2009

Annual Report

Colville Tribes

Fish & Wildlife Department

Okanogan Basin Monitoring & Evaluation Program

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Fish & Wildlife Department
Anadromous Fish Division

Okanogan Basin Monitoring & Evaluation Program

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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.

2009 was marked as another productive year through completion of 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 agencies in Canada. Data and reports are available on the internet, which 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) 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.

The primary project goals of OBMEP include: (1) determining if there is a meaningful biological change at the population scale for summer/fall Chinook, spring Chinook, sockeye, and steelhead in the Okanogan basin; (2) if meaningful change in selected physical habitat parameters are occurring over time; (3) if selected water quality parameters are changing in mainstem and tributary locations; (4) if change is occurring in VSP parameter from the cumulative habitat restoration actions occurring throughout the Okanogan basin; and (5) administering contracts and ensure that this effort continues in a scientifically sound manner that is closely coordinated across the Okanogan River basin, geo-political boundaries, upper Columbia ESU, Columbia River basin, and Pacific Northwest region.

Methods

As adapted from 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 2008 through February 2009. 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/Reports.htm

This report is a synopsis of all data collections and reporting efforts conducted under OBMEP for contract year 2009. 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: Produce Annual Report

Each year, OBMEP produces an annual report. Several additional documents 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 primarily for operation and collection of fish at our rotary screw trap. All permits were procured before active trapping began. The permits obtained and issuing agencies are as follows:

Title of Permit	Permit #	Issuing Agency
Section 10 Incidental Take Permit	#1520	NOAA Fisheries
Hydraulic Project Approval (HPA)	#104024-3	WDFW
Scientific Collection Permit	# 09-406	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 D: Develop Picket Weir Trapping Protocols and Update Smolt Trapping Protocols

OBMEP frequently updates protocols in order to reflect any additions, changes, or refinements to methodology. In 2009, the smolt trapping protocol was updated to include modifications to previous methods and an adult picket-weir trapping protocol was created. Updated protocols, along with previous versions, are posted to the website.

Work Element E: Monitoring Changes in Freshwater Productivity using Snorkel Surveys at 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 2009 snorkel surveys represented a vast improvement over previous year's data. Thirty-nine of the 50 sites were snorkeled by trained observers and fish observations recorded in order to establish fish densities within the respective reaches. Sites not snorkeled were due to dry creek beds or access related issues. For the mainstem Okanogan and Similkameen Rivers, five crew members snorkeled and observed fish within specific transects. One snorkeler and one recorder performed surveys on tributaries.

In 2009, a total of 760 juvenile *Oncorhynchus mykiss* were observed in the United States' portion of the mainstem Okanogan and its tributaries. Only 4 fish were observed in the mainstem Okanogan and the mean density of fish was 0.2 fish/ha. Similarly, a low number of 8 juveniles were observed in the mainstem Similkameen River, which had a mean density of 1.5 fish/ha. The tributaries were the most productive locations for juvenile *O. mykiss*, with totals of 391 and 357 observed in Omak Creek and Salmon Creek, respectively. The mean density of fish was 1351.1 fish/ha in Omak Creek and 1829.6 fish/ha in Salmon Creek. No juvenile *O. mykiss* were observed in the habitat site located in Johnson Creek.

Consistency of skilled observers across all survey sites likely increased success of snorkel surveys, especially in tributary locations. The same observers will again perform surveys in 2010, adding to inter-year consistency of data collection. In future years, we hope to maintain a continued level of quality data collection, in order to complete population level trend analysis.

A pilot study was also conducted which included collection of macro-invertebrate data at EMAP tributary sites. In 2010, these efforts will be expanded to cover all OBMEP EMAP sites, tributaries and mainstem-Okanogan, within the U.S. and Canada. Macro-invertebrate data will be compared to standing crop of fish, to help further describe population structures.

Work Element F: Okanogan River Summer Chinook and Steelhead Smolt Trapping

The Colville Tribes' Fish and Wildlife Department continued enumerating juvenile salmonids using rotary screw traps in 2009. 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 3 July 2009. 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.

Chinook salmon were the most abundant species of fish trapped in 2009 followed by Steelhead and Sockeye (Table 1). The Chinook fry catch totaled 16,489 while 40 natural and 11,662 hatchery origin smolts were captured for a total of 28,489 Chinook. Also caught were 4,029 Sockeye smolts of which 2,437 were natural and 1,592 were hatchery origin and 2,600 Steelhead smolts of which 292 were natural and 2,308 were hatchery origin.

Daily trapping indicate that the run timing of Chinook smolt migration occurred earlier than the fry migration (Figure 2). Smolts were first observed 9 April and catches peaked on 11 May when 1,928 were counted in the traps. Chinook fry were first seen in the traps on 16 April but it was the third week in May before significant numbers emigrated. The peak daily count for fry occurred on 26 June when 885 were caught in the traps. Run timing of Sockeye peaked 22 May at 878 while Steelhead peaked 13 May at 215.

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.

The 2009 rotary screw trap brief is included in this document as Appendix 1.

Work Element G: Enumerate Adult Salmonids using Underwater Video

OBMEP used 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 distributions, status and trends of adult returns, and origin information. Additionally, three video systems were installed on tributaries within the Okanogan Basin: Salmon, Antoine, and Ninemile Creeks; this work is outlined in Work Element H.

Adult Chinook and sockeye salmon passage counts at Zosel Dam are presented based on video data collected 1 January through 31 December 2009. 256 Chinook salmon were observed passing in 2009. A total of 61,400 adult sockeye salmon were observed passing through the Zosel Dam fishways in 2009.

Video data pertaining to summer steelhead passage at Zosel dam were analyzed in conjunction with redd surveys to provide a complete description of the species utilization of the Okanogan Basin. A total of 434 summer steelhead passed Zosel dam, 15.1% with an intact adipose fin. Detailed information on summer steelhead passage is outlined within the 2009 Steelhead Redd Survey Report (Appendix 2).

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

Work Element H: Steelhead Enumeration in Tributary Streams using Picket Weir Traps, Video Counts, and PIT Tags

In order to examine summer steelhead utilization of tributaries in the Okanogan basin, OBMEP used picket weir trap and underwater video systems, in conjunction with redd surveys. Video counting stations offer a 'hands-off' approach to counting fish passage in the creeks. Additionally, there is no delay in migration associated with video stations. These systems were installed in Ninemile, Antoine, and Salmon Creeks.

A video weir installed on Ninemile Creek 1.7 km from the confluence with Lake Osoyoos and documented three adult steelhead passing through the video chute on April 26, May 1, and May 11. Two of these fish had intact adipose fins. No adult steelhead were observed passing through the Antoine Creek video box. PIT tag arrays were installed on both Ninemile and Antoine creeks, however, interference with the light ballasts in the video boxes caused them to work improperly.

Since the early 1900's, Salmon Creek has been entirely diverted for irrigation usage resulting in a dry stream channel, which extends from the Okanogan Irrigation District (OID) diversion dam (7.2 km) to the confluence with the Okanogan River. In 2009, 1,220 ac-ft of water were released over a period of 53 days (April 9 through May 28), and discharge ranged from 7.84 cfs to 21.39 cfs, with a mean of 13.2 cfs (Pers. Comm. Chris Fisher, Fish Biologist, Colville Tribes). A specialized underwater video apparatus was custom-designed to fit into the fish ladder of the OID diversion dam in 2009. A total of 24 adult steelhead passed through the video chamber within a six-day period and five had intact adipose fins. The total number of steelhead counted passing the diversion dam was likely an underestimate because 12 days of video data was overwritten before being reviewed (April 9-May 4 and May 14-20).

Picket weirs were installed and operated on Omak and Bonaparte Creeks in order to enumerate adult steelhead and collect data pertaining to sex, age, length, and origin. OBMEP used these data to evaluate steelhead utilization of those respective tributary systems. Additionally, the Okanagan Nation Alliance operated an adult fish weir on Inkaneep Creek in 2009 (Appendix 3). The fish fence captured 20 total *O. mykiss* from March 31 to June 5. Of the 20 fish captured, 2 were ad-clipped and of hatchery origin, with the remaining having intact adipose fins (90% ad-present). A mean fork length of 50.8 + 8.1 cm was determined. Due to the fact that the weir trap was not effective in capturing all migrating fish, two redd surveys were conducted on Inkaneep Creek on May 31 and June 1, 2009 with 86 redds identified.

Video and weir data at select tributaries were analyzed in conjunction with redd surveys to provide a complete description of the species utilization of the Okanogan Basin. This information is specifically outlined under Work Element I and within the 2009 Steelhead Redd Survey Report, which can be found in Appendix 2.

Work Element I: Conduct Census Redd Counts for Summer Steelhead throughout the Okanogan River Subbasin (U.S. only)

Redd surveys of spawning steelhead were conducted in the Okanogan River Basin in 2009. A total of 566 steelhead redds were observed along the mainstem Okanogan and 244 redds in the Similkameen River. Tributaries within the basin that were utilized by anadromous steelhead in 2009 included Salmon, Omak, Bonaparte, and Tunk Creeks. Escapement estimates for the entire Okanogan Basin were between 2,020 and 2,198 summer steelhead and of those, 178 to 241 were considered of natural origin. This wild designation was complicated by continued releases of ad-present hatchery steelhead into the Okanogan River. Escapement into Canada was estimated at 434 summer steelhead with 15.1% having intact adipose fins. 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 the majority of 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 form favorable habitat for summer steelhead spawning. 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.

The data on steelhead spawning distribution can be viewed on our web site at:

http://nrd.colvilletribes.com/obmep/pdfs/2009_Okanogan_Sth_Redd_Surveys_rev1.pdf

The complete report is attached as Appendix 2.

Work Element J: Collect Water Quality Data for all EMAP Tributary Sites

In 2009, water quality protocols were updated and a new study design enacted. Data collection began in late 2009 and will continue into the 2010 field season. These procedures are modeled after the Department of Ecology's water quality protocols, which is a more rigorous testing regime. A total of 21 sites were selected; five on the mainstem Okanogan, two on the Similkameen River, and 14 on the tributaries. Since the reintroduction of water quality data collection into OBMEPs field regime, there has been an expansion in the number of parameters that are collected at each location, most notably nitrites/nitrates. Additionally, samples are collected twice as often as previous years. New water quality probes were purchased to in order to obtain more precise data measurements; the previous equipment is being refurbished and will be used for extended deployments.

Work Element K: Monitor Threats to Salmonid Habitats at up to 50 Sites

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, 25B Mission 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 L: Operate and Maintain Real-Time Discharge, Temperature Gauging Stations in the Okanogan Subbasin

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 easy access to the public and other agencies. 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:
    a. INKANEEP CREEK NEAR THE MOUTH (08NM200)
    b. VASEUX CREEK NEAR THE MOUTH (08NM246)
    c. SHUTTLEWORTH CREEK AT THE MOUTH (08NM149)

Work Element M: Collect Continuous Water Temperature Data from EMAP Sites

Water temperature is largely accepted as the largest limiting factors for steelhead recovery in the Okanogan River. In order to monitor water temperatures, OBMEP began deploying Onset® temperature data loggers in streams at all annual and panel tributary sites in May of 2005. Data was again collected in 2009 at all EMAP sites located in the U.S. and Canadian portions of the Okanogan Basin. 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, 25B Mission 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.

Work Element N: Address Known Data Gaps in the Okanogan Basin: Predator Study

A literature based assessment of predation by smallmouth bass on juvenile salmon was examined in 2009 (Appendix 4). Given the wide range of estimates from juvenile salmon predation, additional field data must be collected in order to accurately depict predation estimates. Results from snorkel surveys and observed predators will be used to perform further analysis on predator populations and possible predation rates on juvenile salmon.

In order to more comprehensively examine the effects of invasive predators on juvenile salmonids, a study plan was developed in 2009 (Appendix 5). Methods include estimating juvenile salmonid production and migration timing, smallmouth bass population size and structure, and consumption estimates.

Work Element P: Project Coordination and Public Outreach

OBMEP biologists 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 System-wide 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 R: Manage, Maintain, and Expand the OBMEP 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 user's 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

Work Element T: Develop RM&E Methods and Designs for EDT Assessment and Reports

The Ecosystem Diagnosis and Treatment (EDT) approach provides a framework for integrating site specific information with larger spatial scales and broader ecological processes. Methods were developed by ICF International to examine the potential of habitat in the Okanogan River to support spring Chinook salmon and steelhead. The EDT process provides a framework for the evaluation of habitat data collected within the Okanogan River basin; the production version of EDT3 is due for release in 2011 and includes software and tools that will be used to conduct ecosystem status and trend analysis.

The executive summary for work conducted in 2009 can be found in Appendix 6.

Conclusions

The Okanogan Basin Monitoring and Evaluation Program completed another year of data collection, coordination, and reporting in 2009 to add to data collected since 2004. All tasks were completed on time and within budget. Among the most valued reports have been the annual spring spawning reports; therefore, this report will continue to be produced on an annual basis. Other data types will be consolidated into report form on a five year basis. However, data from these sampling events will be analyzed in a timely fashion and made available at request from other agencies. Technical documents will continue to be posted on the OBMEP and BPA web sites for public access. Access to OBMEP data will also 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 OBMEP staff 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 has been expanded to include multiple tributaries and time saving technologies. We are also testing methods to monitor water levels in tributaries in order to improve the accuracy and efficiency of water temperature monitoring. In late 2010, OBMEP will work in conjunction with WDFW to implement a basin-wide PIT tag detection project, expanding our capabilities of monitoring steelhead utilization of the mainstem Okanogan and tributaries.

Improved methods to collect and analyze habitat data are being applied in order maintain standardization throughout the upper Columbia, while maintaining consistency with our existing datasets. In order to holistically characterize the suitability of habitat within the Okanogan basin for steelhead utilization, our data is being analyzed through the EDT3 model. This new technology incorporates discrete habitat metrics, historically analyzed on an individual basis, into a comprehensive approach. 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, adapting from other project developments.

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Appendix 1

2009 Okanogan Basin Monitoring & Evaluation Program Rotary Screw Trap Brief

Performance Period: April 1, 2009 – July 16, 2009

BPA Project # 200302200

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December 2009

Discharge, water temperature, and rotary screw trap collection counts for the Okanogan River in 2009 were accessed via the internet from the Columbia River DART website on November 25, 2009.

Environmental Parameters

From 1 April, the beginning of the sampling period, to 22 May, 2009 discharge of the Okanogan River at Malott gradually rose to reach 3,500 cfs (Figure 1). This was followed by a sharp increase to a peak flow of 11,300 cfs on 1 June. Discharge then steadily decreased throughout the remainder of the sampling period which finished on 16 July. Water temperatures steadily increased through mid June and was at it's highest on 16 July at 23.9 °C.

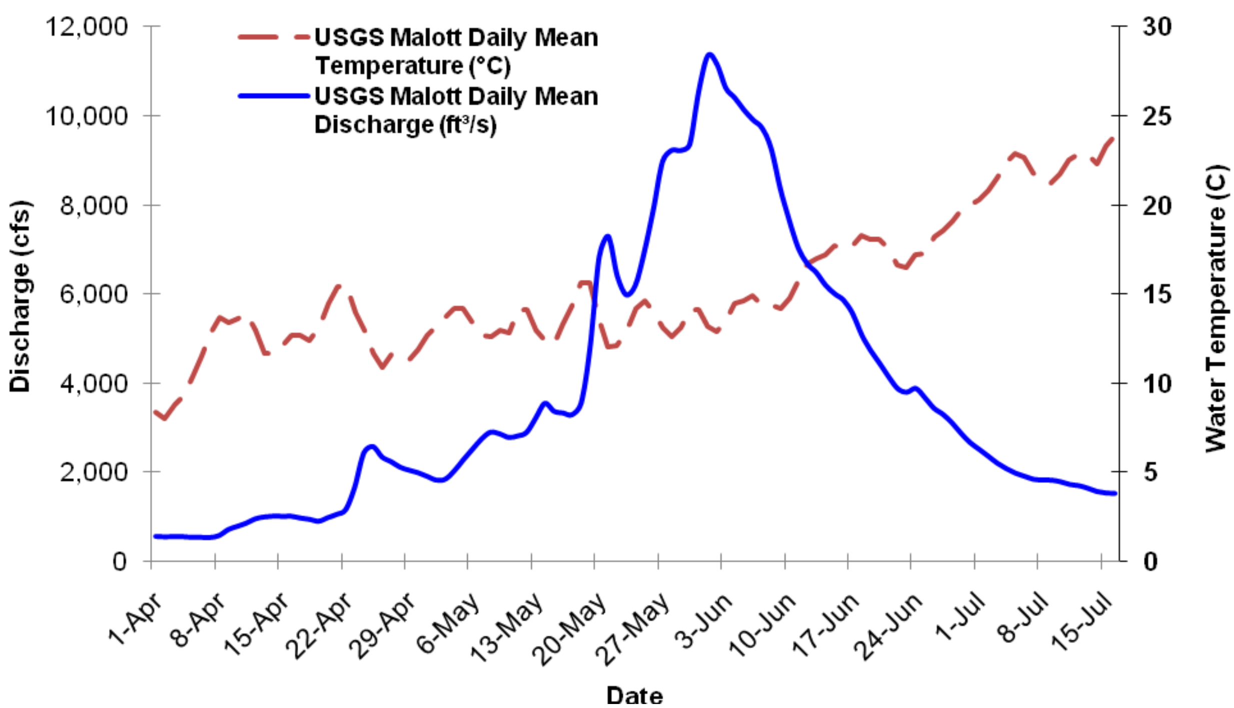

Figure 1. Daily mean discharge and water temperature in the Okanogan River throughout the 2009 sampling season.

Fish Trapping

Chinook salmon were the most abundant species of fish trapped in 2009 followed by Steelhead and Sockeye (Table 1). The Chinook fry catch totaled 16,489 while 40 natural and 11,662 hatchery origin smolts were captured for a total of 28,489 Chinook. Also caught were 4,029 Sockeye smolts of which 2,437 were natural and 1,592 were hatchery origin and 2,600 Steelhead smolts of which 292 were natural and 2,308 were hatchery origin. Sockeye and Steelhead fry were not caught.

Daily trapping indicate that the run timing of Chinook smolt migration occurred earlier than the fry migration (Figure 2). Smolts were first observed 9 April and catches peaked on 11 May when 1,928 were counted in the traps. Chinook fry were first seen in the traps on 16 April but it was the third week in May before significant numbers emigrated. The peak daily count for fry occurred on 26 June when 885 were caught in the traps. Run timing of Sockeye peaked 22 May at 878 while Steelhead peaked 13 May at 215.

Species	Natural Origin Smolt	Hatchery Smolt	Natural Origin Fry	Total
Chinook	40	11,662	16,489	28,191
Sockeye	2,437	1,592	0	4,029
Steelhead	292	2,308	0	2,600
Total	2,769	15,562	16,489	34,820

Table 1. 2009 rotary screw trap salmon catch by species and life stage.

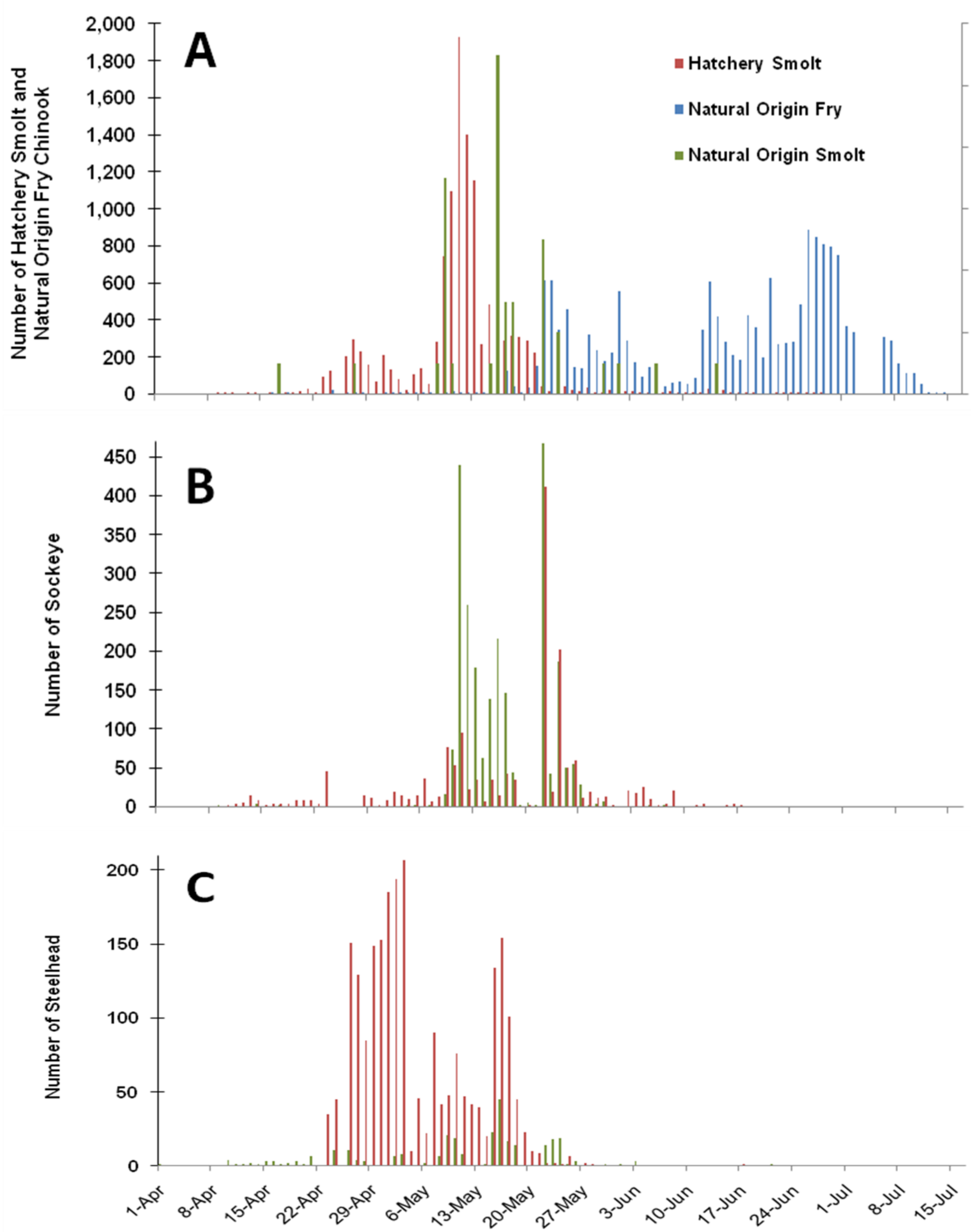

Figure 2. Chinook smolt and fry (A), Sockeye smolt (B), and Steelhead smolt (C) caught in rotary screw traps on the Okanogan River in 2009.

Appendix 2

2009 Okanogan Basin Steelhead Redd Surveys

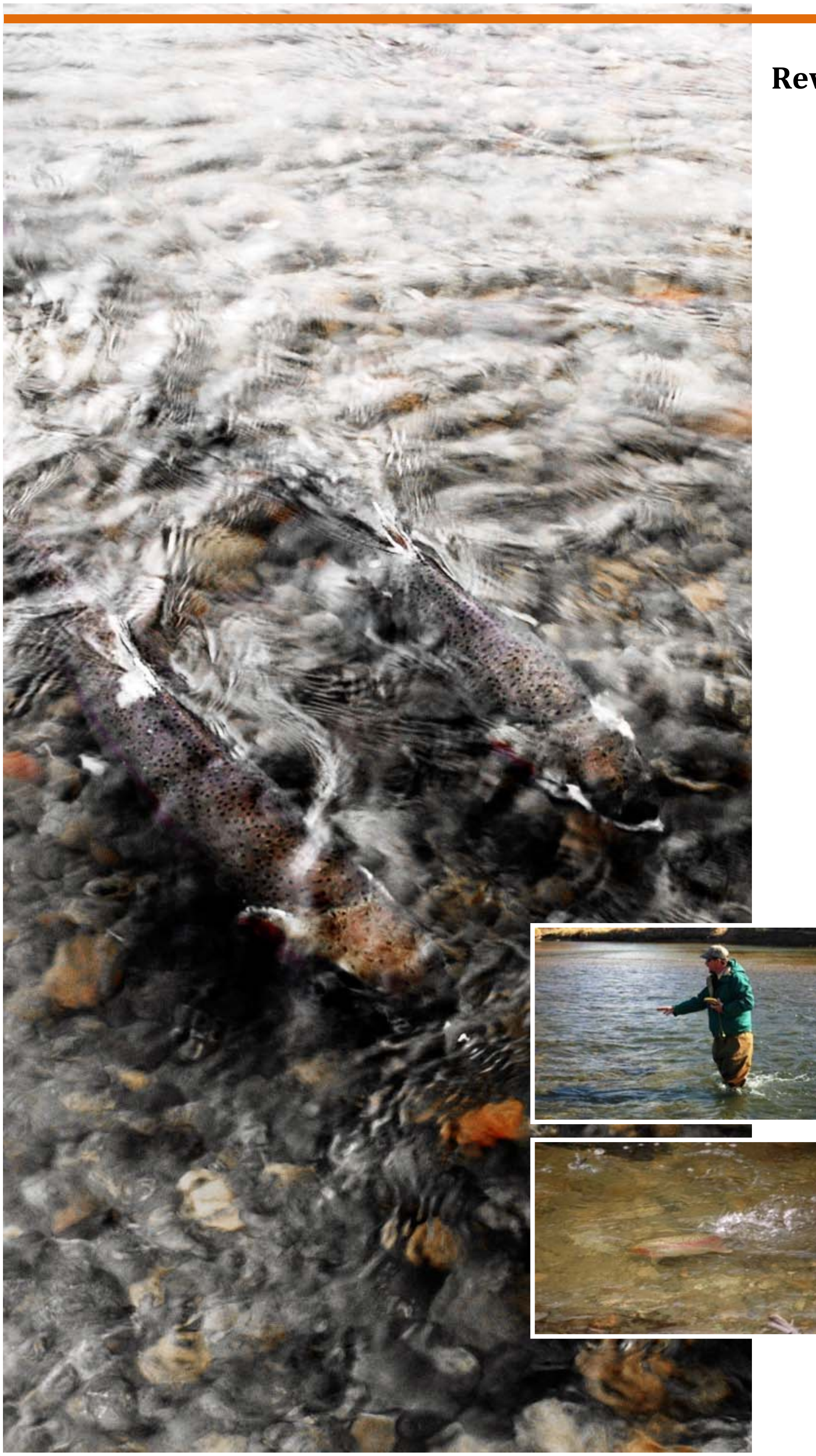

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Table of Contents

Abstract

Redd surveys of spawning steelhead were conducted in the Okanogan River Basin in 2009 as part of the Colville Tribes' Okanogan Basin Monitoring and Evaluation Program. A total of 566 steelhead redds were observed along the mainstem Okanogan and 244 redds in the Similkameen River. Tributaries within the basin that were utilized by anadromous steelhead in 2009 included Salmon, Omak, Bonaparte, and Tunk Creeks. Escapement estimates for the entire Okanogan River were between 2,020 and 2,198 summer steelhead and of those, 178 to 241 were considered of natural origin. This wild designation was complicated by continued releases of ad-present hatchery steelhead into the Okanogan River. Escapement into Canada was estimated at 434 summer steelhead with 15.1% having intact adipose fins. 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 the majority of 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 form favorable habitat for summer steelhead spawning. 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 characterizing 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 number of redds within already-established index areas, or in randomly selected reaches using an Environmental Monitoring and Assessment Program (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 mainstem habitats was conducted within the U.S. and identified several large areas that contained no redds due to unsuitable habitat for spawning. Eliminating these areas from future surveys reduced program costs without the loss of any biologically important data. Recommendations from the 2005 census helped define the actual reaches that would be surveyed in 2006-2009.

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). In 2009, the fifth year of steelhead redd surveys was conducted by the Colville Tribes in the Okanogan Basin. This document builds upon previous information and the entirety of previous years spawning 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 mainstem and all accessible tributaries of the Okanogan River and Similkameen River drainages (Arterburn et al. 2007a, Walsh and Long 2006). Survey reaches encompassed 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). Designated main stem and tributary survey reaches have been defined and can be viewed in Table 1. The area of the Okanogan River 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.

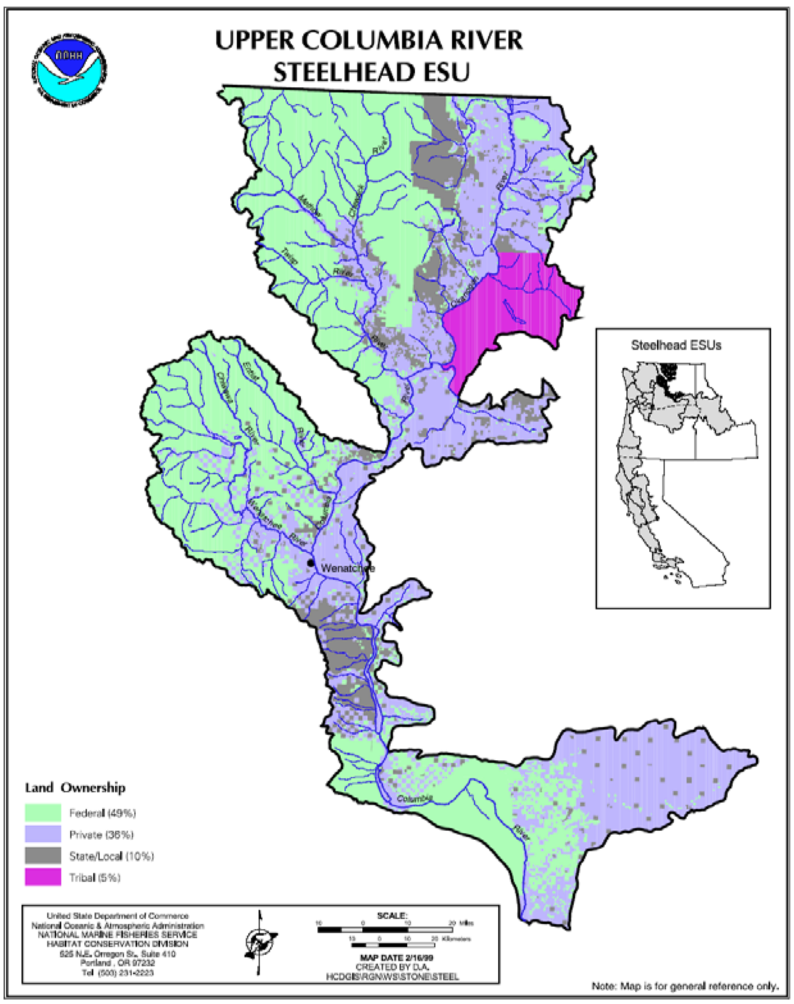

Figure 1. The Upper Columbia River summer steelhead evolutionarily significant unit showing land ownership. *Map courtesy of NMFS-HCD* (http://www.nwr.noaa.gov/reference/frn/1997/62FR43937.pdf).

Each reach was surveyed three times along the mainstem Okanogan River between March 24 and May 4, discharge levels remained below 3,000cfs for the entire period. Tributaries were surveyed one to three times, starting on April 13 and ending May 26, when all tributary reach surveys were completed.

Table 1. Designated redd survey reaches in the United States with location description and length in kilometers used by OBMEP in 2009.

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 at 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 video weir (1.7)	1.7
TO1	Tonasket Creek/Okanogan River confluence (0) to Tonasket Falls (3.5)	3.5
A1	Antoine Creek/Okanogan River confluence (0) to video weir (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)	2.0
SC1	Salmon Creek confluence with the Okanogan (0) to OID diversion (7.2)	7.2

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

The Okanogan River was divided into seven segments based on access points. The Similkameen River was surveyed as two reaches and these data were later combined into one reach (S1) to maintain consistency with previous reports. All mainstem reaches were located upstream of Chiliwist Creek confluence (immediately upriver of the influence of Wells' pool). We used data (discharge, air and water temperature, knowledge of fish movements) collected from previous years to determine when to begin surveys on the mainstem for that calendar year.

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. 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 differentially corrected. Escapement calculations were made for each mainstem 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 was 1.5:1.0 males to females, the expansion factor for the run would be 2.5 fish/redd. All escapement calculations using sex ratio multipliers would assume that each female will produce only one redd. This method is used for all supplemented stocks within the Upper Columbia Basin. Sex ratio data was used to provide estimates of total spawner escapement for the population, sub-watershed, or reach.

We refined 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), were summed to estimate total escapement within sub-watersheds, resulting in a highly accurate estimate. 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 was used representatively for the streams where fish were trapped. Values derived from Wells Dam data were applied to mainstem habitats, and the sex ratio from the Omak Creek trap was applied to medium-sized tributaries in the United States. The sex ratio from the Bonaparte Creek trap was applied to similar sized small streams. For fish collected at the trap in 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.

When a trap or video weir did not exist on tributaries, a range of population escapement estimates was created by manipulating the local sub-watershed sex ratios. These range estimates were much more likely than a point estimate to contain the “true” value because range estimates incorporated the variability contained within the raw data.

Results and Discussion

Sex ratios

At Wells Dam, a sample of 1,089 summer steelhead were examined in order to determine a sex ratio for upstream migrants during 2009. A total of 477 male and 612 female steelhead were sexed by Washington Department of Fish and Wildlife personnel (Charlie Snow -personal communications). Wells Dam data resulted in a sex ratio of 0.78 males per female or a sex ratio multiplier of 1.78 steelhead/redd. Forty summer steelhead were collected at the Omak Creek trap (29 males; 11 females) and a ratio of 2.6 males for each female was observed; therefore, we used a sex ratio multiplier of 3.6 steelhead per redd. Twenty-eight summer steelhead (21 males; 7 females) were collected at Bonaparte Creek in 2009, resulting in a sex ratio multiplier of 3.9 steelhead per redd. Field personnel did not document sex at the Inkaneep Creek trap in Canada.

Percent wild

In 2009, WDFW estimated the number of wild summer steelhead that escaped above Wells Dam was 942 or 10.4% 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 (Charles Frady, WDFW Pers. Comm.). The proportion of wild fish assumed to be bound for the Okanogan River was 192 or 8.5% of the total escapement assumed to be bound for the Okanogan River. This percentage was applied to all mainstem Okanogan reaches to estimate the likely number of wild spawners.

The percent of wild summer steelhead estimated as returning to tributary traps was determined by the presence of an intact adipose fin. The number of natural origin steelhead returning to Omak Creek was estimated at 12.5% (5 out of 40 total fish). Six wild fish were captured in the Bonaparte Creek trap out of 28 total fish; therefore, 21.4% were wild. Only two out of 20 fish at the Inkaneep Trap in Canada had clipped adipose fins, resulting in 90.0% of all steelhead returning to Inkaneep Creek considered wild. At Zosel Dam, 66 out of 437 summer steelhead (15.1%) were documented having intact adipose fins.

Okanogan and Similkameen River Mainstem

Discharge remained below the threshold of 3,000cfs (which has constrained surveys in the past) throughout our surveys in 2009. Visibility was excellent during the majority of mainstem surveys on the Okanogan and Similkameen Rivers. However, the third survey for reach O5 was severely impaired by a lack of visibility in late April because of a sharp increase in discharge (Figure 2).

Detailed escapement calculations, summarized by individual reach, are presented in Table 8.

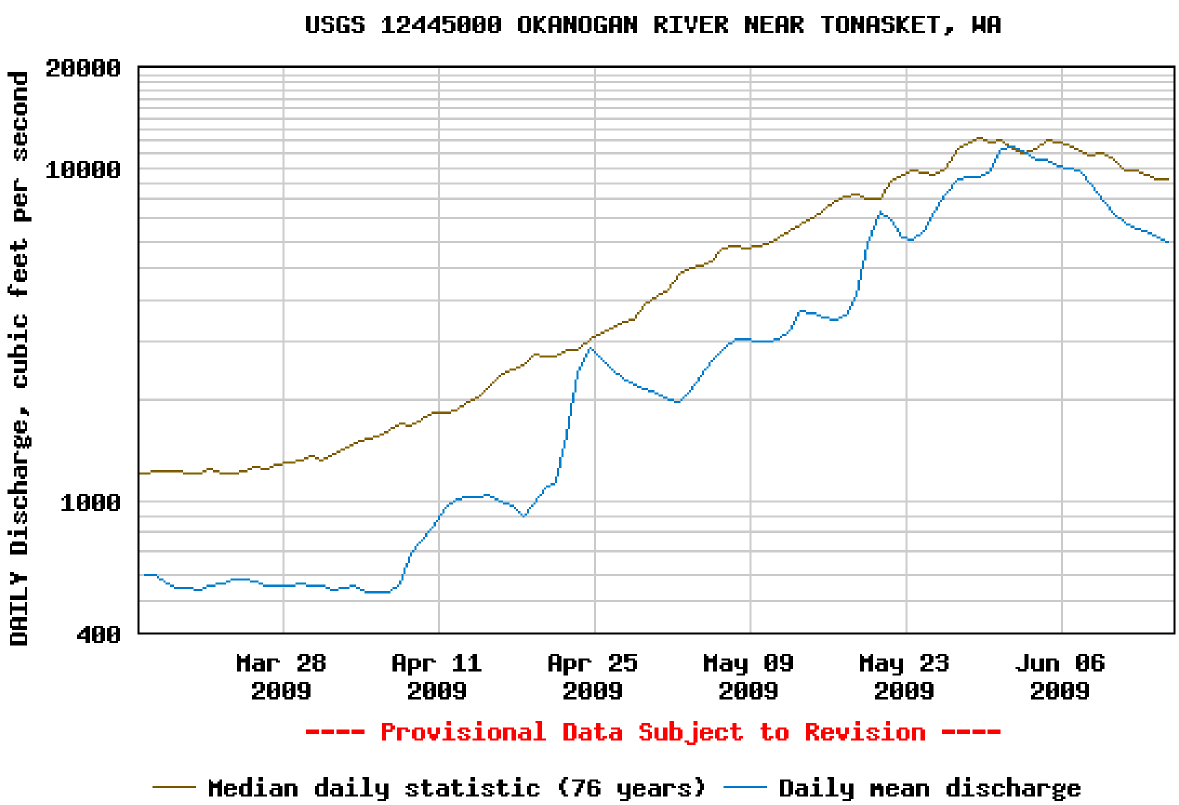

Figure 2. Discharge of Okanogan River as measured at Tonasket, WA for the period from March to June, 2009 compared to the 76-year historic average (graph obtained from the USGS website at www.usgs.gov).

The lower-most reach on the Okanogan River (O1) was surveyed March 24, April 7, and April 29 (Figure 3). A total of seven steelhead redds were documented (1 during the first survey and 6 during the second survey). No new redds were observed during the third survey. Most of the redds found in reach O1 were on the river right side of a mid-stream island, just downstream from the Loup Loup Creek confluence.

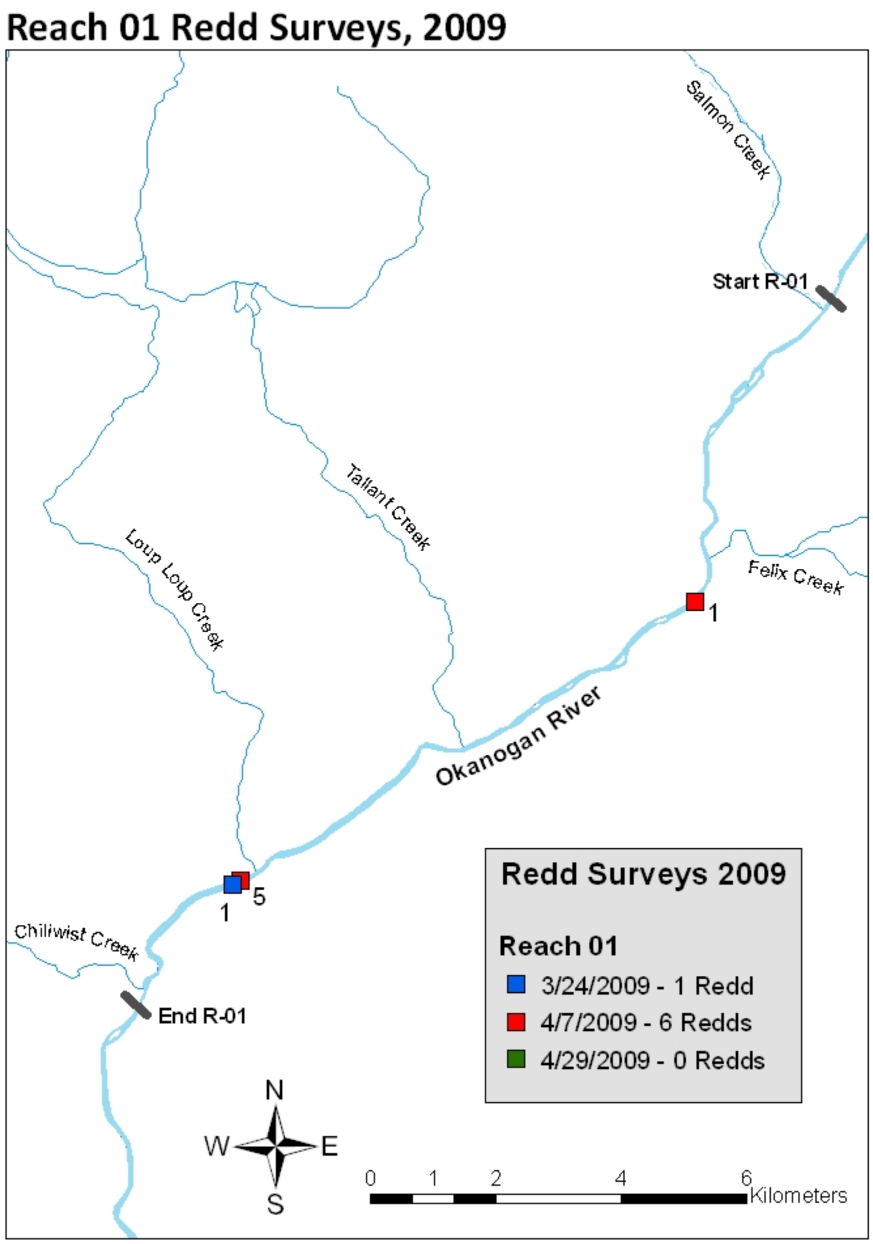

Figure 3. Redd distribution observed in 2009 for Okanogan River reach O1 from the confluence of Salmon Creek downstream to the confluence of Chiliwist Creek.

A total of 16 steelhead redds were identified in the Okanogan River reach O2 in 2009 (Figure 4). The majority of the redds were observed just downstream of the Highway 155 bridge located in Omak, WA and the island complex upriver of Shellrock Point. The first survey was conducted on March 25 and five redds were observed. The second survey occurred April 8 and eight additional redds were observed. On April 21, three redds were observed.

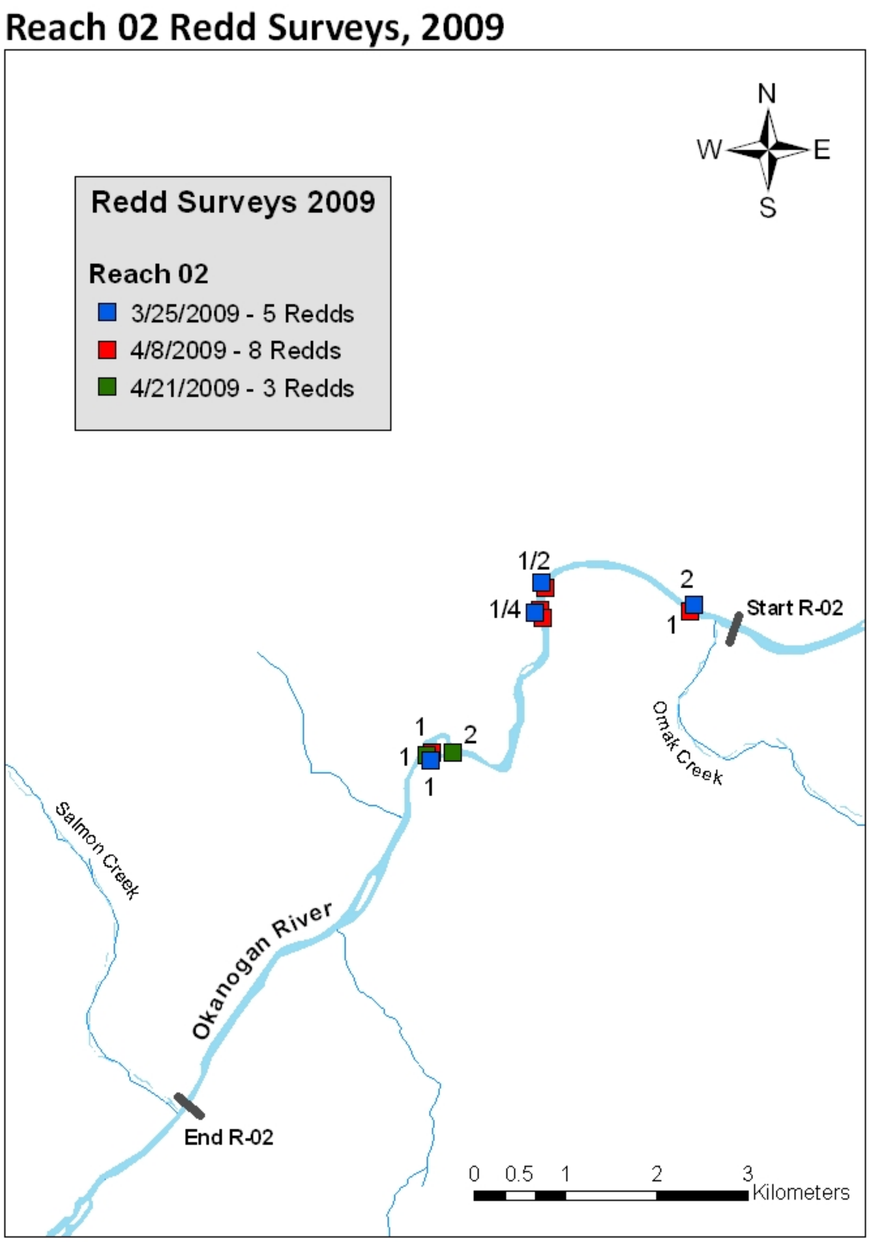

Figure 4. Redd distribution observed in 2009 for Okanogan River reach O2 from the confluence of Omak Creek in Omak downstream to Salmon Creek.

Okanogan River Reach O3 was surveyed on March 26, April 9, and April 22. Only one redd was found during the three rounds of surveys (Figure 5). The one redd observed in reach O3 during 2009 was the fewest recorded during five years of redd surveys.

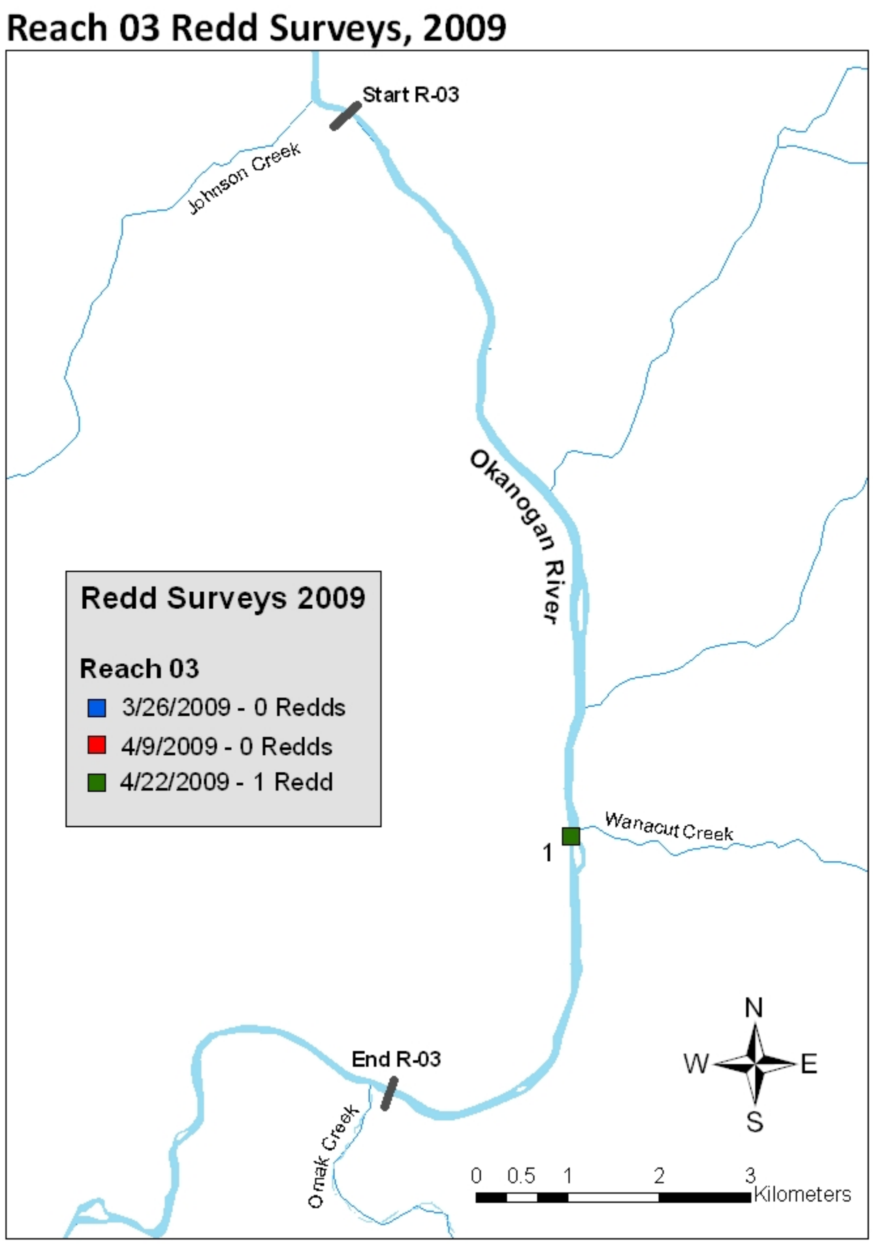

Figure 5. Redd distribution observed in 2009 for Okanogan River reach O3 from the town of Riverside, WA downstream to the confluence with Omak Creek in Omak, WA.

Okanogan River reach O4 was surveyed on March 30, April 14, and April 23 (Figure 6). Ten redds were counted on the first survey, three on the second, and no new redds observed on the final round. The redds were located in two frequently used spawning locations, in the vicinity of Janis Rapids downstream of the confluence with Chewiliken Creek and at the lower end of the braided channel below McAllister Rapids near the confluence with Tunk Creek. The number of redds observed in 2009 was near the lower range of previously observed redds (11-58 redds) within this reach.

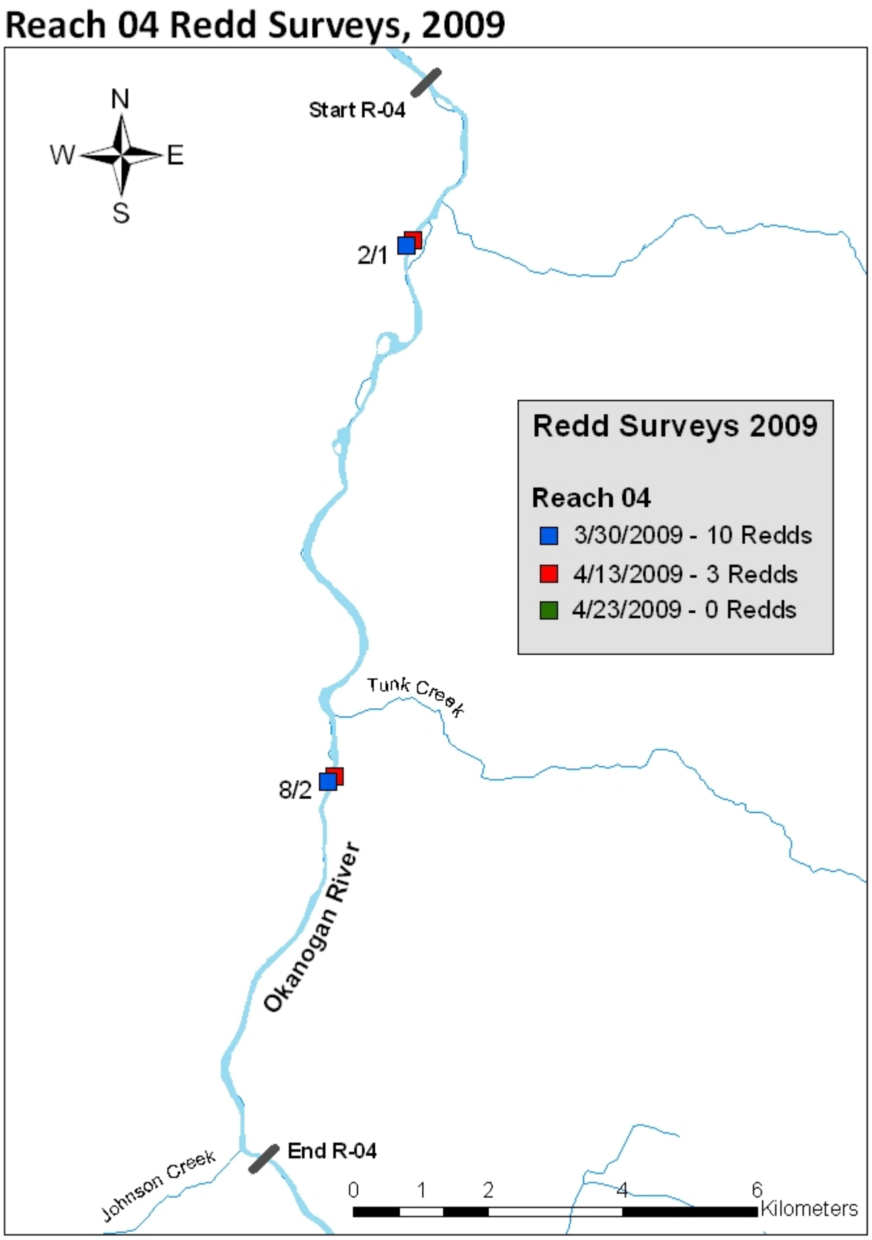

Figure 6. Redd distribution observed in 2009 for Okanogan River reach O4 from Janis Bridge downstream to the town of Riverside, WA.

Okanogan River Reach O5 was surveyed on April 1 and April 14. A total of five redds were identified within this reach on the first survey and none were identified on the second survey (Figure 7). A third survey was conducted on April 27, but no redds were identified, partly due to a sharp increase in runoff and subsequent adverse water clarity. Redds were observed in areas with braided channels downstream of the town of Tonasket, WA. The number of redds observed in 2009 was lower than the previous record low in 2008 (19 redds) and became the lowest recorded within this reach (previous range was 19-63 redds from 2005-2007).

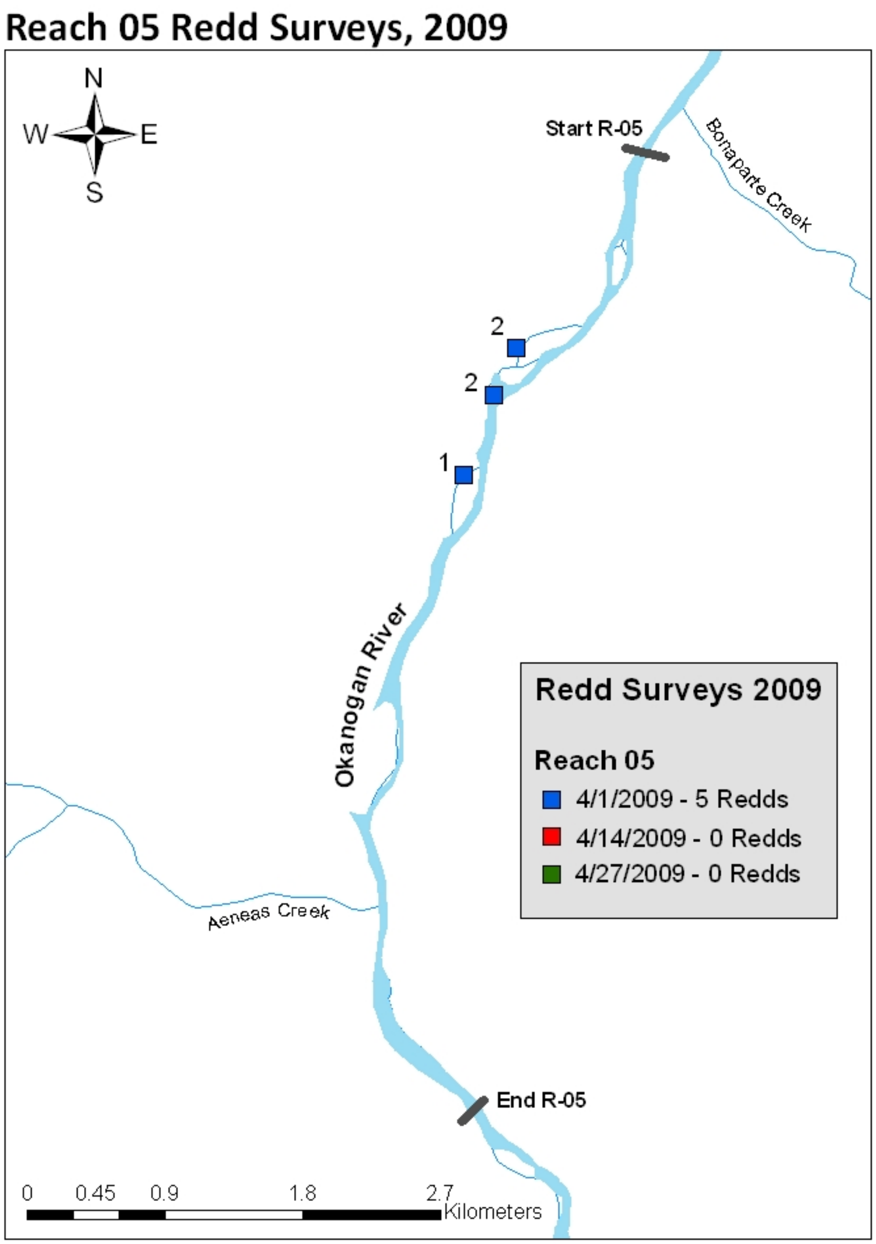

Figure 7. Okanogan River redd distribution observed in 2009 within reach O5 from the Chief Tonasket Park located in the town of Tonasket, WA downstream to the Highway 97 Bridge at Janis, WA.

Surveys were conducted three times during 2009 on Okanogan River Reach O6 (April 2, April 15, and May 1) and no redds were observed during the course of the three surveys. Zero redds were also found in 2008. However, previous annual surveys identified 3-19 redds within this reach. Isolated spawning habitat exists within this reach, but is surrounded by mostly sand substrates. The quality of the spawning habitat may have degraded to the point that it was no longer of a high enough quality to attract adult steelhead spawners.

Okanogan River Reach O7 was surveyed three times in 2009 and a total of 524 summer steelhead redds were identified. On April 6, two redds were identified, 260 redds on April 20, and 262 redds on May 4. A majority of redds were observed downstream of Zosel Dam, but above Driscoll Island in 2009 (Figure 8). The number of redds observed in 2009 exceeded the record number of redds (249) observed in 2008 and became the highest number recorded within this reach (previous range was 141-249 redds from 2005-2008). Spawning habitat within this reach was of high quality and hatchery stocking also occurred near this reach; therefore high redd counts in this reach was not surprising.

Similkameen River reaches S1 and S2 were each surveyed three times in 2009 with a total of 244 summer steelhead redds identified. Most of the steelhead redds were observed downstream of Oroville High School where a braided channel existed (Figure 9). The total number of redds observed in 2009 exceeded the previous record of 132 in 2008 and became the highest number observed in this reach (previous range was 98-132 redds from 2005-2008).

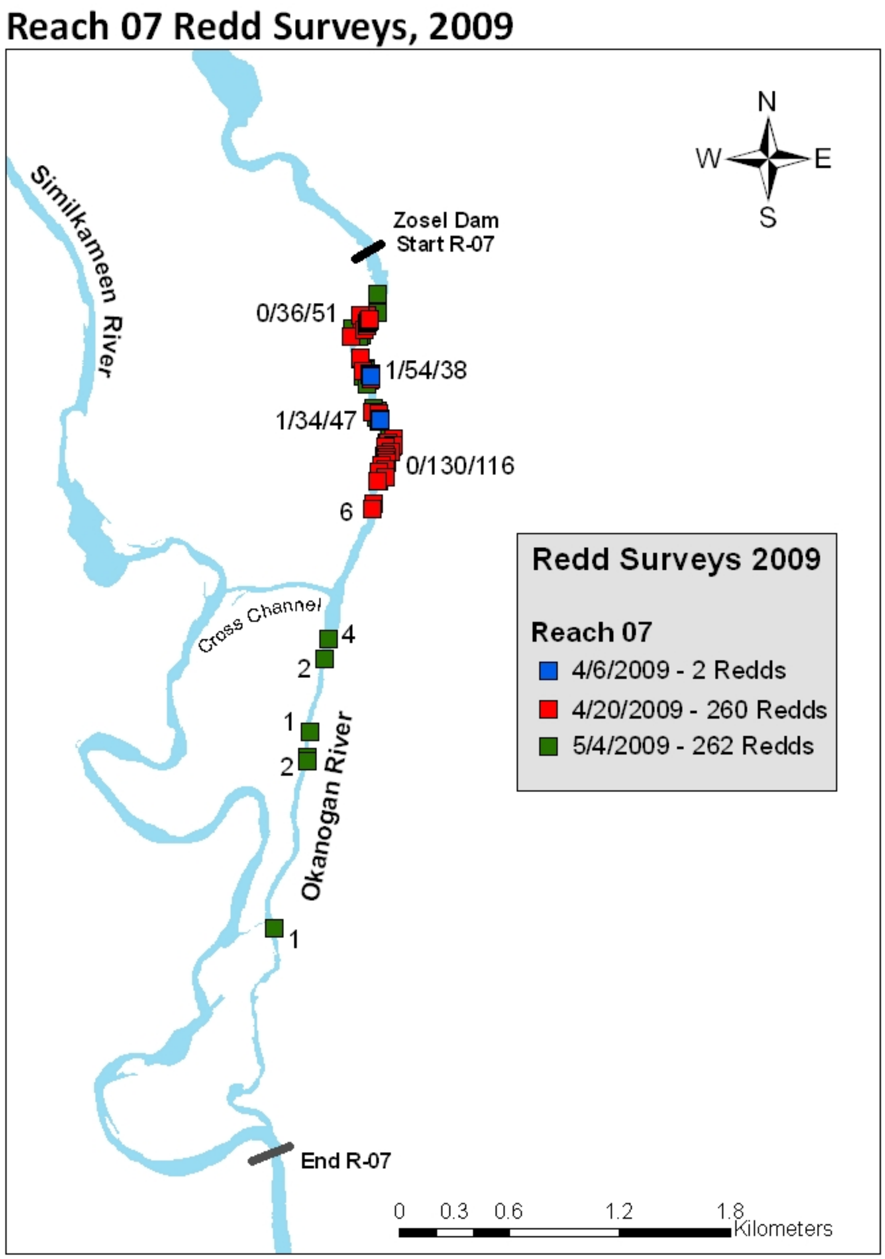

Figure 8. Redd distribution observed in 2009 for Okanogan River reach O7 which extends from Zosel Dam downstream to the confluence with the Similkameen River.

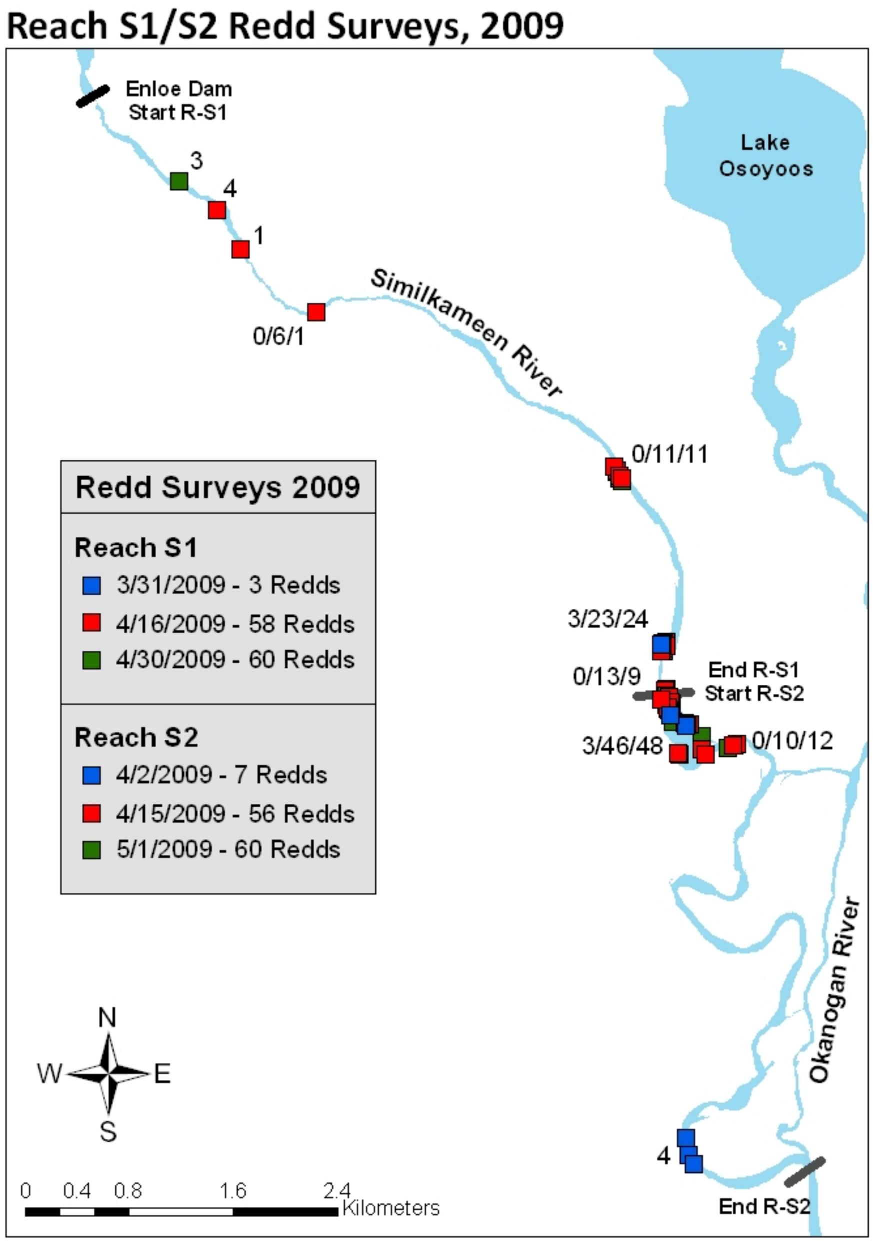

Figure 9. Redd distribution observed in 2009 for Similkameen River reach S1 and Similkameen River Reach S2. Reach S1 extends from the base of Enloe Dam downstream to the water treatment plant in Oroville, WA. Reach S2 extends from the end of Reach S1 to the confluence with the Okanogan River. Any redds observed within the cross-channel are considered a part of S2.

Tributary redd surveys in the Okanogan River Basin

Tributary habitats surveys began as soon as water clarity allowed. Varying snow packs and elevations of different sub-watersheds required unique schedules when surveying redds. Steelhead redd surveys within each tributary were conducted beginning on April 13. The upstream extent of each survey was limited by either a natural fish passage barrier or access to private land, as described in Arterburn et al. (2007a). Precipitation data is listed in Table 2. With little storage in the smaller watersheds and minimal precipitation in April, many adult steelhead had difficulty gaining access into tributaries from the Okanogan River (Figure 10). Below-normal discharge in the Okanogan River mainstem further limited access into the tributaries by failing to inundate impassible deltas at the confluence of some streams (Figure 2).

Table 2. Precipitation totals measured by the National Weather Service at Omak Airport.
http://www.crh.noaa.gov/product.php?site=NWS&issuedby=OMK&product=CLM&format=CI&version=6&glossary=0

Month	Precipitation in 2009 (inches)	Precipitation in 2008 (inches)	Precipitation in 2007 (inches)	Precipitation in 2006 (inches)	Average Precipitation (70 year mean)
March	0.93	0.73	0.08	0.81	1.00
April	0.19	0.19	0.06	0.89	1.11
May	1.23	0.18	0.74	1.35	1.08
Total	2.35	1.10	0.88	3.05	3.19

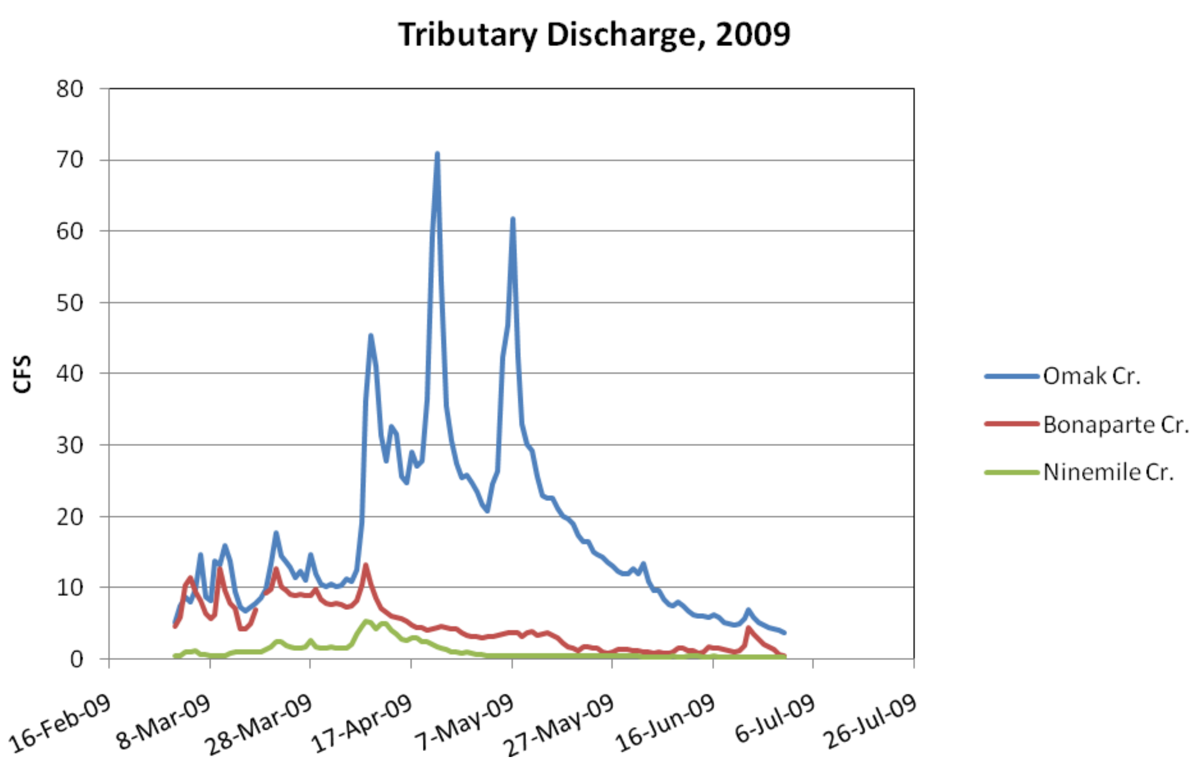

Figure 10. Discharge from March through June of 2009 for three tributary streams known to produce summer steelhead in the Okanogan Basin. https://fortress.wa.gov/ecy/wrx/wrx/flows/station.asp?sta=49F070

Ninemile Creek

The lower 1.7 km of Ninemile Creek was surveyed on May 26th, and no redds were seen. However, a video weir installed 1.7 km from the confluence with Lake Osoyoos documented three adult steelhead passing through the video chute on April 26, May 1, and May 11. Two of these fish had intact adipose fins.

Tonasket Creek

Steelhead redd surveys were not conducted on Tonasket Creek in 2009 due to lack of sufficient flows to provide connectivity to the mainstem Okanogan River. Past summer steelhead spawner escapement estimates for this creek were 8 in 2006, 17 in 2007, and zero in 2008. During most years, Tonasket Creek flows intermittently during the spring and dries up by mid-summer in the lower most 3 km.

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. Wild Horse Spring Creek was surveyed April 15, 2009 and no redds were observed. 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 of adult steelhead throughout the 2009 spawning season. When the stream was surveyed on May 6th, no summer steelhead or redds were observed from the confluence with the Okanogan River to the video box and no adult steelhead were documented passing through the video box.

Although escapement was zero in 2008 and 2009, 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). However, 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 in 2009. Twenty-eight summer steelhead (21 males; 7 females) were collected at the Bonaparte Creek weir and passed upstream in 2009 (Table 3). An additional three male and four female steelhead were captured and transported to the Cassimer Hatchery as kelts (1 male; 3 female) or for broodstock (2 male; 1 female).

Table 3. Proportions and totals of male, female, and wild summer steelhead passed above the Bonaparte Creek trap in 2009.

Bonaparte Creek Weir Trap, 2009

Description	Total (N)	Wild (N)	Percent Wild (%)
Males	21	5	23.8%
Females	7	1	14.3%
Total	**28**	**6**	**21.4%**

Redd surveys downstream of the Bonaparte Creek weir were conducted on April 13, 23, and 28 and a total of four 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 15 summer steelhead spawned downstream. Of the fish enumerated at the trap, 21.4% had intact adipose fins. From these ratios, an estimated range of 3 natural-origin steelhead spawned downstream of the trap site. The total number of summer steelhead spawners utilizing Bonaparte Creek was estimated to be 43, a minimum of 6 and a maximum of 9 were of natural origin.

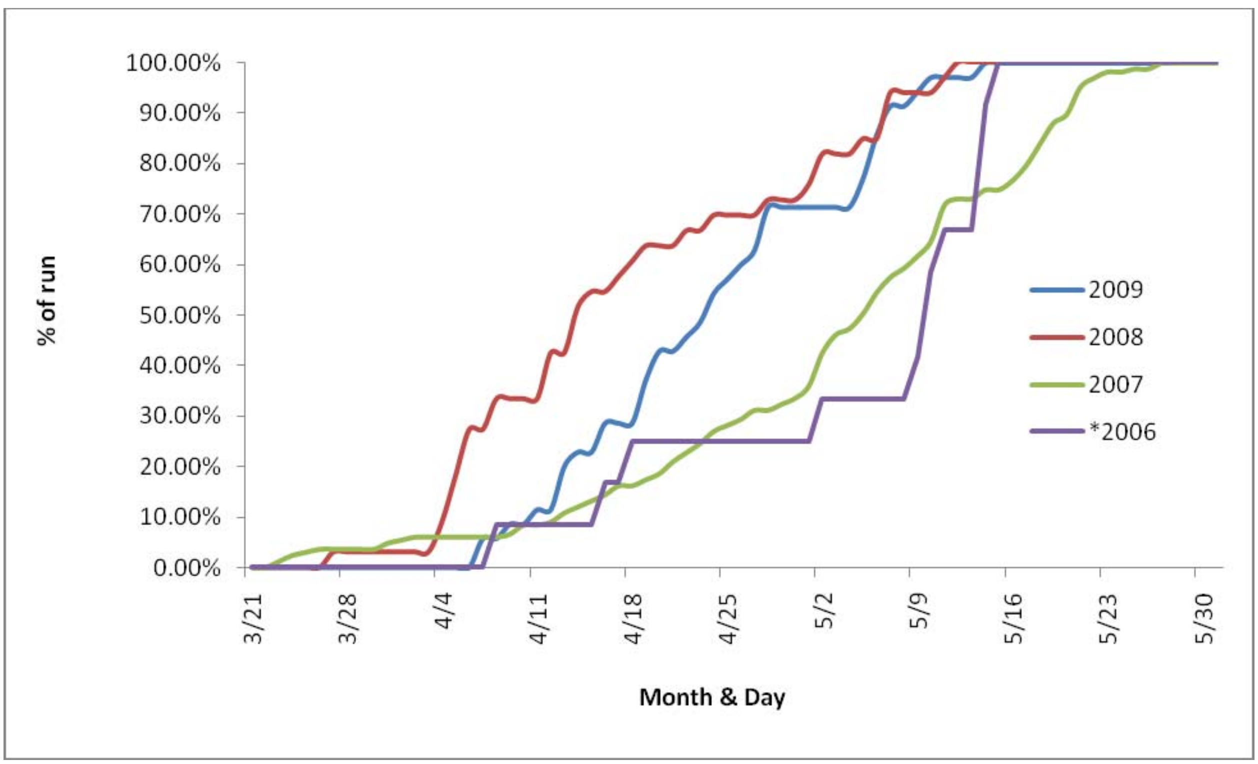

Figure 11. Run timing of summer steelhead at the Bonaparte Creek trap, 2006-2009. *The 2006 trap was only operated for part of the season.

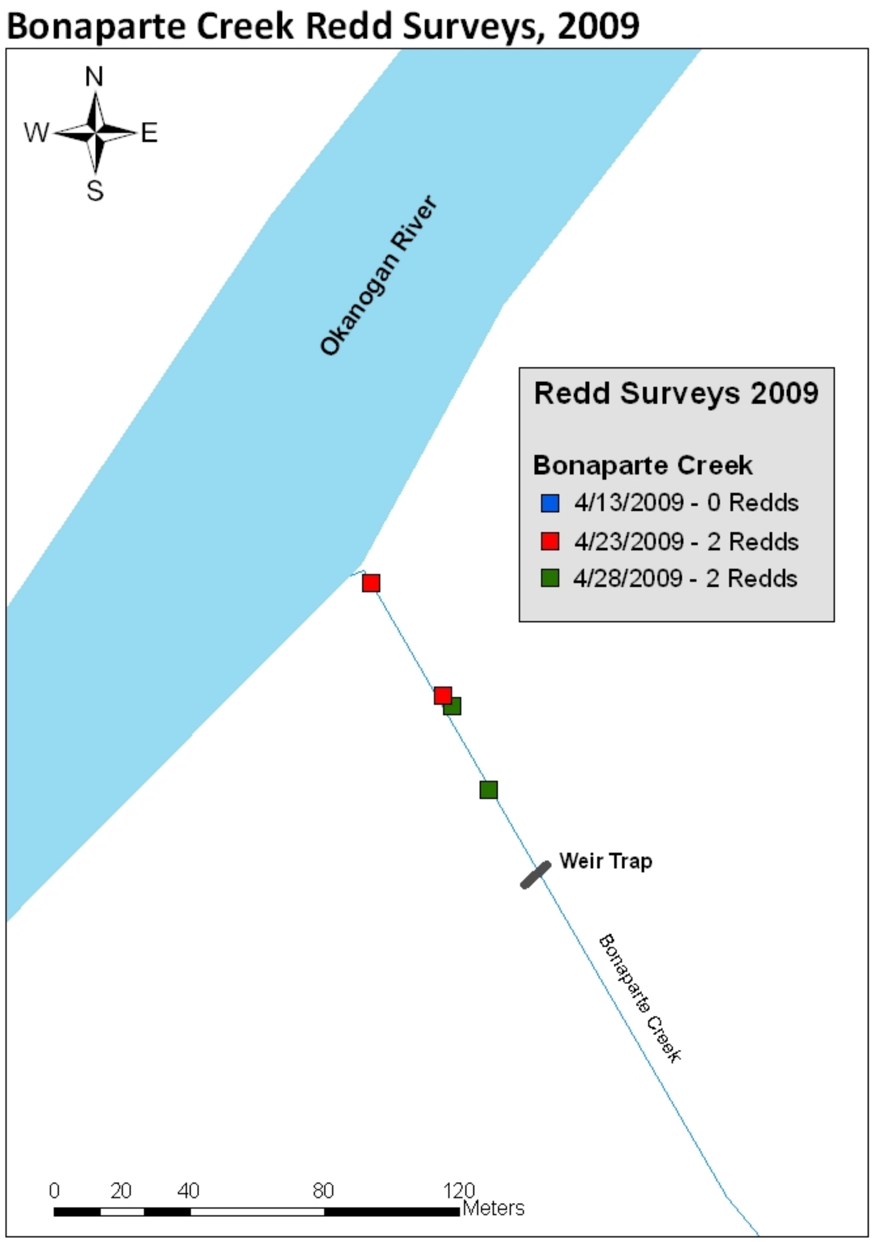

Figure 12. Distribution of redds observed in Bonaparte Creek during 2009 from the confluence with the Okanogan River upstream to the Bonaparte weir trap.

Tunk Creek

On April 13, two redds were identified at the Tunk Creek confluence and one more was identified on April 23. No new redds were observed during the final survey, May 6 (Figure 13). Ten steelhead were estimated to be utilizing the creek in 2009 (using sex ratio multipliers from Bonaparte Creek), two of these were likely of natural origin.

One man-made structure was observed just above the confluence and no redds were found above this structure in 2009, suggesting that it remained an impediment to migrating adults at low discharges. Past steelhead spawner escapements at the confluence were seven in 2005, two in 2006, unknown in 2007, and two in 2008. A section of Tunk Creek approximately ½ mile long was de-watered in 2009, probably due to a nearby well (~ 125 ft. from channel) that waters an agricultural field at a rate of 1,000gpm. Dewatering likely reduces steelhead production in Tunk Creek.

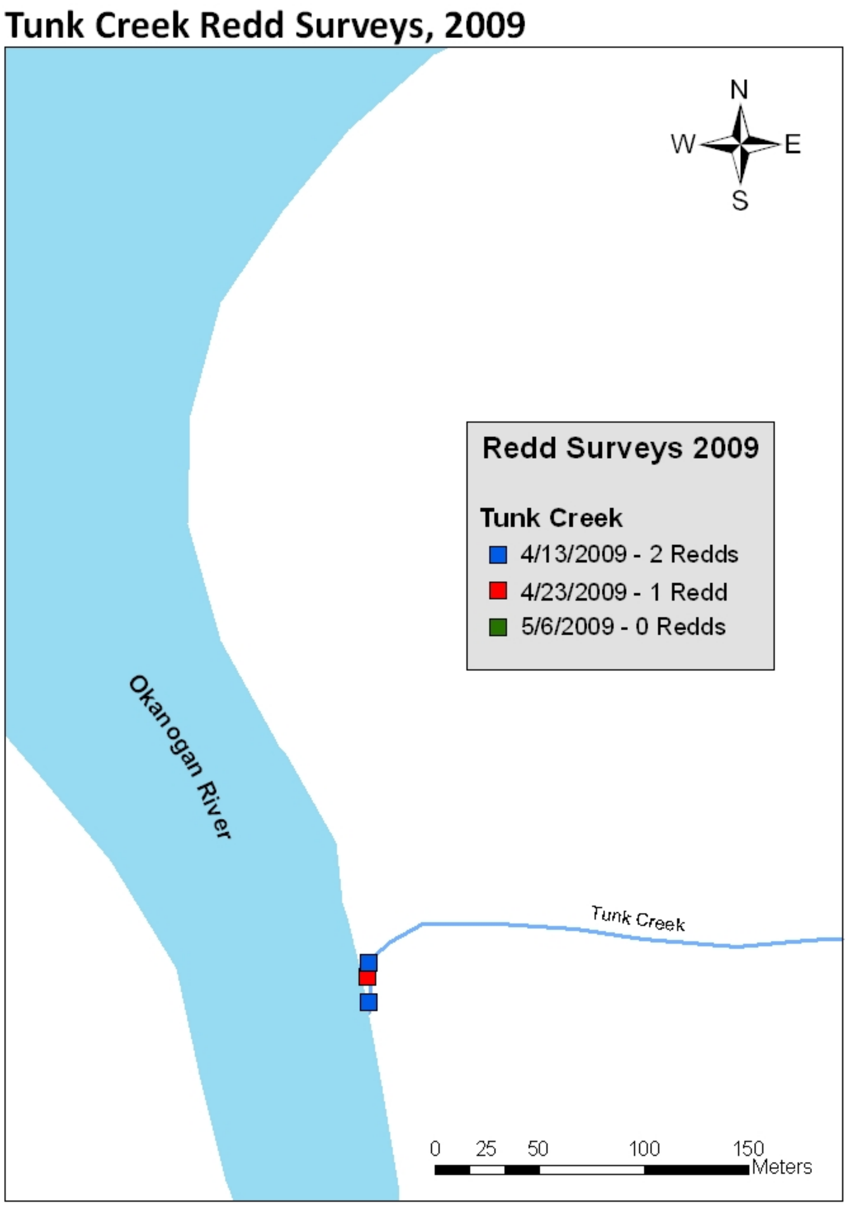

Figure 13. The distribution of redds observed in Tunk Creek during 2009 from the confluence with the Okanogan River upstream to the falls.

Wanacut Creek

Similar to 2008, water from Wanacut Creek in 2009 never reached the Okanogan River. 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. Access to spawning habitat in Wanacut Creek is only available during years when snow pack is above normal, as it was in 2007. During the spring of 2007, Swimptkin Canyon, Pothole Canyon, and Wanacut Creeks were flowing to the Okanogan River allowing access by summer steelhead. Habitat accessible to anadromous salmonids was documented at river kilometer 2.64 (Arterburn et al. 2007).

Omak Creek

Forty summer steelhead were collected at the Omak Creek trap (29 males; 11 females) and a ratio of 2.6 males for each female was observed (Table 4). Four steelhead were identified as originating from the Cassimer Hatchery (3 males; 1 female). In addition to the 40 fish that passed upstream of the trap, 5 male and 5 female summer steelhead were transported to the Cassimer Hatchery as kelts (3 male; 1 female) or broodstock (2 male; 4 female).

A total of 25 redds were observed downstream of the trap (Figure 14). The Omak Creek weir sex ratio was multiplied by redds observed downstream of the trap, which resulted in an estimate of 90 adults. Therefore, a total of 130 summer steelhead (trap and redd count estimate) returned to Omak Creek in 2009. Of these fish, 16 were estimated to be of natural origin. The 2009 spawning escapement was comparable with data from the last six years (Figure 16), but this obscures the real restoration story in Omak Creek that has taken this stream form near zero spawners in 1997 to where it is today (an 8 year average of 121 spawners per year). 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.

Table 4. Proportions and totals of male, female, and wild summer steelhead passed above the Omak Creek trap in 2009.

Omak Creek Weir Trap, 2009

Description	Total (N)	Wild (N)	Percent Wild (%)
Males	29	5	17.2%
Females	11	0	0.0%
Total	**40**	**5**	**12.5%**

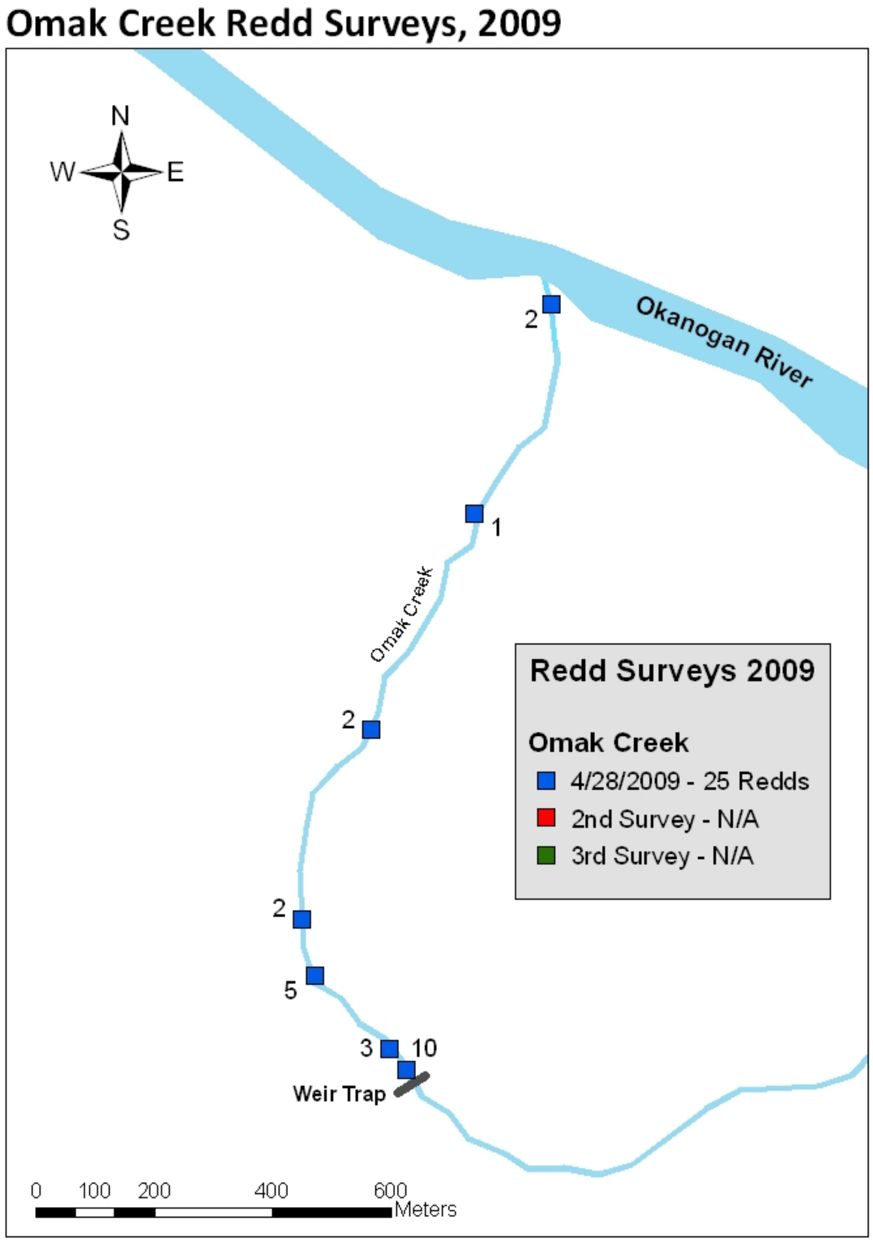

Figure 14. Map of summer steelhead redds observed below the Omak Creek trap during the spring of 2009.

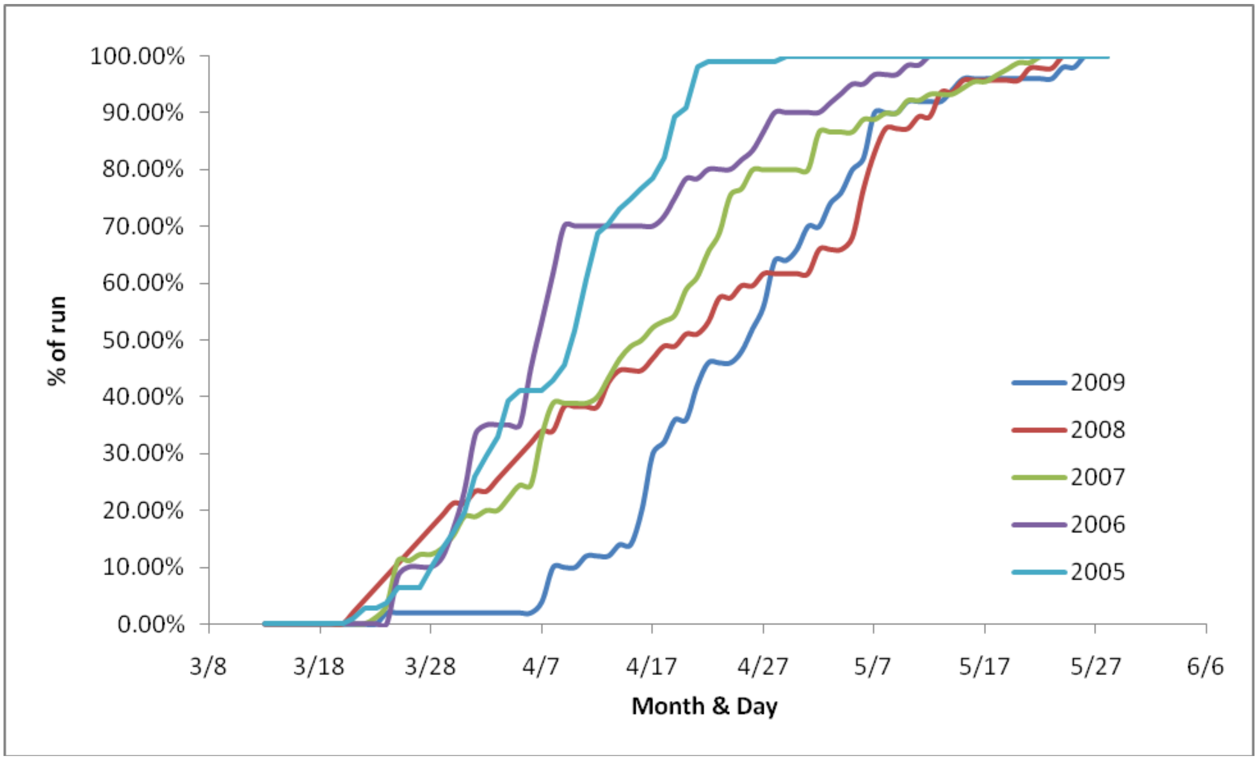

Figure 15. Run timing of summer steelhead at the Omak Creek trap, 2005-2009.

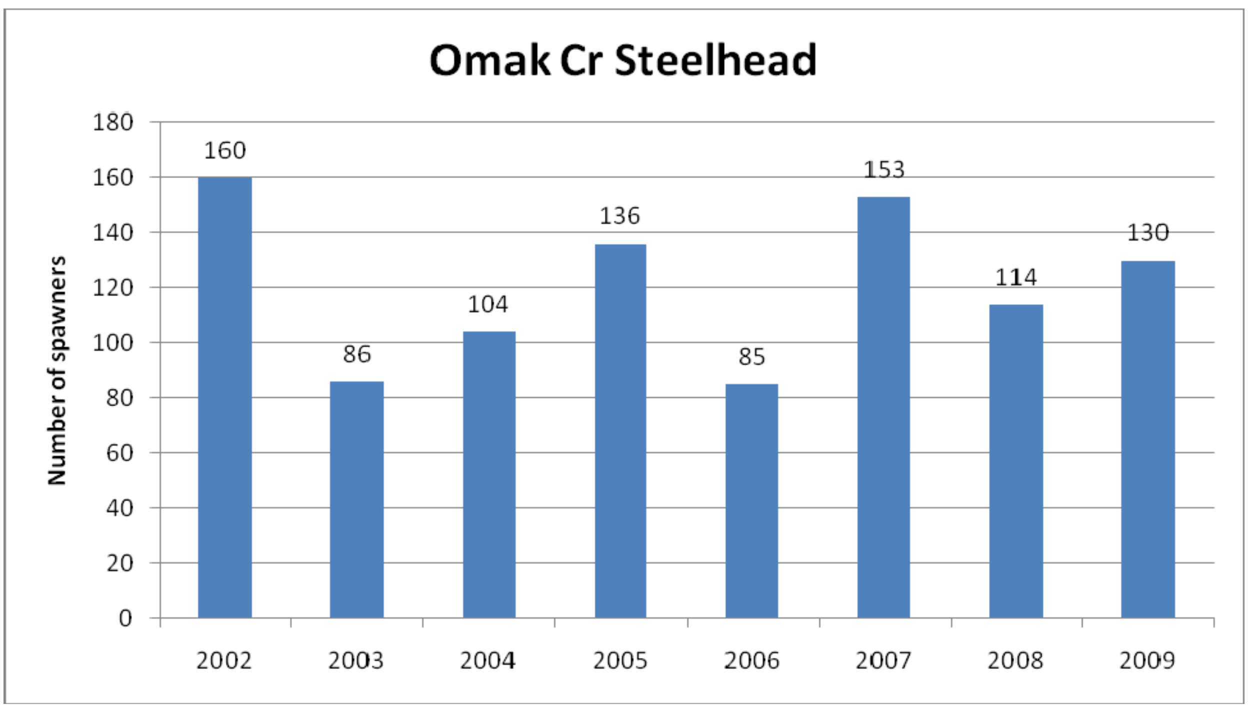

Figure 16. Number of summer steelhead spawners in Omak Creek from 2002 to 2009.

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 since 2007. A low flow channel was constructed in the fall of 2008 to improve access for adult steelhead. In 2009, 1,220 ac-ft of water were released over a period of 53 days (April 9 through May 28), and discharge ranged from 7.84 cfs to 21.39 cfs (Figure 17), with a mean of 13.2 cfs (Pers. Comm. Chris Fisher Colville Tribes Fish Biologist). During that time, 12 redds were observed in the lower 7.2 km of Salmon Creek (Figure 18). Using a sex multiplier of 3.7 (average of Omak and Bonaparte Creeks) rendered 45 spawners below the diversion. Ad-present fish made up 20.1% of the fish observed in the video counting chamber and because we were uncertain how many of these were truly of natural origin below the OID diversion, a range of 4-9 naturally produced steelhead was estimated.

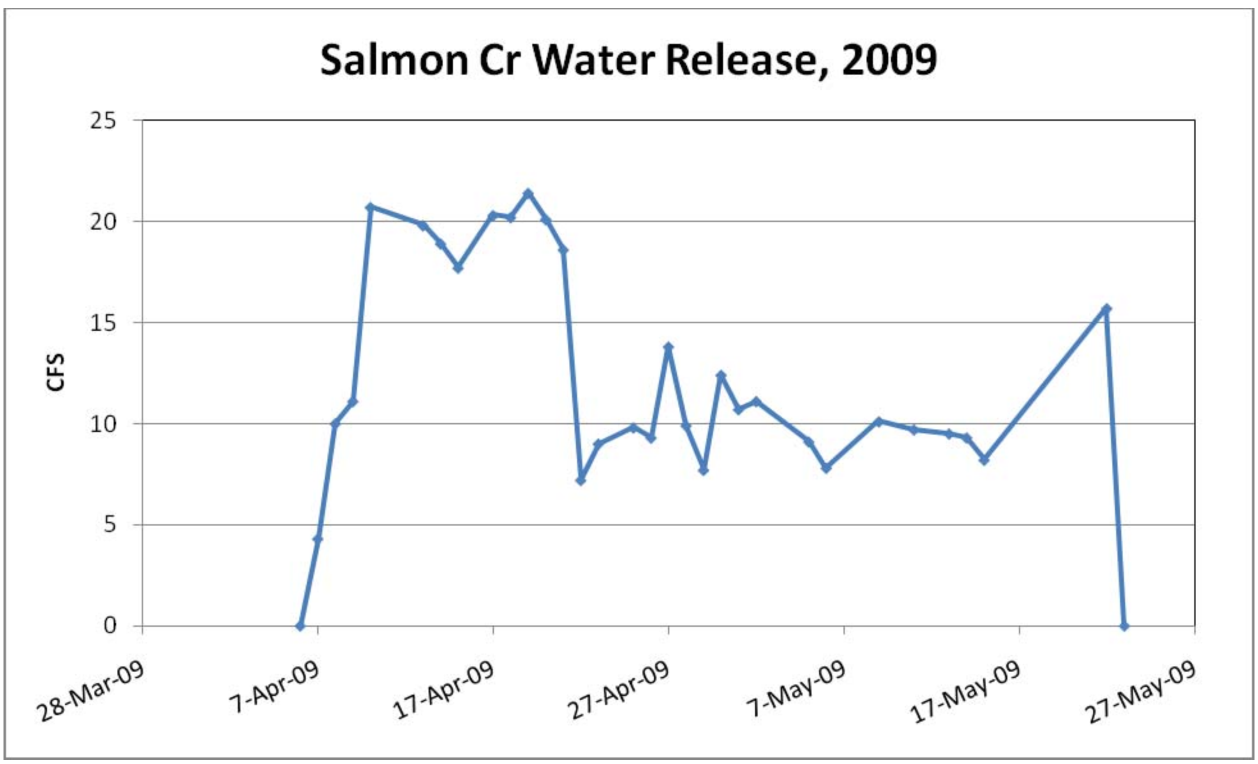

Figure 17. Release of water from Salmon Creek (2009) to allow steelhead passage.

In addition to redd surveys below the OID diversion, a specialized underwater video apparatus was custom-designed to fit into the fish ladder of the OID diversion dam in 2009. A total of 24 adult steelhead passed through the video chamber within a six-day period and 5 had intact adipose fins. The total number of steelhead counted as passing the diversion dam was likely an underestimate because 12 days of video data was overwritten before being reviewed (April 9-May 4 and May 14-20). Three adult steelhead were observed upstream of the diversion dam prior to April 16 and were not recorded passing through the video chamber. Two of these fish were mortalities immediately upstream of the diversion dam and another adult steelhead was observed spawning approximately 0.18 miles upstream of the diversion dam. It was suspected that these fish and possibly more adult steelhead jumped over the diversion dam and avoided swimming through the video chamber when discharge was approximately 20 cfs. Total escapement estimates into Salmon Creek are considered very conservative because of difficulties with data collection during the first year of monitoring adult returns. In order to improve next year's data collection, video equipment will be installed and tested earlier, adding expanded memory in the DVR units thus providing a larger buffer before overwriting of data begins, and installing deflectors to ensure that steelhead do not bypass the video array.

A conservative estimate of 27 summer steelhead spawners were observed above the OID diversion and 45 spawners were estimated below the diversion. Combining these values results in a total spawner count of 72 summer steelhead returning to Salmon Creek in 2009 with a best estimate of 11 being of natural origin.

Table 5. Adult steelhead enumerated at the video weir on Salmon Creek during 2009.

Salmon Creek Video Data

Date	Ad-Clipped	Ad-Present	Total Steelhead
4/16	3	1	4
4/17	0	1	1
4/18	3	2	5
4/19	9	0	9
4/20	3	1	4
4/21	1	0	1
Total*	**19**	**5**	**24**

*Due to overwrite of hard drives, data was not recorded for the time periods of 4/29 thru 5/4 and 5/14 thru 5/20.

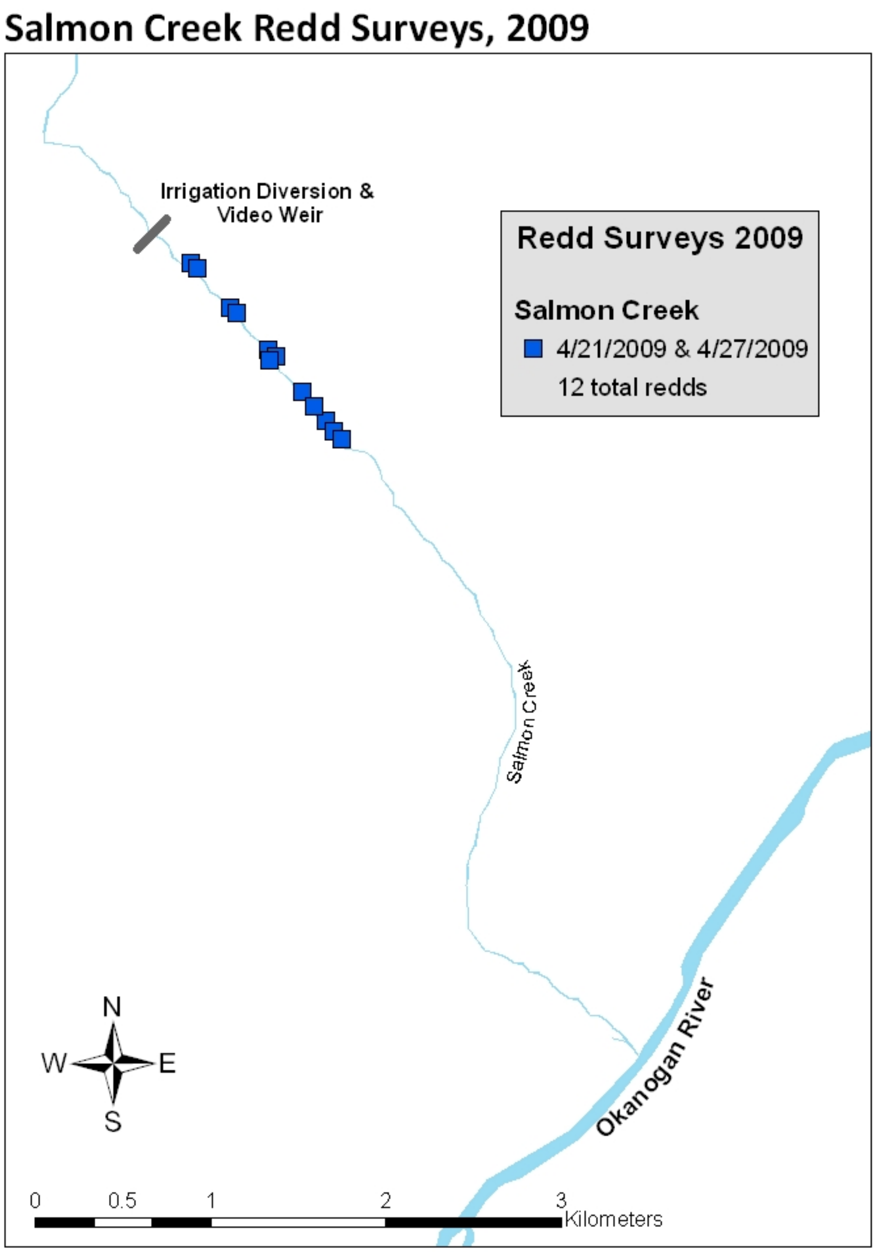

Figure 18. Map of summer steelhead redds observed below the Salmon Creek trap during the spring of 2009.

Loup Loup Creek

Low stream flows in 2009 on Loup Loup Creek 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), in-channel habitats were improved, 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

To accurately calculate steelhead escapement into Canada, video counts at Zosel Dam and a removable trap located on Inkaneep Creek were utilized.

To calculate the number of spawners entering Canada, the estimated number of spawners that entered Ninemile (3) and Tonasket (0) Creeks were 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 2009, 437 summer steelhead were counted passing Zosel Dam. Three were observed entering Ninemile Creek, a United States tributaries above Zosel Dam. Therefore, 434 summer steelhead were observed in close proximity to the 49th parallel during the time steelhead were expected to spawn. However, the distribution of spawners north of the United States boarder with Canada remains unknown even though considerable funds have been expended to try and more accurately define steelhead spawning habitat since 2005.

Sixty-six ad-present summer steelhead were enumerated at Zosel Dam (Table 6). The estimated number entering Ninemile (2) and Tonasket (0) Creeks was subtracted from the total (66), resulting in an estimate of 64 ad-present summer steelhead. Of the total number of summer steelhead destined for Canada, 15% were observed with intact adipose fins. However, there is concern about overestimating the extent of natural origin fish, based on the fact that a proportion of hatchery fish are released unmarked. A more conservative wild estimate was derived from averaging the WDFW Okanogan River wild estimate (8.5%) and Zosel ad-present value (15.1%) to render a value of 11.8%. This would represent an approximate value of 52 naturally produced steelhead from a total of 437 fish.

Table 6. The number of summer steelhead that passed Zosel Dam by month for the 2009 spawner cohort, July 2008 to June 2009.

Zosel Dam Steelhead Passage

Month	Ad-Clipped	Ad-Present	Total
July	0	1	1
August	2	0	2
September	0	1	1
October	0	2	2
November	0	1	1
December	5	1	6
January	0	0	0
February	0	0	0
March	0	1	1
April	345	52	397
May	17	6	23
June	2	1	3
Total	**371**	**66**	**437**

Inkaneep Creek

The Okanagan Nation Alliance operated an adult fish weir on Inkaneep Creek in 2009. The fish fence captured 20 total fish from March 31 to June 5. Of the 20 fish captured, 2 were ad-clipped and of hatchery origin, with the remaining having intact adipose fins (90% ad-present). A mean fork length of 50.8 $\pm$ 8.1 cm was determined.

Due to the fact that the weir trap was not effective in capturing all migrating fish, two redd surveys were conducted on Inkaneep Creek on 5/31/2009 and 6/1/2009 with 86 redds identified. Four additional redds were not included in this count, as they were likely created by smaller resident trout. A disagreement exists on the actual proportion of anadromous steelhead and resident trout that utilize this creek. However, this value cannot be resolved without stable isotope analysis. Without this fundamental piece of data, along with accurate sex ratios, it may be impossible to definitively determine the proportion of resident vs. anadromous *O. mykiss* utilizing the creek. Thus, in the interim, a calculation must be used to estimate escapement into Inkaneep Creek.

In order to determine an estimated range of *O. mykiss* that entered Inkaneep Creek, a sex ratio needed to be determined. Due to the fact that sex was not evaluated at the weir trap in 2009, a surrogate was used; therefore, a conservative estimate of a 1:1 male to female ratio (sex multiplier 2 fish/redd) was used. When the observed 86 redds was multiplied by 2, an estimated 172 *O. mykiss* spawned in Inkaneep Creek. This number likely represented a minimum escapement estimate. In order to obtain a maximum value, the 86 redds were multiplied by the Omak Creek weir sex multiplier of 3.6, a creek of similar size; therefore, a maximum estimate of 310 spawning adult *O. mykiss* was determined.

It is unfortunate that the proportion of anadromy could not have been examined more closely due to problematic trap operations. However, an extrapolation was drawn to predict the number of ad-clipped steelhead spawners in Inkaneep Creek. Using the minimum *O. mykiss* population estimate of 172, multiplied by the ratio of hatchery steelhead handled at the weir in 2009 (0.10), a value of 17 ad-clipped anadromous steelhead likely spawned in Inkaneep Creek. It would be difficult to predict the number of wild steelhead that spawned, as insufficient data exists to perform a meaningful estimate because stable isotope data is lacking.

Remaining Canadian Distribution

Annually, a large number of summer steelhead pass Zosel Dam and enter Canada with an undefined natal stream (Table 7). In 2009, 417 summer steelhead have a distribution that remains undefined. It has been suggested that fall back at Zosel Dam would account for these disparities but no evidence of this has been observed and all downstream passage at Zosel Dam is already removed from any estimates during video data processing. Fallback issues at other facilities has been closely studied, for example, a minimum of 94% of steelhead passing mainstem Columbia River dams survived to known spawning areas, or remained above the dam (English et al. 2001, 2003). More recent PIT tag data indicate that survival from McNary Dam to Wells Dam averaged 97% per project. Using these values may result in a reduction in Zosel Dam counts by between 13 and 28 summer steelhead but would still leave at least 386 summer steelhead unaccounted for in Canada.

Recreational harvest in Osoyoos Lake on both sides of the boarder could account for some of these fish, but it is unknown to what extent. Most of the fish passed Zosel dam in April, which was after the closure of the steelhead fishery (March 15) in the United States, and therefore, it would be illegal to possess these fish in the United States. Harvest estimated for the steelhead fishery in the United States portion of the Okanogan and Similkameen Rivers indicates a mortality of 13.6% for 2009 (WDFW 2009). If the same proportion of the counts at Zosel was removed, this would account for an additional 56 summer steelhead harvested before spawning above Zosel Dam due to recreational fishing. With both potential recreational fishing and fallback accounted for there are still 330 summer steelhead left unaccounted for above Zosel Dam.

The most likely scenario is that, at a minimum, 330 summer steelhead do spawn in Canada. However, past and on-going efforts have failed to determine the quantity and location of spawning with the exception of in Inkaneep Creek. In the future, PIT-tag data collected at VDS-3 and radio-isotope sampling at Inkaneep Creek will greatly help expand our current knowledge about how many steelhead are spawning in certain areas of the Okanogan River in Canada. As these new data become available they will be used to focus our search for the most productive natal streams first before worrying about identifying less productive environments.

Table 7. Summer steelhead spawners with unknown natal stream located above Zosel Dam from 2007-2009

Year	Number of Spawners with unknown distribution in Canada
2009	417
2008	94
2007	24

Bringing it all together

In the United States, summer steelhead are currently listed as "threatened" under the Endangered Species Act in the Upper Columbia River Evolutionary Significant Unit. Detailed percent-wild information for 2009 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 if is currently impossible to define natal origin through visual observation alone. 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 2009 was between 2,020 and 2,198 (Table 9). In 2009, WDFW estimated maximum spawner escapement into the Okanogan River Basin at 2,263 summer steelhead (Charles Frady, WDFW, Personal Communications). The WDFW estimates were 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). However, the radio telemetry data is over a decade old and perhaps these values need to be revalidated.

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 192 and OBMEP estimated that between 178 and 241 wild summer steelhead likely spawned within the Okanogan River Basin in 2009 (Table 10). The wide range in our wild fish estimates is directly linked to hatchery programs that do not clip all of their production released in the Upper Columbia. In the future, we plan to install PIT-tag arrays at the downstream extent of most spawning areas or streams throughout the Okanogan River Basin. Once this Okanogan Basin wide PIT-tag array is in place, ad-present adults will be PIT-tagged at mid-Columbia PUD facilities and will carry with them very precise age, sex, and origin data. Recovery of this tag information could be used directly to evaluate the proportion of spawners that are of natural origin and sex ratio with a high degree of certainty, allowing us to incorporate age data into life cycle models, and provide a mechanism for validating our redd surveys with mark-recapture estimates. The mark-recapture methods could help determine spawner distributions throughout Canada but this system is unlikely to be in place, especially in Canada, until 2012 at the earliest.

A summary of the best available counts and estimates for each reach or sub-watershed throughout the Okanogan River Basin is presented in Table 8. Our surveys indicate that mainstem spawning is common throughout the Okanogan River and is most heavily focused in the northern portion of the Okanogan and lower Similkameen rivers. The lack of redds in the mainstem Okanagan River in Canada is surprising because 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, but no hatchery stocking occurs in Canada. It is highly likely that redd distributions in the United States portion of the Okanogan 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 mainstem. Therefore, if more summer steelhead were stocked into Okanogan Basin tributaries, the chances of these tributaries contributing to recovery efforts could be greatly enhanced.

Table 8. 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 2009. The grand total for the entire Okanogan River population is presented with subtotals for tributary and mainstem habitat types in the United States and Canada.

Distribution of Steelhead Spawners in the Okanogan Basin

Category	Description/location	2009 Spawners	Redd count	# wild
US Mainstem	Spawners into reach O1	12	7	1
US Mainstem	Spawners into reach O2	28	16	2
US Mainstem	Spawners into reach O3	2	1	0
US Mainstem	Spawners into reach O4	23	13	2
US Mainstem	Spawners into reach O5	9	5	1
US Mainstem	Spawners into reach O6	0	0	0
US Mainstem	Spawners into reach O7	933	524	79
US Mainstem	Spawners into reach SI/S2	434	244	37
US Tributary	Spawners into Loup Loup Creek	0	0	0
US Tributary	Spawners above Salmon Creek diversion	27	N/A	5
US Tributary	Spawners below Salmon Creek diversion	45	12	6
US Tributary	Spawners placed above Omak trap	40	N/A	5
US Tributary	Spawners below Omak trap	90	25	11
US Tributary	Spawners into Wanacut Creek	0	0	0
US Tributary	Spawners into Tunk Creek	10	3	2
US Tributary	Spawners placed above Bonaparte trap	28	N/A	6
US Tributary	Spawners below Bonaparte trap	15	4	3
US Tributary	Spawners into Antoine Creek	0	0	0
US Tributary	Spawners into Wild Horse Spring Creek	0	0	0
Zosel Dam Count	Spawners observed passing **Zosel Dam**	437	N/A	52
US Tributary	Spawners into Tonasket Creek	0	0	0
US Tributary	Spawners above Ninemile Video Box	3	0	2
US Tributary	Spawners into lower Ninemile Creek	0	0	0
Canada Tributary	Spawners placed above Inkaneep trap	17	N/A	N/D
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 Mainstem	Spawners into Canadian mainstem	N/D	N/D	N/D
Canada	Unknown or undefined distribution	417	N/D	50
Subtotals	**Adult escapement into US mainstem**	**1,441**	**810**	**122**
Subtotals	**Adult escapement into US tributaries**	**258**	**N/A**	**40**
Subtotals	**Adult escapement into Canada**	**434**	**N/D**	**50**
Grand total		**2,133**		**212**

Table 9. 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 mainstem 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
2009	2,263	2,020	2,133	2,198

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

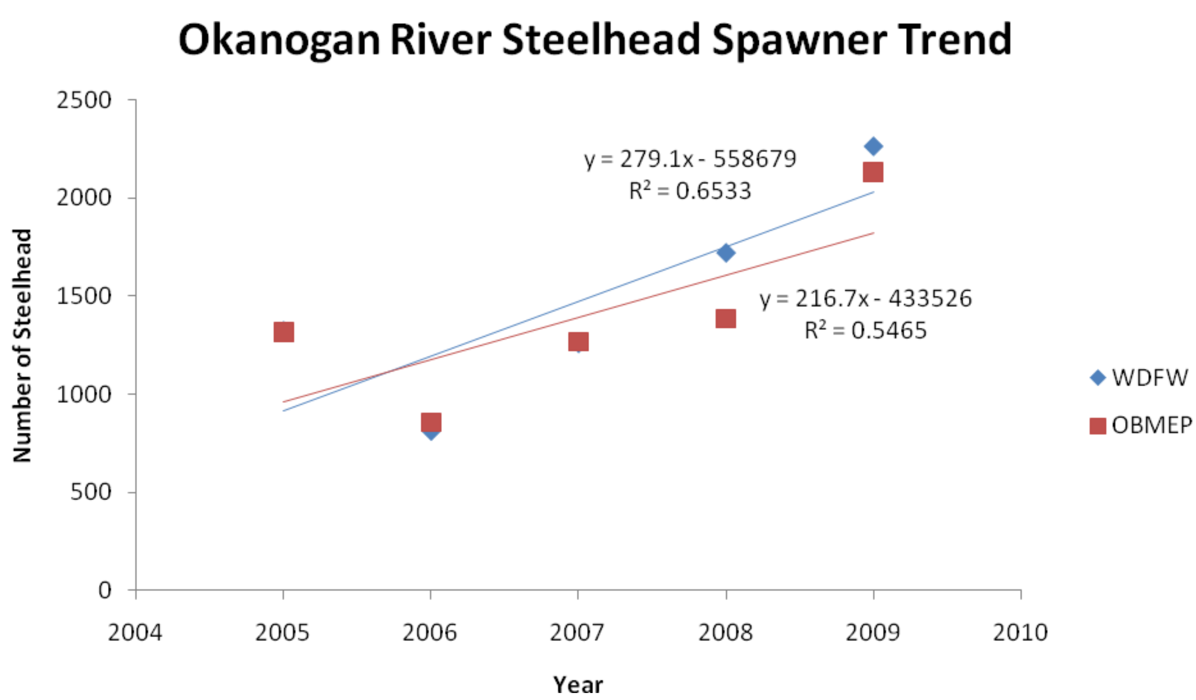

Figure 19. Trends in Okanogan River steelhead spawners, 2005-2009.

Table 10. 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 mainstem 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
2009	192	178	212	241

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

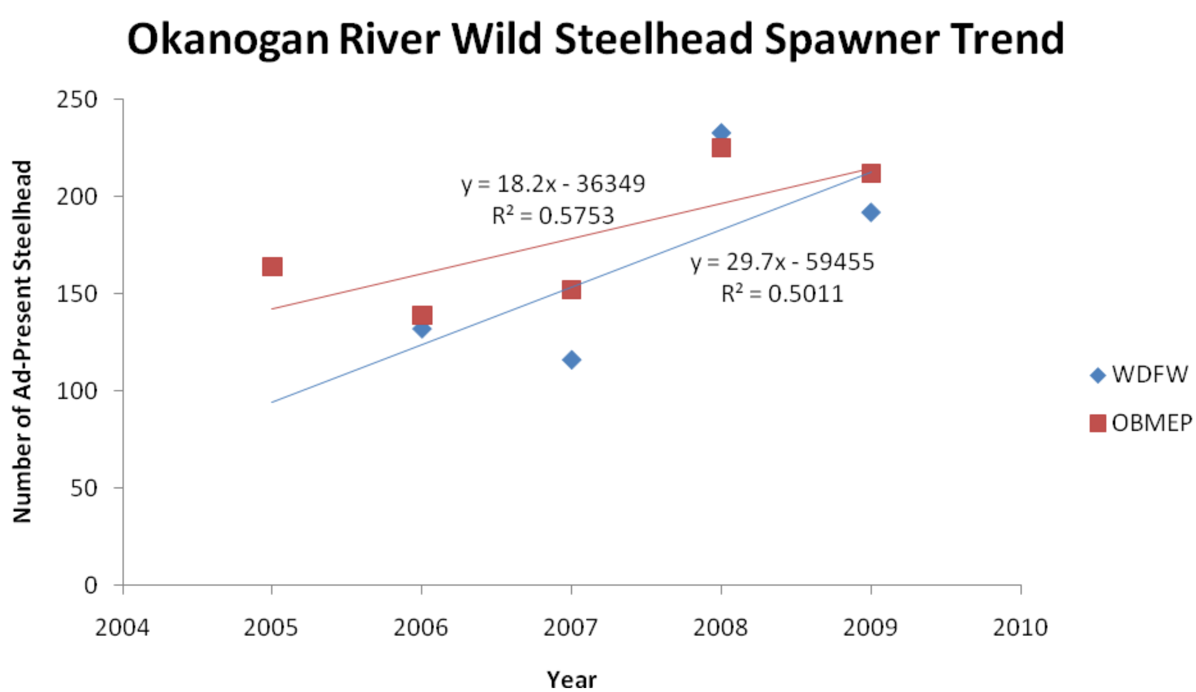

Figure 20. Trends in Okanogan River Ad-Present steelhead spawners, 2005-2009.

Conclusions

Summer steelhead spawner data clearly show that redd surveys throughout the United States portion of the Okanogan River Basin are possible in both tributary and mainstem 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 used in trend analysis. Spring spawner data provides a reliable estimate of spawner abundance and 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, 2008 and 2009 clearly show how low tributary discharge can dramatically alter spawning locations and reduce the number of summer steelhead utilizing tributary streams, especially when coupled with a later than normal runoff of the mainstem Okanogan River. Habitat alterations at the mouths of key spawning tributaries can help, provided sufficient discharge is available for adult steelhead to migrate.

In 2009, 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 focus on providing and sustaining more sites that support a gravel substrate along the mainstem Okanogan River and in close proximity to a cold water refugia to improve egg to fry production for summer steelhead.

Water availability in the Okanogan River Basin was below normal in 2009, and much of the snow runoff in the lower elevations occurred prior to steelhead spawning. Many of the small tributaries were either inaccessible due to the low elevation of the Okanogan River or had insufficient discharge for upstream migration of adult steelhead; therefore, many steelhead selected spawning locations along the mainstem Okanogan and Similkameen Rivers.

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 and PIT tagging those that are not clipped and expanding the number of PIT tag arrays 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 will allow for future trend analysis.

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Revision 1

After completion of the 2009 Okanogan Basin Steelhead Redd Surveys Report, a corruption in a GPS file was discovered which subsequently changed the number of redds reported in the preliminary version of this report. In order to ensure accurate reporting of steelhead escapement estimates, a revision was conducted.

Specific changes from the original document include:

Pg. 4 – Updated number of redds for the mainstem Okanogan River and total escapement estimates
Pg. 16 – Reorganized redd distribution for reach 07 for April 20 and May 4, 2009, as well as total redd count for reach 07
Pg. 17 – Updated survey map for reach 07
Pg. 32 – Escapement estimate adjusted to reflect updated numbers
Pg. 33 – OBMEP wild summer steelhead escapement ranges adjusted
Pg. 34 – Table updated to reflect changes in reach 07, subtotal, and grand total numbers
Pg. 35 – Table 9 and Figure 19 updated
Pg. 36 – Table 10 and Figure 20 updated

Appendix 3

Steelhead Spawner Enumeration in Inkaneep Creek – 2009

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EXECUTIVE SUMMARY

Steelhead salmon that return to the Canadian Okanagan Basin migrate from the Pacific 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 424 adult steelhead (adipose clipped and unmarked) that were migrating into Osoyoos Lake between January and May, 2009. Less than this number would 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 *et al.* (2010) have estimated that three (3) steelhead/rainbow trout entered Nine Mile Creek, while Tonasket Creek did not have sufficient flow for migration to occur.

The general timing of steelhead/rainbow trout spawning in Inkaneep Creek differed slightly compared to previous sampling years with fish presence beginning at the end of April and persisting to the first week of June. Migration through the fish fence on Inkaneep Creek began March 31st and continued to June 5th with no peak data indicated due to the lack of fish captured.

The fish fence enumerated a total of 20 steelhead/rainbow trout. Two were adipose clipped and of hatchery origin, with the remainder being of wild origin. The sex ratio was not determined this year. The mean fork length of all fish captured measured 50.84 $\pm$ 8.1cm.

Stable isotope analyses ($\delta^{13}C$ and $\delta^{15}N$) were used to differentiate between steelhead and rainbow trout spawners when we counted and bio-sampled them at the fish fence in 2008 and 2009. These analyses showed that spawners were mostly represented by rainbow trout. From 58 fish analyzed in 2008, 51 were rainbow trout and 7 were steelhead. From 19 fish analyzed in 2009, 16 were rainbow trout and 3 were steelhead.

A total of 93 redds were observed in the Canadian Okanagan Basin in the spring of 2009. Seventy five were located within Inkaneep Creek, while the remaining 5 were found in Vaseux Creek within the Canyon Reach below the migration barrier. Redds in both creeks were observed June 1st, and June 4th, 2009. The improved number of redds surveyed compared to previous years (Long *et al.* 2006, Benson and Squakin 2007, Folks *et al.* 2009) was likely the result of a lesser snowpack and reduced freshet resulting in less turbid conditions within the creeks.

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. and T. Kozlova. 2010. Steelhead spawner enumeration in Inkaneep Creek – 2009. Within the Okanagan Basin Monitoring and Evaluation Program (OBMEP). Prepared by the Okanagan Nation Alliance Fisheries Department, Westbank, BC.

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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 2009, 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 fifth year of the OBMEP program, while being the fourth year of steelhead spawner surveys in the Canadian portion of the Okanagan Basin. Only three years of the spawner surveys have included the use of 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 and Vaseux creeks were conducted as part of another project. The end objective is to determine the timing and distribution of the steelhead spawning run.

Specific objectives for operating the Inkaneep Creek fish fence included:

- Re-installation and maintenance of the fish fence on the lower reach of Inkaneep Creek throughout the spawner returns (end of March to June)
- Enumeration of all fish migrating upstream (primarily steelhead and rainbow trout)
- Collection of biological information including fish length and ratio of male to female trout
- Collection of fin samples for stable isotope analyses ($\delta^{13}C$ and $\delta^{15}N$)

Specific objectives for the redd surveys included:

- Focusing on redd surveys efforts to regions previously determined to have significant numbers of steelhead redds (Long *et al.* 2006; Benson and Squakin, 2008).
- Utilizing 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 (24 km 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 again the focus of this year's steelhead spawner surveys conducted in the spring of 2009 and based on previous years sampling. In 2006 (Long *et al.* 2006) it was determined that Inkaneep Creek was the most productive spawning creek of those 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. The remainder is blocked by a 6 m high waterfall (Walsh and Long 2005). The accessible 3.7 km length of Inkaneep Creek was surveyed for steelhead redds. In addition, steelhead migrations were monitored through a fish fence located 600 m from the mouth of the creek.

In response to the blockage of fish migration at McIntyre Dam, the ONAFD and other groups have lobbied for fish passage. Construction has taken place to install 5 overshot gates at McIntyre Dam which now provide access upriver. Upstream migration was possible for the 2009 Sockeye migration period through October. Also, historically, prior to overshot gate installation, McIntyre Dam could be operated for short periods of time during the spring freshet in such a way that migration of salmon was possible. For these reasons, a main tributary upstream of McIntyre Dam - Shuttleworth Creek was occasionally included in enumerations. With fish passage now possible Shuttleworth Creek may be also included in surveys. This would help to assess the effectiveness of steelhead passage at McIntyre Dam.

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

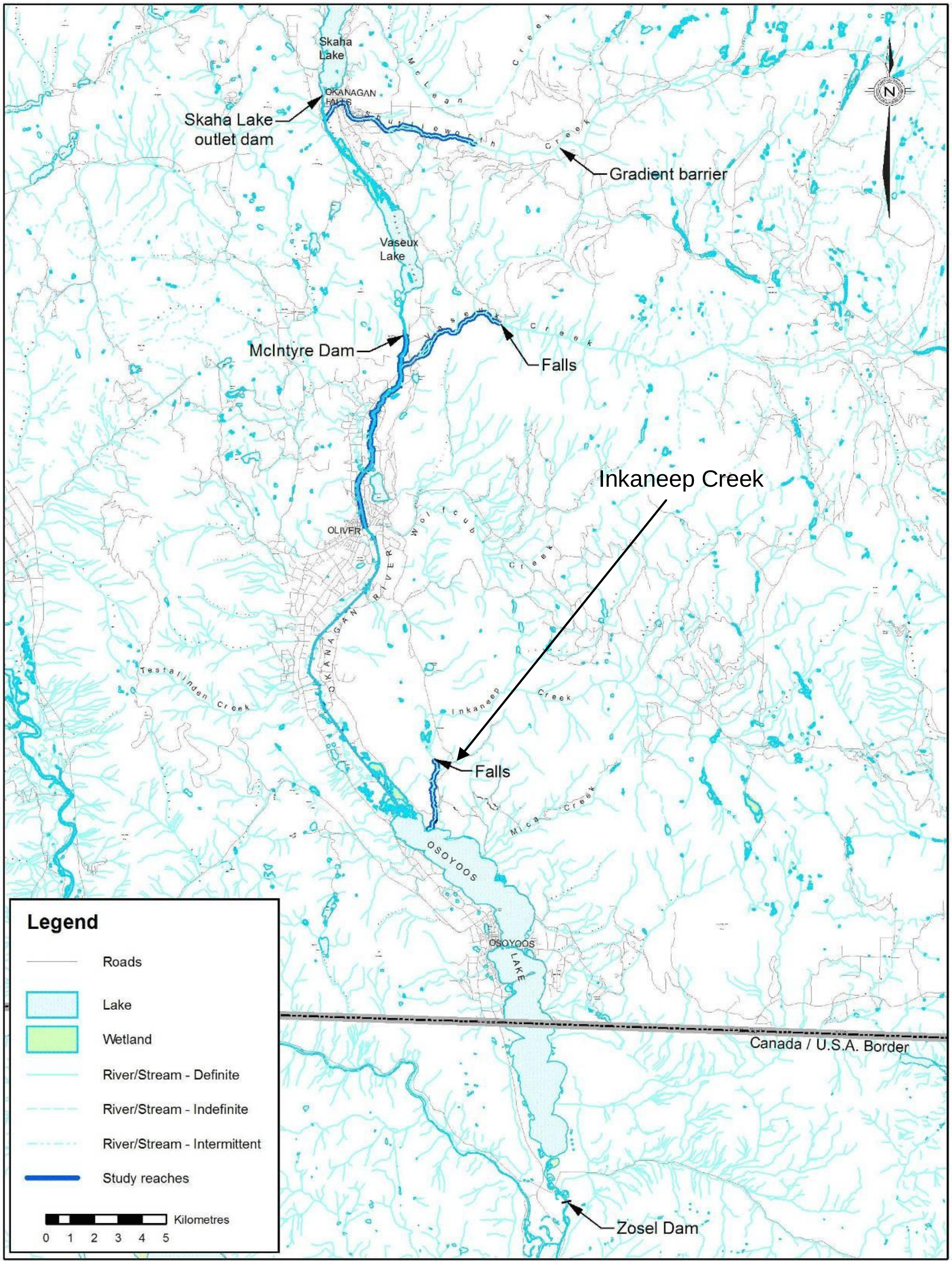

Figure 1. Canadian Okanagan Basin steelhead/rainbow trout study area

2.0 METHODS

2.1 Inkaneep Creek Fish Fence Monitoring

This year, 2009, is the fourth year of the steelhead/rainbow spawner monitoring within the Canadian Okanagan Basin, and the third year in which a fish fence has been used on Inkaneep Creek. In 2006, a fish fence provided good enumeration results compared to the sampling season in 2007 which relied primarily on redd surveys. This year's fence was installed on March 31st, 2009 and located 600m from the mouth of Inkaneep Creek (GPS N49.00077220, W119.50360). The fence was constructed during low flow conditions at mean depths of approximately 1.78m (WSC 2009). Inkaneep Creek typically experiences flash flood flow dynamics where the water levels in the creek are prone to rapid changes over a short time period (Long *et al.* 2006). In response to this, the fish fence orientation is occasionally altered to adapt to Inkaneep Creek in order to reduce the likelihood of failure.

Counts of steelhead/rainbow trout migrating into Inkaneep Creek to spawn were conducted March 31st to June 5th, 2009. 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 2. Inkaneep Creek fish fence 2009

Figure 3. Inkaneep Creek fish fence and observed vandalism/public interference

The fish fence was checked daily from March 31st to June 5th, 2009. 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[1], adipose fin presence, fin tissue and scale samples[2]. 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 4. Female steelhead/rainbow trout sampled May 2009

2.2 Redd Surveys

Based on the failure of previous years surveys (2006 and 2007) to significantly detect and quantify steelhead/rainbow spawner redds, the redd survey methodology was modified to include only Vaseux and Inkaneep creeks with the majority of the survey effort in the latter. Redd detection has previously been difficult within Okanagan River tributaries due to high turbidity and high freshet flows. The decision to modify the

[1] While the intention was to collect sex data, this data is unfortunately missing.
[2] These samples will be processed in 2009/2010 for aging and stable isotope analysis to determine exposure to marine environments.

surveys was made in order to allocate resources to streams 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 within both Inkaneep Creek and other COB waterways. Redd surveys, as mentioned, have proven difficult in previous years and have failed to provide a reliable record of spawner distribution. Thus, with improved enumeration in Inkaneep Creek along with continually improving data from Zosel Dam a more complete picture of steelhead spawning distribution can be determined.

Redd surveys were conducted by two ONAFD personnel versed in redd survey methodology. Also, one member of the Colville Confederated Tribes (CCT) participated in the survey on a number of days. The surveys took place in early June while fish were observed in the fish fence (Arterburn *et al.* 2007a; Benson and Squakin, 2008)[3]. The entire reach of Inkaneep Creek accessible to steelhead/rainbow was surveyed from the stream mouth upstream to the permanent fish barrier. 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 and Wright 2004). Information collected to determine the quality of the counts included:

- water clarity (water depth of visibility)
- weather conditions (cloud cover, brightness, precipitation)
- survey crew
- starting and ending times 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*. (2007a). 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 redds from the flag.

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] Redd surveys were conducted under the Okanogan Sub-basin Habitat Improvement Program (OSHIP)

3.0 RESULTS

3.1 Inkaneep Fish Fence Monitoring

The Inkaneep fish fence was monitored for 66 days (March 31st to June 5th, 2009). After that the fence was disassembled due to warmer water temperatures and dates beyond typical migration and spawning peak times (Appendix A). During the sampling period a total of 20 steelhead/rainbows were enumerated. The fence was left in place for longer than in previous years since numbers were low. A number of factors could have affected the numbers such as any combination of low freshet, later onset of snowmelt, cooler stream temperatures, or dysfunctional fish fence. Fish were spaced over the entire sampling period and the daily catch never surpassed 5 fish.

Table 1. Counts of steelhead/rainbow trout through the Inkaneep fish fence

Date	Number of fish
21-Apr-09	3
22-Apr-09	1
2-May-09	1
3-May-09	1
9-May-09	1
12-May-09	1
14-May-09	1
16-May-09	1
24-May-09	1
26-May-09	5
1-Jun-09	2
2-Jun-09	2

Based on data collected by the ONAFD a peak date of migration and spawning is difficult to estimate this year. The fish fence did not capture enough steelhead/rainbow trout to indicate a peak date. The redd surveys in early June showed a good number of redds which indicates that spawning occurred in May, and the surveys also showed the distribution of redds. Typically, migration has occurred in the latter half of April and the 1st week of May in previous years (Benson and Squakin 2008; Folks *et al.* 2009). Arterburn *et al.* (2007) make mention that this time period is also experienced in tributaries to the Okanogan River in Washington State. Peak dates have previously tended to correlate with peak water flows through Inkaneep Creek monitored at the Water Survey of Canada water gauge 08NM200 (Fig. 5). The fish fence was installed when water depths were less than 1.8 m.

In previous years, the fish fence has experienced stability issues due to freshet flows. This year, however, a year of reduced snowpack and minimal spring precipitation (WSC 2009) led to consistent flows of less than 0.8 m^3/s (Fig. 5). Previous year's peak flows have exceeded 2.0 m^3/s). While the fish fence was not structurally compromised this year, there have still been issues with either public vandalism (Fig 2) or the possibility of fish passage due to a weakened fence. Passage may have possibly occurred under the fence as a result of this year's fish fence orientation and construction.

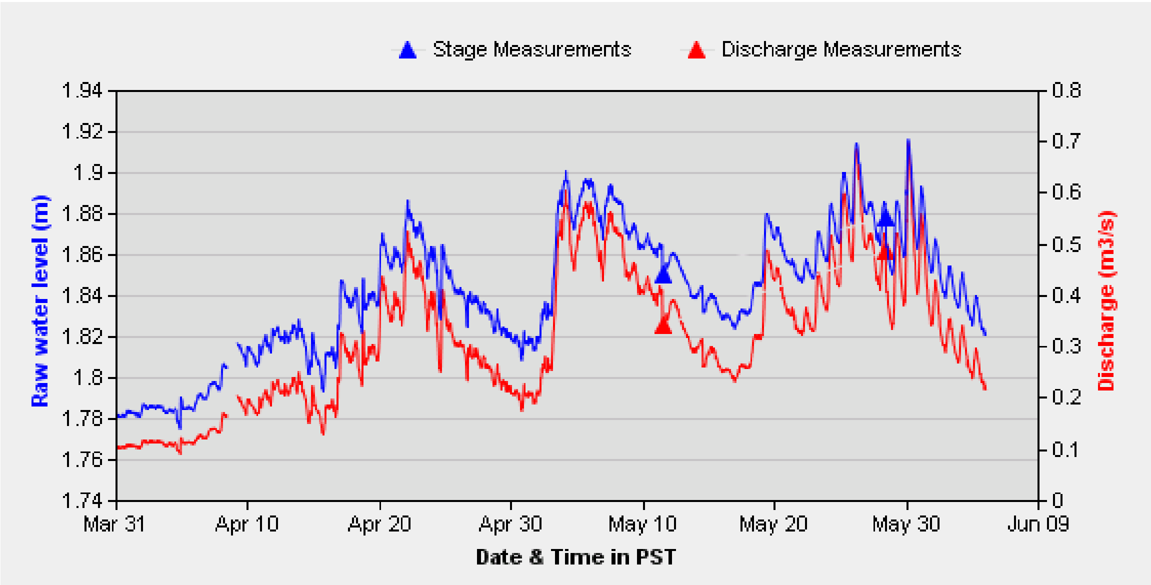

Figure 5. Water levels (blue) and discharge (red) in Inkaneep Creek at station 08NM200 (WSC 2009).

The fish fence data from Long *et al.* (2006) corroborates the timing witnessed this season, with peak migration periods occurring 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. Peak timing this season was based on consistency of fish movement over a number of days, while the presence of 5 fish on May 26th may indicate later onset of migration. The lack of data makes peak timing determination difficult.

3.1.1 Biological sampling of Inkaneep Creek steelhead/rainbow trout

Of the 20 fish captured, 2 were adipose clipped and of hatchery origin (Appendix A). As per previous years, the majority (90% compared to 91.53% in 2008; Folks *et al.* 2009) of the fish enumerated were most likely a wild population of steelhead and/or rainbow trout. The fish fence caught 3 females, and 17 of unknown sex. Sex determination is lacking due to a miscommunication with field crews. Previous years female to male sex ratios however, have been 0.69 in 2008 and 0.85 in 2007. Osoyoos Lake is also known for having a resident adfluvial rainbow population (Long *et al.* 2006). The interaction and influence of this population on the steelhead spawners is still unknown. Stable isotope analyses (carbon δ13C and nitrogen $\delta^{15}N$) on fin tissue samples are ongoing attempts to answers these unknowns.

The average length of all the steelhead/rainbow trout that passed through the fish fence was 50.8± 8.08cm (Table 2). Comparison of male versus female mean lengths is not possible, however the range of all fish observed lies within previously observed values (Long *et al.* 2006; Benson & Squakin, 2008, Folks *et al.* 2009).

Table 2. Length of Canadian Okanagan Basin male and female steelhead/rainbow trout in 2006, 2008, and 2009.

	Count			Length			Std Dev		
	2006	2008	2009	2006	2008	2009	2006	2008	2009
Female	27	32	-	45	44	-	9	11	-
Male	23	22	-	49	46	-	11	11	-
Unknown	14	5	20	-	-	50.8	-	-	8.07

	Length Min			Length Max		
	2006	2008	2009	2006	2008	2009
Female	16	16	-	59	60	-
Male	31	20	-	76	67	-
Unknown	-	-	37	-	-	75

3.2 Stable isotope analyses for steelhead/rainbow trout spawners collected in 2008 and 2009

It is known, that Okanagan steelhead is an anadromous (migrating) rainbow trout that has spent a part of its life in the ocean. Rainbows remain in their native rivers and streams throughout their entire life cycle. Steelhead and rainbow trout belong to the same species *Oncorhynchus mykiss*, and there are no major physical differences between them other than the general difference in size and subtle difference in color.

In order to determine exposure to marine environment and differentiate between steelhead and rainbow trout spawners when we counted and bio-sampled them at the fish fence, stable isotope analyses (carbon $\delta^{13}C$ and nitrogen $\delta^{15}N$) were used for 2008 and 2009 samples. A total of 58 non-destructive fin tissue samples in 2008 and 19 in 2009 were collected in Inkaneep Creek. Samples were sent to the University of Regina for stable isotope analyses. The principal investigator was Dr. Bjoern Wissel.

Identifying migratory fish using stable isotope analyses is easier when the fish migrate between marine and freshwater system, which differ greatly (up to 10-15 ‰) in their stable isotope values (Peterson and Fry 1987; Doucett *et al*. 1999). Marine food webs are typically enriched in the heavier carbon isotope ($\delta^{13}C$) compared to freshwater food webs, and these distinct signatures are reflected in the tissue of animals living in these ecosystems. It usually takes from several weeks to several months for the isotope ratio to change in fish muscle tissue (Hesslein *et al*. 1993).

As stable isotope results show (Table 3), mean $\delta^{13}C$ and $\delta^{15}N$ of the rainbow trout fins were significantly depleted compared with the steelhead fins ($\delta^{13}C$, -25.1 ±0.79‰ cf. -19.2±0.84‰; $\delta^{15}N$, 15.4±1.25‰ cf. 11.9±0.96‰).

Table 3. Mean values (± standard deviation) for $\delta^{13}C$ and $\delta^{15}N$ in fins of O. mykiss sampled in Inkaneep Creek fish fence in 2008 and 2009

	Rainbow trout	**Steelhead**
$\delta^{13}C$	-25.1 (0.79)	-19.2 (0.84)
$\delta^{15}N$	15.4 (1.25)	11.9 (0.96)
Number of fish	67	10

Our data are within the range of $\delta^{13}C$ known for freshwater and migratory fish. For example, $\delta^{13}C$ in freshwater *Salmo trutta* and *Salvelinus alpines* was -28.1±0.7‰ and -27.5±0.7‰, respectively, whereas in migratory *S.alpinus*, Salmo salar, and *Oncorhynchus kisutch* it was -22.1±1.3‰, -19.5±1.0‰, and -17.9±0.3‰, respectively (McCarthy and Waldron 2000).

Resident freshwater rainbow trout and anadromous steelhead were clearly identifiable as two distinct groups and are displayed on Figure 6 using a combined δ13C and δ15N scatter plot. All rainbow trout has a carbon value of from -27 to -23‰, whereas steelhead of from -21 to -18‰.

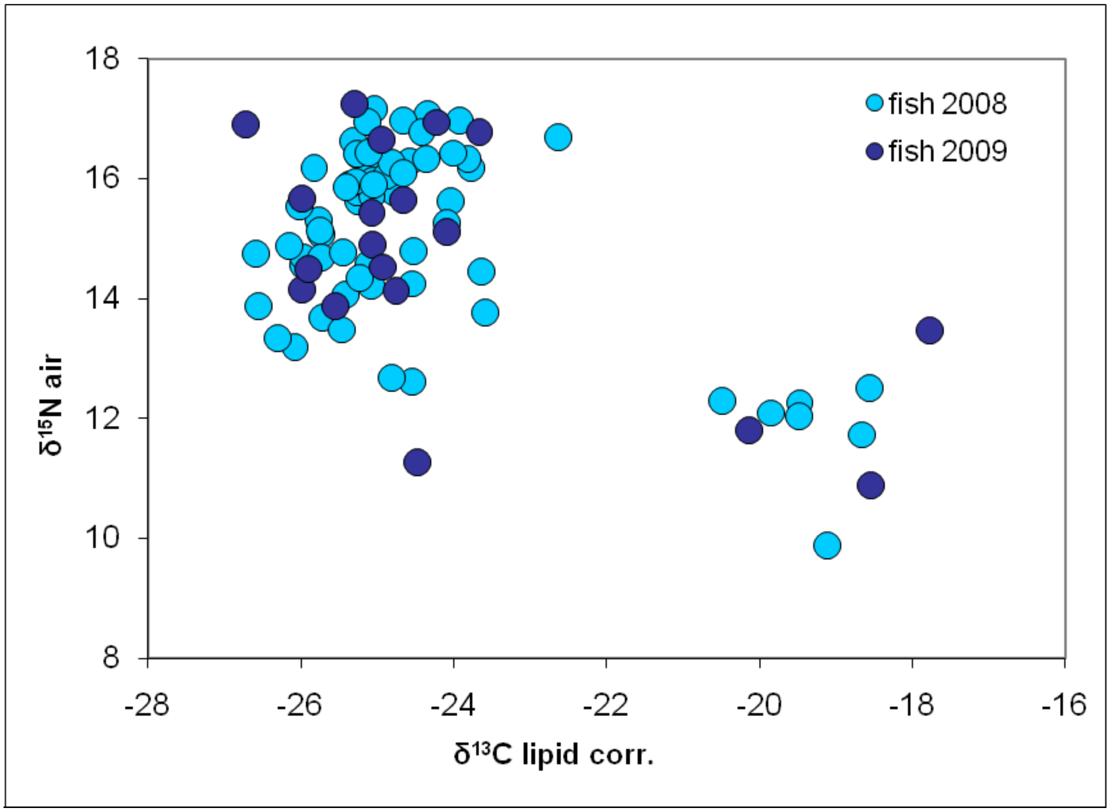

Figure 6. Combined δ13C and δ15N signatures of fin samples from *O. mykiss* (sampled in Inkaneep Creek fish fence in 2008 and 2009) identified as either resident freshwater rainbow trout (left group) or anadromous steelhead (right group).

According to stable isotope data, *O. mykiss* enumerated in Inkaneep Creek fish fence in 2008 and 2009 was mostly represented by rainbow trout (51 rainbows out of 58 fish in 2008 and 16 rainbows out of 19 fish in 2009).

The results of this study show that the measurement of $\delta^{13}C$ and $\delta^{15}N$ signatures can clearly distinguish between non-anadromous and anadromous fish, and can be used for further studies in order to separate rainbow trout and steelhead.

3.3 Redd Survey Results

Inkaneep and Vaseux creeks were surveyed by ONAFD members versed in redd survey methodology. A total of 93 redds were observed in Inkaneep Creek in the spring of 2009 while 5 redds were observed in Vaseux Creek (Table 4). Distribution in both Inkaneep and Vaseux creeks were similar to what has been observed in previous years (Long *et* *al.* 2006; Folks *et al.* 2009). Inkaneep Creek redds have been observed primarily near the mouth of the creek and near the impassable falls 3.7 Km upstream. Within Vaseux Creek redds were primarily upstream within the canyon section and below the fish passage barrier where pockets of gravel accumulate around boulder-step-pool habitats.

Table 4. Steelhead redd surveys data in the Canadian Okanagan Basin

Waterbody	No of redds	Reach	Date	Comments
Inkaneep Creek	11	Mouth to fish fence	1-Jun-09	
Inkaneep Creek	10	Fish fence to Bridge	1-Jun-09	
Inkaneep Creek	72	Bridge to canyon barrier	1-Jun-09	
Vaseux Creek	0	Mouth to HWY bridge	4-Jun-09	Turbid flow, many locations could have contained redds.
Vaseux Creek	1	HWY bridge to end of braided section	4-Jun-09	
Vaseux Creek	4	End of braided section to canyon barrier	4-Jun-09	

Shuttleworth Creek and the Okanagan River were not surveyed given lack of redds in previous sampling years (Long *et al.* 2006; Benson & Squakin, 2008; Folks *et al.* 2009). However, the increased number of redds in Inkaneep Creek would lead one to expect there could have been spawning within each system. Long *et al.* (2006) found redds within side channels of the Okanagan River, which would lend one to expect additional redds within these regions for this year; however, estimates for production are not possible given the lack of surveys conducted within these regions. Table 5 demonstrates redd numbers found in both creeks in the past as well as those for this season in Inkaneep and Vaseux creeks.

Table 5. Steelhead redd surveys in the Canadian Okanagan Basin

Redd Locations	2006	2007	2008	2009
Inkaneep	10	2	6	93
Vaseux	10	1	-	5
Okanagan[4]	2	-	-	-
Shuttleworth	-	1	-	-

The total number of redds observed in 2009 has far exceeded all previous numbers – as is shown in table 5. Redd survey data clearly demonstrate a greater number of fish present than the results from the Inkaneep fish fence. Without reliable numbers from the

[4] Okanagan River and Shuttleworth Creek were not surveyed for redds in 2008 and 2009.

fish fence, population estimates should be read with an air of caution. However, based on the success of the redd surveys and the fish passage numbers at Zosel Dam one can speculate that a minimum of 196 steelhead/rainbow trout have entered the Canadian portion of the Okanagan Basin (COB). The Zosel Dam fish counter, operated by the Colville Confederated Tribes (CCT), indicates 424 clipped and unclipped steelhead/rainbow trout entered Osoyoos Lake between January and May 2009. Arterburn *et al.* (2010) note that only three fish were observed in either Nine Mile or Tonasket creeks. Subtracting fish spawned in Inkaneep Creek (93 observed redds x 2: 186 minimum), Vaseux Creek (5 observed redds x 2: 10 minimum) and the three observed in Nine Mile Creek, 225 adults remain unaccounted for.

4.0 DISCUSSION

Steelhead returning to the Canadian Okanagan Basin migrate up the Columbia River and 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 424 hatchery and wild adult steelhead (or possibly rainbow trout): a 38% increase over the same time period in 2008, and the single largest return in the past 4 season's worth of enumeration data (Figure 7).

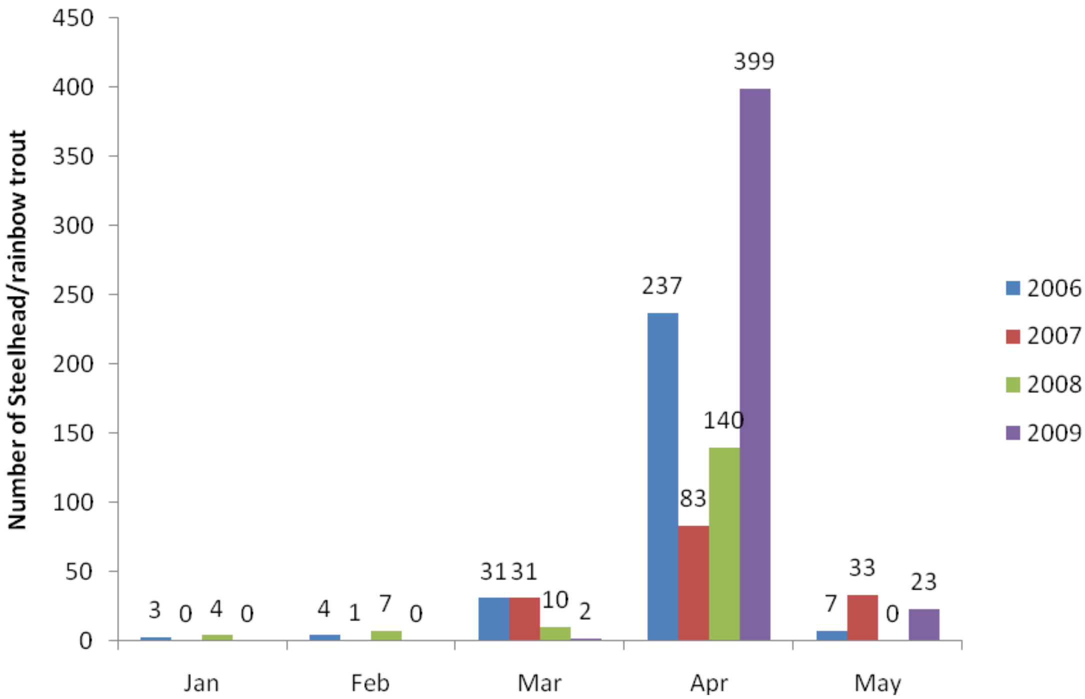

Figure 7. Adult steelhead (hatchery and wild) migrations through the Zosel Dam fish counter for 2006-2009 (Long *et al*. 2006; Benson and Squakin 2008; Columbia River DART 2009).

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 and Miller 2008). These numbers should be subtracted from the numbers presented as Zosel dam counts; however, as mentioned in Arterburn and Miller (2008), enumerations within these creeks has proven difficult due to private land ownership and lack of access to the creeks. The use of the fish counter on Nine Mile Creek, and counts from Tonasket Creek during flow years would be helpful 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. As in 2008, again in 2009 most of the sampling effort was allocated to this stream. Enumeration results provided a count of 20 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. While this year the fish fence did not experience structural failures due to freshet flows, the fence did experience problems associated with the base of the fence. Steelhead/rainbow trout were presumed to have been able to pass under the fence through excavating bed material. For the 2010 field season a better location is required, as well as a structurally sound fish fence so as to meet both the freshet pulse demands on the fence, as well as being able to efficiently trap fish. Despite the flaws of the fish fence, an improved version should continue to be employed as an enumeration technique within Inkaneep Creek.

Population estimates will be calculated for Inkaneep Creek, Vaseux Creek, and the Okanagan River upon further collection of data from within the COB. From improved population data, distribution results will then be possible. While there are estimates from Arterburn and Miller (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 is an ongoing question. The level of interaction between these fish and anadromous steelhead/rainbow trout is currently unknown. Our first data from stable isotope analyses (carbon $\delta^{13}C$ and nitrogen $\delta^{15}N$) showed that *O. mykiss* enumerated in Inkaneep Creek fish fence in 2008 and 2009 was mostly represented by rainbow trout (67 rainbow trout out of 77 fish). 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.

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). Due to budget constraints future steelhead research and management will focus on this tributary. Future studies may include the use of Passive Integrated Transponder (PIT) tag technology, so that passage and timing of Steelhead/rainbow trout will be improved in the Okanagan River, Zosel Dam, and Inkaneep Creek.

5.0 RECOMMENDATIONS

1. Future steelhead surveys should continue to focus on Inkaneep Creek, as this tributary has the strongest spawning run. An improved fish counting fence used in conjunction with improved Zosel Dam counts and/or future PIT tag readers 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 and should be installed with more vertical slots so as to minimize fish passage under the fence.

4. Bio-sample collection and stable isotope analyses should continue in 2010 to move towards better understanding the adfluvial/anadromous interaction and life history of Okanagan steelhead/rainbow trout. Also, sex ratio data should be collected in the future.

5. Redd surveys on all Canadian Okanagan Basin (COB) tributaries and streams should be utilized to determine fish distribution and to strengthen information collected at the fish fence.

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

7. The public should be informed about the reason for the fish fence to help prevent future vandalism. Perhaps a fixed sign on site explaining both the structure and the project would help. In addition, a press release should be produced for the Community of Oliver and for the Osoyoos Indian Band.

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APPENDIX A – 2009 Fish Fence Survey Data

Steelhead Bio-sampling					
Fish #	Length (cm)	Adipose clip	Fin sample	Scale# book-box	Photo #
27950	54.5	N	Y	69472-1	
27951	44	N	Y	69472-2	
27952	45	N	Y	69472-3	
27953	75	N	Y	69472-4	
27954	60	Y	Y	69472-5	129-2377
27955	49.5	N	Y	69473-6	AS photos
27957	56	Y	Y	69472-7	N/A
27959	44	N	Y	69472-8	N/A
					137-2446
N/A	45.5	N/A	N/A	69472-9	137
27960	57.5	N	Y	69472-10	
27961	51	N	Y	69472-11	
27962	51.5	N	Y	69472-12	N/A
27963	51	N	Y	69472-13	Y
27964	47.5	N	N/A	69472-14	Y
27965	52	N	Y	69472-15	N
27992 (?)		N	Y	N/A	Y
27972	44	N	Y		167-blue
27973	37	N	Y		167-blue
27970	53	N	Y	69472-17	N/A
27971	48	N	Y	69472-16	N/A
COUNT	**20**				

APPENDIX B – Carbon and nitrogen isotope data in steelhead and rainbow trout

Sample ID	type	date	$\delta^{15}N_{AIR}$	$\delta^{13}C_{VPDB}$	%N	%C	C/N	% fat	$\delta^{13}C_{VPDB}$ lipid corr. Sweeting
27950	fish fin	spring 2009	15.67	-26.23	14.22	43.69	3.58	0.04	-26.0
27951	fish fin	spring 2009	13.88	-26.39	6.85	23.46	3.99	0.14	-25.6
27952	fish fin	spring 2009	14.15	-26.56	64.85	211.44	3.80	0.10	-26.0
27953	fish fin	spring 2009	11.81	-20.71	12.31	40.14	3.80	0.10	-20.1
27954	fish fin	spring 2009	13.47	-17.81	10.87	32.26	3.46	0.01	-17.8
27955	fish fin	spring 2009	14.13	-25.39	7.28	24.02	3.85	0.11	-24.8
27957	fish fin	spring 2009	10.89	-19.08	9.69	31.38	3.78	0.09	-18.5
27959	fish fin	spring 2009	16.91	-28.06	8.64	32.76	4.42	0.22	-26.7
27960	fish fin	spring 2009	17.25	-25.50	11.32	34.55	3.56	0.03	-25.3
27962	fish fin	spring 2009	15.65	-25.00	9.03	28.22	3.65	0.06	-24.7
27963	fish fin	spring 2009	16.64	-25.29	8.35	26.07	3.64	0.06	-24.9
27964	fish fin	spring 2009	16.78	-24.08	5.30	16.80	3.70	0.07	-23.7
27965	fish fin	spring 2009	16.94	-24.62	6.90	21.77	3.68	0.07	-24.2
27970	fish fin	spring 2009	15.11	-24.54	107.11	341.83	3.72	0.08	-24.1
27971	fish fin	spring 2009	14.89	-25.47	9.91	31.28	3.68	0.07	-25.1
27972	fish fin	spring 2009	14.50	-26.13	7.47	22.91	3.58	0.04	-25.9
27973	fish fin	spring 2009	14.52	-24.95	11.66	34.50	3.45	0.00	-24.9
27992	fish fin	spring 2009	15.44	-25.99	11.14	38.74	4.06	0.15	-25.1
27993	fish fin	spring 2009	11.27	-25.57	7.19	25.92	4.21	0.18	-24.5
36541 01	fish fin	spring 2008	12.26	-19.75	13.31	41.09	3.60	0.05	-19.5
36541 02	fish fin	spring 2008	16.18	-24.23	10.06	32.05	3.72	0.07	-23.8
36541 03	fish fin	spring 2008	12.61	-24.70	7.20	21.78	3.53	0.03	-24.5
36541 03	fish fin	spring 2008	12.68	-24.86	7.42	22.03	3.46	0.01	-24.8
36541 04	fish fin	spring 2008	14.22	-25.44	8.88	27.88	3.66	0.06	-25.1
36541 05	fish fin	spring 2008	11.73	-18.85	10.53	32.01	3.55	0.03	-18.7
36541 06	fish fin	spring 2008	15.63	-24.62	7.65	24.97	3.81	0.10	-24.0
36541 07	fish fin	spring 2008	16.62	-25.43	15.19	45.63	3.50	0.02	-25.3
36541 07a	fish fin	spring 2008	12.09	-20.25	14.45	45.63	3.68	0.07	-19.9
36541 07a	fish fin	spring 2008	12.03	-20.00	14.45	46.70	3.77	0.09	-19.5
36541 08	fish fin	spring 2008	14.56	-26.46	8.83	28.33	3.74	0.08	-26.0

sample ID	type	date	$\delta^{15}N_{AIR}$	$\delta^{13}C_{VPDB}$	%N	%C	C/N	% fat lipid corr.	$\delta^{13}C_{VPDB}$ Sweeting
36541 09	fish fin	spring 2008	15.07	-26.45	10.47	35.06	3.91	0.12	-25.7
36541 10	fish fin	spring 2008	12.51	-18.76	9.18	27.99	3.56	0.03	-18.6
36541 11	fish fin	spring 2008	14.45	-24.50	6.21	21.38	4.01	0.14	-23.6
36541 12	fish fin	spring 2008	17.08	-24.68	11.33	35.36	3.64	0.05	-24.3
36541 13	fish fin	spring 2008	15.62	-26.00	10.87	36.58	3.93	0.12	-25.3
36541 14	fish fin	spring 2008	12.29	-21.39	13.38	46.33	4.04	0.15	-20.5
36541 15	fish fin	spring 2008	16.18	-25.95	10.31	31.02	3.51	0.02	-25.8
36541 16	fish fin	spring 2008	16.69	-22.70	9.89	29.52	3.48	0.01	-22.6
36541 17	fish fin	spring 2008	15.77	-25.80	9.95	32.23	3.78	0.09	-25.3
36541 18	fish fin	spring 2008	14.07	-25.72	10.32	32.07	3.62	0.05	-25.4
36541 19	fish fin	spring 2008	9.87	-19.38	12.16	37.51	3.60	0.04	-19.1
36541 20	fish fin	spring 2008	17.17	-25.12	21.95	65.59	3.49	0.01	-25.0
36541 21	fish fin	spring 2008	14.58	-25.57	8.89	28.37	3.72	0.08	-25.1
36541 22	fish fin	spring 2008	16.98	-24.82	11.16	33.77	3.53	0.03	-24.7
36541 22	fish fin	spring 2008	16.77	-24.67	10.43	32.11	3.59	0.04	-24.4
36541 23	fish fin	spring 2008	16.33	-24.00	9.98	30.38	3.55	0.03	-23.8
36541 23	fish fin	spring 2008	16.43	-24.31	10.28	31.90	3.62	0.05	-24.0
36541 24	fish fin	spring 2008	14.25	-25.14	8.94	29.23	3.81	0.10	-24.5
36541 25	fish fin	spring 2008	14.35	-25.70	8.79	28.12	3.73	0.08	-25.2
36542 01	fish fin	spring 2008	16.95	-25.36	14.78	45.33	3.58	0.04	-25.1
36542 02	fish fin	spring 2008	16.38	-25.83	14.14	46.12	3.81	0.10	-25.3
36542 02	fish fin	spring 2008	16.22	-25.52	9.10	28.92	3.71	0.07	-25.1
36542 03	fish fin	spring 2008	16.29	-24.85	14.73	45.54	3.61	0.05	-24.6
36542 04	fish fin	spring 2008	16.97	-24.24	10.66	33.12	3.63	0.05	-23.9
36542 06	fish fin	spring 2008	16.41	-25.61	14.41	45.10	3.65	0.06	-25.3
36542 07	fish fin	spring 2008	13.76	-24.18	5.94	19.43	3.81	0.10	-23.6
36542 08	fish fin	spring 2008	15.31	-26.17	10.84	34.29	3.69	0.07	-25.8
36542 10	fish fin	spring 2008	15.96	-25.35	13.09	40.52	3.61	0.05	-25.1
36542 10	fish fin	spring 2008	15.78	-25.21	10.61	33.65	3.70	0.07	-24.8
36542 11	fish fin	spring 2008	13.68	-26.00	10.50	32.49	3.61	0.05	-25.7
36542 12	fish fin	spring 2008	15.90	-25.59	11.00	33.69	3.57	0.04	-25.4
36542 13	fish fin	spring 2008	15.27	-24.62	10.01	32.36	3.77	0.09	-24.1
36543 01	fish fin	spring 2008	13.48	-26.17	7.69	25.68	3.90	0.12	-25.5

sample ID	type	date	$\delta^{15}N_{AIR}$	$\delta^{13}C_{VPDB}$	%N	%C	C/N	% fat lipid corr.	$\delta^{13}C_{VPDB}$ Sweeting
36543 02	fish fin	spring 2008	15.71	-25.54	10.06	32.16	3.73	0.08	-25.1
36543 03	fish fin	spring 2008	14.69	-26.53	13.84	44.93	3.79	0.09	-26.0
36543 04	fish fin	spring 2008	16.34	-24.89	9.72	31.38	3.77	0.09	-24.4
36543 05	fish fin	spring 2008	15.54	-26.31	14.36	44.50	3.62	0.05	-26.0
36543 06	fish fin	spring 2008	14.75	-27.23	13.63	45.01	3.85	0.11	-26.6
36543 07	fish fin	spring 2008	13.18	-27.24	11.82	43.19	4.26	0.19	-26.1
36543 08	fish fin	spring 2008	14.80	-24.62	11.71	35.05	3.49	0.02	-24.5
36543 09	fish fin	spring 2008	16.05	-25.00	14.37	43.18	3.51	0.02	-24.9
36543 10	fish fin	spring 2008	14.69	-25.96	9.21	28.22	3.57	0.04	-25.7
36543 11	fish fin	spring 2008	16.26	-25.16	11.43	35.75	3.65	0.06	-24.8
36543 12	fish fin	spring 2008	15.96	-25.49	9.95	30.41	3.57	0.04	-25.3
36543 13	fish fin	spring 2008	14.77	-25.82	8.67	27.24	3.67	0.06	-25.5
36543 14	fish fin	spring 2008	15.85	-26.16	13.54	45.66	3.93	0.13	-25.4
36543 15	fish fin	spring 2008	13.88	-27.53	6.83	24.03	4.10	0.16	-26.6
36543 16	fish fin	spring 2008	14.88	-27.08	13.53	47.12	4.06	0.15	-26.2
36543 17	fish fin	spring 2008	16.43	-25.39	14.30	44.18	3.60	0.05	-25.1
36543 18	fish fin	spring 2008	15.90	-25.92	11.65	40.17	4.02	0.14	-25.1
36543 19	fish fin	spring 2008	16.10	-25.17	11.35	36.56	3.76	0.08	-24.7
36543 20	fish fin	spring 2008	15.13	-27.68	11.46	49.82	5.07	0.32	-25.7
36543 23	fish fin	spring 2008	13.34	-27.43	11.88	43.12	4.23	0.19	-26.3

Appendix 4

LITERATURE BASED ASSESSMENT OF PREDATION BY SMALLMOUTH BASS ON JUVENILE SALMON IN THE OKANOGAN RIVER, WA

Prepared for:
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June 2010

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1.0 Introduction

The Confederated Tribes of the Colville Reservation (CT) requested the development of a literature-based evaluation on the extent of predation on juvenile salmon (Chinook, sockeye, and steelhead) by smallmouth bass (SMB) in the Okanogan River. This activity is being conducted as a component of the Okanogan Basin Monitoring and Evaluation Program (OBMEP) designed to provide population-scale status data for anadromous fish species and their habitats. A literature-based approach for this assessment was developed in lieu of conducting extensive field sampling to estimate the SMB population and quantify predation rates (Jahns and Nass, 2009). This alternate approach is being conducted to provide information to assess the potential magnitude and variability of predation and determine if a field-based project is warranted. The purpose of this report is to estimate the SMB population size, SMB consumption rates of juvenile salmon (JS), and the percentage of JS consumed by SMB as based on existing literature.

For the purpose of this study, the Okanogan River has been divided into three geo-hydraulic strata; 1) Wells Reservoir (including the inundation portion of the Okanogan River up to Chilliwist Creek), 2) Okanogan River at Chilliwist Creek to Zosel Dam, and the Similkameen River to Enlow Dam, and 3) Okanogan River at Zosel Dam to McIntyre Dam (Canada) (Figure 1). Data and estimates within this report apply to Strata 2, which encompasses 118.70 km of the Okanogan River.

2.0 Methods

2.1 Salmon Population

There are three species of salmon, including Chinook, sockeye and steelhead which inhabit Strata 2 of the Okanogan River. Within these species are specific groups of fish including natural origin sub-yearling Chinook, hatchery origin yearling Chinook, natural origin sockeye, hatchery origin sockeye, natural origin steelhead, and hatchery origin steelhead. Each of these groups are described by unique population sizes and migration timing trends, but in general, can be characterized by a combined population of 2.4 – 3.1 million that migrate from April to June (Table 1). All of these JS are of an appropriate size for consumption by SMB and can be anticipated to be present in the diet of those predators.

2.2 Smallmouth Bass Population

Roughly 25,000 SMB, or 211 fish /km (25,000 fish / 118.7 km = 210.6 fish/km), are estimated to be in Strata 2 as based on estimates of >150-mm bass in the lower Yakima River, WA (Fritts and Pearsons, 2006). The lower Yakima is comparable to Strata 2 of the Okanogan River in maximum and minimum discharge profiles, water temperature, and its capability to support salmon populations. An assumption being made in this report is that the SMB population estimate in the Yakima River is representative of Strata 2 in the Okanogan River.

2.3 Consumption Rates

We conducted a literature review to summarize the consumption of JS by SMB in Washington to determine 1) the extent to which this topic has been investigated, 2) the location of these studies, and 3) the mean number of salmon consumed daily per SMB (Table 2). Many values in Table 2 were not presented in the papers, so they were calculated from the data. The specific calculations are explained in the notes section of Table 2. Most papers described their sampling periods, but few indicated the months in which SMB were and were not caught, or the time period in which they consumed JS. If consumption periods were present in a paper, then the 'mean number of salmon consumed daily per SMB' was calculated. Without this data, the 'mean number of salmon consumed daily per SMB' was calculated using a mean JS migration period of 90 days (Table 1). The range of salmon consumed daily per SMB provided by the literature (0.004-1.400) is wide when its' relative impact on consumption estimates is considered. In Tabor et al. 1993, sampling only occurred on four days and the 90 day calculation was not used. As these four days of sampling took place during the height of JS migration, the associated values represent the upper bound of consumption. An assumption being made in this report is that consumption rates within water bodies throughout Washington are representative of Strata 2 in the Okanogan River.

Methods for calculating consumption estimates varied in the literature and included a bioenergetics model and three different forms of a meal turnover calculation. The bioenergetics model is a calorie intake based model and run in the Fish Bioenergetic 3.0 program (Hanson et al. 1997). The meal turnover method is based on time of digestion and can vary slightly from one researcher to the next (Meal turnover methods 1, 2, 3 in Table 2). An assumption being made in this report is that no method used to estimate consumption is considered more accurate than another.

2.4 Consumption Estimate

The 'mean number of salmon consumed daily per SMB' from each literature source and a range of SMB population estimates were used to calculate potential numbers of individual salmon consumed by SMB in Strata 2 (Table 3). Plausible ranges of SMB population sizes above and below 25,000 are included in the table. The 'mean number of salmon consumed daily per SMB' from each source was also used to graph estimates of JS consumed by assuming a SMB population of 25,000 (Figure 2). The variability in the rate of salmon consumed daily per SMB provided by the literature results in a substantial range of the potential number of JS consumed.

2.5 Percent JS Consumption

For the purposes of analysis, an overall mean number of salmon consumed daily per SMB was calculated from the individual means presented or derived from the literature, and was used to calculate potential numbers of individual salmon consumed by SMB in Strata 2 (Table 3). Consumption estimates were compared with an estimated range of migrating JS (Table 1) to calculate a range of percent JS consumed by SMB in Strata 2 (Table 4).

3.0 Results

Assuming the mean estimate of JS consumption by SMB and the estimate of SMB population density from the Yakima River can be applied to Strata 2 of the Okanogan River, and that methods for estimating consumption rates are comparable between studies, a SMB population of 25,000 would consume approximately 506,097 JS during the 90 day migration period (Table 3). This consumption rate is approximately 18% of the potentially 2,750,000 (Table 1, (2,414,000+3,121,000)/2) out-migrating JS (Table 4).

Ranges of the potential SMB population and respective SMB consumption of JS (Table 3), and the migrating JS population (Table 4) provide the reader with an opportunity to investigate other plausible calculation outcomes. For example, if the SMB population was 9,000 then the estimated number of JS consumed would be 182,195 or approximately 7% of a migrating population of 2,750,000 JS (Table 4).

Similarly, we can also infer how an adjustment in the consumption rate effects total consumption. Figure 2 illustrates estimated JS consumption by a SMB population of 25,000 as calculated for each daily consumption estimate presented or derived from the literature. Total consumption ranges between 6,100 JS using a daily rate of 0.004 and 2,135,000 using a daily rate of 1.4.

The mostly likely scenario to illustrate Strata 2 of the Okanogan River may be achieved by selecting the most representative parameters from the literature. For example, two of the of the six sources analyzed for calculating JS consumption took place in the lower 68 km of the Yakima River. This river is more comparable to Strata 2 of the Okanogan River than the other water bodies for which information is available (as based on physical and hydraulic characteristics) and an individual river to river comparison may be worthwhile. To do so, the mean of 'Mean number of salmon consumed daily per SMB' was calculated (Table 5, Figure 3) and the percent JS consumed determined (Table 6) using only data from Fritts and Pearsons (2004) and Fritts and Pearsons (2006), as opposed to using all sources (Table 3, Figure 2, and Table 4). Assuming that estimates of JS consumption by SMB and estimates of the SMB population from the lower 68 km of the Yakima River can be applied to Strata 2 of the Okanogan River, then Strata 2 is likely to have a SMB population of 25,000 which consumes approximately 474,057 (Table 5) JS during the 90 day migration period. This consumption is approximately 17% (Table 6) of the potentially 2,750,000 (Table 1) out-migrating JS.

Given the relatively wide range in the potential value of input parameters for calculating total JS consumption by bass, it appears that the actual magnitude of predation occurring in Strata 2 of the Okanogan is difficult to accurately estimate from literature values. In order to be confident in an estimate of predation, the CT would need to validate the input parameters by additional supporting data. Alternatively, the CT could resign to making potentially invalid assumptions to estimate predation.

4.0 References

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Tabor R.A., R.S. Shively, and T.P. Poe. 1993. Predation on juvenile salmonids by smallmouth bass and northern squawfish in the Columbia River near Richland, Washington. North American Journal of Fisheries Management. 13:831–838.

Tabor, R. A., B. A. Footen, K. L. Fresh, M. T. Celedonia, F. Mejial, D. L. Lowe, and L. K. Park. 2007. Predation of juvenile Chinook salmon and other salmonids by smallmouth bass and largemouth bass in the Lake Washington Basin. North American Journal of Fisheries Management. 27(4):1174-1188.

5.0 Tables and Figures

Figure 1. Three primary strata of the Okanogan River.

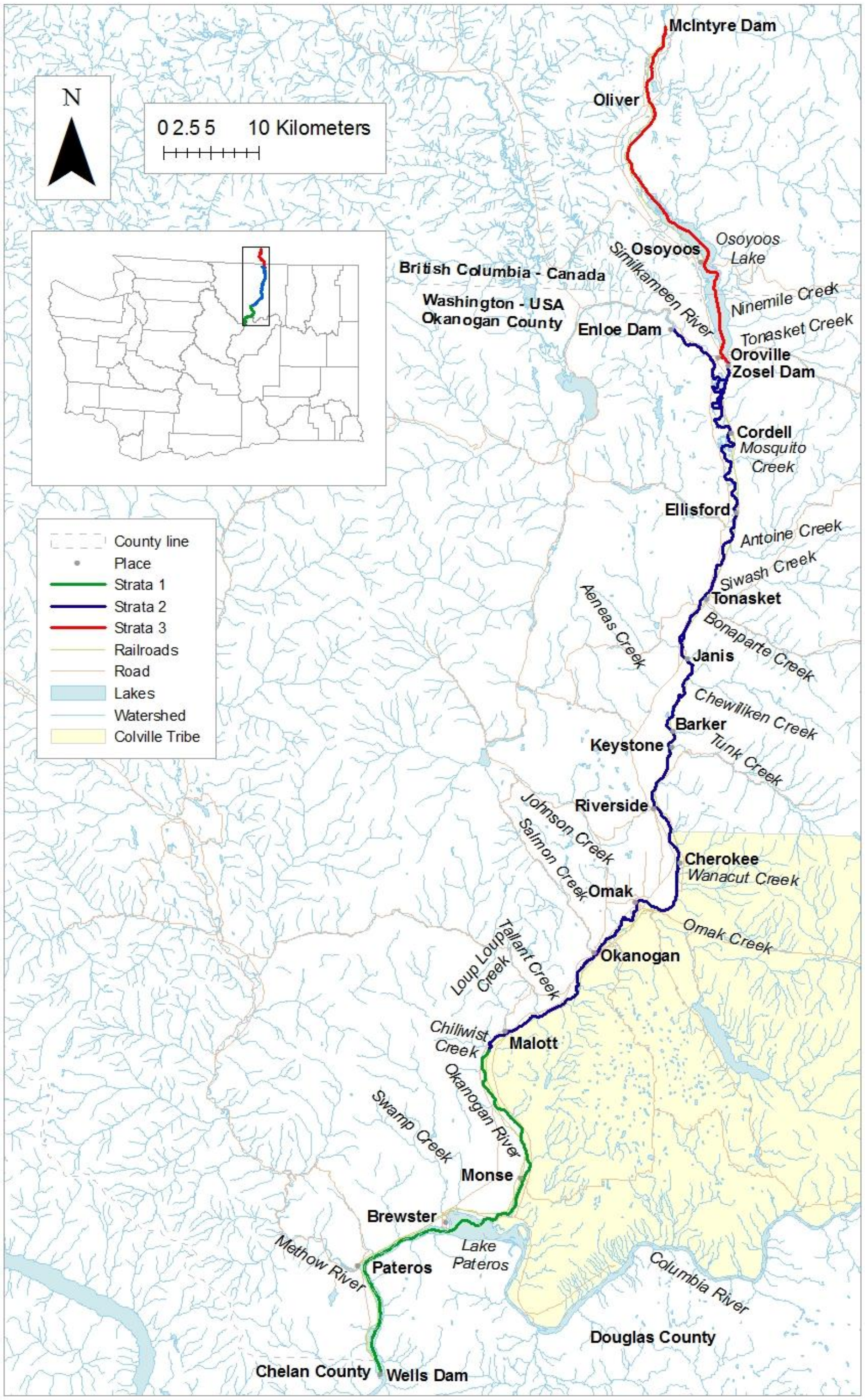

Table 1. Juvenile Salmon of the Okanogan River (Johnson and Rayton 2007, Rayton and Arterburn 2008).

Characteristic / Species	Sub-yearling Chinook	Yearling Chinook	Sockeye	Sockeye	Steelhead	Steelhead	Total
Origin	natural origin, summer run, Similkameen	hatchery origin, summer run, Similkameen	natural origin, Osoyoos Lake	hatchery origin, Skaha Lake	natural origin, Okanogan	hatchery origin, Okanogan	
Population Size	400,000-1,100,000	270,000	1,500,000	140,000	7,000-14,000	97,000	2,414,000-3,121,000
Migration Timing	May-June	late April-early June	May	April	mid April-mid June	May	90 days

Table 2. Estimated consumption of salmon by Smallmouth bass in water bodies throughout Washington.

Source	Year(s) sampled	Water body	Salmon prey species	SMB population estimate	Sample period	Days in sampling period(s)	Consumption estimate calculation method	Size of SMB sampled	Number of SMB stomach examined	SMB population consumption estimate	Mean number of salmon consumed per SMB	Mean number of salmon consumed daily per SMB	Percent salmon of diet by weight	Other important findings
Fayram and Sibley 2000	1995	Lake Washington, WA	Chinook, coho, steelhead	807 - 27,463	March–Sept	214[3]	Bioenergetics model	> 150 mm TL	82	87,792 - 258,139	6.4[7]	0.071[9]	38% Apr-Jun	
	1995	Lake Washington navigation canal, WA	Chinook, coho, steelhead	9,360	March–Sept	214[3]	Bioenergetics model	> 150 mm TL	82	258,139	8.8 7	0.098[9]	38% Apr-Jun	
Fritts and Pearsons 2004	1998-2001	Yakima River, WA	Chinook, steelhead, coho	3,347 (March) - 1,9438 (June)	Late March - June	98[3]	Meal turnover 1	> 150 mm FL	3,159	1630.75[5] (March) - 29572.5[5] (June)	0.49[8] (March) - 1.52[8] (June)	0.005[9] (March) -0.017[9] (June)		Consumption quickly rose in early May to peak in late May, declined through mid-June
Fritts and Pearsons 2006	1998	Yakima River, WA	Chinook, Coho, steelhead	3757[1]	March–June	122[3]	Meal turnover 1	> 150 mm FL	438[4]	273180[6]	72.71[8]	0.808[9]		150–199 mm consumed most salmon
	1999	Yakima River, WA	Chinook, Coho, steelhead	3757[1]	March–June	122[3]	Meal turnover 1	> 150 mm FL	1252[4]	96951[6]	25.81[8]	0.287[9]		200–249 mm consumed most salmon
	2000	Yakima River, WA	Chinook, Coho, steelhead	3757[1]	March–June	122[3]	Meal turnover 1	> 150 mm FL	1026[4]	107360[6]	28.58[8]	0.318[9]		150–199 mm consumed most salmon

Source	Year(s) sampled	Water body	Salmon prey species	SMB population estimate	Sample period	Days in sampling period(s)	Consumption estimate calculation method	Size of SMB sampled	Number of SMB stomach examined	SMB population consumption estimate	Mean number of salmon consumed per SMB	Mean number of salmon consumed daily per SMB	Percent salmon of diet by weight	Other important findings
	2001	Yakima River, WA	Chinook, Coho, steelhead	3757 [1]	March–June	122 [3]	Meal turnover 1	> 150 mm FL	434 [4]	128635 [6]	34.24 [8]	0.380 [9]		150–199 mm consumed most salmon
	2002	Yakima River, WA	Chinook, Coho, steelhead	3757 [1]	March–June	122 [3]	Meal turnover 1	> 150 mm FL	985 [4]	122035 [6]	32.48 [8]	0.361 [9]		150–199 mm consumed most salmon
Naughton et al 2004	1996	Lower Granite Reservoir, Snake River, WA & ID	Chinook (18%), steelhead (82%)	18734 [2]	April - August	153 [3]	Meal turnover 2	> 175 mm FL	3,589	6,728	0.36 [8]	0.004 [9]	< 11%	JS consumption was highest in June
	1997	Lower Granite Reservoir, Snake River, WA & ID	Chinook (59%), steelhead (41%)	18734 [2]	April - August	153 [3]	Meal turnover 2	> 175 mm FL	5,020	10,809	0.58 [8]	0.006 [9]	< 11%	JS consumption was highest in August
Tabor et al. 1993	1990	Columbia River, WA	Chinook (100%)	x	May 2-3	2	Meal turnover 3	> 200 mm FL	60	x	x	1.400 [10]	59%	
	1990	Columbia River, WA	Chinook (100%)	x	June 20-21	2	Meal turnover 3	> 200 mm FL	60	x	x	1.000 [10]	59%	
Tabor et al. 2007	1999	Lake Washington Ship Canal, WA	Chinook (37%), coho, sockeye	3,388	April to July	122 [3]	Bioenergetics model	> 100 mm FL	508	27,262	8.05 [8]	0.089 [9]		200–299-mm FL class had highest salmonid diet percentage (54% by weight)
	1999	Lake Washington Ship Canal, WA	Chinook (37%), coho, sockeye	3,388	April to July	122 [3]	Meal turnover 2	> 100 mm FL	508	41,115	12.14 [8]	0.134 [9]		200–299-mm FL class had highest salmonid diet percentage (54% by weight)

[1] Values obtained from adding together 'Mean estimated abundances' in Table 4 of article.
[2] Value obtained from adding together 'N' in Table 1 of article.
[3] Estimated number of days based on vague descriptions of sampling time periods.
[4] Value obtained from adding together 'Size-groups' in Table 1 of article for respective year.
[5] Values obtained from adding together species and years for March and June in Table 10 of article.
[6] Value obtained from adding together 'Size-groups' in Table 3 of article for respective year.
[7] Values obtained from weight produced by the bienergetics model and assuming the average juvenile salmon weighs 12 g.
[8] Calculated as: (SMB population consumption estimate)/(SMB population estimate).
[9] Calculated as: (Mean # of salmon consumed per SMB)/(90 days of salmon migration).
[10] Example of upper bound as these two day periods are during peak migration

Table 3. Estimated juvenile salmon consumption in the Okanogan River over a range of smallmouth bass populations (Fritts and Pearsons 2006) during the 90 day JS migration period (Table 1). These values are calculated based on consumption estimates in other Washington water bodies (Table 2). Numbers in bold indicate the means.

Source	Year(s) sampled	Water body	Consumption estimate calculation method	Mean no. salmon consumed daily per SMB	Estimated number of Okanogan River JS consumed by a range of SMB populations																
					9000	11000	13000	15000	17000	19000	21000	23000	**25000**	27000	29000	31000	33000	35000	37000	39000	41000
Naughton et al 2004	1996	Lower Granite Reservoir, Snake River, WA and ID	Meal turnover 2	0.004	2196	2684	3172	3660	4148	4636	5124	5612	6100	6588	7076	7564	8052	8540	9028	9516	10004
Fritts and Pearsons 2004	1998-2001	Lower 68 km of the Yakima River, WA	Meal turnover 1	0.005	2745	3355	3965	4575	5185	5795	6405	7015	7625	8235	8845	9455	10065	10675	11285	11895	12505
Naughton et al 2004	1997	Lower Granite Reservoir, Snake River, WA and ID	Meal turnover 2	0.006	3294	4026	4758	5490	6222	6954	7686	8418	9150	9882	10614	11346	12078	12810	13542	14274	15006
Fritts and Pearsons 2004	1998-2001	Lower 68 km of the Yakima River, WA	Meal turnover 1	0.017	9333	11407	13481	15555	17629	19703	21777	23851	25925	27999	30073	32147	34221	36295	38369	40443	42517
Fayram and Sibley 2000	1995	Lake Washington, WA	Bioenergetics model	0.071	38979	47641	56303	64965	73627	82289	90951	99613	108275	116937	125599	134261	142923	151585	160247	168909	177571
Tabor et al. 2007	1999	Lake Washington Ship canal, WA	Bioenergetics model	0.089	48861	59719	70577	81435	92293	103151	114009	124867	135725	146583	157441	168299	179157	190015	200873	211731	222589
Fayram and Sibley 2000	1995	Lake Washington navigation canal, WA	Bioenergetics model	0.098	53802	65758	77714	89670	101626	113582	125538	137494	149450	161406	173362	185318	197274	209230	221186	233142	245098
Tabor et al. 2007	1999	Lake Washington Ship canal, WA	Meal turnover 2	0.134	73566	89914	106262	122610	138958	155306	171654	188002	204350	220698	237046	253394	269742	286090	302438	318786	335134
Fritts and Pearsons 2006	1999	Lower 68 km of the Yakima River	Meal turnover 1	0.287	157563	192577	227591	262605	297619	332633	367647	402661	437675	472689	507703	542717	577731	612745	647759	682773	717787

Source	Year(s) sampled	Water body	Consumption estimate calculation method	Mean no. salmon consumed daily per SMB	Estimated number of Okanogan River JS consumed by a range of SMB populations																
					9000	11000	13000	15000	17000	19000	21000	23000	**25000**	27000	29000	31000	33000	35000	37000	39000	41000
Fritts and Pearsons 2006	2000	Lower 68 km of the Yakima River	Meal turnover 1	0.318	174582	213378	252174	290970	329766	368562	407358	446154	484950	523746	562542	601338	640134	678930	717726	756522	795318
Mean				**0.332**	182195	222683	263170	303658	344146	384633	425121	465609	**506097**	546584	587072	627560	668048	708535	749023	789511	829999
Fritts and Pearsons 2006	2002	Lower 68 km of the Yakima River	Meal turnover 1	0.361	198189	242231	286273	330315	374357	418399	462441	506483	550525	594567	638609	682651	726693	770735	814777	858819	902861
Fritts and Pearsons 2006	2001	Lower 68 km of the Yakima River	Meal turnover 1	0.380	208620	254980	301340	347700	394060	440420	486780	533140	579500	625860	672220	718580	764940	811300	857660	904020	950380
Fritts and Pearsons 2006	1998	Lower 68 km of the Yakima River	Meal turnover 1	0.808	443592	542168	640744	739320	837896	936472	1035048	1133624	1232200	1330776	1429352	1527928	1626504	1725080	1823656	1922232	2020808
Tabor et al. 1993	1990	Columbia River, WA	Meal turnover 3	1.000	549000	671000	793000	915000	1037000	1159000	1281000	1403000	1525000	1647000	1769000	1891000	2013000	2135000	2257000	2379000	2501000
Tabor et al. 1993	1990	Columbia River, WA	Meal turnover 3	1.400	768600	939400	1110200	1281000	1451800	1622600	1793400	1964200	2135000	2305800	2476600	2647400	2818200	2989000	3159800	3330600	3501400

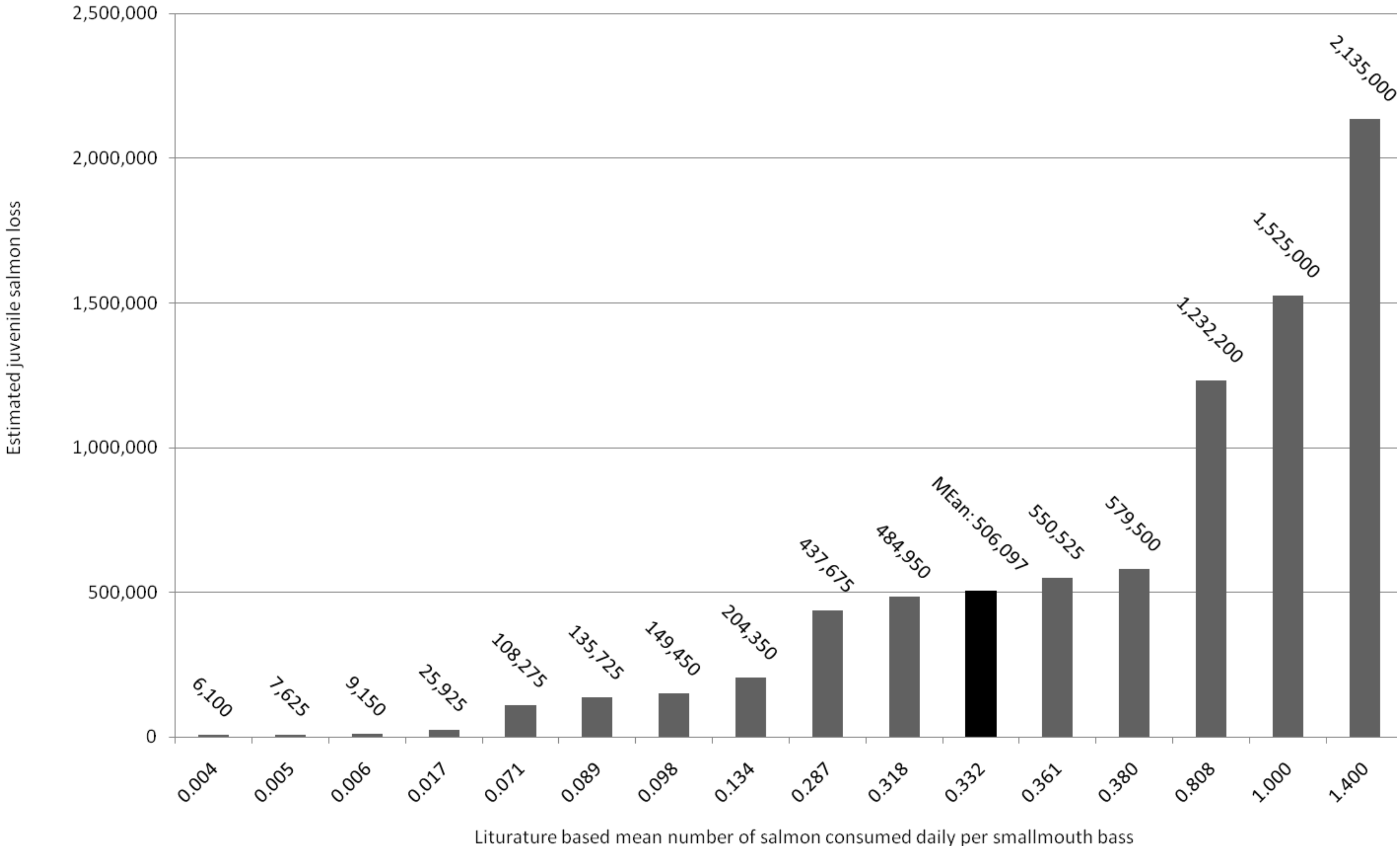

Figure 2. Estimated total juvenile salmon consumption by SMB in the Okanogan River over a range of individual predator daily consumption calculated from water bodies throughout Washington (Table 3). This model is based on a predicted population of 25,000 smallmouth bass (Fritts and Pearsons 2006) in the Okanogan River for the 90 day migration season (Table 1).

Table 4. Percent salmon consumption in the Okanogan River. These values are calculated from an estimated range of number of migrating JS (Table 1) and estimated SMB populations (Fritts and Pearsons 2006) with associated mean salmon consumption estimates from water bodies throughout Washington (Table 3). Numbers in bold indicate the means.

Estimated number of migrating JS	**SMB populations (top number) and associated number of salmon consumed (bottom number)**																
	9000	11000	13000	15000	17000	19000	21000	23000	**25000**	27000	29000	31000	33000	35000	37000	39000	41000
	182195	222683	263170	303658	344146	384633	425121	465609	**506097**	546584	587072	627560	668048	708535	749023	789511	829999
2350000	7.8	9.5	11.2	12.9	14.6	16.4	18.1	19.8	21.5	23.3	25.0	26.7	28.4	30.2	31.9	33.6	35.3
2400000	7.6	9.3	11.0	12.7	14.3	16.0	17.7	19.4	21.1	22.8	24.5	26.1	27.8	29.5	31.2	32.9	34.6
2450000	7.4	9.1	10.7	12.4	14.0	15.7	17.4	19.0	20.7	22.3	24.0	25.6	27.3	28.9	30.6	32.2	33.9
2500000	7.3	8.9	10.5	12.1	13.8	15.4	17.0	18.6	20.2	21.9	23.5	25.1	26.7	28.3	30.0	31.6	33.2
2550000	7.1	8.7	10.3	11.9	13.5	15.1	16.7	18.3	19.8	21.4	23.0	24.6	26.2	27.8	29.4	31.0	32.5
2600000	7.0	8.6	10.1	11.7	13.2	14.8	16.4	17.9	19.5	21.0	22.6	24.1	25.7	27.3	28.8	30.4	31.9
2650000	6.9	8.4	9.9	11.5	13.0	14.5	16.0	17.6	19.1	20.6	22.2	23.7	25.2	26.7	28.3	29.8	31.3
2700000	6.7	8.2	9.7	11.2	12.7	14.2	15.7	17.2	18.7	20.2	21.7	23.2	24.7	26.2	27.7	29.2	30.7
2750000	6.6	8.1	9.6	11.0	12.5	14.0	15.5	16.9	**18.4**	19.9	21.3	22.8	24.3	25.8	27.2	28.7	30.2
2800000	6.5	8.0	9.4	10.8	12.3	13.7	15.2	16.6	18.1	19.5	21.0	22.4	23.9	25.3	26.8	28.2	29.6
2850000	6.4	7.8	9.2	10.7	12.1	13.5	14.9	16.3	17.8	19.2	20.6	22.0	23.4	24.9	26.3	27.7	29.1
2900000	6.3	7.7	9.1	10.5	11.9	13.3	14.7	16.1	17.5	18.8	20.2	21.6	23.0	24.4	25.8	27.2	28.6
2950000	6.2	7.5	8.9	10.3	11.7	13.0	14.4	15.8	17.2	18.5	19.9	21.3	22.6	24.0	25.4	26.8	28.1
3000000	6.1	7.4	8.8	10.1	11.5	12.8	14.2	15.5	16.9	18.2	19.6	20.9	22.3	23.6	25.0	26.3	27.7
3050000	6.0	7.3	8.6	10.0	11.3	12.6	13.9	15.3	16.6	17.9	19.2	20.6	21.9	23.2	24.6	25.9	27.2
3100000	5.9	7.2	8.5	9.8	11.1	12.4	13.7	15.0	16.3	17.6	18.9	20.2	21.5	22.9	24.2	25.5	26.8
3150000	5.8	7.1	8.4	9.6	10.9	12.2	13.5	14.8	16.1	17.4	18.6	19.9	21.2	22.5	23.8	25.1	26.3

Table 5. Estimated juvenile salmon consumption in the Okanogan River over a range of smallmouth bass populations (Fritts and Pearsons 2006) during the 90 day JS migration period (Table 1). These values are calculated based on consumption estimates in the lower 68 km of the Yakima River (Table 2). Numbers in bold indicate the means.

Source	**Year(s) sampled**	**Consumption estimate calculation method**	**Mean number of salmon consumed daily per SMB**	**Estimated number of Okanogan River JS consumed by a range of SMB populations**																
				9000	11000	13000	15000	17000	19000	21000	23000	**25000**	27000	29000	31000	33000	35000	37000	39000	41000
Fritts and Pearsons 2004	1998-2001	Meal turnover 1	0.005	2745	3355	3965	4575	5185	5795	6405	7015	7625	8235	8845	9455	10065	10675	11285	11895	12505
Fritts and Pearsons 2004	1998-2001	Meal turnover 1	0.017	9333	11407	13481	15555	17629	19703	21777	23851	25925	27999	30073	32147	34221	36295	38369	40443	42517
Fritts and Pearsons 2006	1999	Meal turnover 1	0.287	157563	192577	227591	262605	297619	332633	367647	402661	437675	472689	507703	542717	577731	612745	647759	682773	717787
Mean			**0.311**	170661	208585	246510	284434	322359	360283	398208	436133	**474057**	511982	549906	587831	625755	663680	701605	739529	777454
Fritts and Pearsons 2006	2000	Meal turnover 1	0.318	174582	213378	252174	290970	329766	368562	407358	446154	484950	523746	562542	601338	640134	678930	717726	756522	795318
Fritts and Pearsons 2006	2002	Meal turnover 1	0.361	198189	242231	286273	330315	374357	418399	462441	506483	550525	594567	638609	682651	726693	770735	814777	858819	902861
Fritts and Pearsons 2006	2001	Meal turnover 1	0.380	208620	254980	301340	347700	394060	440420	486780	533140	579500	625860	672220	718580	764940	811300	857660	904020	950380
Fritts and Pearsons 2006	1998	Meal turnover 1	0.808	443592	542168	640744	739320	837896	936472	1035048	1133624	1232200	1330776	1429352	1527928	1626504	1725080	1823656	1922232	2020808

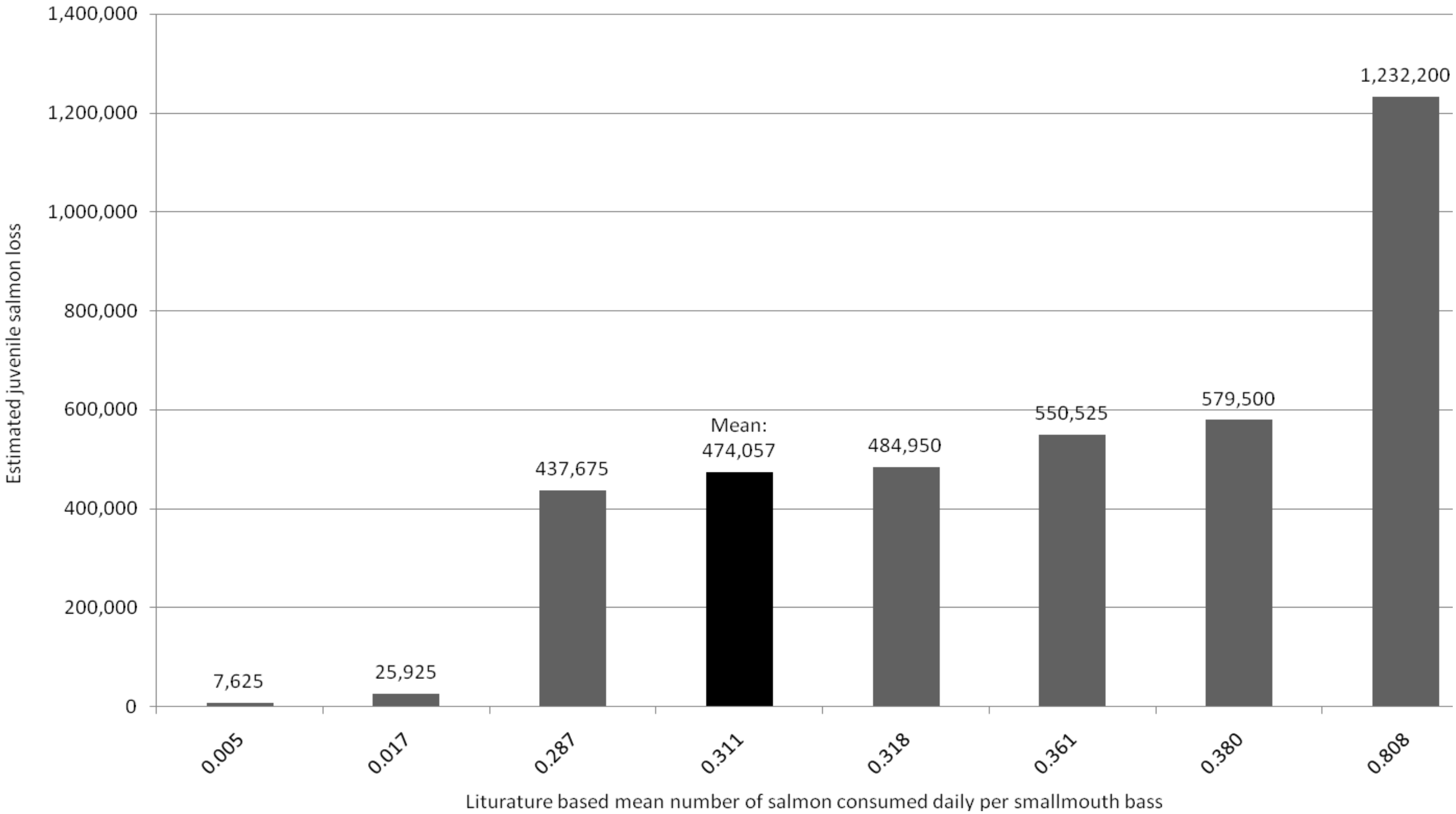

Figure 3. Estimated total juvenile salmon consumption by SMB in the Okanogan River over a range of individual predator daily consumption in the lower 68 km of the Yakima River (Table 5). This model is based on a predicted population of 25,000 smallmouth bass (Fritts and Pearsons 2006) in the Okanogan River for the 90 day migration season (Table 1).

Table 6. Percent salmon consumption in the Okanogan River. These values are calculated from an estimated range of number of migrating JS (Table 1) and estimated SMB populations (Fritts and Pearsons 2006) with associated mean salmon consumption estimates from the lower 68 km of the Yakima River (Table 5). Numbers in bold indicate the means.

Estimated number of migrating JS	**Percent salmon consumed by SMB populations (top number) and associated number of salmon consumed (bottom number)**																
	9000	11000	13000	15000	17000	19000	21000	23000	**25000**	27000	29000	31000	33000	35000	37000	39000	41000
	170661	208585	246510	284434	322359	360283	398208	436133	**474057**	511982	549906	587831	625755	663680	701605	739529	777454
2350000	7.3	8.9	10.5	12.1	13.7	15.3	16.9	18.6	20.2	21.8	23.4	25.0	26.6	28.2	29.9	31.5	33.1
2400000	7.1	8.7	10.3	11.9	13.4	15.0	16.6	18.2	19.8	21.3	22.9	24.5	26.1	27.7	29.2	30.8	32.4
2450000	7.0	8.5	10.1	11.6	13.2	14.7	16.3	17.8	19.3	20.9	22.4	24.0	25.5	27.1	28.6	30.2	31.7
2500000	6.8	8.3	9.9	11.4	12.9	14.4	15.9	17.4	19.0	20.5	22.0	23.5	25.0	26.5	28.1	29.6	31.1
2550000	6.7	8.2	9.7	11.2	12.6	14.1	15.6	17.1	18.6	20.1	21.6	23.1	24.5	26.0	27.5	29.0	30.5
2600000	6.6	8.0	9.5	10.9	12.4	13.9	15.3	16.8	18.2	19.7	21.2	22.6	24.1	25.5	27.0	28.4	29.9
2650000	6.4	7.9	9.3	10.7	12.2	13.6	15.0	16.5	17.9	19.3	20.8	22.2	23.6	25.0	26.5	27.9	29.3
2700000	6.3	7.7	9.1	10.5	11.9	13.3	14.7	16.2	17.6	19.0	20.4	21.8	23.2	24.6	26.0	27.4	28.8
2750000	6.2	7.6	9.0	10.3	11.7	13.1	14.5	15.9	**17.2**	18.6	20.0	21.4	22.8	24.1	25.5	26.9	28.3
2800000	6.1	7.4	8.8	10.2	11.5	12.9	14.2	15.6	16.9	18.3	19.6	21.0	22.3	23.7	25.1	26.4	27.8
2850000	6.0	7.3	8.6	10.0	11.3	12.6	14.0	15.3	16.6	18.0	19.3	20.6	22.0	23.3	24.6	25.9	27.3
2900000	5.9	7.2	8.5	9.8	11.1	12.4	13.7	15.0	16.3	17.7	19.0	20.3	21.6	22.9	24.2	25.5	26.8
2950000	5.8	7.1	8.4	9.6	10.9	12.2	13.5	14.8	16.1	17.4	18.6	19.9	21.2	22.5	23.8	25.1	26.4
3000000	5.7	7.0	8.2	9.5	10.7	12.0	13.3	14.5	15.8	17.1	18.3	19.6	20.9	22.1	23.4	24.7	25.9
3050000	5.6	6.8	8.1	9.3	10.6	11.8	13.1	14.3	15.5	16.8	18.0	19.3	20.5	21.8	23.0	24.2	25.5
3100000	5.5	6.7	8.0	9.2	10.4	11.6	12.8	14.1	15.3	16.5	17.7	19.0	20.2	21.4	22.6	23.9	25.1
3150000	5.4	6.6	7.8	9.0	10.2	11.4	12.6	13.8	15.0	16.3	17.5	18.7	19.9	21.1	22.3	23.5	24.7

Appendix 5

DRAFT STUDY PLAN FOR THE

ASSESSMENT OF PREDATION ON JUVENILE SALMON IN THE OKANOGAN RIVER, WA

Prepared for:
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1.0 INTRODUCTION

The Confederated Tribes of the Colville Reservation (CCT) requested the development of a study plan to assess the extent of predation on juvenile salmon (Chinook, Sockeye, and Steelhead) by resident fish and birds of the Okanogan River (i.e., Predation Assessment Program, or PAP). The development of this study is a component of the Okanogan Basin Monitoring and Evaluation Program (OBMEP) designed for providing population scale status data for all anadromous fish species and their habitats.

Predation by fish and birds on juvenile salmon has been intensively studied in the Columbia River Basin (Fritts and Pearsons, 2006; Naughton and Bennett 2003; Antolos et. al 2005; Ruggerone 1986) to ascertain the relative impact on early life-history survival in the hydro-system. Listing of several basin stocks under the Endangered Species Act (ESA) and the substantial funding directed toward rebuilding depressed runs has resulted in a concerted effort to evaluate predatory mortality. In some cases, management actions have included the direct take of predators in an attempt to minimize the impact on juvenile salmon populations (Jerald 2003; Jerald 2005; Turner et al. 2005; Turner et al. 2006). Similarly, the impact of predators on juvenile salmon populations in the Okanogan River is of interest to managers, however a comprehensive study has never been conducted in that region. To address this gap in information, the CCT have proposed to conduct a study to assess the relative magnitude of predation on juvenile salmon stocks of the Okanogan Basin.

The Okanogan River Basin and the adjacent waters of Wells Dam Reservoir (Columbia River) are inhabited by a variety of potential fish and bird predators. There are select species of high enough abundance to potentially consume a substantial number of juvenile salmon. In particular, piscivorous fish include smallmouth bass (SMB), northern pikeminnow (NPM), and walleye and birds include gulls and cormorants (Douglas PUD, 2006). The primary objective of PAP is to quantify the consumption of juvenile salmon so that it may be assessed relative to juvenile salmon abundance. Therefore, the general hypothesis for the program is that juvenile salmon are being consumed by fish and birds in the area extending from Wells Dam to McIntyre Dam on the Okanogan River. More specifically, PAP will quantify and evaluate the magnitude of predation on juvenile salmon.

The approach to achieving the objective of PAP is to partition the study area into geo-hydraulic strata and the predators by class (fish, birds) so that manageable and directed effort can be prioritized. The program is to be implemented in stages as based on funding, information needs, and logistical considerations. For the purpose of this study, and potential future studies, there are three primary strata in the study area; 1) Wells Reservoir (including the inundation portion of the Okanogan River up to Chilliwist Creek), 2) Okanogan River at Chilliwist Creek to Zosel Dam and the Similkameen River to Enlow Dam, and 3) Okanogan River at Zosel Dam to McIntyre Dam (Canada) (Figure 1).

There are five primary tasks of PAP:

1. Determine a reach stratified population estimate and size distribution for predators (fish, birds) of juvenile salmon.
2. Assess the reach stratified abundance of juvenile salmon by year class (young of year and yearling) in the stomachs of predators in order to assess the presence and timing of salmon and other food items in their diet.
3. Apply reach stratified predator stomach content analysis to the reach stratified predator population estimate to determine the relative consumption of juvenile salmon.
4. Compare estimated total juvenile consumption to juvenile population estimates to assess the relative take by predators.
5. Provide recommendations for management of predator species.
6. Identify potential data gaps related to evaluating predation of juvenile salmon within Okanagan River.

This document presents the overarching goals of PAP and details the implementation activities of stage one to be conducted in the summers of 2010, 2011, and 2012. More specifically, a pilot study in Strata 2 will occur in the first year with focused research activities in the second and third years. The rationale for beginning in this area and with this class of predator is based on the assumption that the populations of predator and salmon are the most concentrated and likely to overlap in space and time. Juvenile salmon production in the Okanogan Basin originates in Strata 2 and 3, and anecdotal evidence suggests two primary fish predators, SMB and NPM, reside in Strata 2 (Johnson et. al 2008; Colville Tribes, 2001, 2002). Consumption by other predatory fish is negligible and will not be considered in this strata. Research on fish predators and research in Strata 1 and 3 will take place in the future as separate stages, as will research on bird predators in all three strata.

2.0 TECHNICAL PROPOSAL

Stage one of PAP, as defined above by geo-hydraulic strata, class of predator, and biological rationale will address the hypothesis that juvenile salmon are being consumed by piscivorous fish in Strata 2 of the study area. The relative effect of data resulting in acceptance of this hypothesis will be evaluated by comparing total predation (number of juveniles) to estimates of their respective population estimate. It is anticipated that juvenile salmon predation will be assessed by species and year class. While there does not exist rigorous estimates of the juvenile salmon populations, best estimates will be derived from existing information on spawner populations and their potential production.

In each year of the study, specific objectives and questions will be addressed. The focus of the pilot year to asses methods and gather qualitative population and consumption data in order to fine tune effort, procedures, and schedule for use in the following years. With each year, increasing focus will be placed on areas of the river with a high population of predator in order to increase precision of population and consumption estimates. Objectives and questions to be addressed in stage one are as follows:

Pilot year - 2010

1. Assess population of NPM and SMB within Strata 2.
   - What is the relative abundance and distribution of predators?
   - Which reaches have the greatest relative abundance of predators?
   - What is the extent of predator movement?
2. Observe stomach contents of NPM and SMB within Strata 2.
   - When do the predators begin consuming juvenile salmon?
   - What other animals are being consumed?
   - What is the frequency of observing a predator with an empty stomach?
3. Determine effectiveness of proposed methods and schedule within Strata 2.
   - Is electroshocking sufficiently effective during times of increased flow and turbidity?
   - Will other gears be necessary?
   - Are there periods of time throughout the study period when sampling for population and/or stomach content assessment is not feasible?
   - What level of effort is required to adequate sample Strata 2?
   - Based on the collected data, will an adequate number of fish be caught to facilitate population and consumption estimates in 2011 when focus on specific reaches are altered.
   - What is the extent of predator movement and will the proposed population estimate methods need to be altered accordingly?

Study year one - 2011

1. Assess population of NPM and SMB within Strata 2.
   - What is the estimated abundance and distribution of predators?
   - Which reaches have the greatest estimated abundance of predators?
   - With what habitat features do the predators associate?
2. Examine stomach contents of NPM and SMB within Strata 2.
   - What is the estimated consumption of juvenile salmon?
   - Is there a preference by the predators to salmon year class?
   - When do the predators begin consuming juvenile salmon?
   - What other animals are being consumed?

Study year two - 2012

1. Assess population of NPM and SMB throughout Strata 2
    - What is the estimated abundance and distribution of predators?
    - Does the population of predators change throughout the sampling period?
2. Observe consumption habits of NPM and SMB
    - What are the consumption estimate by reach and section?
    - When do the predators begin consuming juvenile salmon and how does their diet change over the sampling period?
    - What other animals are being consumed?

2.1 STUDY AREA

The Okanogan River in Strata 2 is partitioned into 33 reaches based on physical and biological characteristics (Figure 2) for EDT sampling and analysis. The total length of Strata 2 is 118.70 km and individual reaches range from 0.34 to 15.55 km in length. Parameters used to define these reaches included water depth and velocity; substrate gradient and type; riparian structure and slope; and presence of riffles, structure, holding areas, islands, tributaries, and impassable rapids and falls (Table 1). The reaches for this study were derived from GIS attribute data information collected and compiled by OBMEP. No major flooding events or construction resulting in changed physical and biological river characteristics have occurred since this survey and it is assumed to still be accurate. Each reach is partitioned into five equal length sections for the purpose of predator population sampling. Having the river separated into heterogeneous reaches (i.e., relatively homogenous within reaches) and sections will result in more accurate statistical results and allow for comparison of predator density and salmon consumption between portions of the river.

2.2 JUVENILE SALMON

There are three species of salmon that inhabit the Okanogan River and sustain juvenile production including Chinook, sockeye and steelhead. Within these species are specific classes of fish including natural origin sub-yearling Chinook, hatchery origin yearling Chinook, natural origin sockeye, hatchery origin sockeye, natural origin steelhead, and hatchery origin steelhead. Each of these classes have population characteristics that define their life history in the Okanogan River (Table 2).

All of these juvenile salmon are of an appropriate size for consumption by SMB and NPM and can be anticipated to be present in the diet of those predators. However, the smaller sized fish are likely more susceptible to predation.

2.3 TIMING OF SAMPLING

The proposed sampling period for Strata 2 is April 5 – Aug 20, 2010, April 4 – Aug 19, 2011, and March 30 – Aug 14, 2012 (Table 2). Based on underwater video monitoring at Zosel Dam from prior years, starting the sampling period at the beginning of April coincided with SMB migration from wintering habitats. Northern pikeminnow begin actively moving in May (John Arterburn, Colville Confederated Tribes, Pers. Comm.). Also, salmon alevin have already emerged from the gravel at the beginning of April (Rayton and Arterburn 2008) and consequently become a potential food source. All juvenile salmon appear to complete their out-migration before the end of July when water temperature in the Okanogan River exceeds criteria for survival (John Arterburn, Colville Confederated Tribes, Pers. Comm.). Commencing sampling with the redistribution of predators from wintering habitats and ending sampling with the cessation of migration ensures that predators are assessed throughout the entire period they are feeding on juvenile salmon in Strata 2.

2.4 RADIO TAGGING PREDATORS

The primarily goal of the radio tracking performed in the pilot study (2010) is to document the extent of SMB and NPM movement throughout the Okanogan River and adjust the population and consumption estimate procedures if needed. This portion of this study has been designed and will be conducted by Ed Zaple as part of his Ph.D. thesis with the University of Washington. Mr. Zaple will also investigate real-time correlated foraging routes, preferred foraging locations, and flow velocity-related behaviors as documented by frequent observations in particular areas. Mr. Zaple will also perform analysis of stomach contents which will inform as to the relative success of particular foraging behaviors exhibited by individual fish. From these data, it's hoped that strong correlations might be drawn regarding preferred foraging behaviors by NPM and SMB in the Okanogan River. This data will possible be utilized in the continuing development of a predator fish bioenergetics and behavior model that may be applied to more generalized sites, both in the Okanogan River and throughout the Columbia River system.

For the purpose of Mr. Zaple's research, tracking data collection will focus efforts, to the extent practical, within river segments in which there are known bathymetric and velocity data. Of particular interest will be the river segments immediately downstream of Zosel Dam (Figure 2), near the cross channel confluence of the Okanogan River and the Similkameen Rivers, and downstream of two major steelhead smolt producing tributaries (Keith Kistler, Colville Confederated Tribes, Pers. Comm.). When not available, velocity data will be collected over a range of outflow conditions.

SMB and NPM will be captured initially using electrofishing, seine, or hook and line methods from the aforementioned radio tag segments. A minimum of six healthy fish, each greater than 300 mm in length, from each segment will be sampled. NPM are the preferred species, but if insufficient numbers are available, SMB will be substituted. Each candidate fish will be anesthetized with carbon dioxide, weighed, measured, have a radio tag surgically inserted into their body cavity, have the wound sutured, and, last, be placed into a recovery tank for monitoring over a period of no less than 1 hour.. Upon recovery, each tagged fish will be returned to the approximate location in which it was captured.

Movement of these tagged fish will be observed using a network of stationary receivers as well as periodically utilized boat-mounted or automobile-mounted radio receivers. Fixed radio receivers will be positioned in optimal locations for relative position at the three segments identified. Up to four receivers will be deployed at each segment. The receiver network will be calibrated using a manually controlled radio tag which is recorded at regular intervals and moved throughout the sampling area by a boat with known horizontal position. Radio tag tracks will be recorded continuous by the fixed receivers and during biweekly site visits by portable receivers in boats or automobiles. Individual tag tracks will be unique to the particular fish in which the tags were implanted.

At bi-weekly intervals, during each site visit to the three sample segments, tagged fish will be recaptured during the fish capture activities associated with the population and stomach content assessments. They will be physically separated from the other untagged fish and have their stomach contents purged using the lavage technique. Samples will be individually stored for later analysis. Sampled fish will be placed into the on-board recovery tank following the procedure, then released back the river in the same general location as they were captured. Again, unhealthy fish or those not recovering quickly will be rejected if necessary to maintain future sample viability.

Also during the bi-weekly sampling site visits, flow velocity will be recorded throughout the study area using a portable Acoustic Doppler Velocimeter (ADV) and highly accurate GPS locating unit suitable for use in moving boats. These velocity data will be correlated with current conditions of flow as recorded by available gages along the river. Up to 50 individual measurement points may be specified within each of the three study reaches. Also, river flow and water temperature data will be collected from existing gauge and data sites operated by the USGS, the Washington Department of Ecology, and/or other entities.

At the conclusion of the study, radio tag tracking data will be evaluated with the velocity and water temperature data, as well as stomach contents, to determine the particular foraging habits and behavior of the tagged fish.

2.5 PREDATOR POPULATION ASSESSMENT

Predatory fish populations will be assessed using boat electrofishing (400 volts at 3-5 amps, and 30 Hz, Erick Van Dyke, Oregon Department of Fish and Wildlife, Pers. Comm.) according to a sampling regime stratified by reach and section. A survey will be conducted using two boats, one on each bank, and fishing downstream in tandem. Each boat will have a GPS unit with an uploaded map of sections. Alternative methods (seine, tangle net) may be used for specific types of habitat where electrofishing is not sufficiently effective, although hook and line methods will be avoided for NPM due to this species tendency to regurgitate stomach contents (Erick Van Dyke, Oregon Department of Fish and Wildlife, Pers. Comm.). Observance of other predator fish species (of which there are expected to be few, John Arterburn, Colville Confederated Tribes, Pers. Comm.), percentage of habitat type (pool, riffle, run, substrate, cover) within a section, and seconds of electrofishing pedal time will be recorded. A specific electroshocking procedure will be developed and electroshocking rules and regulations will be investigated at a later time.

A WDFW scientific fish collection permit will be obtained for sampling activities and sample collection. ESA summer steelhead juveniles and adults will likely be in the study area during sampling, so protocols will be adjusted according to the terms of the permit.

During the pilot study (2010), every reach of the Okanogan River will be examined uniformly in order to determine the reaches with a large population of predators (Table 1). Over the course of 10 sampling days, the northern most of the five sections (section one) within each of the 33 reaches will be sampled. The next ten sampling days will consist of the adjacent southern section (section 2) of each reach. Systematically sampling among groups of identically numbered sections will continue for 50 sampling days until all five sections within each reach are complete. Twenty percent of the river is sampled with each pass of the river and, after five passes, the entire river is sampled.

Previous redd surveys have determined ten portions of the river which can be covered in a day's time (Table 1). Each area is a different length as certain portions of the river take a longer time than others to pass due to variable velocity and depth (John Arterburn, Colville Confederated Tribes, Pers. Comm.). The sections also differ in length between reaches and therefore the number of sections sampled in a day will vary. The access points do not fall directly on reach boarders and GPS units will be used to find reach and section borders. Sampling areas begin and end with an access point (Brian Miller, Colville Confederated Tribes, Pers. Comm.) and will be used in this study for logistical purposed with no biological significance. During the redd surveys, many suspected spawning SMB beds were observed and it is believed that feeding may be concentrated at these locations. Catch at these beds will be noted in order to investigate whether the observed depressions overlap with catch of bass.

Sampling will occur according to an "every other" Monday through Friday schedule (Table 1) or a "two week on, two week off" schedule in which fish are sampled Monday through Friday over two consecutive weeks followed by two weeks of no sampling. Both schedules would allow for non-sampling periods to organize supplies, review previously collected data, and provide an opportunity make up sampling effort missed due to unforeseen circumstances. The "every other" schedule would provide a greater spread of sampling days throughout the study period than the "two week on, two week off" schedule. Therefore, the "every other" schedule would leave less chance of missing and important biological event such as fish migration or a shift in predator diet. The "two week on, two week off" schedule would result in more simultaneous data collection from reaches than the "every other" schedule. Also, the "two week on, two week off" schedule results in a lower probability than the "every other" schedule of having to fill an entire block of non-sampling days (two weeks versus one week) with make-up sampling days. The schedule to be used will be determined at a later time.

It is assumed that multiple reaches sampled in the pilot study (2010) will produce very few fish. In the first study year (2011), these reaches will be excluded with a threshold developed upon data analysis. With less reaches to be sampled, data precision and accuracy can be improved by increasing the number of sampling sessions within reaches and sections with a larger number of predators. For instance, if half of the 33 reaches sampled in the pilot study have very few predators and are omitted in the first study year (2011), then each reach can be sampled twice creating roughly the same amount of effort as in the pilot study (2010). Systematically sampling among groups of identically numbered sections will still occur as in the pilot study (2010) but will be repeated twice in this scenario. With this schedule, no section will be sampled twice within five days (Fresh et al. 2003).

During the second study year (2012), precision and accuracy will be increased even further. Specific section in each reach with the greatest number of predators will be chosen as index sections and receive a greater sampling effort. The number of index sections and sampling events at sections will be determined upon first study year (2011) data analysis. For example, if two index sections are chosen per reach, then they may be sampled 16 times while the non index sites are sampled six times. The overall number of sampling events has not changed from the previous year but the focus has shifted. Another systematic sampling schedule will have to be developed for this year as there are no longer a consistent number of sampling events at all sections. This new schedule will involve frequent and consistent sampling of index sites and provide fish data for a temporal examination of population and consumption changes.

Mark and recapture will be the primary method for estimating predator population abundance. The Bayes sequential model (Gazey and Staley 1986) will be applied to the time and space stratified mark-recapture data to estimate mean and 95% Highest Probability Density bounds. Mark-recapture estimates may not be robust in a study such where fish movement is potentially extensive (Karl English, LGL Limited, Pers. Comm.) or the population is sparse, but the model can be adjusted for these conditions. Model assumptions will be evaluated by assessment of the successive posterior distributions. Alternative models will be considered depending on the distribution and abundance of the predator populations.

Catch rate (length-of-shoreline based surveys) of SMB and NPM will be used as the secondary method to index predator population abundance. Catch rate will be calculated as the number of predators captured (by species), divided by the distance of river sampled and will be presented as the number of fish per kilometer. Catch data by section will be combined where appropriate as based on variance and extrapolated to the sampling area. Further, catch rate as based on sampling effort (electrofishing time on) will also be evaluated. These methods have the advantage of not requiring tags and do not need to meet the assumptions of using mark-recapture models. However, this method does use the fundamental assumption that the observed densities of predators at sampled locations are representative of the areas to which the densities are extrapolated.

Target fish will include smallmouth bass longer than 100 mm and NPM longer than 200 mm as these are the approximate lengths at which each species become piscivorous (Poe et al. 1991; Fritts and Pearson 2006; Vigg et al. 1991; Naughton 2004). Target fish will be measured for length and weight to obtain information on size distribution. Size selectivity of electrofishing will assumed to be negligible over the targeted fish size range (Erick Van Dyke, Oregon Department of Fish and Wildlife, Pers. Comm.).

Full-duplex PIT tags will be used for marking predators. Tagged fish will be released in proximity to the location in which they were captured. Fish will be marked continuously over the study period and previously marked fish will be recorded as recaptures. These types of tags have the added benefit of being observable in video collected at Zosel Dam.

For both SMB and NPM, a minimum of 780 tags will be targeted for release and a minimum of 766 marked fish will be recaptured. These targets for marks applied and fish examined were determined based on sample size formulas for mark-recapture experiments (Robson and Regier, 1964). The targets are based on population estimates of 25,000 for both SMB and NPM in Strata

2 and an accuracy goal of ±50% on 95% precision confidence bounds. The SMB population estimate is based on the estimated number of bass per mile (>150 mm) in the lower Yakima River, WA (Fritts and Pearsons, 2006). The NPM population estimate is based on the estimated number of pikeminnow (>300 mm) per mile in the lower Chehalis River, WA (Fresh et al. 2003). These two rivers are comparable to the Okanogan River in maximum and minimum discharge profiles and support salmon populations. A specific tagging procedure will be developed at a later time.

In the pilot study (2010), a minimum of seven fish per species per kilometer will be targeted to mark (780 target tags / 118.70 km Strata 2 = 6.57 tags/km) which equals 831 tagged individuals (6.57 tags/km x 118.70 km Strata 2 = 830.97 target tags). Two hundred and eleven SMB (Fritts and Pearsons, 2006) and NPM (Fresh et al. 2003) are estimated to be in each kilometer of the Okanogan River (25000 fish / 118.70 km = 210.61 fish/km.). It is predicted that roughly 3% (Karl English, LGL, Pers. Comm.) of all fish, or seven fish, per kilometer will be collected through electrofishing efforts (25000 fish x .03 / 118.70 km = 6.32 fish/km.). This estimate of catch is sufficient to facilitate the seven fish per kilometer target. Target tag calculations for the first and second study year (2011 and 2012) cannot be calculated at this time as estimated fish populations and fish per kilometer may be altered based on the previous year's data and the number of kilometers to be sampled may change. Extra sampling days at sections may be required to meet the targeted number of mark and recapture. Additional days will not be incorporated into the pilot data (2010).

Descriptive statistics will be calculated for SMB and NPM populations within Strata 2 of the Okanogan in order to summarize data. Predator size frequency distributions will also be developed for each reach. Habitat type, fishing effort, and number of fish caught will be used to calculate densities of predators. Habitat percentages will also be correlated with fish densities to determine predator substrate preference. Mark and recapture will be analyzed using the Bayes open population models (Gazey and Staley 1986) in Program MARK to confirm the area based population estimates.

2.6 PREDATOR STOMACH CONTENT ASSESSMENT

During the pilot study (2010), one fish per day will be retained for an "in boat" stomach content analysis. These fish will be weighed, have their lengths and weights measured, and then be euthanized in MS222. Body cavities will be cut open and entire digestive tracts contents will be removed and visually examined. Empty stomachs or a percentage of stomach content estimates by phylum will be noted. Presence of salmon by species will also be noted if possible. The lavage technique will not be utilized because food is often left in the stomach and therefore underestimates total consumption. It is predicted that roughly 50% of stomachs will be empty. If this is the case, subsequent fish will be sampled until stomach contents are found within at least one fish. This will ensure sufficient stomach observations to assess contents. A specific stomach sampling procedure will be developed at a later time.

During the first and second study year (2011 and 2012), a minimum sample each year of 200 SMB and NPM will be retained for stomach content analysis. The number of stomach samples to take was derived from previous studies (Karl English, LGL, Pers. Comm.) and has been spread throughout the sampling periods so that a temporal aspect of diet shifts can be investigated. Stomach sampling effort is subject to change based upon pilot year (2010) results. The 200 fish will be divided by the number of kilometers retained from the previous year's study in order to calculate how many stomach samples to obtain per kilometer and section. These stomach samples will be placed in ethanol for analysis at a later time. Again, if all fish sampled for a section have empty stomachs, subsequent fish will be sampled until stomach contents are found within and collected from at least one fish. This will ensure sufficient stomach contents for a thorough diet analysis. If the beginning or end of SMB or NPM's predation on juvenile salmon is not observed during the sampling period, sites may be visited again in September to determine prey in the absence of juvenile salmon.

Stomach contents will be analyzed in a laboratory. Identifiable food items will be sorted and enumerated (to species if possible) and salmon will be measured for length to determine year class. Sub-yearling and swim up Chinook and multiple year class steelheads are anticipated in the samples (John Arterburn, Colville Confederated Tribes, Pers. Comm.). Macroinvertebrates and zooplankton will also be identified and sorted by family with the use of a dissecting scope. Unidentifiable digested matter will be classified as "other". The soft tissue of partially digested unidentifiable food items will be digested in a pancreatin (8x porcine digestive enzyme) solution. With the use of the dissecting scope, characteristics of the remaining diagnostic bones, such as vertebrae, cleithra, dentaries, and opercles shape, can be used to distinguish between salmonid and non-salmonid fish (and between species if possible) (Fritts and Pearsons, 2006; Frost 2000; Hansel et al. 1988). This method is particularly useful for northern pikeminnow as they have a non-acidic digestive system and bones are left undamaged (Frost 2000). A specific stomach content analysis will be developed at a later time.

Salmon length will be characterized weekly from salmon captured in annual rotary trap surveys performed by the CCT. Descriptive statistics of salmon found in predator stomachs and salmon found in rotary trap will be compared to determine if predators have a preference to salmon species and year class. Numerical percentage, weight percentage, and percent frequency of occurrence of salmon found in predator stomachs will be combined into a hybrid index of relative importance to predator diet. This calculation reduces biases associated with each of the individual calculations (Bowen 1983).

2.7 PREDATOR CONSUMPTION ASSESSMENT

The *Bioenergetics Model 3.0 for Windows* from the University of Wisconsin (Hanson et al. 1997) will be used to determine consumption rates of salmon by SMB and NPM. This model utilizes data entered by the user (Table 4) and parameters from the program's database to calculate a variety of values including growth and consumption rate and weight for cohorts and the entire population. Smallmouth bass physiological parameters are already within the database but will be updated if found necessary (Hyslop 1980; Whitledge 2002; Whitledge 2003). Physiological parameters for NPM will be obtained from other sources (Zorich 2004; Petersen 1999) as they are not within the database. Many prey energy densities are not in the database and will have to be found in the existing literature. Sensitivity of this program will be determined with fake data prior to study commencement.

Consumption estimated can be compared to salmon out-migration estimates, as determined from rotary trap surveys performed by the CCT, to assess whether or not a substantial number of juvenile salmon are being consumed by SMB and NPM. In addition, the specific year classes of salmon being consumed and the date at which consumption began can be determined. These results can be used to develop fisheries management strategies for the Okanogan River.

2.8 DATA GAP ANALYSIS

All available information (grey and white literature) on the Okanogan River, including the Canadian portion of the study area, will be complied and reviewed to determine what is known about the abundance, distribution and consumption of juvenile salmon by predatory fish and birds. Additional personal contacts will be made with past and current researchers and agencies in the Okanogan River to identify unpublished data for the region. Data gaps will be identified as critical or non-critical and any assumptions that were made in the collection or processing of data will be identified to aid in the development of standardized sampling protocols.

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4.0 TABLES

Table 1. Reach, section, and sampling area descriptions and "every other" week schedule.

Reach Name (in sampling order)	EDT Description	Length (km)	Section length (km)	Target tags per sect per species	Sum of sections within sample (km)	Survey area name	Sampling Schedule Section 1	Section 2	Section 3	Section 4	Section 5
SR05	RR crossing at increased confinement segment to Enloe Falls (not dam yet)	3.311641	0.662328	5							
SR04	Beginning of valley confinement to the RR crossing at increased confinement	1.609087	0.321817	3							
SR03	Kay Street to the beginning of valley confinement (1.5 miles upstream)	1.848910	0.369782	3	3.012404	S1/S2	4/5	5/3	5/31	6/28	7/26
SR02	Just above N. backflow channel to Kay Street (river bend at Peninsula)	2.158104	0.431621	3							
SR01	Confluence with Okanogan to backflow channel	6.134280	1.226856	8							
BF	East end of channel to West end of channel	0.645794	0.129159	1							
OR28b	Backflow channel reach to the confluence of Tonasket creek	1.894257	0.378851	3	1.180378	O7	4/6	5/4	6/1	6/29	7/27
OR28a	Confluence with Okanogan below Eyhott Island to N. backwater channel	3.361840	0.672368	5							
OR27	Below Horseshoe Lake RM 69.5 to the confluence with Similkameen	7.909700	1.581940	10	1.581940	O6	4/7	5/5	6/2	6/30	7/28
OR26b	Okanogan 26h release point to below Horseshoe Lake at RM 69.5	8.441395	1.688279	11							
OR26a	Mouth of Whitestone creek to Okanogan 26h hatchery release point	2.014768	0.402954	3							
OR25	Mouth of Antoine creek to the mouth of Whitestone creek	2.022834	0.404567	3	3.945998	O5*	4/8	5/6	6/3	7/1	7/29
OR24	Mouth of Siwash creek to the mouth of Antione creek	6.317122	1.263424	8							
OR23	Mouth of Bonaparte creek to the mouth of Siwash creek	0.933869	0.186774	2							
OR22	Mouth of Aeneas creek to Bonaparte creek	7.084012	1.416802	9	2.199424	O5	4/9	5/7	6/4	7/2	7/30
OR21	Chewiliken to the mouth of Aeneas creek	3.913109	0.782622	5							
OR20	Janis Rapids to Chewiliken	0.339762	0.067952	1							
OR19	Upper end of mainstem constriction point to Janis Rapids	2.612893	0.522579	4							
OR18	McLouglin Falls to upper end of mainstem constriction point	0.635109	0.127022	1	2.088615	O4	4/19	5/17	6/14	7/12	8/9
OR17	Point of constriction above Barker to McLoughlin Falls	1.928276	0.385655	3							
OR16	Mouth of Tunk creek to point of constriction past orchards above Barker	4.186609	0.837322	6							
OR15	Southermost mid channel island/bar below McAllister rapids to Tunk Creek	0.740426	0.148085	1							
OR14	Wannacut to southermost mid channel island/bar below McAllister rapids	15.554451	3.110890	20	4.081120	O3	4/20	5/18	6/15	7/13	8/10
OR13	Omak Creek Mouth to mouth of Wannacut Creek	4.851150	0.970230	7							
OR12	Sewage disposal site near RM 30 to the mouth of Omak Creek	3.320587	0.664117	5							
OR11	Pumping station by hospital in Okanogan to right bank sewage disposal site	2.055425	0.411085	3							
OR10	Oak St. Bridge in the town of Okanogan to Pumping Station near Hospital	5.062557	1.012511	7	2.928894	O2	4/21	5/19	6/16	7/14	8/11
OR09	Mouth of Salmon Creek to the Oak Street Bridge in the town of Okanogan	0.489445	0.097889	1							
OR08	Cornett roperty to mouth of Salmon Creek	3.716454	0.743291	5							
OR07	Barnholt Loop to the Cornett property	2.871754	0.574351	4							
OR06	Mouth of Tallant Creek to Barnholt Loop	3.592735	0.718547	5	2.112026	O1*	4/22	5/20	6/17	7/15	8/12
OR05	Mouth of Loup Loup to mouth of Tallant Creek	4.095639	0.819128	6							
OR04	Mouth of Chilliwist Creek to Mouth of Loup Loup Creek	3.047200	0.609440	4	0.609440	O1	4/23	5/21	6/18	7/16	8/13
Totals:	**33 Sections**	**118.701194**	**23.740239**	**165**	**23.7402388**	**10 Areas**			**50 Days**		

Table 2. Juvenile Salmon of the Okanogan River. Data from Johnson and Rayton (2007) and Rayton and Arterburn (2008).

Characteristic / Species	**Sub-yearling Chinook**	**Yearling Chinook**	**Sockeye**	**Sockeye**	**Steelhead**	**Steelhead**
Origin	natural origin, summer run, Similkameen	hatchery origin, summer run, Similkameen	natural origin, Osoyoos Lake	hatchery origin, Skaha Lake	natural origin, Okanogan	hatchery origin, Okanogan
Population Size	400k to 1.1 mill	270k	1.5 mill	140k	7k - 14k	97k
Migration Timing	May-June	late April-early June	May	April	mid April-mid June	May
Size [a]	54 mm	133 mm	100 mm	140 mm	155 mm	200 mm
Age	0+	1+	1+	1+	1+, 2+, 3+, 4+	1+

[a] unpublished data, rotary trap catch, Colville Tribes 2008 & 2009

Table 3. Strata 2 project task schedule

	Feb	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**
2010										
Organize equipment, schedules, and protocols	X	X								
Abundance estimate										
Mark and recapture			X	X	X	X	X			
Calculate abundance							X	X		
Consumption estimate										
Observe stomach contents			X	X	X	X				
2011										
Organize equipment, schedules, and protocols	X	X								
Abundance estimate										
Mark and recapture			X	X	X	X	X			
Calculate abundance							X	X		
Consumption estimate										
Collect fish for stomach contents			X	X	X	X	X			
Analyzing stomach contents			X	X	X	X	X			
Calculate consumption							X	X	X	
2012										
Organize equipment, schedules, and protocols	X	X								
Abundance estimate										
Mark and recapture			X	X	X	X				
Calculate abundance							X	X	X	
Consumption estimate										
Collect fish for stomach contents			X	X	X	X				
Analyzing stomach contents			X	X	X	X				
Calculate consumption							X	X	X	
Generate report								X	X	X

Table 4. Bioenergetics 3.0 input required from user

Input	**Data Source**
Dates of sampling	Collected in Field
Water temperature for each day of sampling period	Collected in Field
Weight of fish on first day of sampling	Collected in Field
Weight of fish on last day of sampling	Collected in Field
Proportion of each prey species in stomach for each stomach sampling day	Determined in Lab
Prey energy density for each stomach sampling day	Existing literature; Bioenergetics 3.0 manual
Predator energy density for each stomach sampling day	Existing literature; Bioenergetics 3.0 manual

5.0 FIGURES

Figure 1. Three primary strata in the study area.

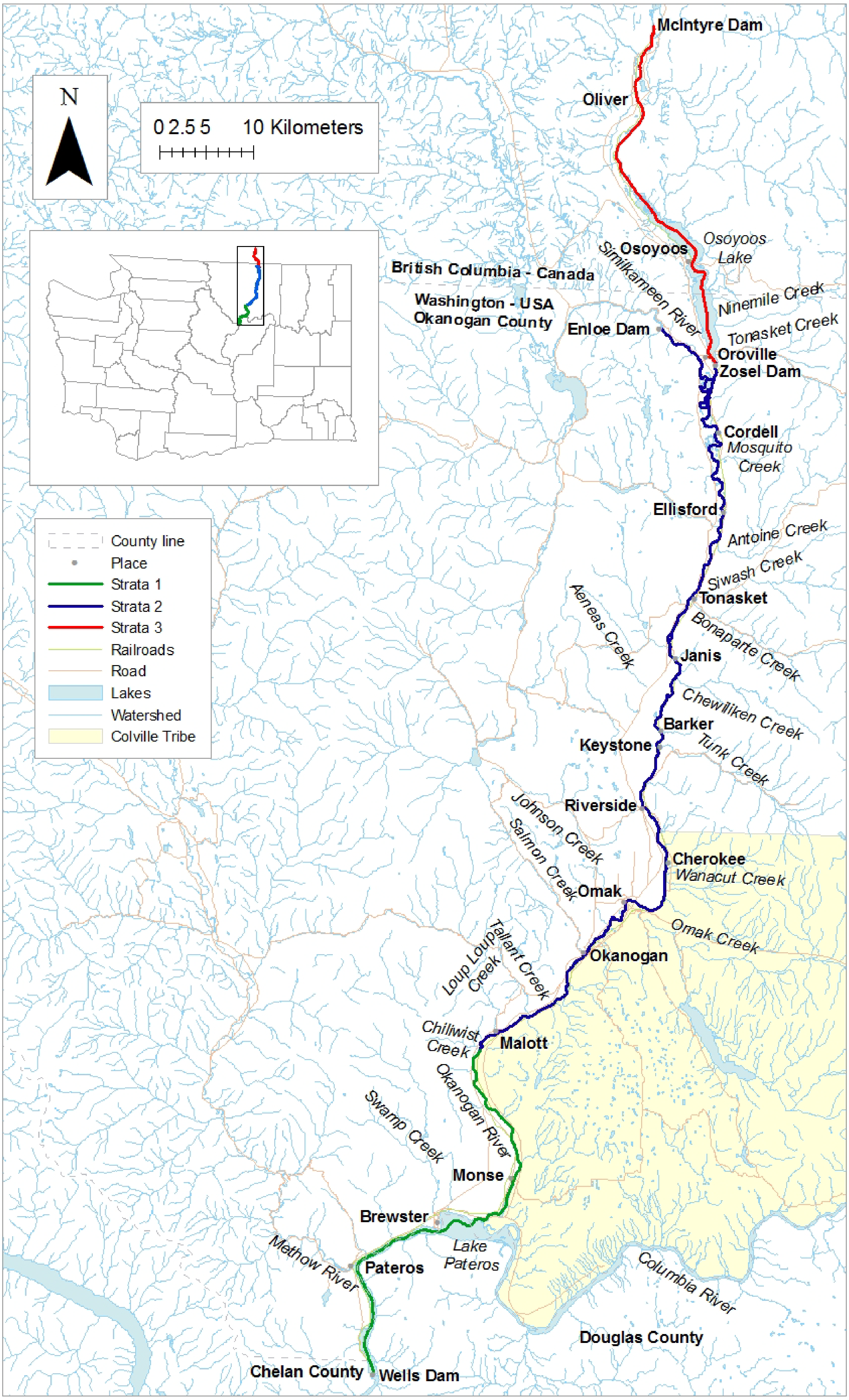

Figure 2. Section 1, Chillowist, WA to Zosel Dam in Oroville, WA, divided and sequentially numbered into sample reaches and sampling areas.

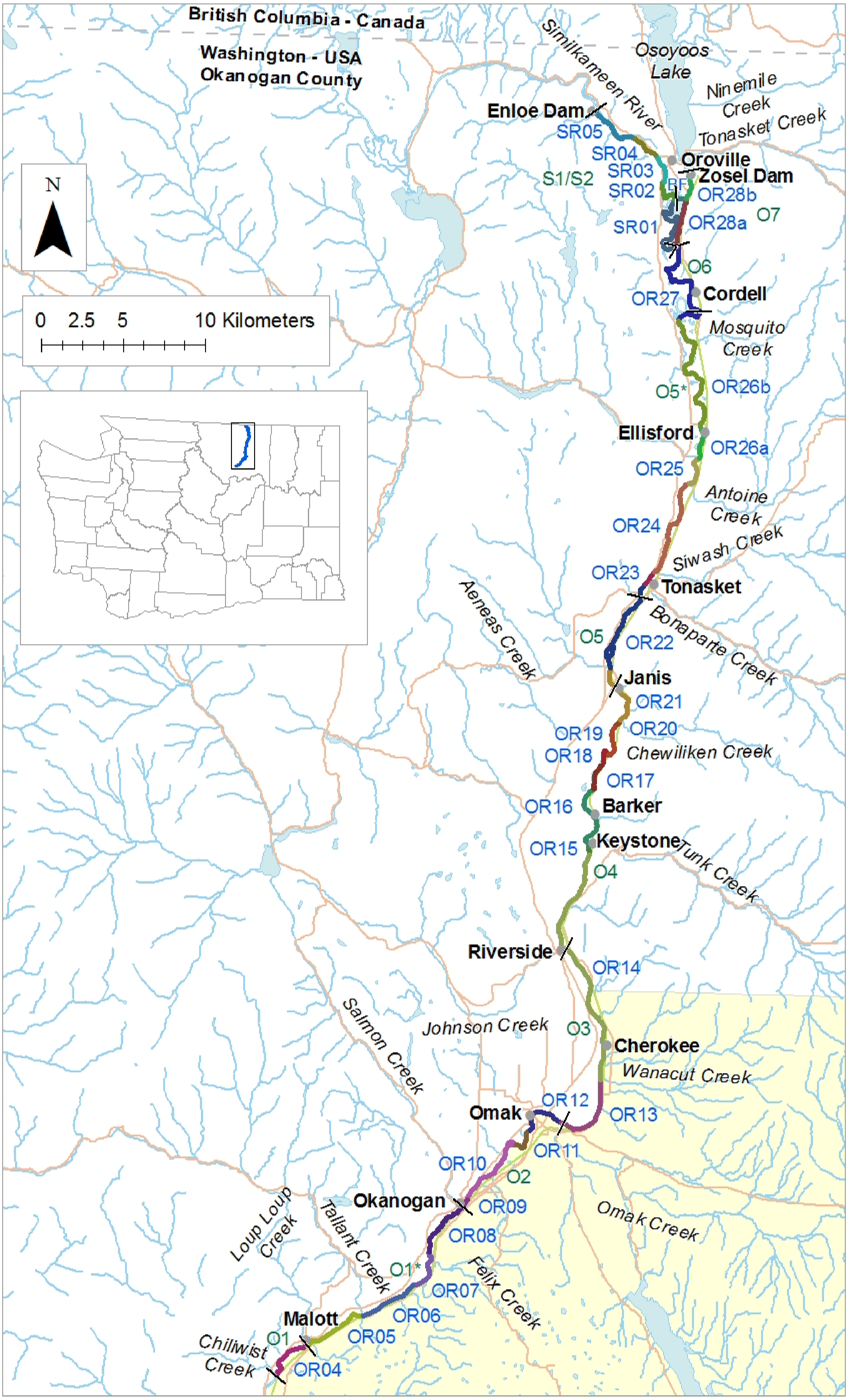

Figure 3. Map legend for Section 1, Chillowist, WA to Zosel Dam in Oroville, WA.

BF01, East end of channel to West end of channel.
OR04, Mouth of Chilliwist Creek to Mouth of Loup Loup Creek
OR05, Mouth of Loup Loup to mouth of Tallant Creek
OR06, Mouth of Tallant Creek to Barnholt Loop
OR07, Barnholt Loop to the Cornett property
OR08, Cornett roperty to mouth of Salmon Creek
OR09, Mouth of Salmon Creek to the Oak Street Bridge in the town of Okanogan
OR10, Oak St. Bridge in the town of Okanogan to Pumping Station near Hospital
OR11, Pumping station by hospital in Okanogan to right bank sewage disposal site
OR12, Sewage disposal site near RM 30 to the mouth of Omak Creek
OR13, Omak Creek Mouth to mouth of Wannacut Creek
OR14, Wannacut to southermost mid channel island/bar below McAllister rapids
OR15, Southermost mid channel island/bar below McAllister rapids to Tunk Creek
OR16, Mouth of Tunk creek to point of constriction past orchards above Barker
OR17, Point of constriction above Barker to McLoughlin Falls
OR18, McLouglin Falls to upper end of mainstem constriction point
OR19, Upper end of mainstem constriction point to Janis Rapids
OR20, Janis Rapids to Chewiliken
OR21, Chewiliken to the mouth of Aeneas creek
OR22, Mouth of Aeneas creek to Bonaparte creek
OR23, Mouth of Bonaparte creek to the mouth of Siwash creek
OR24, Mouth of Siwash creek to the mouth of Antione creek
OR25, Mouth of Antoine creek to the mouth of Whitestone creek
OR26a, Mouth of Whitestone creek to Okanogan 26h hatchery release point
OR26b, Okanogan 26h release point to below Horseshoe Lake at RM 69.5
OR27, Below Horseshoe Lake RM 69.5 to the confluence with Similkameen
OR28a, Confluence with Okanogan below Eyhott Island to N. backwater channel
OR28b, Backflow channel reach to the confluence of Tonasket creek
SR01, Confluence with Okanogan to backflow channel
SR02, Just above N. backflow channel to Kay Street (river bend at Peninsula)
SR03, Kay Street to the beginning of valley confinement (1.5 miles upsteam)
SR04, Beginning of valley confinement to the RR crossing at increased confinement
SR05, RR crossing at increased confinement segment to Enloe Falls (not dam yet)
Railroad
Road
Watershed
Lakes
Colville Tribe Land
County Line
Sampling Area (O1-O7, S1/S2)
Place

6.0 ANNOTATED BIBLIOGRAPHY

Citation

Naughton, G. P., D. H. Bennett, and K. B. Newman. 2004. Predation on juvenile salmonids by smallmouth bass in the Lower Granite Reservoir system, Snake River. North American Journal of Fisheries Management 24:534-544.

Geographic Location

Lower Granite Reservoir, Snake River, is in Southeastern Washington

Purpose

Estimate the number of smallmouth bass and quantify their consumption of juvenile salmon and steelhead in the tailrace and forebay of the lower granite dam, and compare these results with those for the free-flowing to impoundment transitional areas in the Snake and Clearwater River areas of the upper Lower Granite Reservoir.

Relevant facts

Length of smallmouth when they switch from eating insects to fish; explanation of bioenergetics, fish collection, and stomach content analysis

Conclusion

Juvenile salmon were not a major prey of smallmouth bass at any location in either 1996 or 1997. Highest percentage of consumption in smallmouth between the sites diet was 11%. High amount of variability between years due to water temp, flow and tubidity.

Citation

Fritts, A.L., and T.N. Pearsons. 2006. Effects of predation by nonnative smallmouth bass on native salmonid prey: The role of predator and prey size. Transactions of the American Fisheries Society 2006 135:853-860.

Purpose

Provide detailed information about the minimum, average, and maximum sizes of prey fish consumed by smallmouth bass and the per capita and population consumption of salmonids by different sizes of smallmouth bass in the lower Yakima River. Discuss the potential predation risks to salmonids posed by nonnative smallmouth bass and compare these risks to those posed by northern pikeminnow.

Geographic Location

The Yakima River is a Columbia River tributary located in south-central Washington State

Relevant facts

Most of the salmonids were consumed by smallmouth bass smaller than 250 mm, and the vast majority was consumed by smallmouth bass smaller than 300 mm (mean of 83.6% over the 5-year period). Salmonids were less common in the guts of larger smallmouth bass than in the guts of smaller individuals. Length of salmonids consumed by smallmouth bass decreased with increasing predator length. The mean relative length of salmonids consumed by smallmouth bass was 25.0%. The size range of salmonids consumed by smallmouth bass was 22–153 mm, and the mean size consumed was 59 mm. Covered mark-recapture, stomach sampling, and bioenergetics.

Conclusion

After piscivory begins in bass, number of salmon consumed decreased with an increase in predator size. For pikeminnow, these are positively correlated. Smallmouth bass become piscivorous approximately 2 or 3 years earlier than do northern pikeminnow.

Citation

Vigg, S., T. P. Poe, A. L. Prendergast, and H. C. Hansel. 1991. Rates of consumption of juvenile salmonids and alternative prey by northern squawfish, walleyes, smallmouth bass, and channel catfish in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:421-438.

Geographic Location

John Day Reservoir on the Columbia

Purpose

Document the feeding ecology of northern squawfish, walleyes, smallmouth bass, and channel catfish in John Day Reservoir, quantifying the diets of these four predators temporally and spatially, and evaluating predation dynamics with respect to out-migrations of juvenile salmonids.

Relevant facts

The importance of fish in northern squawfish diets increased with the predators' length Fish shorter than 200 mm ate mainly ephemeropterans and hymenopterans (41.2-90.5%). As they grew, the predators switched first to crayfish and then to fish. Salmonids composed 21% of the diet of 300-mm northern squawfish and 83% of the diet of the larger fish. Crustaceans (crayfish and amphipods) were the most important food of smallmouth bass 50-100 mm long, accounting for 57% of the diet. Smallmouth bass longer than 100 mm began switching to fish as the major dietary component and the importance of crayfish decreased as predator size increased. Also covered fish sampling and stomach contents analysis.

Conclusion

Of the four predator species studied, only northern squawfish included juvenile salmonids as a dominant food during salmonid emigrations through John Day Reservoir. They also found that the areas near the dams were the locations where northern squawfish predation on juvenile salmonids was most intense. The walleye was the second most important predator on juvenile salmonids, followed by channel catfish. Diet composition indicated that the smallmouth bass was the least important predator on juvenile salmonids (4% by number overall) emigrating through John Day Reservoir. Northern squawfish and, to a lesser degree, channel catfish, were the only predators that preferred juvenile salmonids more during their peak migratory densities. Northern squawfish consistently consumed more juvenile salmonids from the smaller size-groups available, especially in April, May, and August.

Citation

Scholz. 2009. Analysis of walleye, smallmouth bass and burbot food habits in the San Poil River to determine the number of stocked kokanee and naturally produced rainbow trout consumed by their populations. Unpublished.

Purpose

Determine walleye and smallmouth bass population abundance in the inundated section of the San Poil River, determine walleye, smallmouth bass and burbot food habits using traditional methods (numerical percentage, weight percentage, frequency of occurrence, and index of relative importance), determine total consumption of individual types of prey in the diets of walleye, smallmouth bass, and burbot by applying specific bioenergetics models, combine the above data to determine the total biomass (number) of each type of prey consumed by each predator. Particular attention will be focused on the number (biomass) of kokanee and rainbow trout consumed by each predator. Total consumption of kokanee and rainbow trout by all predators combined will be compared to the number of hatchery kokanee released into the San Poil drainage and the number of rainbow trout estimated to have migrated down the San Poil River (data provided by the CCT).

Geographic Location

The inundated section of the San Poil River

Relevant facts

Looked at for study design example. Methods: fish collection, stomach content, fish consumption.

Conclusion

n/a: proposal

Citation

Fresh, K. L. and S. L. Schroder. 2003. Predation by northern pikeminnow on hatchery and wild coho salmon smolts in the Chehalis River, Washington. North American Journal of Fisheries Management, 23:1257-1264

Purpose

Test the hypothesis that northern pikeminnow predation was responsible for the low smolt-to-adult survival rates of Chehalis River coho salmon. A secondary objective was to ascertain if northern pikeminnow predation could account for the 2–4 times higher survival rates that wild coho salmon smolts have compared with those of hatchery coho salmon smolts in the basin.

Geographic Location

Chehalis River basin, Washington

Relevant facts

Methods included Number of smolts eaten calculation, digestive tract analyses, mark-recapture (justification for eaiting 5 days inbetween) with population estimates, and calculating ET90%. Coho salmon smolts were the most frequently occurring fish species in northern pikeminnow digestive tracts and were found in 12.6% of northern pikeminnow in 1988 and 3.5% in 1989.

Conclusion

The results of this study suggest that predation by northern pikeminnow in the Chehalis River below rkm 82 during the April–May smolt migration period was not the primary factor responsible for the low smolt-to-adult survival rates of coho salmon in this basin. The hatchery-produced salmonids are more vulnerable to predation by northern pikeminnow.

Citation

Hansel, H. C., S. D. Duke, P. T. Lofy, and G. A. Gray. 1988. Use of diagnostic bones to identify and estimate original lengths of ingested prey fishes. Transactions of the American Fisheries Society 117:55–62.

Purpose

To describe the use of diagnostic characteristics of selected bones to identify prey fishes obtained from predator stomachs and to estimate original prey size from measurements of selected bones.

Geographic Location

Fish were collected in John Day Reservoir on the Columbia or were obtained from fish hatcheries.

Relevant facts

The cleithrum was diagnostic for all genera except those of the Salmonidae, in which steelhead could not be distinguished from the three salmon species. The cleithra of salmonids are crescent-shaped and expanded along most of both limbs. Genera within a family can also be distinguished on the basis of the leithra. Dentaries were diagnostic for all genera. Dentaries were useful in distinguishing the three salmon species from steelhead; the dentary was wider and its ventral limb was relatively longer in the steelhead than in the salmons. Other diagnostic characters of dentaries were the general shape, presence, and distribution of teeth (e.g., single row of canine teeth in steelhead versus a cardiform pad in species of Ictalurus). Opercles, though diagnostic for all families and most genera, were less resistant than other bones to digestion. Cleithra and dentaries were more persistent in the stomach contents of predators and served as the best means of identifying prey fishes. The cleithrum, because it is relatively large and is one of the first diagnostic bones to develop, was generally the most useful bone for identifying youngof-year fishes.

Conclusion

Results suggest that the identification and measurement of cleithra, dentaries, opercles, and pharyngeal arches of prey species provide an easy and reasonably accurate method of estimating original length of prey fish in partly digested remains. This method may enable investigators to gain useful information that might otherwise be lost when prey fish lengths cannot be obtained by direct measurement.

Citation

Poe, T.P., H.C. Hansel, S. Vigg, D.E. Palmer, and L.A. Prendergast. 1991. Feeding of predaceous fishes on out-migrating juvenile juvenile salmonids in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:405-420.

Purpose

Document the feeding ecology of northern squawfish, walleyes, smallmouth bass, and channel catfish in John Day Reservoir, quantifying the diets of these four predators temporally and spatially, and valuating predation dynamics with respect to out-migrations of juvenile salmonids.

Geographic Location

John Day Reservoir of the Columbia River

Relevant facts

Methods include fish sampling and stomach content analysis. The importance of fish in northern squawfish diets increased with the predators' length. Fish shorter than 200 mm ate mainly ephemeropterans and hymenopterans (41.2-90.5%). As they grew, the predators switched first to crayfish and then to fish. Salmonids composed 21% of the diet of 300-mm northern squawfish and 83% of the diet of the larger fish. Smallmouth bass longer than 100 mm began switching to fish as the major dietary component and the importance of crayfish decreased as predator size increased.

Conclusion

As judged by the dietary composition and prey selectivity of the four predators studied, the northern squawnsh was clearly the major predator on juvenile salmonids in John Day Reservoir. Channel catfish were also important in spring in the upper reservoir. Walleyes and smallmouth bass appeared to select salmonids only when their distributions overlapped that of subyearling Chinook salmon. Size-selective predation by northern squawfish may also play an important role in reducing survival of the smaller individuals within each run of out-migrating juvenile salmonids.

Citation

Mesa, M., J. Beeman, T. Counihan and D. Burgess. 2009. Predator-prey interaction of fishes within the Priest Rapids Project. Unpublished.

Purpose

Increase understanding of predator prey interactions within the Priest Rapids project.

Geographic Location

Priest Rapids project area

Relevant facts

Looked at for study design example. Proposing to use mark recapture, bioenergetics modeling (Bioenergetics 3.0), and stable isotopes.

Conclusion

n/a: proposal

Appendix 6

Habitat Status and Trends

Diagnosis and Treatment of the Okanogan Ecosystem Through Time

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Executive Summary

Habitat restoration is a continuous improvement process aimed to restore impaired ecosystems and protect against future threats. Multiple restoration actions may be implemented across a watershed at multiple scales using various techniques that mature at variable lag times with uncertain efficacy. Single actions occur simultaneous with other restoration and degradation actions, and concurrent with natural decay and recovery, masking or amplifying their actual efficacy. Therefore, the effects of actions on ecosystem status can be difficult to validate at the site level due to its limited scale and context.

The Ecosystem Diagnosis & Treatment (EDT) approach provides a framework for integrating site specific information with larger spatial scales and broader ecological processes. EDT scenarios represent a snap shot of environmental attributes that, when coupled with appropriate biological assumptions, can be used to evaluate the status of an ecosystem through the eyes of a focal species in terms of their performance and limiting factors. The use of a focal species provides a common currency by which multiple scenarios can be compared through time, allowing for the evaluation of habitat status and trends.

The potential of habitat in the Okanogan River to support spring Chinook salmon and steelhead was analyzed for a template (system potential) scenario and for two patient scenarios; 2004 and 2008. The 2004 scenario consisted of the Okanogan Subbasin Plan model that relied heavily, though not entirely, on professional judgment of ecological conditions. The 2008 scenario was developed using information from the Okanogan Basin Monitoring and Evaluation Program (OBMEP) data which was collected by the Confederated Tribes of the Colville Indian Reservation.

Previously published techniques were used to process OBMEP level 1 data into level 2 EDT environmental attributes. OBMEP estimates of alkalinity, dissolved oxygen, embeddedness, fine sediment, flow, gradient, large woody debris, and wetted width were used to populate attribute rankings to produce the 2008 scenario. The remaining attribute rankings remained in common between the 2004 and 2008 scenarios. The two patient scenarios had different values for 681 attribute rankings across 84 stream reaches. Each scenario used the same river geometry, life history assumptions, and out-of-basin survival assumptions. The original template scenario was used in the diagnostic comparison against both the 2004 & 2008 scenario to evaluate changes in the limiting factors analysis through time.

We evaluated habitat status and trends in terms of the performance of each focal species, and the change in limiting conditions relative to the template using Patient-Template Analysis (PTA). We compared habitat performance between the 2004 and 2008 scenarios based on the estimates of the level 5 population performance metrics of diversity, productivity, capacity and equilibrium abundance from the Beverton-Holt stock recruitment curves produced by EDT. We evaluated changes in limiting factors based on the level 3 attribute sensitivities at the diagnostic-unit and life stage level using three status and trend diagnostic factors; condition, prevalence of sensitivities, and severity of impairment.

Change in the condition of each diagnostic unit was evaluated in terms of decreased restoration rank or increased protection rank for each level 5 metric based on the diagnostic unit priorities analysis. Change in prevalence of sensitivity was evaluated in terms of the fraction of EDT level 3 attribute sensitivities that improved in the limiting factors analysis for each life stage, and the fraction of level 5 metrics that improved in the limiting factors analysis for each diagnostic unit. Change in the severity of impairment was evaluated in terms of the change in the relative magnitude of degradation in productivity for each level 3 attribute for each life stage, and the change in relative degradation of each level 5 metric for each diagnostic unit. An index of improvement was generated for each diagnostic unit by assigning a -1 (increased impairment), 0 (no change), or +1 (improvement) to each of the three status and trend diagnostic factors.

Based on the limiting factors analysis the priority life stage for summer Chinook remained egg incubation for both focal species. The relative importance of spawning increased for summer Chinook, with a corresponding decrease in the relative importance of pre-spawning, due to a small shift in the temperature patterns between the two patient scenarios. The importance of fry colonization decreased for summer steelhead due to revised estimates of habitat diversity in the 2008 scenario. Across all summer Chinook life stages and attributes there was a 4% increase in the prevalence of sensitivities, but an 11% improvement in the severity of impairment. For summer steelhead there was no change in the prevalence of sensitivities, but a 21% improvement in the severity of impairment.

When comparing the 2004 versus the 2008 scenario the mainstem Okanogan and Similkameen River remain the priority restoration and protection areas for summer Chinook. For summer steelhead Omak Creek remained the priority restoration area, and the Lower Salmon remained the priority protection area. The condition of 73% and 63% of the diagnostic units improved for summer Chinook and summer steelhead accordingly. Across all diagnostic units and performance metrics there was a 52% improvement in prevalence of sensitivities for summer Chinook, and a 36% improvement for summer steelhead. There was a 17% improvement in the severity of impairment for summer Chinook, and a 26% improvement for summer steelhead. The overall index of improvement was 1.47 for summer Chinook and 0.95 for summer steelhead.

In comparing the performance of the 2004 versus 2008 scenarios the estimate of life history diversity decreased from 19% to 64% for summer Chinook, and remained <1% for steelhead in both scenarios. Excluding the effects of harvest the estimate of productivity increased from 1.7 to 3.0 for Chinook, and decreased from 1.6 to 1.5 for steelhead. The estimate of habitat capacity increased from 9,972 to 24,421 for Chinook, and from 126 to 422 for steelhead. The estimate of equilibrium abundance of Okanogan habitat excluding harvest increased from 4,159 to 16,218 for Chinook, and from 49 to 139.

The status and trend assessment includes two sources of change; change in accuracy and change in condition. For summer Chinook this initial status and trends assessment was highly influenced by a change in accuracy of the information used to populate the patient scenario. The estimates of wetted width in the priority areas were highly understated in the 2004 scenario, creating an artificial bottleneck for sub-yearling summer Chinook. The correction of those values resulted in the dramatic change in capacity between the two scenarios.

Trends in the other ecosystem performance metrics resulted from some combination of better scientific information and actual change in the Okanogan ecosystem. Future ecosystem status and trends analyses will be influenced by both of these contributing factors. Restoration actions will continue to improve the quality of the Okanogan ecosystem, and this influence will begin to dominate the evaluation of trends. Information provided by OBMEP has and will continue to improve the quality of the patient scenario and the influence of information quality on the evaluation of status and trends should decrease through time.

The EDT process provides a much needed framework for synthesizing habitat information collected from the environment, and evaluating the efficacy of restoration programs. Previous attempts to evaluate the ecological effectiveness of restoration programs have focused on project-level accounting of action types, efficacy, and lag time with limited results. The EDT process uses incorporates project accounting as part of the treatment planning step. In this context specific restoration actions are evaluated against the limiting factors analysis, and adopted based on their expected outcomes under ideal conditions. Ecosystem status and trends analysis provides an opportunity to evaluate the actual conditions, to revise the understanding of limiting factors, and to adapt the treatment plan as new knowledge becomes available. Though imperfect, the approach is free from many of the assumptions and uncertainties at the project level, and provides a common currency and lexicon for tackling these complex issues.

The production version of EDT3, due for release in Q1 of 2011, includes the software and tools needed to conduct and ecosystem status and trends analysis. The system includes an online help file which includes tutorials and walkthroughs for conducting the analyses and downloading the relevant reports. The system provides the ability to maintain and evaluate multiple patient scenarios through time, and to evaluate each time period against a common template scenario. The most recent patient analysis can be cloned in the system, and then updated with revised estimates of environmental attributes for the new time period. The new patient scenario can then be compared against the template to provide an updated limiting factor analysis, and can be compared against previous time periods to evaluate trends in ecosystem status in terms of condition, prevalence, severity and an index of improvement. The results are incorporated in an “Ecosystem Status & Trends” report which can be retrieved from the EDT3 system.