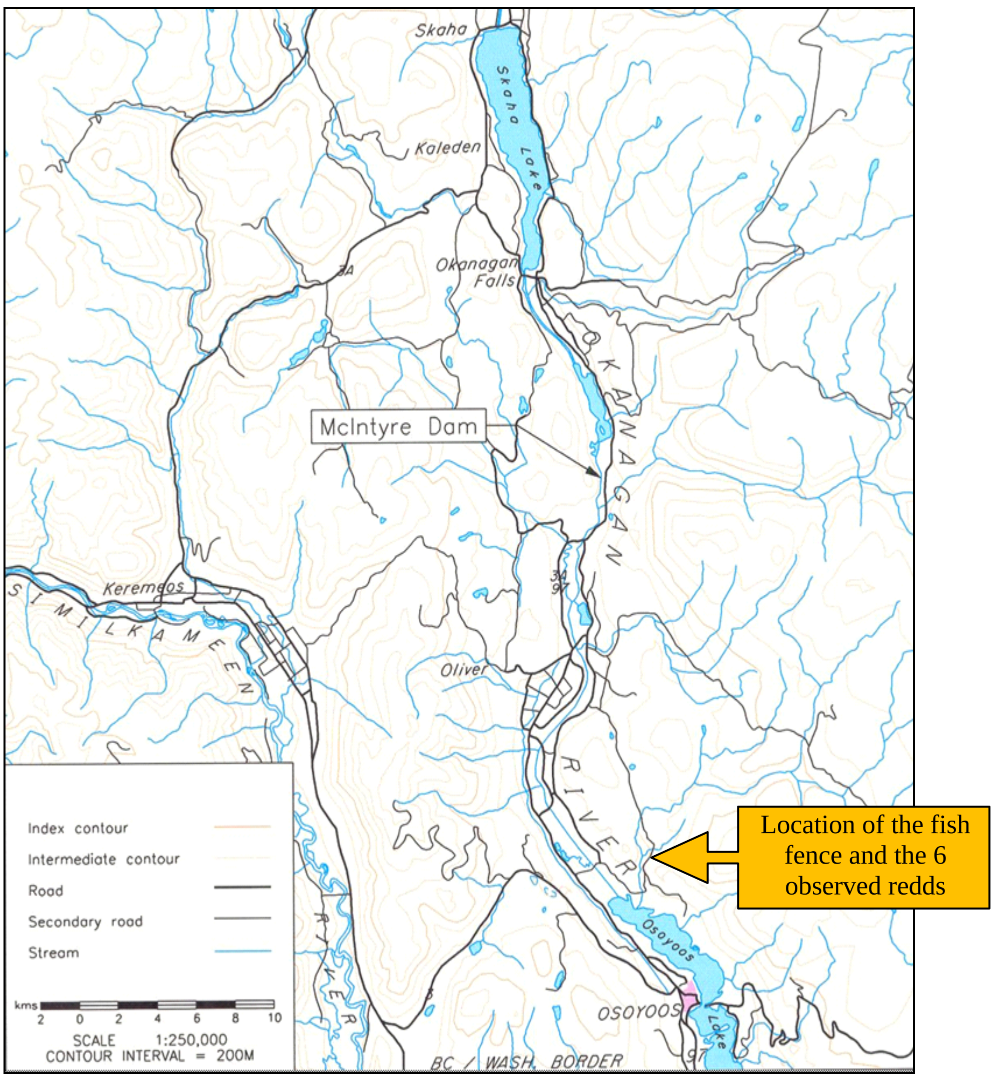


**Figure 27 Location of steelhead/rainbow trout redds in the Okanagan Basin, 2008.**

# 4.0 DISCUSSION AND RECOMMENDATIONS

Steelhead returning to the Canadian Okanagan Basin migrates up the Columbia River, enter the Okanogan River in Washington, then pass through Zosel Dam at the Osoyoos Lake outlet.  The video counter at Zosel Dam counted a total of 162 hatchery and wild adult steelhead (or possibly rainbow trout)  a 10% increase over the same time period as 2007, but a 40% reduction over the same time period as in 2006 (Figure 9).

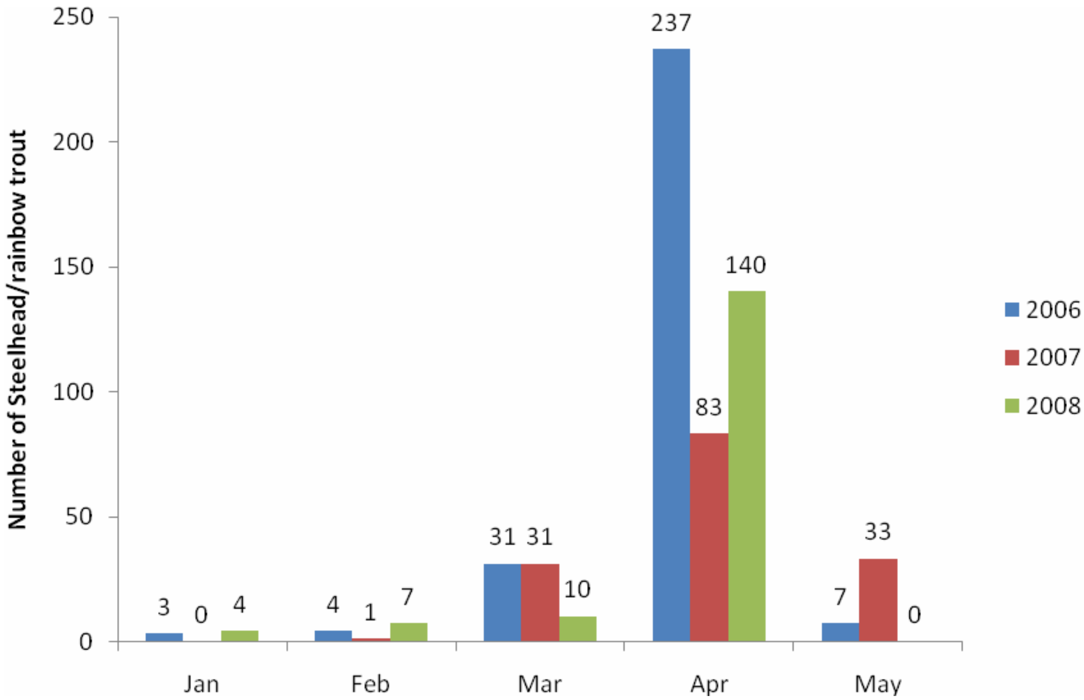


**Figure 28 Adult steelhead (hatchery and wild) migrations through the Zosel Dam fish counter for 2006-2008 (Long et al. 2006; Benson and Squakin 2008; Columbia River DART 2008).**

Within the American portion of the Southern Basin of Osoyoos Lake both Nine Mile and Tonasket Creeks host populations of spawning steelhead/rainbow trout (Arterburn *et al.* 2007). These numbers should be subtracted from the numbers presented as Zosel dam counts; however, as mentioned in Arterburn *et al.* (2007) enumerations within these creeks has proven difficult due to private land ownership and access to the creeks. Future amelioration of these counts is required to improve both the estimates of escapement within these creeks as well as steelhead/rainbow trout entering the Canadian Okanagan Basin (COB).

Of the steelhead/rainbow trout entering the COB it has been noted by Long *et al.* (2006) and Benson and Squakin (2008) that the majority return to Inkaneep Creek. In 2008 more sampling effort was allocated to this stream. Enumeration results provided a count of 59 adults migrating past the Inkaneep Creek fish fence. These results demonstrate a consistent migration pattern to that of previous years (late April to Early May peak). However, this seasons sampling continued to demonstrate limitations of the current fish fence utilized by the ONAFD. The fish fence is structurally unable to withstand freshet flows within Inkaneep Creek. As a result there are periods in which the fence is navigable to fish thereby reducing the reliability of the total spawner counts. Despite these flaws however the count for the 2008 season represents a good portion of the steelhead/rainbow trout that spawn within the COB.

Population estimates will be calculated for Inkaneep, Vaseux, and the Okanagan River upon further collection of data from within the COB. From ameliorated population data, distribution results will then be possible. While there are estimates from Arterburn *et al.* (2008) for Canadian tributaries to the Okanagan River, further analysis of said estimates is required for management decisions to be made.

In addition to distribution and population estimates, the interaction and role of adfluvial rainbow trout needs to be assessed. The level of interaction between these fish and anadromous steelhead/rainbow trout is unknown. The determination of the role of these fish in the life history of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) listed Okanagan Basin steelhead is of importance in determining the fate of this population.

Within the Canadian Okanagan basin Inkaneep Creek continues to appear to have the most steelhead spawners in the entire Canadian Okanagan Basin (Long *et al*. 2006; Arterburn *et al*. 2007b). Future steelhead spawner and habitat research, and management, due to budget constraints will focus on this tributary.

### *4.1 Recommendations*

1. Future steelhead surveys should continue to focus on Inkaneep Creek, as this tributary has the strongest spawning run. A fish counting fence used in conjunction with improved Zosel Dam counts could be used to obtain a population estimate.

2. Operation of the Inkaneep Creek fish fence should follow the recommendations outlined by Long *et al*. (2006).

3. The Inkaneep fish fence should be reinforced to better cope with spring freshet flows in stream.

4. Currently, there is limited data on the adfluvial rainbow trout population in Osoyoos Lake. Strontium isotope analysis of the bio-samples collected from 2008 should be conducted. Also bio-sample collection should continue in 2009 to move towards better understanding the adfluvial/anadromous interaction and life history of Okanagan steelhead/rainbow trout.

5. Redd surveys on all Canadian Okanagan Basin (COB) tributaries and streams should be discontinued.

6. Continue to examine alternative enumeration methods to better determine distribution results of steelhead/rainbow trout within the COB.

7. The public should be informed as to the reasoning behind the fish fence to prevent future vandalism. Perhaps a fixed sign on site explaining both the structure and the project. As well as a press release to the community of Oliver and surrounding first nations should be employed.

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# APPENDIX A – 2008 Redd Survey Raw Data

| Date | Steelhead Biosampling | | | | | | | Other | Water | Water | | Crew |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2008 | Fish # | Sex | Length (cm) | Adipose Clip | Fin Sample | Scale # (book-box) | Photo # | Fish | Temp °C | Level cm | °C | |
| **7-Apr** | - | - | - | - | - | - | - | - | 8.2 | - | - | CM/RF |
| 7-Apr | - | - | - | - | - | - | - | - | 8.7 | - | - | MS/DH/CM |
| **8-Apr** | - | - | - | - | - | - | - | - | 5.6 | Up 2-5 cm | 7 | MS/DH |
| **9-Apr** | - | - | - | - | - | - | - | - | 7.4 | Low | 10 | MS/DH |
| **10-Apr** | - | - | - | - | - | - | - | - | - | | - | MS/CM/DH |
| 10-Apr | - | - | - | - | - | - | - | - | 10 | | - | CM/AB |
| **11-Apr** | - | - | - | - | - | - | - | - | 4.6 | Low | 6 | MS/DH |
| 11-Apr | - | - | - | - | - | - | - | - | 11.5 | | - | CM/AB |
| **12-Apr** | - | - | - | - | - | - | - | - | 7 | Low | 12 | MS |
| 12-Apr | - | - | - | - | - | - | - | - | 13.4 | | 21 | CM/AB |
| **13-Apr** | - | - | - | - | - | - | - | - | 8.7 | Low | - | MS/NP |
| 13-Apr | - | - | - | - | - | - | - | - | 13.4 | | 19 | CM/AB |
| **14-Apr** | - | - | - | - | - | - | - | - | 10.1 | Up 10 cm | 9 | MS/DH |
| 14-Apr | - | - | - | - | - | - | - | - | 8.5 | | - | CM/RF |
| **15-Apr** | - | - | - | - | - | - | - | - | 6.4 | | 11 | MS/JS |
| 15-Apr | 18650 | M | 59 | N | Y | 36541-1 | 1,2 | - | 8.8 | | - | CM/AB |
| **16-Apr** | - | - | - | - | - | - | - | - | 4 | | - | MS/DH |
| 16-Apr | - | - | - | - | - | - | - | - | 10.3 | | - | CM/DG |
| **17-Apr** | 18651 | - | 49 | N | Y | 36541 | - | - | 5.5 | | - | MS/DH |
| 17-Apr | - | - | - | - | - | - | - | - | 11.3 | | - | CM/RF |
| **18-Apr** | - | - | - | - | - | - | - | - | 5.4 | | - | MS/DH |
| 18- | - | - | - | - | - | - | - | - | 7.2 | | - | CM/RF |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apr | | | | | | | | | | | | |
| **19-Apr** | - | - | - | - | - | - | - | - | 3.6 | | - | NP |
| 19-Apr | 18652 | | 30 | N | Y | 36541-3 | 100-0063, -0064 | - | 7.2 | | 4 | CM/RF |
| **20-Apr** | - | - | - | - | - | - | - | - | 3 | | - | NP/DH |
| 20-Apr | - | - | - | - | - | - | 100-0065 | - | 7.5 | | 7 | CM/RF |
| **21-Apr** | - | - | - | - | - | - | - | - | 4.9 | Low | 7 | MS/DH |
| 21-Apr | - | - | - | - | - | - | - | - | 8 | | - | CM/CRS |
| **22-Apr** | 18653 | | 39 | N | Y | 36541, #4 | 21 | - | 2.8 | | - | MS/DH |
| 22-Apr | - | - | - | - | - | - | - | - | 9.9 | | - | CM/DG |
| **23-Apr** | - | - | - | - | - | - | - | - | 5 | | 4 | MS/DH |
| 23-Apr | 18654 | F | 58.5 | N | Y | 36541-5 | 1-3: 18654_A/B/C.JPG | - | 7.3 | | - | CM/DG |
| 23-Apr | 18655 | M | 37 | N | Y | 36541-6 | 4-5: 18655_A/B.JPG | - | - | | - | |
| **24-Apr** | - | - | - | - | - | - | - | - | 5.2 | | 10 | MS/CM |
| 24-Apr | 18656 | M | 58 | N | Y | 36541-7 | 1 | | 7.6 | | - | CM/DG |
| **25-Apr** | - | - | - | - | - | - | - | - | 7.3 | 37 | - | CRS/AS |
| 25-Apr | 18657 | F | 35 | | | 36541-8 | 1-3. | | 10.6 | | - | CM/DG |
| **26-Apr** | - | - | - | - | - | - | - | - | 5.8 | 38 | - | MS/RF |
| 26-Apr | 18658 | F | 60 | N | Y | 36541-9 | 1-3. | - | 10.9 | 37 - 38 | - | CM/DG |
| 26-Apr | 18659 | M | 59 | N | Y | 36541-10 | 4-5. | - | | | - | |
| **27-Apr** | 18660 | F | 39 | N | Y | 36541-11 | Y | - | 7.4 | 41 | 12 | MS/RF |
| 27-Apr | 18661 | F | 52 | N | Y | 36541-12 | Y | - | - | | - | |
| 27-Apr | 18662 | F | 47 | N | Y | 36541-13 | Y | - | - | | - | |
| 27-Apr | 18663 | F | 58.5 | Y | Y | 36541-14 | Y | - | - | | - | |
| 27-Apr | 18664 | F | 37.5 | N | Y | 36541-15 | Y | - | - | | - | |
| 27-Apr | 18665 | M | 43 | N | Y | 36541-16 | 1 | - | 10.6 | 42 | - | CM/DG |
| 27-Apr | 18666 | M | 52 | N | Y | 36541-17 | 2-3. | - | - | | - | |

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| 27-Apr | 18667 | M | 40 | N | Y | 36541-18 | 5 | - | - | | - | |
| 27-Apr | 18668 | F | 59 | Y | Y | 36541-19 | 6-7. | - | - | | - | |
| **28-Apr** | 18669 | M | 55.5 | Y | Y | 36541-20 | Y | - | 10.9 | | - | AS/RF |
| 28-Apr | 18670 | F | 39 | N | Y | 36541-21 | Y | - | - | | - | |
| 28-Apr | 18671 | M | 50.5 | N | Y | 36542-1 | 1 | - | 12.5 | 45 | - | CRS/BL |
| 28-Apr | 18672 | M | 50 | N | Y | 36542-2 | 2 | - | - | | - | |
| 28-Apr | 18673 | F | 56 | N | Y | 36542-3 | 3 | - | - | | - | |
| 28-Apr | 18674 | M | 56 | N | Y | 36542-4 | 4 | - | - | | - | |
| **29-Apr** | 18675 | M | 67 | N | Y | 36541-22 | Y | 1 RT | 7 | 53 | - | MS/RF |
| 29-Apr | 18676 | F | 47 | N | Y | 36541-23 | Y | 1 Sucker (fish #25) | - | | - | |
| 29-Apr | 18677 | F | 44 | N | Y | 36541-24 | Y | - | - | | - | |
| 29-Apr | 18678 | F | 42 | N | N | 36541-25 | Y | - | - | | - | |
| 29-Apr | 18679 | F | 39 | N | Y | 36541-26 | Y | - | - | | - | |
| 29-Apr | 18680 | F | 54 | N | N | 36542-5 | Y | - | - | | - | |
| 29-Apr | 18681 | F | 59 | N | Y | 36542-6 | 1 | - | 8.8 | 52 | - | CM/CRS |
| 29-Apr | 18682 | F | 47 | N | Y | 36542-7 | 2,3 | - | - | | - | |
| **30-Apr** | - | - | - | - | - | - | - | 1 Sculpin Prickley (dead) | 5.2 | 65 | - | MS/RF/KL |
| **1-May** | - | - | - | - | - | - | - | - | 5.8 | 55 | - | CM/CRS/WP |
| 1-May | - | - | - | - | - | - | - | - | 4.2 | | - | MS/RF |
| 1-May | - | - | - | - | - | - | - | - | 8.7 | | - | CRS/WP |
| **2-May** | 18684 | | 18 | N | Y | 36542-9 | 1, 2 | - | 11.4 | 50 | - | CM/JS |
| **3-May** | 18685 | F | 47 | Y | Y | 36542-10 | MS Cellphone | 1 RT | 7.2 | 49 | 17 | MS/RF |
| 3-May | 18686 | M | 39 | Y | Y | 36542-11 | - | - | - | | - | |
| 3-May | - | - | - | - | - | - | - | - | 10.9 | 50 | - | CM/CRS |
| **4-May** | 18688 | - | 43 | N | Y | 36542-12 | Y | - | 7 | 51 | - | MS/RF |
| 4-May | 18689 | M? | 29 | N | Y | 36542-13 | 1 | - | 11 | 60 | - | CRS/WP |
| 4-May | 18690 | F | 36 | N | Y | 36543-1 | 2 | - | - | | - | |

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| 4-May | 18691 | M | 40 | N | Y | 36543-2 | 3 | - | - | | - | |
| 4-May | 18692 | M? | 40 | N | Y | 36543-3 | 4 | - | - | | - | |
| 4-May | 18693 | F | 52 | N | Y | 36543-4 | 5 | - | - | | - | |
| 4-May | 18694 | M | 42 | N | Y | 36543-5 | 6 | - | - | | - | |
| 4-May | 18695 | M | 38 | N | Y | 36543-6 | 7,8 | - | - | | - | |
| 4-May | 18696 | F | 39 | N | Y | 36543-7 | 9, 10 | - | - | | - | |
| **5-May** | 18697 | M | 37 | N | Y | 36543-8 | Y | - | 7.8 | | - | MS/RF |
| 5-May | - | - | - | - | - | - | - | - | 11.2 | 22 | - | CM/CL |
| **6-May** | - | - | - | - | - | - | - | - | 6.8 | high | - | MS/RF |
| 6-May | - | - | - | - | - | - | - | - | 10.3 | 30 | - | CRS/CL |
| **7-May** | - | - | - | - | - | - | - | - | 6.9 | | - | MS/RF |
| 7-May | 18698 | M | 50 | N | Y | 36543-9 | 1 | Sucker | 8.3 | 18 | - | CRS/CL |
| 7-May | 18699 | F | 37 | N | Y | 36543-10 | 2,3 | - | - | | - | |
| 7-May | 18700 | F | 53 | N | Y | 36543-11 | 4 | - | - | | - | |
| **8-May** | 18701 | M | 51 | N | Y | 36543-12 | Y | - | 6.1 | | - | MS/RF |
| 8-May | - | - | - | - | - | - | - | - | 7.7 | 24 | - | CRS/CL |
| **9-May** | - | - | - | - | - | - | - | - | 6.1 | 24 | - | CM/RF/JS |
| 9-May | 18702 | F | 41.5 | N | Y | 36543-13 | 1, 2 | - | 10.3 | 20 | - | CRS/CL |
| **10-May** | 18703 | M? | 20.1 | N | Y | 36543-14 | 1 | - | 7.8 | 25 | | JS/JP |
| 10-May | 18704 | F | 18.5 | N | Y | 36543-15 | 1 | - | 8.7 | 22 | 15 | CM/CL |
| 10-May | 18705 | F | 16 | N | Y | 36543-16 | 1 | - | - | | - | |
| **11-May** | - | - | - | - | - | - | - | - | 7.6 | 19 | 12 | MS/CT |
| 11-May | 18706 | F | 22 | N | Y | 36543-17 | 2 | - | 7.7 | 17 | - | CL/JS |
| **12-May** | 18707 | F | 48 | N | Y | 36543-18 | Y | - | 6.6 | | - | MS/RF |
| 12-May | - | - | - | - | - | - | - | - | 10.7 | 15 | - | CL/JS |
| **13-May** | 18708 | - | 49 | N | Y | 36543-19 | RF Camera | 3 Sucker | 8.3 | 19 | 15 | MS/RF/AS/CT/JP |
| 13-May | - | - | - | - | - | - | - | - | 8.4 | 18 | - | CL/JS |
| **14-May** | 18709 | F | 43 | N | Y | 36543-20 | Y | - | 7.5 | | 16 | MS/RF |

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| 14-May | - | - | - | - | - | - | - | - | 9.3 | 24 | - | CM/CL |
| **15-May** | 18710 | F | 38 | N | Y | 36543-23 | Y | 6 Suckers | 8.7 | | - | MS/RF |