THE COLVILLE TRIBES OKANOGAN BASIN MONITORING AND EVALUATION PROGRAM ANNUAL REPORT FOR 2005

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Colville Confederated Tribes Fish and Wildlife Department
Anadromous Fish Division

Colville Tribes Okanogan Basin Monitoring and Evaluation Report for 2005

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Prepared by

John Arterburn, Keith Kistler and Michael Rayton

Prepared for

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

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EXECUTIVE SUMMARY

The Colville Tribes Anadromous Fisheries Department undertook this effort in the spring of 2004 to provide essential information on habitat conditions and fish populations in the Okanogan River basin. The collected data have already greatly expanded the level of knowledge being used for planning efforts and 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 action effectiveness.

The Okanogan Basin Monitoring and Evaluation Program (OBMEP) is not just another regional monitoring strategy. Rather, this plan draws from the existing strategies (ISAB, Action Agencies/NOAA Fisheries, and WSRFB) and outlines an approach for addressing questions specifically related to anadromous fish management and recovery in the Upper Columbia Basin and more specifically the Okanogan River Basin. OBMEP addresses the following basic questions:

1. What are the current habitat conditions and abundance, distribution, life-stage survival, and age-composition of anadromous fish in the Okanogan River Basin (status monitoring)?

2. How do these factors change over time (trend monitoring)?

3. Are tributary habitat actions effective for increasing fish populations and improving habitat conditions (baseline effectiveness monitoring)?

4. What is the cumulative effect of watershed management actions on fish populations (effectiveness monitoring)?

The plan is designed to address these questions and at the same time eliminate duplication of work, reduce costs, and increase monitoring efficiency.

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ACRONYMS

CCT: Colville Confederated Tribes
CSMEP: Coordinated System-wide Monitoring and Evaluation Project
DFO: Department of Fisheries and Oceans, Canada
EDT: Ecosystem Diagnosis and Treatment
EMAP: Environmental Monitoring and Assessment Program
EPA: Environmental Protection Agency
GIS: Geographic Information System
GRTS: Generalized Random Tessellation Stratified
ISAB: Independent Scientific Advisory Board
ISRP: Independent Scientific Review Panel
NPCC: Northwest Power and Conservation Council
NTU: nephelometric turbidity unit
OBMEP: Okanogan Basin Monitoring and Evaluation Program
ONA: Okanagan Nation Alliance
PNAMP: Pacific Northwest Aquatic Monitoring Partnership
RTT: Regional Technical Team
USGS: U.S. Geological Survey
WDFW: Washington Department of Fish and Wildlife
WDOE: Washington Department of Ecology
WSRFB: Washington Salmon Recovery Funding Board

INTRODUCTION

Federal hydropower projects, private power utility systems, habitat degradation, excessive harvest, and human development have all had major negative impacts on anadromous fish that once flourished in the Columbia River and its tributaries. A coordinated and comprehensive approach to the 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 subbasin in particular. Currently, independent research projects and some monitoring activities are conducted by various state and federal agencies, tribes, and to some extent by watershed councils or landowners, but there has been no overall framework for coordination of efforts or for interpretation and synthesis of results until the Okanogan Basin Monitoring and Evaluation Project (OBMEP).

Managers often implement actions within tributary streams to improve the status of fish populations and their habitats. Until recently, there was little incentive to monitor such actions to see if they met their desired effects. Now, however, many programs require that funded actions include monitoring efforts and coordinated measures to reduce duplication or contrary effort and to provide a process for more universal reporting and strategic planning. Within the Upper Columbia Basin, several different organizations, including federal, state, tribal, local, and private entities currently implement tributary actions and conduct monitoring studies. Each monitoring effort has different goals and objectives, therefore, entities use different monitoring approaches and protocols. In some cases, different entities are measuring the same (or similar) things in the same streams with little coordination or awareness of each other's efforts (this is mainly a problem in the Wenatchee subbasin). The Upper Columbia Regional Technical Team (RTT) is aware of this problem and desires a monitoring strategy or plan that reduces redundancy, increases efficiency, and meets the goals and objectives of the various entities.

We have used the structure and methods employed by the Monitoring Strategy for the Upper Columbia Basin (Hillman 2004) and extended and modified them for the Okanogan subbasin. The Colville Tribes and Upper Columbia RTT have identified this project as a high priority based on the close alignment with the NPCC Fish and Wildlife Program, Subbasin Plans, NOAA fisheries guidance. The Independent Scientific Review Panel has given this project high marks in all of its reviews. The overall goal of this program is to provide the real-time data needed to guide restoration and adaptive management in the region.

OBMEP was specifically designed to monitor key components of juvenile fish production, habitat condition, water quality, and adult enumeration. The program also fills identified data gaps, and examines future research needs throughout the Okanogan River watershed.

Methods

As adapted from Hillman (2004), we implemented the Environmental Monitoring and Assessment Program (EMAP) sampling framework, a statistically based and spatially explicit sampling design, to quantify status and trends in juvenile and adult salmonid stream habitats. During the 2005 contract period, 50 randomly selected sites were sampled for juvenile salmonids, water quality, temperature, and physical habitat conditions in the Okanogan River subbasin from late March 2005 through February 2006.

Generally, methods from Hillman (2004) and Kauffmann et al. (1999) were utilized and refined to specifically address the needs of the Okanogan Basin Monitoring and Evaluation Project (OBMEP). Field manuals for collecting habitat and water quality data are in a final draft form, a biological sampling manual for redd surveys, snorkel surveys, macro-invertebrates, rotary screw trapping, and video enumeration are in various draft stages of completion but all protocols are scheduled to be completed by March of 2007. Until all manuals are final, current draft field manuals developed to date can be viewed at our web-site: http://nrd.colvilletribes.com/obmep/.

Project Goals

This monitoring plan requires a long-term commitment as most outcomes will not be realized for 7 to 20+ years. This project is designed to ultimately achieve these goals:

1. Determine if there is a statistically significant difference in biological parameters of summer/fall, spring Chinook, sockeye, and steelhead in the Okanogan basin (7-20+ year time frame).

2. Determine if there is a statistically significant difference in selected physical habitat parameters and characteristics for the Okanogan basin resulting from the cumulative benefits of habitat actions (7-20+ year time frame).

3. Determine if there is a statistically significant difference in selected water quality parameters for the Okanogan basin (7-20+ year time frame).

4. Conduct a baseline Okanogan basin inventory and analysis to: a.) collect data, to raise physical habitat data to an empirical level for use in ecosystem diagnosis and treatment (EDT); b.) collect data on historical and current fish population distributions; and c.) collect passage and other watershed assessment information throughout the basin for use in EDT modeling runs (Lestelle 2004) or to assist in future enhancement planning processes (1-20+ year time frame).

The plan is designed to address these questions and at the same time eliminate duplication of work, reduce costs, and increase monitoring efficiency. The implementation of valid statistical designs, probabilistic sampling, standardized data collection protocols, consistent data reporting methods, and selection of sensitive indicators will increase monitoring efficiency.

For this plan to be successful, all organizations involved must be willing to cooperate and freely share information. Cooperation includes sharing monitoring responsibilities, adjusting or changing sampling methods to comport with standardized protocols, and adhering to statistical design criteria. In those cases where the standardized method for measuring an indicator is different from what was used in the past, it may be necessary to measure the indicator with both methods for a few years so that a relationship can be developed between the two methods. Scores generated with a former method could then be adjusted to correct for any bias.

Primary Goal for 2005: To complete initial design of a basin wide monitoring and evaluation program and begin limited data collection and construction of the needed infrastructure. This monitoring and evaluation program will provide status and trend data for all anadromous fish species in the Okanogan River basin for the next 20 years.

RESULTS AND CONCLUSIONS

Work Element 1: Develop RM&E Methods and Designs

Work Element Title: Develop field protocols for biological and water quality sampling.
Deliverable: Field protocol manual (current protocols available at: http://nrd.colvilletribes.com/obmep/).

Field protocol development began in 2004 with our physical habitat protocols. Our field protocols began where the Upper Columbia Strategy (Hillman 2004) and close collaboration with the Integrated System-wide Monitoring and Evaluation Project (BPA#200301700) left off. The OBMEP needed to address Okanogan basin and Colville Tribal specific needs and provide much finer detail so that our protocols could be utilized as a training manual for new staff. In 2004, we also began developing the draft biological protocols starting with snorkel surveys.

In 2005, we continued work on our field protocols by refining our snorkeling and redd survey protocols. By May 2005, we had a set of draft biological protocols that included: snorkeling, smolt trapping, benthic macro-invertebrate assessment, and methods for detecting steelhead redds. We are refining portions of the biological protocols as we are doing these surveys in the field to provide field testing as part of our QA/QC efforts. Water quality protocols were also developed in 2005. We purchased water quality probes that sample for temperature, conductivity, pH, dissolved oxygen, and turbidity. We also purchased Onset® temperature data loggers in 2004. In March 2005, we began developing a water quality field sampling protocol and began taking water quality grab samples and deploying the temperature data loggers at all of the tributary EMAP sites. We refined the water quality protocols throughout the field season and as of November 2005 we have completed a final draft for the water quality protocol. We will have this protocol final at the end of FY2006.

To ensure compatibility with other regional and basin wide projects that are underway, we have and will continue to coordinate our activities with multiple disciplines and agencies throughout the Okanogan River basin, Columbia Cascade Province, and Columbia River Basin. To remain flexible to changes that might develop from the on-going work of the groups mentioned above, we plan to hold off on putting together a completed protocol manual until all protocols can be field tested. The protocols that are developed can be viewed at: http://nrd.colvilletribes.com/obmep/.

Work Element 2: Produce Environmental Compliance Documentation

Work Element Title: Develop and submit permit applications for installing traps, weirs, video counting stations, gauging stations, and other necessary infrastructure for collecting biological, water quality, and physical habitat data.
Deliverable: Federal, State, and other necessary permits.

We applied and were granted a variety of permits in 2005 as part of the OBMEP project. Part of the design of our monitoring project was to minimize fish handling to the maximum extent possible. We had hoped that this approach would minimize issues related to permitting. Because most of our activities do not require us to handle fish, our monitoring activities can largely be included under BPA's programmatic HIP BO in consultation with our environmental compliance officer Kimberly R. St. Hilaire. However, building or installing infrastructure or monitoring activities that require handling fish still require specific permits. All permits associated with our FY2005 scope of work have been forwarded to Ms. St. Hilaire.

OBMEP currently operates under two Section 10 permits issued by NOAA Fisheries. Permit 1412 covers adult trapping and video enumeration operations in Omak Creek and other tributaries. This permit leveraged from one that was already in place for collecting local broodstock in Omak Creek. A second section 10 permit was received from NOAA Fisheries by OBMEP in August of 2005 (permit 1520) and specifically covers our smolt trapping operation on the Okanogan River. These permits are good until the end of 2010. On-going annual reporting and consultation is a requirement of these permits.

Additional permits for the installation of monitoring equipment include:

1) Smolt trap installation and operation permits from WDFW including HPA, scientific collection permit 06-112, and shorelines permit from the City of Okanogan permit# 1040.
2) Tributary video monitoring picket weir HPA's 104318-2, 104318-1, 104332-1.

These additional permits are all issued annually and will require application and payment of fees each year.

Work Element 3: Produce Status Report

Work Element Title: Produce quarterly reports based on tasks identified within this scope of work.
Deliverable: Three quarterly reports.

These quarterly reports were submitted to BPA in Pisces.

Work Element 4: Produce Annual Report

Work Element Title: Produce annual report based on tasks identified within this scope of work.

Deliverable: Annual report

The 2004 Annual Report was completed in May 2005. This 2005 report was begun in December of 2005 and is to be completed by June 2006.

Work Element 5: Manage and Administer Projects

Work Element Title: Manage Projects: produce invoices, accrual estimates, etc.
Deliverable: Invoices, accrual estimates, purchase orders, employee records etc.

This work element involved maintaining files and ensuring compliance with accepted policies and procedure of the Colville Tribes and BPA. Project management efforts include: 1) the development and execution of sub-contracts; 2) personnel tasks such as payroll for staff, completion of job announcements, conducting interviews, and completion of employee hiring packets; 3) purchasing supplies and equipment including development, execution, and follow-up on orders used to purchase necessary items, and completing processing of accounts payable; and 4) responding to BPA requests and requirements including, monitoring the progress of tasks identified in this scope of work, producing accrual estimates, providing metrics information, and other financial or reporting tasks requested by BPA.

The task of contracting work by subcontractors requires the completion and review of scopes of work, review and approval of invoices, coordinating with our accounting and accounts payable departments, and determining if contract deliverables were provided on time and within budget. The OBMEP requires several sub-contractors. In 2005, we administered contracted work with United States Geological Survey (USGS), Okanagan Nation Alliance (ONA), LGL Limited (LGL), Keith Wolf and Associates (KWA), and Environment Canada. This task has largely been completed by our staff assistant, Loni Seymour, under the direction of the project leader, John Arterburn.

Work Element 6: Coordination

Work Element Title: Project coordination/public outreach.
Deliverable: Improved regional and basin wide consistency and efficiency of data collection and dissemination activities.

OBMEP biologists coordinate directly with other entities performing M&E related activities within the region to ensure compatibility with other regional M&E and salmon recovery efforts. Private landowners have been contacted under this task so that OBMEP field personnel may gain access to EMAP sampling sites. Landowner contacts and other coordination activities have been documented.

The OBMEP was developed under a regional monitoring and evaluation scheme involving coordination with multiple entities to ensure that all M&E efforts are compatible throughout the Columbia Basin and the region. Continued coordination with these entities will be necessary as region wide M&E efforts continue to evolve. The Okanogan sub-basin is a transboundary watershed and therefore coordination with Canadian entities has been necessary as well.

The OBMEP utilizes a generalized random tessellation stratified (GRTS) EMAP sampling design provided by the EPA. Under this sampling design, 150 sampling sites (102 U.S., 48 Canadian) are randomly selected throughout the Okanogan watershed. As many of these sites fall within areas of private ownership, landowners must be contacted (public outreach) and access granted before field crews can conduct surveys. In 2005, landowners were contacted and permission granted as necessary to access the 25 annual panel sites and the 25 panel-1 sites visited in 2005. Landowners will continue to be contacted in future years to secure access to all 150 EMAP sampling sites. OBMEP biologists and other field staff have made multiple contacts with landowners throughout the Okanogan basin to gain access to EMAP sampling sites. Most contacts have been positive and access to perform the work of this contract has gone forward as planned. Some changes have been made to sampling strategies in areas where landowners were not cooperative.

There were multiple coordination meetings with the Upper Columbia RTT (Regional Technical Team) in the winter of 2005 and 2006. Data has been shared at these meetings along with field manuals and strategies for field sampling, data archiving, manipulation, and analysis.

<u>2005 OBMEP COORDINATION ACTIVITIES</u>

March

- OBMEP staff met with CCT and Washington state permit staff, real estate staff, and GIS staff to coordinate smolt trapping permitting.
- Contacted USFWS to determine permitting needs relative to ESA listed bull trout.
- Reviewed Douglas County PUD comments on 2005 NOAA Fisheries Smolt Trapping Section 10 Application.
- Attended meeting of RTT monitoring protocol sub-committee to compare protocols used in Wenatchee and Okanogan sub-basins and reviewed meeting minutes.
- Attempted to contract WDOE relative to 2005 water quality monitoring in the Okanogan Sub-basin

April

- Coordinated with WSDOT staff and responded to information requests regarding attachment of the smolt trap to Malott Bridge.
- Met with WDOE staff regarding collaborative water quality monitoring effort and regarding benthic macro-invertebrate sample analysis.

May

- Conference with John Day database managers to get update on geospatial database and protocol builder tool.

- Conference with multiple Coordinated System-wide Monitoring and Evaluation Project (CSMEP) participants and NOAA (project database—Steve Katz) on database structure and design timelines for regional database.
- Prepared responses to requests for additional information from WSDOT (including schematics and site photos) and from CCT cultural department regarding 2005 smolt trapping permits.
- Met with WDFW staff and conducted site visits to smolt trapping operations on Methow River.
- Visited site and reviewed Yakama Nation smolt trapping effort also on Methow River.
- Visited site and reviewed Umatilla tribal smolt trapping program on Umatilla River.

June

- Coordinated OBMEP monitoring efforts in Canada with ONA staff.
- Obtained benthic macro-invertebrate database from WDOE.
- Assembled list of benthic macro-invertebrate labs for contract consideration.
- Attended PNAMP/CSMEP coordination meeting.

July

- CCT staff meet with ONA, WDFW, sub-contractors, and other regional monitoring partners to coordinate activities.

August/September

- Integration of the OBMEP database with the NOAA/John Day effort—final meeting in Montlake (NW Fisheries Science Center) with NOAA. This to continue to ensure that the OBMEP database will be compliant with Protocol Manager and Builder (a center-field programming application for managing RME programs).
- Met with RFEG State Lead Paul Annuch to talk about ways to involve volunteers in OBMEP programs.

October

- Investigating analytical processes and convening experts to begin scoping a regional approach for data analysis.

November

- Coordinated with subcontractors to develop design and templates for an OBMEP public web page.
- Attended Water Quality workshop in Port Townsend, Washington.

December 05 – February 06

- Attended and represented OBMEP at third WDOE Status and Trend Monitoring Workshop.
- Attended CSMEP Fish Monitoring workshop.
- Attended annual upper Columbia RM&E coordination meeting in Chelan, WA.

Work Element 7: Manage/Maintain Database

Work Element Title: Complete, manage, and maintain database.
Deliverable: Components of a Data Management System were developed to handle the archiving, maintenance, and subsequent analysis of historical data collected for the OBMEP Program. CCT staff was trained on basic Access functions.

In 2004, we began entering field data into spreadsheets and creating summary statistics in these spreadsheets. In 2005, we migrated to Trimble® electronic data collectors as well as Palm Pilots and electronic data loggers. From these data collectors we have continued to enter our data into summary spreadsheets. We began conversion of these spreadsheets into Access as a progression towards developing a functional relational database. The database is needed to efficiently address reporting needs for this project and allow us to provide information rapidly when requested.

To summarize data management activities to date, there is ongoing collection of field data in the Okanogan basin to support limited status and trend analysis. The sampling protocols for future data analysis are still under development. At the end of this contract in 2005, our contractor, KWA, delivered a database that contains the some fields to enter habitat data into Access®. Considerable progress was made and the beginning elements of a database have been assembled that provide a framework for functional data management in the future that is fully consistent with metadata and data management standards developed by CSMEP, StreamNet, and NED for monitoring and evaluation projects in the Columbia River basin.

The OBMEP database and data are contained on the OBMEP server located at the Colville Tribes Fish and Wildlife Department offices located in Omak, WA. NOAA Fisheries is working on creating a similar database structure but this effort has lagged behind the needs of the OBMEP to manipulate data that is already being collected. Once this information is available and the structure and function is known we will make certain that our database is capable of providing compatible data with all recommended and necessary metadata.

Work Element 8: Install Fish Trap/Monitoring Weir

Work Element Title: Design, build, and install video counting equipment
Deliverable: Equipment for video counting of adult salmonids constructed and installed

Two video counting arrays at Zosel Dam were custom designed and built to enumerate adult salmonids in the Okanogan Basin (Figures 1 & 2). The arrays installed at this facility will provide data on speciation, enumeration, and origin for all adult salmon and steelhead and partition what portion of the fish entering the Okanogan River are destined for spawning habitats located in Canada. Prior to building the east bank array, to avoid duplication of mistakes, we worked through several issues related to improving the quality of our video images using the west bank array until we were happy with the resolution(Figures 3 & 4). Additionally, we designed and constructed portable video counting arrays that can be used to enumerate summer steelhead entering specific tributary habitats. To monitor the salmonids entering tributary habitats we utilized existing infrastructure where possible or installed portable picket weirs or video camera arrays where needed and functional. To determine the possibility of using portable video we contracted to have 3 portable video arrays constructed by LGL Limited that would be evaluated in FY2006, and picket weirs will be installed in a rotating panel of all anadromous tributaries (access dependent) once every five years. Conceptual design (Nass and Bocking 2005) elements for a video counting facility to be built near Malott, WA, has been completed and can be found on the OBMEP website at http://nrd.colvilletribes.com/obmep/Reports.htm.

Figure 1: West bank video array was custom designed for and installed at Zosel Dam on the Okanogan River and has been collecting data since October 2005. Picture on left shows light tubes and fish passage chamber. Picture on right shows video arrays in installed position with right-turn attachment that was retro-fitted to improve hydraulic function.

Figure 2: East bank video array was custom designed for and installed at Zosel Dam on the Okanogan River and has been collecting data since February 2006. Picture on left shows light tubes and fish passage chamber. Picture on right shows video array in installed position with right-turn anchorage used to attach array to the dam structure and servicing crane.

Figure 3: Summer Chinook salmon image collected on 11/10/05 from the west bank video array at Zosel Dam on the Okanogan River.

Figure 4: Summer steelhead image collected on 3/24/06 from the west bank video array at Zosel Dam on the Okanogan River.

Video enumeration has always been part of the design of the OBMEP. The primary objectives were to design, install, operate, monitor, and evaluate underwater video systems for the Okanogan River basin. Operations began at Zosel Dam on October 19, 2005, when a custom-made fish-passage chute, complete with a state-of-the-art, motion-detection and time-lapse Digital Video Recorder (DVR), was installed on the right-bank fishway to capture fish passage events 24 hours a day, 7 days a week, 365 days a year. The fish passage chute and florescent lighting systems were custom designed to fit the unique configurations of the fishway facility at Zosel Dam. The left-bank system was completed on February 17, 2006.

DVR technology allows for time efficient review of fish passage events in order to document fish abundance and migration timing. The DVR automatically detects motion within a camera's field-of-view and collects video clips for a user-specified time period and frame capture rate. The imagery is stored on a 250 GB hard-drive for later review using the DVR software. At the Zosel Dam site, the system's ether-net capabilities and a wireless router provide the user with internet access to both view images in real-time and archive imagery. This real-time capability allows remote access for checking the system operational status and the efficient servicing of the system when needed. The preliminary parts of a custom database have been developed and expanded in FY2006 to help generate analytical summary reports from the image data.

Suboptimal water clarity has been one of the biggest challenges in completing this project. However, after extensive product and configuration testing, the system is successfully recording the 24-hour passage of fish with excellent image quality. To date, data on several species of fish have been collected while passing Zosel Dam, including data on sockeye, Chinook, steelhead, resident rainbow, bridgelip sucker, common carp, small-mouth bass, mountain whitefish, northern pikeminnow, yellow perch, chiselmouth and burbot. Image quality has been sufficient to allow for anadromous fish speciation, enumeration, and identification of marks such as adipose fin presence/absence. Several video clips have also documented rogue muskrats in search of plunder.

The program includes monitoring tributary sites in the watershed. The application is different from the operation at Zosel Dam in that the video chute (rectangular, open-ended box with side-looking cameras) is installed into the channel of selected tributaries of the Okanogan River. Operating from 1 March through early May, these arrays provide tributary-specific fish-passage counts of adult steelhead moving into spawning areas. The chute provides a controlled passage corridor in which to collect digital imagery. This operation involves anchoring the chute to the streambed with rebar or metal piles. A weir made of temporary picket panels was installed on Bonaparte Creek and used as a fish guidance structure (FGS) funneling upstream-moving fish into and through the chute while prohibiting upstream passage around the structure. These are the same weir components that have been used by the CCT on Omak Creek for locally-adapted steelhead broodstock collection and adult escapement monitoring (authorized by NMFS Direct Take Permit #1412). Installing the chute and panels will not require substrate or shoreline manipulation (Figure 5).

Figure 5: Portable tributary video enumeration station on Bonaparte Creek in 2006. Fish guidance structure and video image chamber are shown installed in Bonaparte Creek with DVR and battery storage unit located chained to a tree on the bank. Hardware for three units were constructed but only one was installed for testing FY2006.

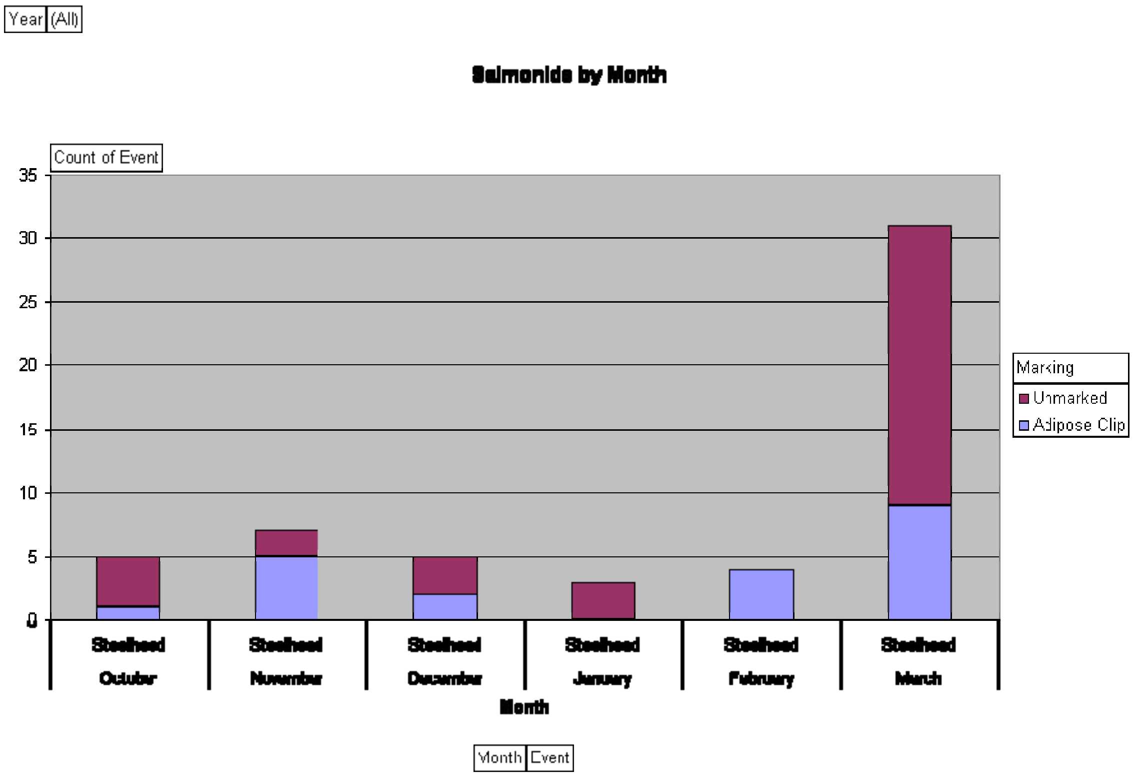

Figure 6: Total summer steelhead that have passed through the video counting chambers located at Zosel Dam through March 31, 2006.

Work Element 9: Collect/Generate/Validate Field and Lab Data

Work Element Title: Collect, verify, and post temperature data from USGS real-time gauging stations along the Okanogan River mainstem and develop agreements to collect additional real-time data throughout the Okanogan River Basin.
Deliverable: Web accessible data for real-time temperatures taken at 3 USGS gauging stations and 3 additional discharge and temperature stations operated by Environment Canada. Cooperator agreements with USGS, and Environment Canada to maintain new and existing real-time discharge and temperature gauging stations will be completed for each site annually.

A contract was initiated with the Department of Ecology in FY2005 and an agreement was developed to expand collection of discharge and temperature data in the Okanogan Basin. The Department of Ecology was unable to fulfill their initial commitments and the money was redirected to the USGS and Environment Canada.

A contract was initiated and completed with the United States Geological Service. Real time temperature data collection upgrades were made at three sites on the Okanogan River in the United States at Oroville, Malott, and Tonasket.

New data has been assimilated into on-going data collection activities within the USGS web sites. This data is available on the World Wide Web to provide transparent public access and appropriate credit is given to BPA and the Colville Tribes for making this data available.

- USGS at Malott; http://waterdata.usgs.gov/wa/nwis/dv?dd_cd=01%2C02%2C05%2C05%2C05&format=gif&period=365&site_no=12447200

- USGS at Tonasket; http://waterdata.usgs.gov/wa/nwis/uv?12445000

- USGS at Oroville; http://waterdata.usgs.gov/wa/nwis/dv/?site_no=12439500&agency_cd=USGS

Real-time data collection at gauging stations is critical to fisheries and regulatory agencies. Last year the OBMEP project determined that no additional information would be gained by collecting water quality data at all EMAP sites located along the Okanogan River mainstem by analyzing existing data with the exception of temperature data (Arterburn and Kistler 2005). Expanding real-time temperature data collection at the above listed discharge stations along the Okanogan River now provides for the ability to manage fish and fisheries using critical information developed on migration timing that relates directly to temperature.

The Okanogan River watershed, especially the Canadian portion, has several tributaries with unknown discharge or temperature regimes. The Colville Tribes developed cooperative agreements between the Okanagan Nation Alliance, The Ministry of Environment, Environment Canada to address these data gaps for Inkaneep, Vaseux, and Shuttleworth Creeks. Flow and temperature have been identified as primary limiting factors throughout the Okanogan River basin. By expanding real time data collection efforts, massive amounts of data can be cost effectively collected and used by a highly diverse group of stakeholders, with a long-term commitment to funding and on-going operation and maintenance. Data will begin streaming from these sites in the summer of 2006 once the stage discharge curves have been developed and verified as accurate according to the standards developed by Environment Canada and available for download at http://scitech.pyr.ec.gc.ca/waterweb/selectProvince.asp.

Work Element 10: Install Flow Measuring Device

Work Element Title: Install one real-time stream gauging station on Nine-Mile Creek.
Deliverable: One real-time gauging site.

One real-time gauging site capable of measuring discharge and temperature was slated to be installed on Nine-mile creek. Contracts were unable to be executed with the Department of Ecology of Washington State. The money for this project was redirected to Canada where a new gauging station was installed on Inkaneep Creek by Environment Canada through a sub-contract with ONA.

This data is available for public access at:
http://scitech.pyr.ec.gc.ca/waterweb/selectProvince.asp.

Work Element 11: Install Flow Measuring Device

Work Element Title: Install one real-time stream gauging station on a creek that is yet to be determined.
Deliverable: One real-time gauging site.

One real-time gauging site capable of measuring discharge and temperature was installed on Vaseux Creek in Canada by Environment Canada through a sub-contract with ONA.
This data is available for public access at:
http://scitech.pyr.ec.gc.ca/waterweb/selectProvince.asp.

Work Element 12: Install Flow Measuring Device

Work Element Title: Install one real-time stream gauging station on a creek that is yet to be determined.
Deliverable: One real-time gauging site.

One real-time gauging site capable of measuring discharge and temperature was installed on Shuttleworth Creek in Canada by Environment Canada through a sub-contract with ONA..
This data is available for public access at:
http://scitech.pyr.ec.gc.ca/waterweb/selectProvince.asp

Work Element 13: Collect/Generate/Validate Field and Lab Data

Work Element Title: Collect water quality data from 30 EMAP sites located throughout the Okanogan River basin
Deliverable: Water Quality data from 30 randomly selected EMAP sites.

Water quality probes were purchased from Eureka Environmental in March of 2005. These probes collect data on temperature, dissolved oxygen, turbidity, conductivity, and pH. Data was collected three times a month at 19 of the randomly selected EMAP sites in water year 2005 (October 2004 to October 2005) within the United States. These sites were on the tributaries of the Okanogan River and associated with either the annual or panel 1 EMAP locations. Four sites on the Okanogan River and one site on the Similkameen River within the Okanogan River were also surveyed during this time period (Figure 7). An additional 6 sites were monitored for part of the year in Canada as a pilot to train staff and insure consistent data collection for FY2006.

We began surveying new sites in October 2005 that are associated with the annual or panel 2 EMAP locations in both the United State and Canada. This data will be reported on in the 2006 annual report.

The 2005 water year data was compiled into spreadsheets and compared between sites. Status analysis was conducted on these data and displayed in graphical form later in this document.

2005 Water Quality Survey Sites

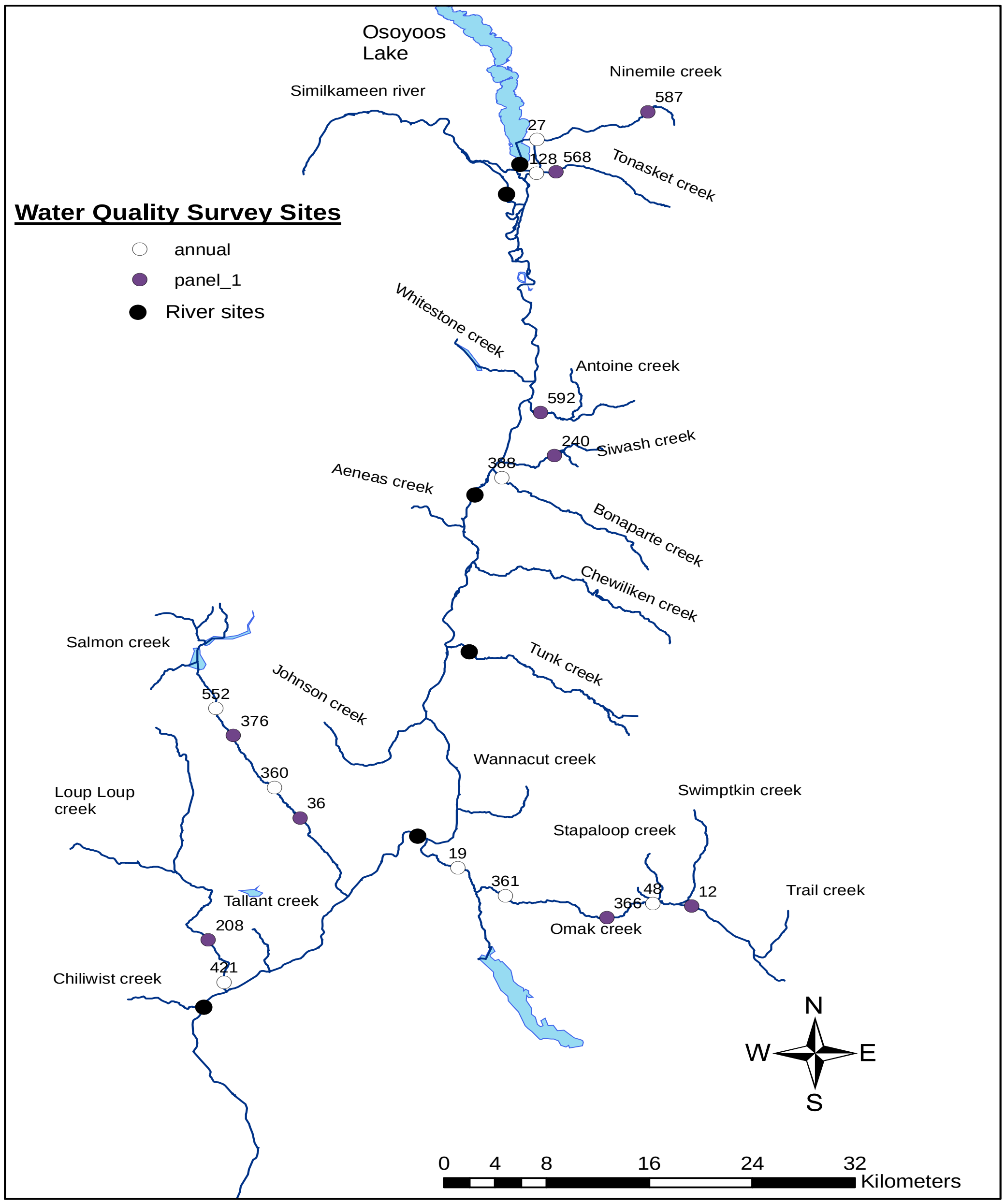

Figure 7: 2005 water quality survey sites. Data collected at these 24 sites includes: dissolved oxygen, turbidity, specific conductivity, pH, and temperature.

Work Element 14: Collect/Generate/Validate Field and Lab Data

Work Element Title: Collection of physical habitat data at EMAP sampling sites.
Deliverable: Physical habitat data for 30 EMAP sampling sites.

Physical habitat data was collected at 50 (25 annual panel, 25 rotating panel) EMAP sampling sites consistent with protocols as developed in work element 1 previously described in this document. 34 sites were surveyed in the United States portion of the Okanogan Basin by the Colville Confederated Tribes and 16 sites were surveyed in the Canadian portion of the Okanagan Basin by the Okanagan Nation Alliance. (Figures 8 & 9)

Physical habitat data was collected at annual and rotating panel sampling sites per EMAP GRTS six panel sampling design (Peck et al. 1999). The 25 rotating panel sites change every year until after the fifth year when you return to the first panel (Hillman 2004). Physical habitat data was collected in electronic format on Trimble GPS data loggers. Information was collected pertaining to 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 (Moore et al. 1998 & 1999).

Data collected in 2004 and 2005 was compared for indicators that were considered likely to remain consistent between years such as bankfull width. These indicators showed little variation between years or between field crews. This indicates that efforts to utilize common protocols and the use of extensive training are producing data with little observer bias and high precision.

2005 OBMEP Survey Sites-US

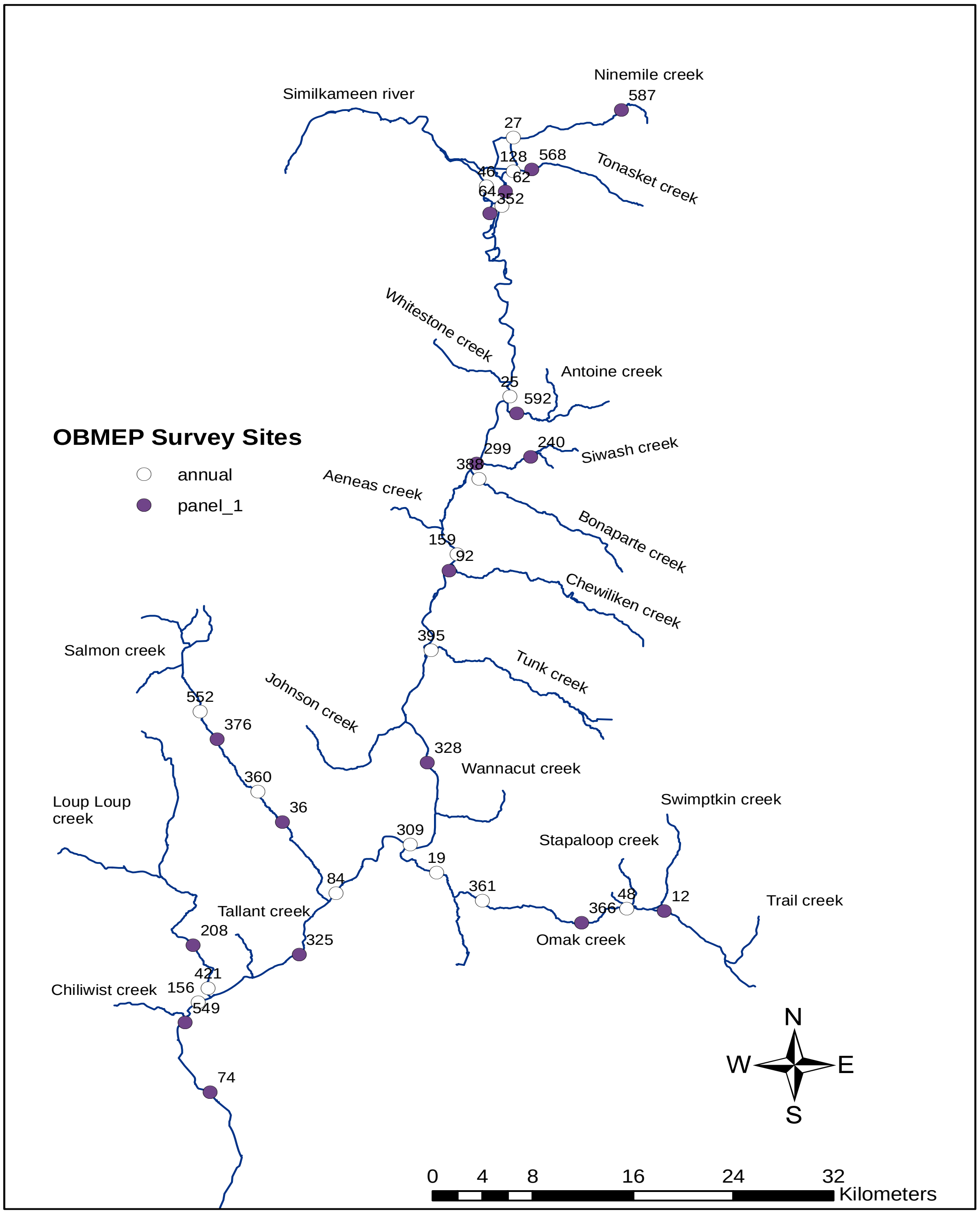

Figure 8: 34 OBMEP-US survey sites 2005

Canada OBMEP Sites-2005

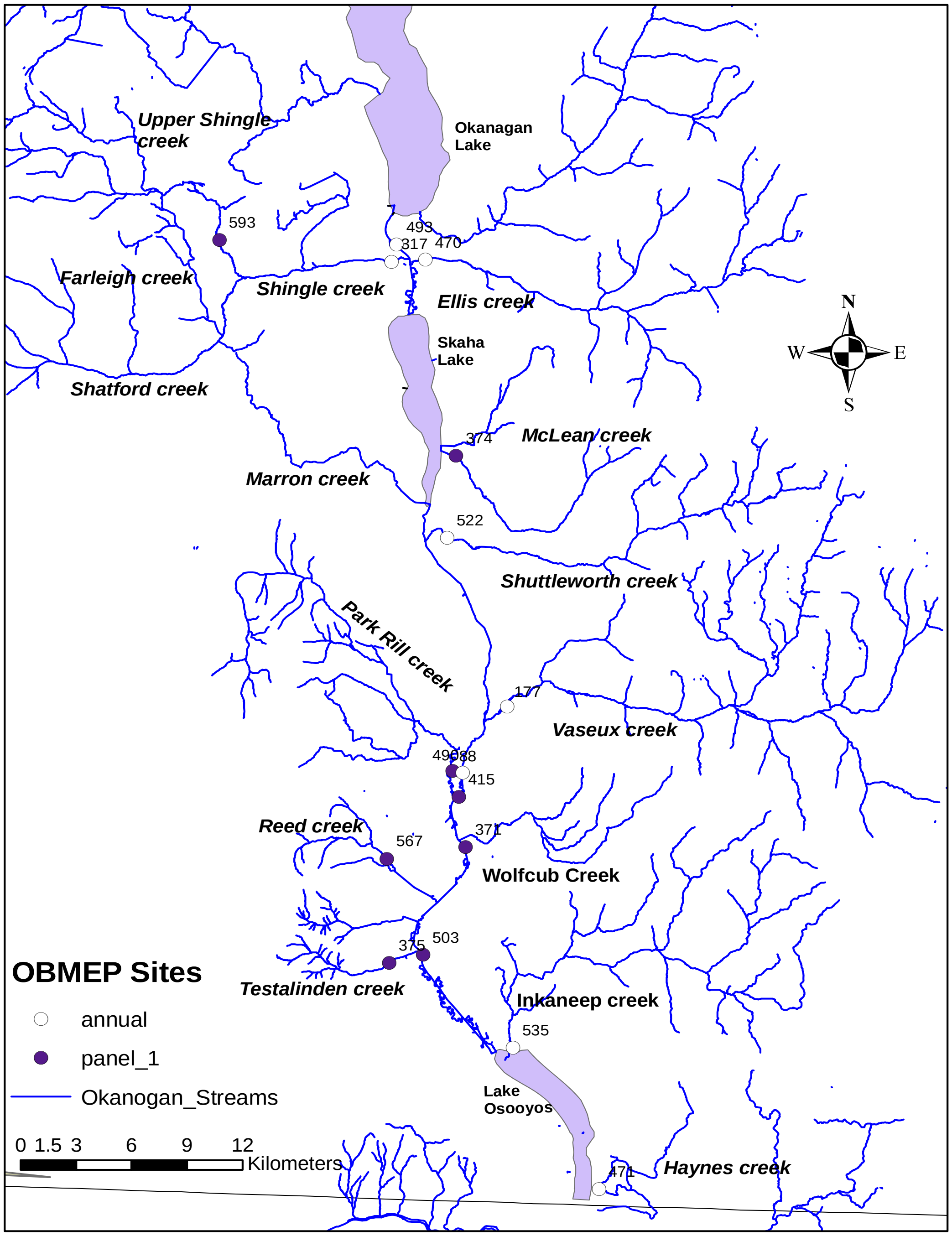

Figure 9: 16 OBMEP survey sites, Canada

Work Element 15: Collect/Generate/Validate Field and Lab Data

Work Element Title: Collect data on adult and juvenile anadromous fish, steelhead redd counts, and macro-invertebrates in the Okanogan River and selected tributaries.
Deliverable: Data on abundance and distribution of juvenile and adult anadromous fish, macro invertebrates, and steelhead redds.

We had hoped to fish a rotary screw trap to collect juvenile anadromous fish but because of delays in obtaining a section 10 permit from NOAA Fisheries we were unable to install the trap prior to July 15. After July 15, it was highly unlikely that any anadromous or listed fish species would be detected because of high summer water temperatures in the Okanogan River. We installed and tested a smolt trap in one location on the Okanogan River at the bridge in Malott, Washington on August 18, 2006. However, the rotation rates of the cone did not exceed 5 revolutions per minute; this is considered the minimum rotational speed for effective operation of a rotary screw trap (Pers. comm. Paul Wagner). We identified a new location at the Highway 20 bridge near the town of Okanogan, WA, but to install the rotary screw trap required a whole new set of permits for this new location. Therefore juvenile fish collection was postponed to FY2006.

We installed video cameras at Zosel Dam for adult anadromous fish enumeration (see work element 8).

We surveyed the Okanogan River and anadromous fish producing tributaries for redds and produced a Redd Survey Report that can be found on the OBMEP web site at: http://nrd.colvilletribes.com/obmep/Reports.htm. Snorkeling was done following the habitat surveys at the EMAP survey sites for all annual and panel 1 sites. A snorkel report can also be found at the above OBMEP web site.

All of the work was done following protocols established for this project by the Colville Confederated Tribes and other contributors as identified in work element 1. There was a high level of coordination with local planners, regional collaborators, and other data collection agencies to achieve the best data available, reduce redundancy, and reduce costs.

Work Element 16: Collect/Generate/Validate Field and Lab Data

Work Element Title: Stream survey and data collection at selected tributaries (McIntyre Creek, Park Rill Creek, and Shuttleworth Creek).
Deliverable: Report on condition and habitat potential of selected tributaries

We gathered data, through the Okanagan Nation Alliance, on barriers and selected habitat parameters along watersheds in Canada that have had only minimal data collected on them.

This data gathered will help to determine the condition of tributaries for anadromous fish production. We will then be able to develop a better idea of habitat potential throughout the Okanogan basin, generate plans for recovering these habitats, and better target future M&E

efforts. Results from the OBMEP barrier survey can be found on our web site at: http://nrd.colvilletribes.com/obmep/Reports.htm.

Work Element 17: Analyze/Interpret Data

Work Element Title: Analyze collected and historical data on habitat, biological, and water quality parameters.
Deliverable: Data summaries of habitat, biological, and water quality parameters.

We gathered data on habitat, water quality, and anadromous fish biology as defined in our protocols. We then synthesized our collected data and data gathered by other agencies and individuals into usable summary tables and graphs.

Data gathered by the Colville Confederated Tribes and other agencies and individuals working in the Okanogan Basin is synthesized and interpreted to confirm that all crucial data is being collected and that we will be able to draw conclusions from this data once a long-term data set is established. Analysis of this data has occurred as part of this annual report writing task.

Historical and current anadromous fish counts over Wells dam.

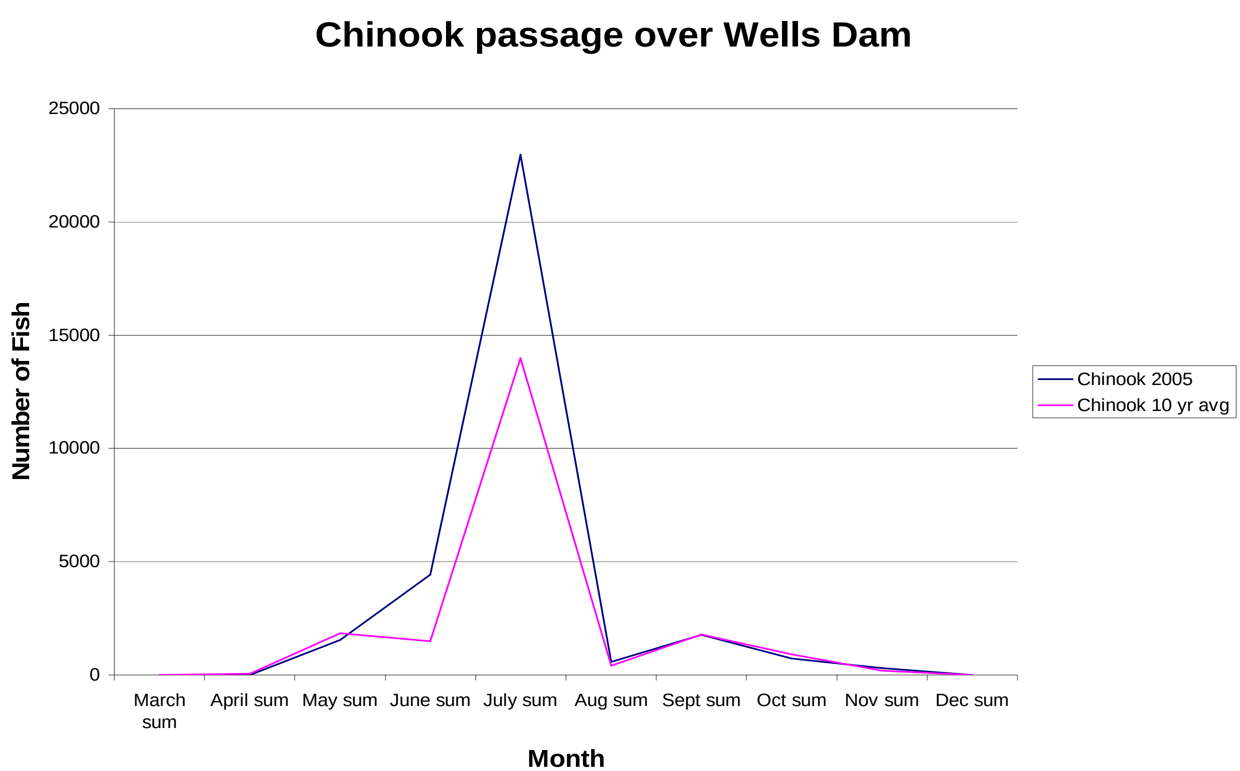

Figure 10: Adult Chinook returns over Wells Dam from 2005 and the last ten year average (http://www.cqs.washington.edu/dart/dart.html).

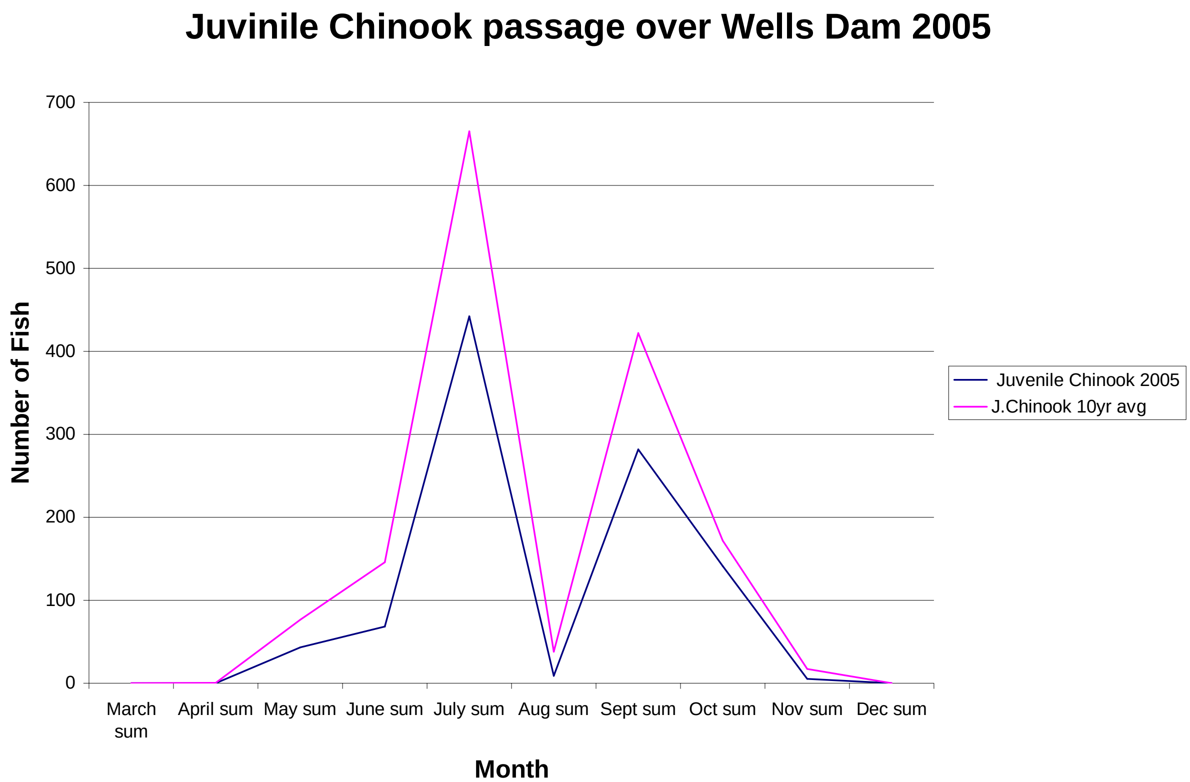

Figure 11: Jack Chinook returns over Wells Dam in 2005 and the last ten year average (http://www.cqs.washington.edu/dart/dart.html).

Wells Dam is located along the Columbia River 515.8 miles upriver of its mouth and was constructed in 1967. Adult Chinook returns to Wells Dam have increased dramatically since 1986, with 2005 being above the last 10 year average. Most salmon stocks throughout the Columbia River have shown increased abundance over this period due to improved ocean productivity and to a lesser extent from habitat improvements. Another reason for increased adult Chinook returns above Wells Dam is supplementation by fish hatcheries, specifically releases from Turtle Rock that are acclimated at the WDFW pond located on the Similkameen River (Figure 10).

The returns of jack Chinook have often been used as an indicator of the next years adult returns because jacks are fish that return from the ocean a year ahead of schedule. However, the trends in jack returns above Wells Dam do not support this assumption. Jack returns are unlikely to be closely correlated with next year's adult returns and should be avoided for predicting returns above Wells Dam (Figure 11).

Sockeye passage in 2005 also was dramatically greater than the previous ten year average. No hatchery supplementation has occurred for this species in recent years. Improvements to spawning habitat, egg to fry survival, rearing conditions, and ocean survival have all contributed to increases since 1987. Dramatic between year fluctuations in abundance are not uncommon in this population. Recently restoration efforts have focused on improved water management (Hyatt and Rankin 2004) but it is not possible to decouple these benefits from the benefits of increased ocean productivity making it difficult to draw cause and effect conclusions. The returns in 2005 can be used to indicate what is possible for sockeye restoration efforts (Figure 12).

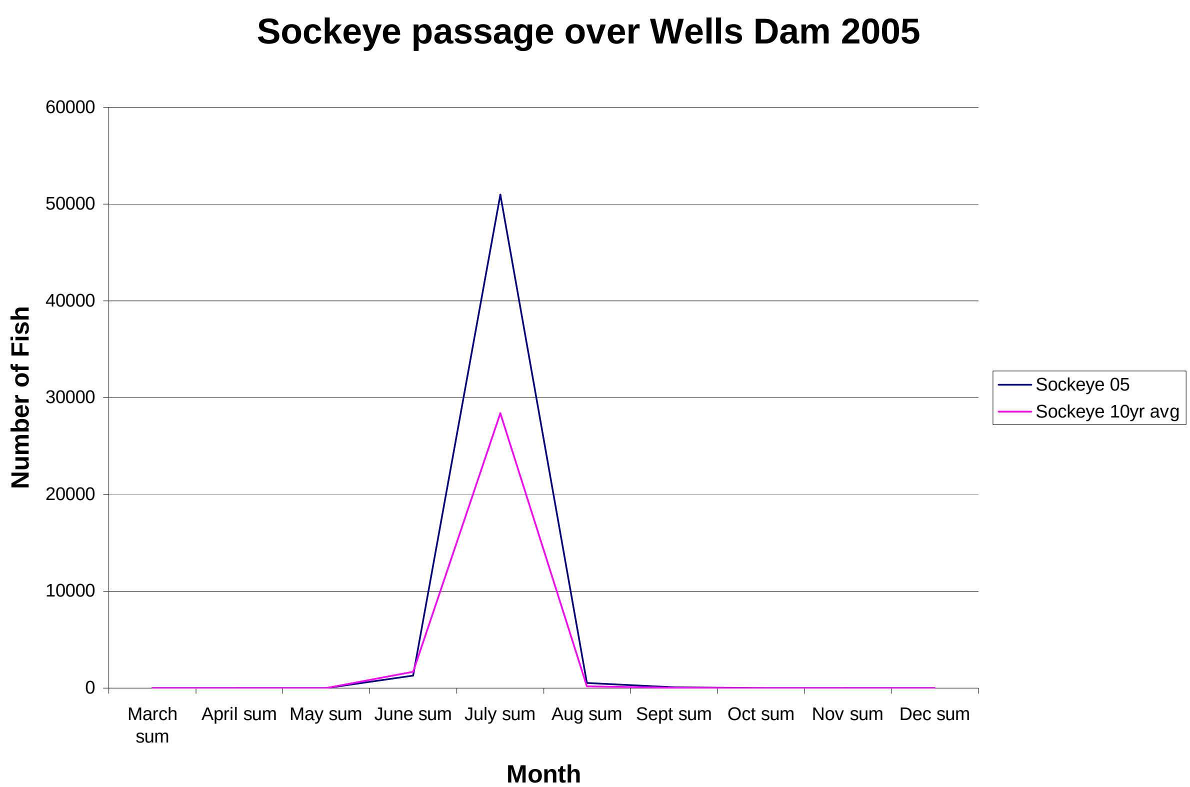

Figure 12: Adult sockeye salmon returns over Wells Dam in 2005 and the last ten year average (http://www.cqs.washington.edu/dart/dart.html).

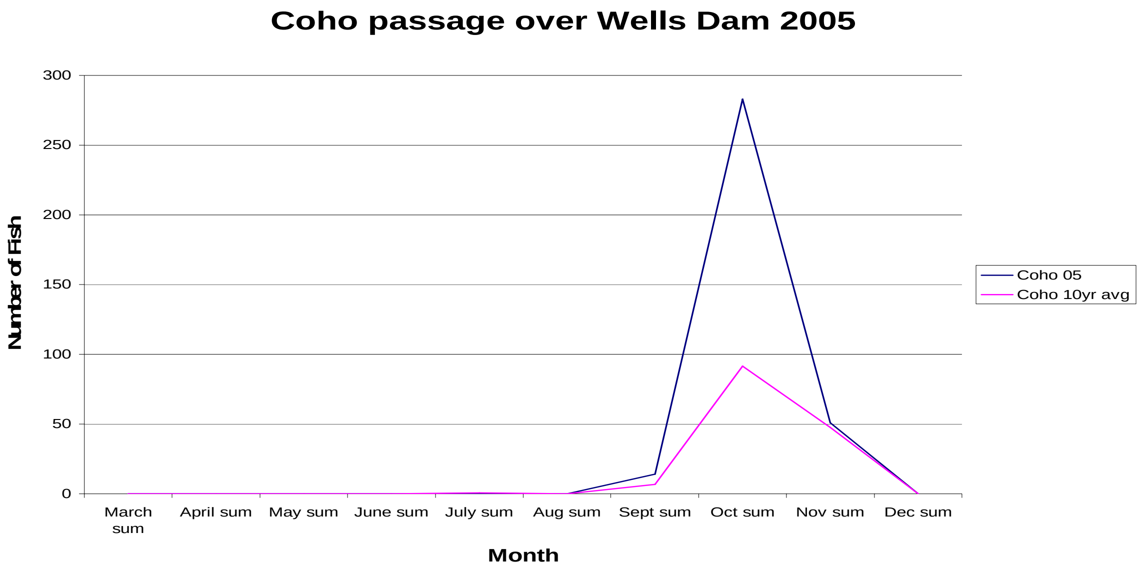

Figure 13: Adult coho salmon returns over Wells Dam in 2005 and the last ten year average (http://www.cqs.washington.edu/dart/dart.html).

Coho have been counted sporadically since 1977. The current increase in numbers in 2005 is attributable to coho reintroduction efforts conducted by the Yakama Indian Nation. The increases in abundance are mainly the result of hatchery supplementation released into the Methow sub-basin (Figure 13). No adult coho returns are know to have occurred in the Okanogan sub-basin from these efforts although a few fish are believed to have entered this river for short periods.

Adult steelhead passage was comparable to the ten year average at Wells Dam in 2005. Approximately 34% of these fish had adipose fins with the rest being of hatchery origin (Figure 14). Steelhead redd surveys were conducted throughout the Okanogan Basin by the Colville Tribes. Redd survey information was used to estimate the number of adult spawners by survey reach and tributary. For more specific data please refer to our Steelhead Spawning Ground Survey Report at http://nrd.colvilletribes.com/obmep/Reports.htm.

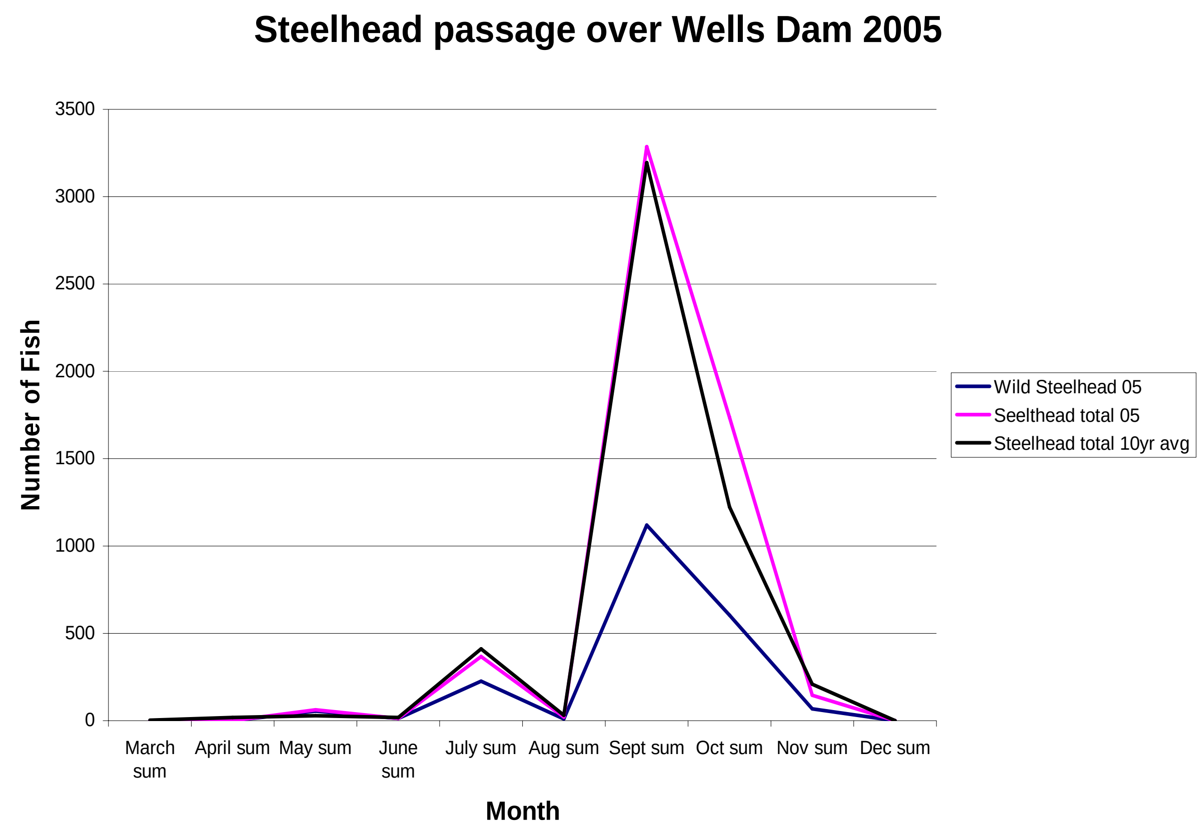

Figure 14: Adult steelhead returns over Wells Dam 2005 and the last ten year average (http://www.cqs.washington.edu/dart/dart.html).

Okanogan River summer/fall Chinook Redd surveys

Annual redd counts have been conducted by Chelan Public Utility District and WDFW for summer/fall Chinook in the Okanogan basin since 1956. Data on the historical number of redds counted on the Okanogan River with aerial and ground surveys can be found on the OBMEP web site at: **http://nrd.colvilletribes.com/obmep/Reports.htm**

Okanogan River Tributary Discharge

Discharge measurements included in the following tables were taken by WDOE and represent, at best, monthly grab sample data currently available.

Table 1: Mean monthly discharge data in cubic feet per second collected from Nine-mile and Tonasket Creeks from 2002 to 2005 by WDOE.

Month	Nine mile cr. mean flow 2005	Nine mile cr. mean flow 2004	Nine mile cr. mean flow 2003	Nine mile cr. mean flow 2002	Tonasket cr. mean flow 2005	Tonasket cr. mean flow 2004	Tonasket cr. mean flow 2003	Tonasket cr. mean flow 2002
Oct mean	NA	1.2	1.1	NA	0	0	0	0

Nov mean	1.3	NA	NA	NA	0	0	0	0
Dec mean	1.25	NA	NA	NA	0	NA	NA	NA
Jan mean	NA	NA	NA	NA	0	NA	NA	NA
Feb mean	1.35	NA	NA	NA	1.8	NA	NA	NA
March mean	2.9	3.55	NA	NA	3.9	1.3	NA	NA
April mean	2.9	1.05	6.8	NA	3.9	0.15	9.25	NA
May mean	1.3	0.2	NA	NA	4.57	0.3	NA	NA
June mean	1.47	0.3	NA	0.42	2.7	NA	NA	0.86
July mean	NA	NA	NA	0.13	0	NA	0.2	0.05
Aug mean	0.4	0.3	NA	0.2	0	NA	NA	NA
Sept mean	0.35	NA	NA	0.25	0	NA	NA	NA

Nine-mile Creek is known to have flow all year and support steelhead spawning and rearing. Tonasket Creek goes dry during part of the year and currently does not support steelhead spawning or rearing in most years. Tonasket Creek had discharge only from February through July in the period from 2002 to 2005 (Table 1).

Johnson and Antoine Creeks flow year round in most years but in 2004 zero discharge was recorded for Antoine Creek during the month of Febuary. Neither creek is known to support steelhead spawning (Table 2). Most tributary streams show low flow characteristics from July through January in the United States portion of the Okanogan River basin (Figure 15). The Okanogan River watershed along with most of eastern Washington have experienced drought conditions over the last 4 years with 2003 being considerably wetter than 2005, 2004, or 2002 (Tables 1&2).

Table 2: Monthly discharge data collected from Johnson and Antoine Creeks from 2002 to 2005 by WDOE.

Month	**Johnson Cr. mean flow 2005**	**Johnson Cr. mean flow 2004**	**Johnson Cr. mean flow 2003**	**Johnson Cr. mean flow 2002**	**Antoine Cr. mean flow 2005**	**Antoine Cr. mean flow 2004**	**Antoine Cr. mean flow 2003**	**Antoine Cr. mean flow 2002**
Oct mean	NA	0.2	0.2	NA	NA	NA	NA	NA
Nov mean	0.5	0.5	NA	NA	11.1	NA	NA	NA
Dec mean	1.05	1.6	NA	NA	6.4	NA	NA	NA
Jan mean	NA	NA	NA	NA	NA	NA	NA	NA
Feb mean	NA	NA	NA	NA	5.15	0	NA	NA
March mean	NA	0.1	NA	NA	3.1	1.5	NA	NA
April mean	0.1	0.4	0.1	NA	2	0.7	NA	NA
May mean	0.53	0.3	1.5	NA	1.35	0.8	NA	NA
June mean	0.85	0.7	4.3	0.43	6.4	1	NA	1.43
July mean	NA	NA	NA	0.45	NA	NA	NA	2.5
Aug mean	0.3	0.1	NA	NA	NA	0.5	NA	4
Sept mean	0.3	NA	NA	NA	1.35	NA	NA	NA

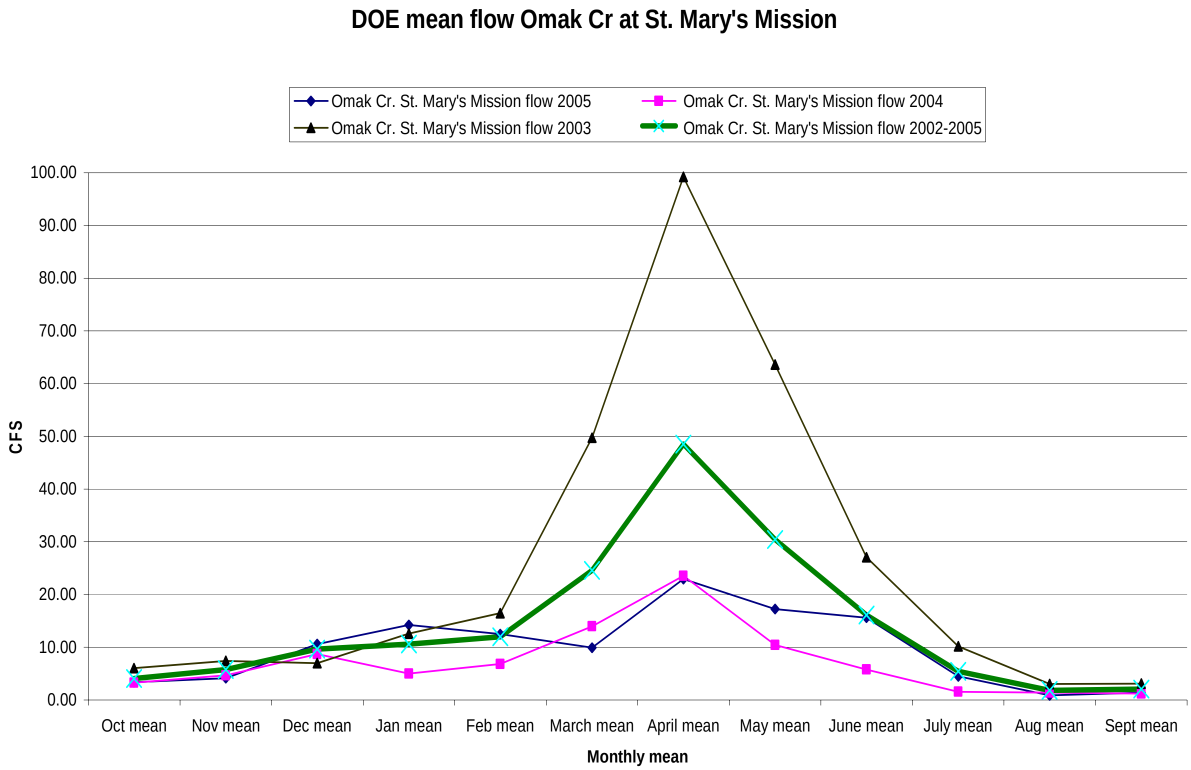

Figure 15: Real-time discharge for WDOE gauge on Omak Creek in 2003 to 2005 and the average flow for 2002 to 2005.

Discharge data collected for Omak Creek is monitored by WDOE at a real-time telemetry gauging station located near the Saint Mary's Mission. Discharge and temperature data have been recorded consistently since 2003. The hydrograph of discharge in Omak Creek typically shows a narrow high flow peak (April) with rapidly increasing (March)/decreasing (May) limbs with base flows in August and September (Figure 15). Low flows were relatively consistent in 2003, 2004, and 2005, with 2003 having a much greater peak discharge in April (Figure 15). 2004 and 2005 had similar flows throughout the year and peak flows were well below the average flow recorded in April from 2002-2005.

Discharge data collected for Tunk Creek is monitored by WDOE at a real-time telemetry gauging station located a short distance above Tunk Falls. Discharge and temperature data have been recorded consistently since 2003. The hydrograph of discharge in Tunk Creek typically shows a high flow during the period from March through May with rapidly increasing/decreasing limbs and low flows typically occurring in the period from July through October with base flows in August (Figure 16). Low flows were relatively consistent in 2003, 2004, and 2005, with 2003 having a much greater peak discharge in April and May than 2004 or 2005 (Figure 16). 2004 and 2005 peak flows were below the average flow for all years surveyed (2003-2005).

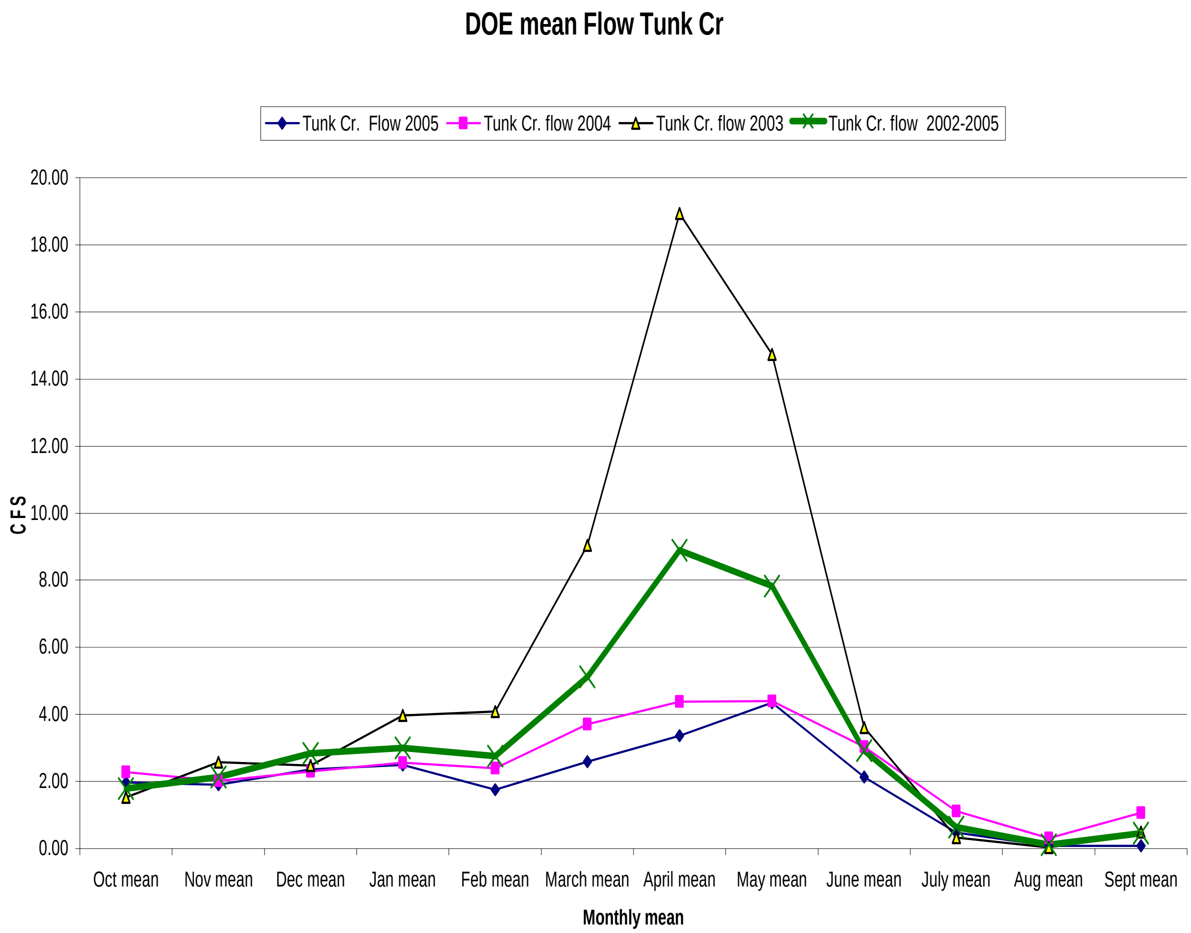

Figure 16: Real-time discharge for WDOE gauge on Tunk Creek in 2004 to 2005.

Discharge data collected for Bonaparte Creek is monitored by WDOE at a real-time telemetry gauging station located at the Highway 97-bridge in the town of Tonasket, Washington. Discharge and temperature data have been recorded consistently since 2003. The hydrograph of discharge in Bonaparte Creek typically shows a high flow during the period from March through June with low flows typically occurring in the period from July through October and base flows in August Winter rain typically increases flows to an intermediate level during the period from November through February (Figure 17). Low flows were relatively consistent in 2003, 2004, and 2005, with 2003 having a much greater peak discharge in April, May, and June (Figure 17). 2005 flow was relatively consistent with the average flow for 2003-2005.

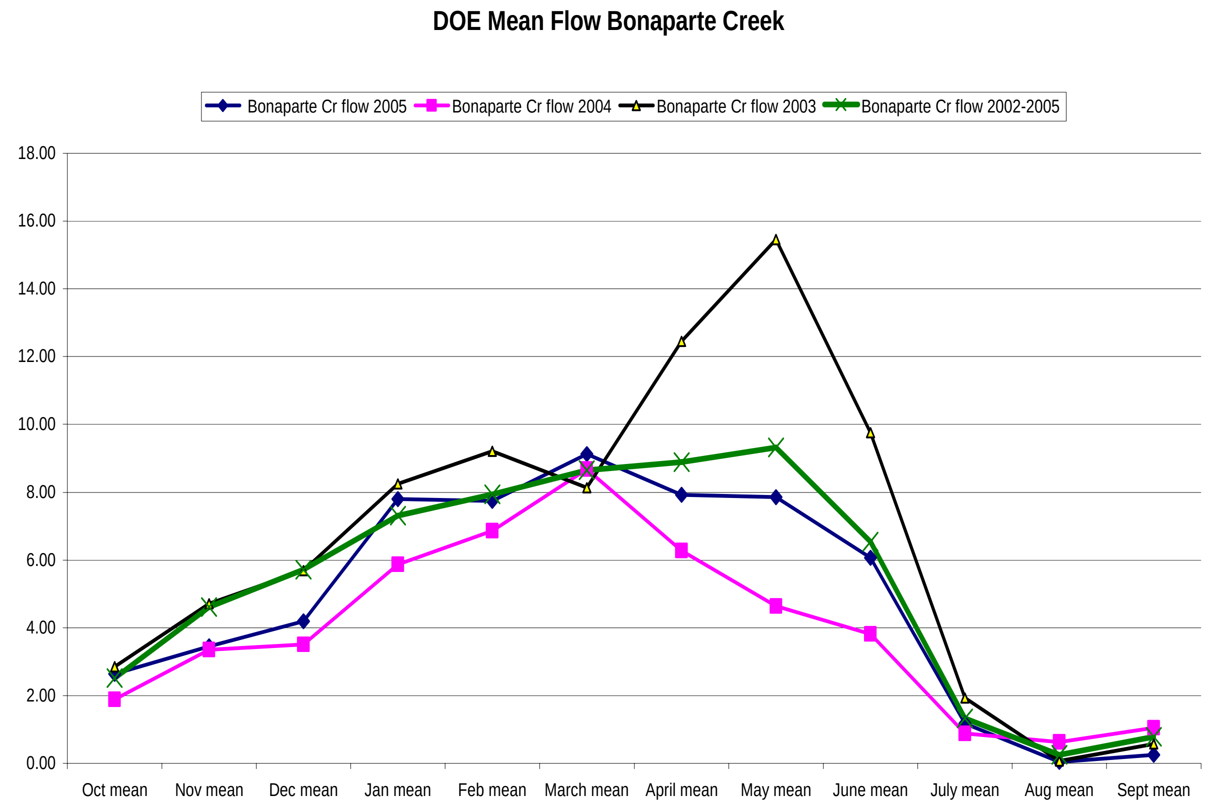

Figure 17: Real-time discharge for WDOE gauge on Bonaparte Creek in 2003 and 2004.

Okanogan River mainstem discharge

Most mainstem flow monitoring is conducted by the United States Geological Survey (USGS) with the exception of one site on the Similkameen River operated by WDOE and one site near the town of Oliver in Canada operated by the Water Survey of Canada. All the United States gauging stations provide real-time discharge data but the site in Canada is only a near real-time station and complete yearly data are not posted until results are one year old. Okanogan River flows were variable in 2005 at the site in Oroville (Figure 18) compared to average flows from 1977 to 2005. The Oroville site had two peaks, one in February and one in July. This gauging station is highly regulated by releases from Zosel Dam that are largely governed by the rules set forth by the International Joint Commission and flows released by Canadian water managers.

The Okanogan River draining out of Canada is regulated at dams located at outlets of the following lakes: Osoyoos, Skaha, and Okanagan. Because this river acts to drain three major lake basins and the releases are managed for flood control, to maintain lake elevation, irrigation, and to enhance fish production, the hydrograph is muted with lower peak flows, higher low flows and higher inter-daily variability than would be expected from the historically unregulated system (Figure 19). Flows typically peak in May or June with low flows in

December and January. The remainder of the year is contained in the ascending limb (February to May) or descending limb (July to November) of the hydrograph (Figure 18).

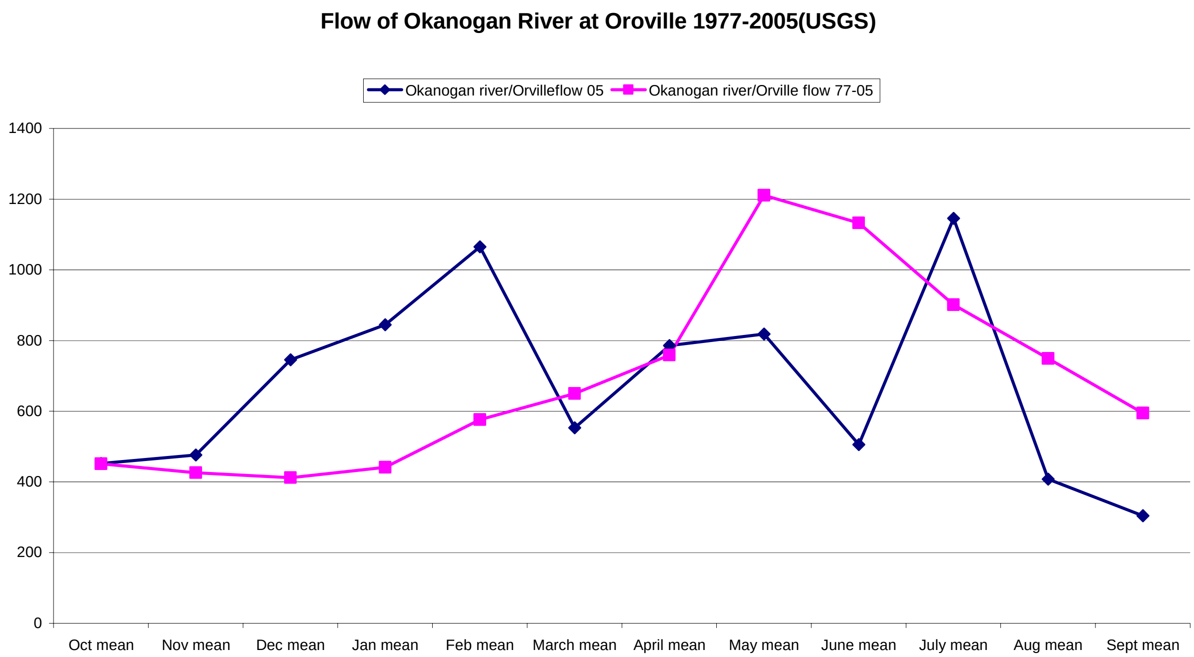

Figure 18: Real-time discharge for USGS gauge on Okanogan River located at the Highway 97 Bridge at the town of Oroville comparing the historical average from 1977 to 2005 and 2005 data.

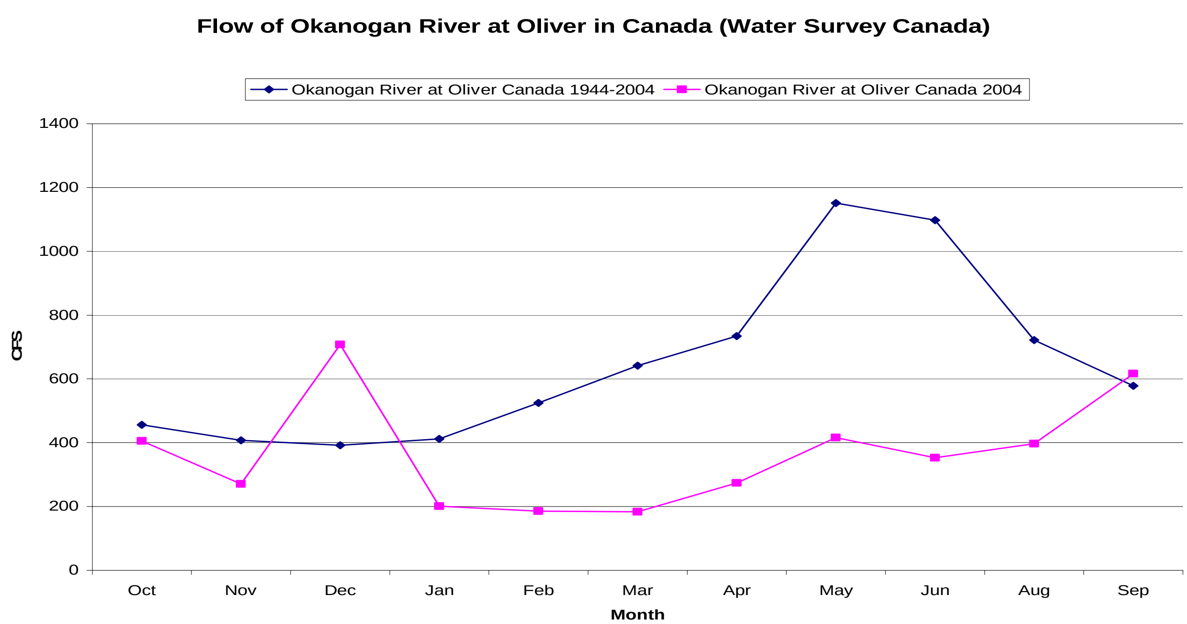

Figure 19: Real-time discharge for gauge on the Okanogan River located at the town of Oliver in Canada showing the historical average from 1944 to 2004 and 2004 data.

The Similkameen River is a free-stone river and has a much flashier hydrograph than the Okanogan River. The hydrograph for the Similkameen River shows a high flow period from May through June and a low flow period that lasts from August to March because most of the flow in this drainage is generated directly from snowmelt (Figure 20). In 2005, drought conditions existed in the Similkameen drainage along with the rest of the Okanogan watershed. The data at this site was not recorded over the winter of 2005 to July of 2005 due to an ice dam damaging the intake pipe (Figure 20).

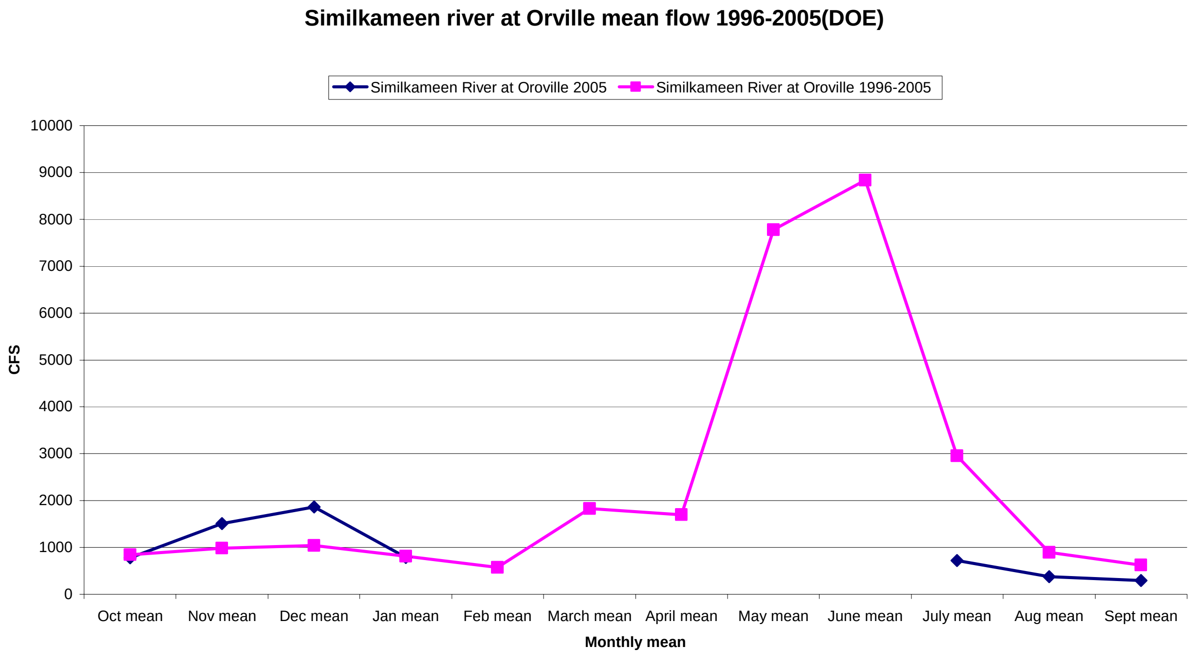

Figure 20: Real-time discharge for WDOE gauge on Similkameen River located at the town of Oroville, Washington, comparing the historical average from 1996 to 2005 and 2005 data.

The Okanogan River mainstem downstream of the confluence with the Similkameen River is monitored by the USGS at two sites, one near the town of Tonasket (Figure 21) and one near the town of Malott, Washington (Figure 22). Flows in 2005 were lower than the long-term average, providing strong evidence as to the severity of the drought conditions that existed throughout the Okanogan sub-basin. Flows were lower than average in 2005 at all the mainstem sites but the sites in Tonasket (Figure 21) and Malott (Figure 22) indicated the extent of the drought conditions throughout the sub-basin more clearly than at other sites.

The 2005 water year started off above normal because winter temperatures especially at the higher elevations were above average. This coupled with an abundance of winter rains reduced mountain snow packs and increase overland flows. As the winter water moved downstream rather than being stored as snow the peak flows occurred earlier than normal and high spring discharges failed to appear. The lack of winter water storage in the form of snow followed by a hot and dry summer resulted in below normal flows for the remainder of the year.

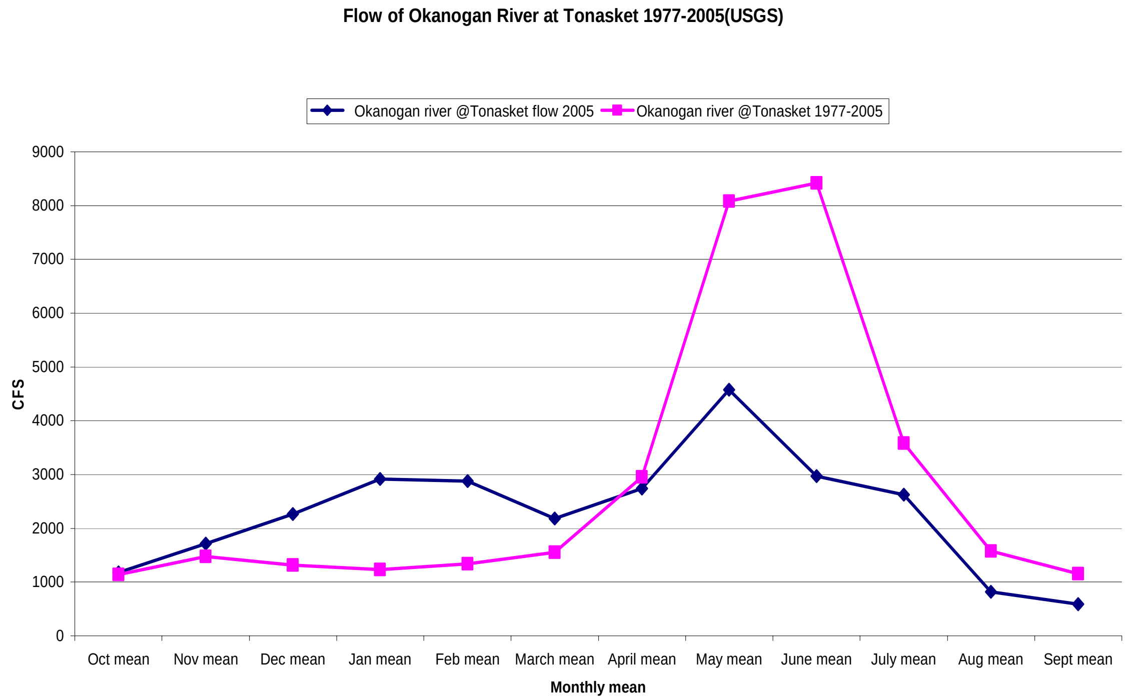

Figure 21: Real-time discharge for USGS gauge on Okanogan River located near the town of Tonasket, Washington, comparing the historical average from 1977 to 2005 and 2005.

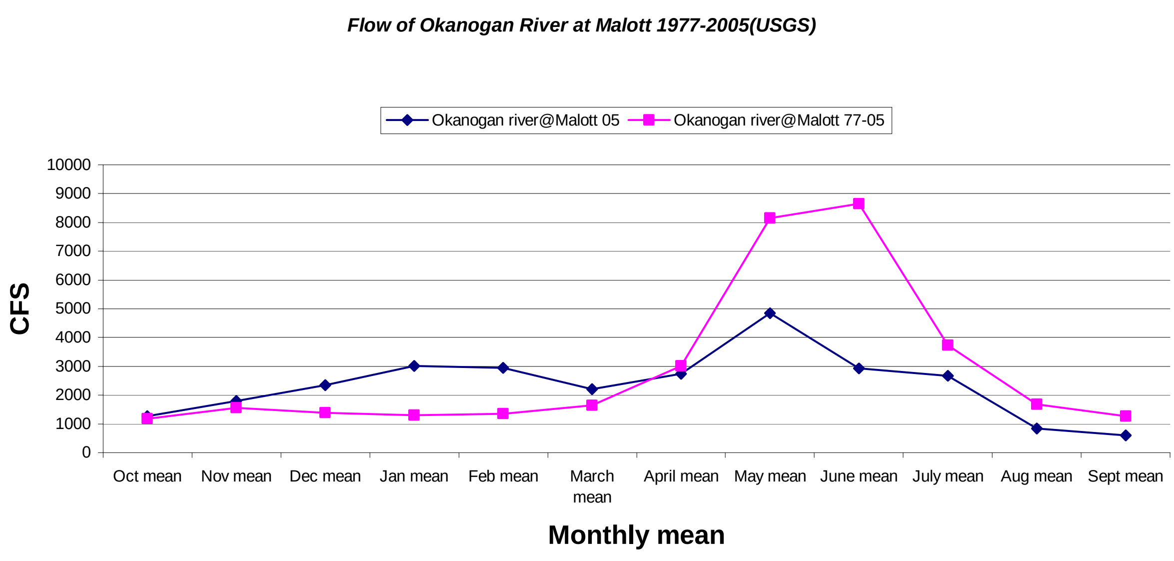

Figure 22: Real-time discharge for USGS gauge on Okanogan River located near the town of Malott, Washington, comparing the historical average from 1977 to 2005 and 2005.

Water Quality

Water quality data reported here was collected by the Colville Tribes and WDOE. The graphs below (Figures 23-44) combine data collected on the Okanogan River in Oroville (upper

Okanogan River), Malott (lower Okanogan River) and in the Similkameen River at Oroville (Similkameen River) and data collected at the OBMEP tributary sites that were sampled in 2005. The parameters we have compared and analyzed include: temperature, conductivity, turbidity, dissolved oxygen, pH, Ammonia, Nitrogen, and Phosphorous. On the main-stem we compared only WDOE collected data. We looked at averages from 1977-2005 with data collected in 2005. On the tributaries, we compared only data collected as part of the OBMEP between years and within streams.

Temperature

Historical temperature data has been collected by WDOE at two sites on the Okanogan River although this data is only monthly grab samples. The WDOE has collected real time temperature data on the Similkameen River and Omak Creek since 2003, and data on Bonaparte and Tunk creeks since 2002. The anadromous division of the Colville Confederate Tribes Fish and Wildlife Department has been collecting data throughout the Okanogan River Basin sporadically since 1999. The OBMEP program began putting out Onset® temperature data loggers at the all of the annual and panel 1 tributary sites in May of 2005. OBMEP also funded real time temperature data gathering at three USGS gauging sites on the Okanogan River: Oroville, Tonasket, and Malott. Data collection at these sites began in March of 2005. Temperature was fairly consistent between the 1977-2005 average and 2005 data at both the upper and lower Okanogan River sites (Figure 23). In 2005, the Okanogan River at Oroville and Malott had higher temperatures during the winter and higher peak temperatures in the month of August than the average from 1977 to 2005. The Similkameen River was cooler than average for most of the year and had a slightly higher peak temperature in August when compared to the average (Figure 24).

Temperatures above 21°C are known to be stressful to most salmonids and direct mortality occurs at temperatures above 25°C (Jenkins and Burkhead 1993). During the month of August the Okanogan River water temperatures rarely exceed 25°C but salmonids do exhibit avoidance behavior for waters that are warmer than 20°C, and this occurs in most years (Figure 23). Typically the upper Okanogan River reaches temperatures above 20°C as early as July and this was the case in 2005 (Figure 23). In the Okanogan River subbasin, summer migrants can encounter a condition termed "The Similkameen Trap," when rapidly warming waters exiting Canada in the upper Okanogan River reach 20◦C prior to the Similkameen River. Because fish try to avoid these warm water conditions, the fish that enter the Okanogan River prior to the thermal barrier occurring in the Lower Okanogan River below Malott, WA, become "trapped" above the confluence with the upper Okanogan and Similkameen Rivers. Early arriving migrants are more susceptible to becoming trapped and in some years high pre-spawn mortality has occurred to both Chinook and sockeye salmon. Pre-spawn mortality typically occurs when fish are trapped for extended periods of very warm water temperatures on the Similkameen River below Enloe Dam. Fish that arrive later and remain in the Columbia River until temperature conditions favor migration in September (Figure 23) typically avoid any negative effects of the Similkameen Trap.

Because the upper Okanogan River reaches stressful temperatures earlier than the lower Okanogan River, fish become trapped in the Similkameen River (Figure 23 & 24) during stressful temperature periods in the month of August However, in 2005 temperatures along the mainstem stayed below the historical averages until August. Lower than normal summer temperatures during July reduced the thermal barrier in the lower Okanogan River, therefore reducing migration delays for summer migrants. Above-average temperatures in August resulted in a "Similkameen trap" developing, but because the stress of being "trapped" with temperatures above 20°C only occurred for a couple of weeks, major pre-spawning mortalities were narrowly avoided.

Data collected in the tributaries has not been analyzed extensively. The OBMEP program will be putting out a temperature report in the near future that compiles status and trend for all water temperature data collected through the 2006 water year. We have looked at average temperature data that we collected in Omak Creek. We surveyed five sites on Omak Creek in 2005 (Figure 7). Figure 25 shows that the highest temperatures were at the lowest places in the watershed, site 19 and the coolest temperatures were in the upper reaches of the creek, site 12 and 48 (Figure 7&25).   This is what we would expect but also reinforces the need for temperature data gathering throughout a watershed to help understand fish abundance and distribution patterns that would occur as a result of water temperature.

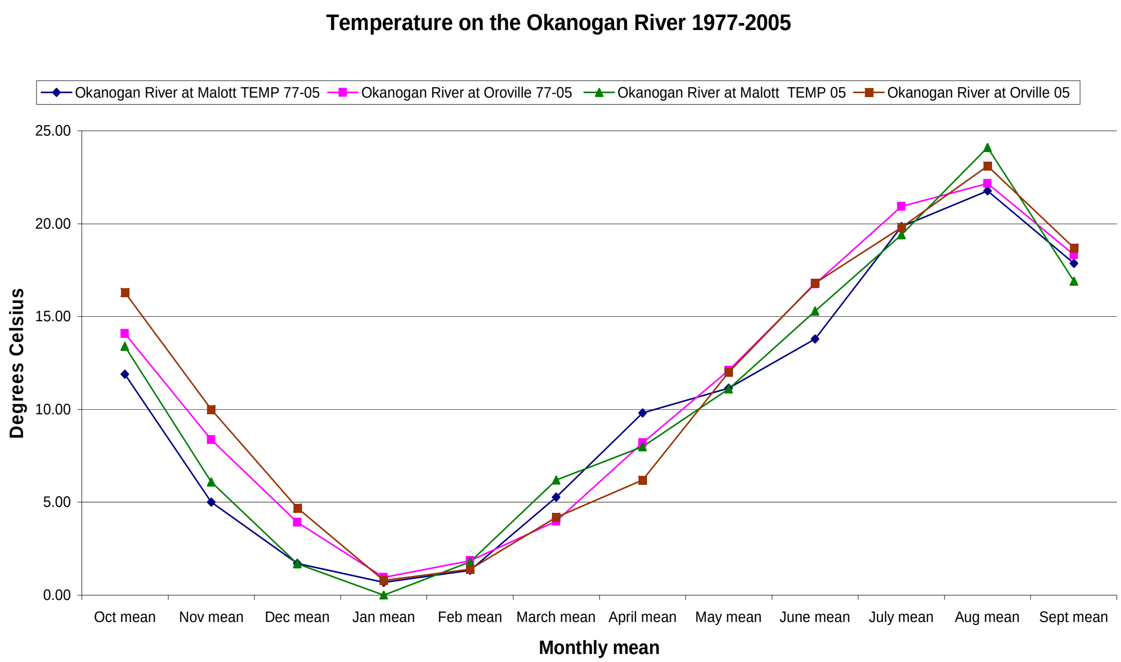

Figure 23: Grab sample temperature data for the Okanogan River from sites located near the towns of Malott and Oroville, Washington, comparing the historical average from 1977 to 2005 and 2005.

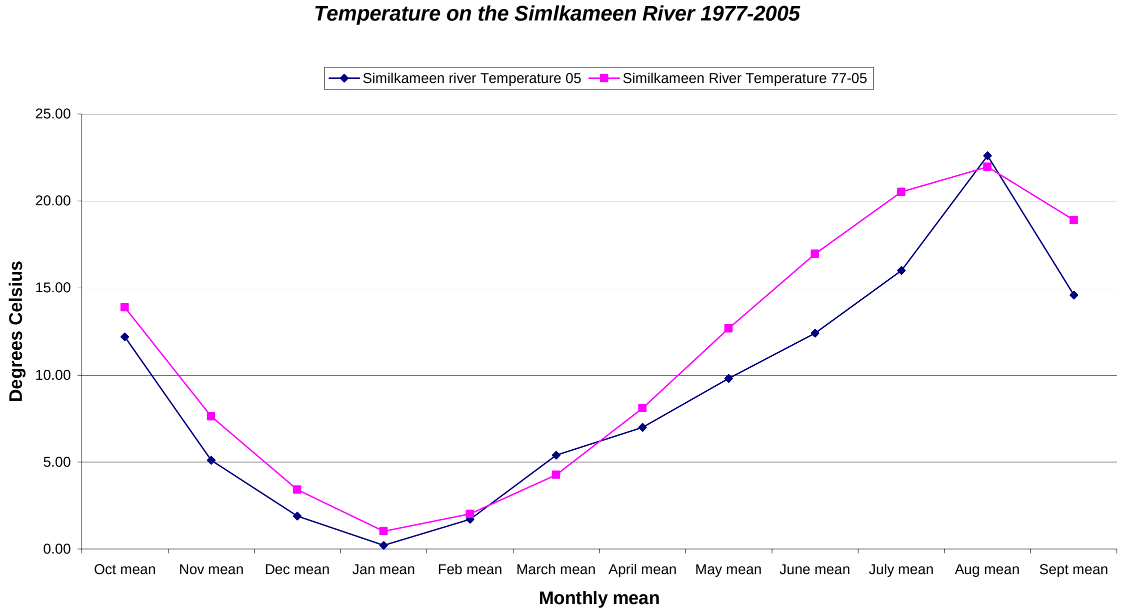

Figure 24: Monthly grab sample temperature data for the Similkameen River site located at the town of Oroville, Washington, comparing the historical average from 1977 to 2005 and 2005.

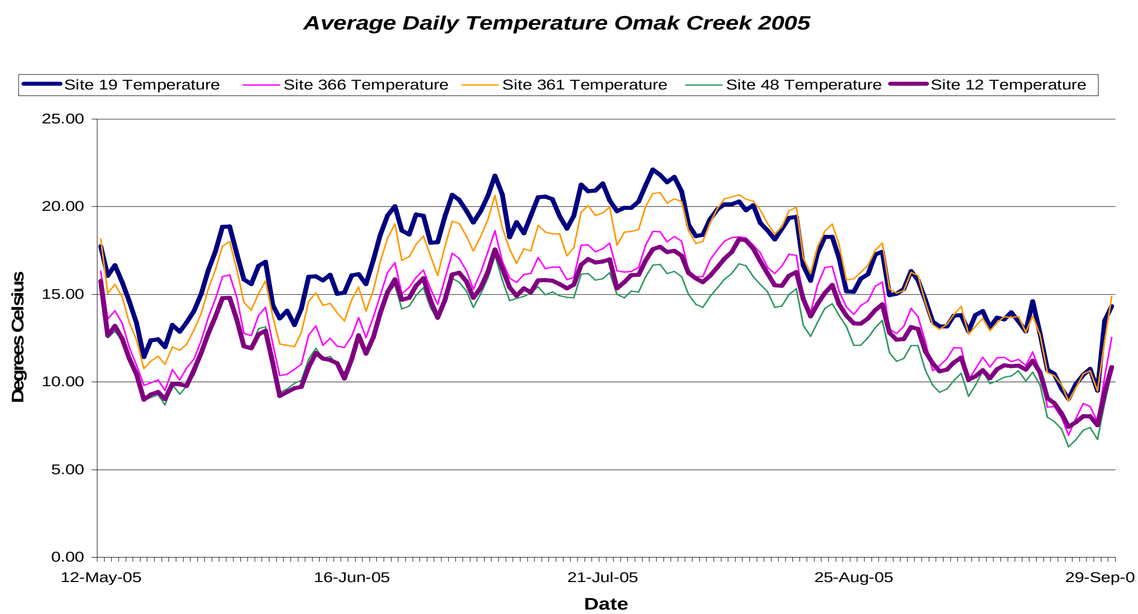

Figure 25: Real-time temperature data for Omak Creek 2005.

Dissolved Oxygen

Oxygen is critical for fish and when oxygen levels drop below 6mg/l adult salmonids can become stressed; this is rarely the case in fluvial environments (Davis 1975). The amount of oxygen that can be dissolved in water is a function of temperature and pressure. To reach solubility below 6mg/l requires temperatures greater than 25°C and atmospheric pressures below 560 mm Hg (Colt and Tomasso 2001).

The average barometric pressure in the Okanogan Valley is 760 mm Hg and temperatures rarely exceed 25°C, therefore the theoretical minimum dissolved oxygen would be approximately 8mg/l (http://www.weatherunderground.com). In the Okanogan basin dissolved oxygen readings below 8ppm can only result from biological oxygen demands or extreme dewatering, and for fluvial systems these impacts are isolated due to air to surface water exchange processes that are enhanced through the turbulence of moving waters. Research has determined that as salmonid eggs begin to hatch, a correlation exists between dissolved oxygen levels and the rate of development and survival of salmonids. If dissolved oxygen levels are below 8mg/l, survival and development at time of hatching reduces rapidly. At levels above 8mg/l, survival and development continue to benefit salmonids at a slower rate until 10mg/l.

Most experts believe that at 8mg/l or more dissolved oxygen is considered to be excellent for salmonids and that levels above 6mg/l are adequate provided no eggs are actively hatching. In 2005, dissolved oxygen levels on the upper Okanogan River fell below 8mg/l during the month of August but only adult fish are present during this time and no eggs are hatching therefore this reading had no biological impact on salmonids (Figure 26). Dissolved oxygen levels in the Similkameen River were excellent in 2005 (Figure 27). Dissolved oxygen levels in the Okanogan and Similkameen rivers typically range from around 14 mg/l in the period from January to March and reach their lowest levels just above 8 mg/l in the period from July to September.

Oxygen levels on the tributaries of the Okanogan River varied more than the main-stem river with low levels of 6 mg/l (Figure 28). We have determined these low levels may be confounded by our water quality sampling methodology, which we are refining, and we are looking forward to a longer data set next year.

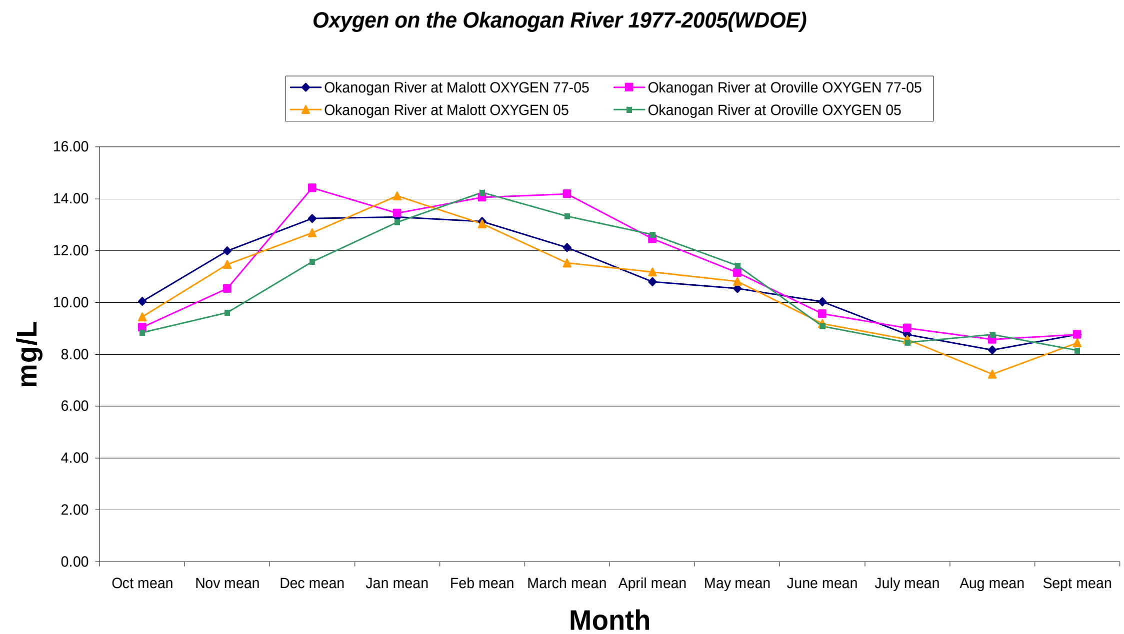

Figure 26: Grab sample data for dissolved oxygen collected by WDOE for the Okanogan River site located near the town of Malott, and Oroville, Washington, comparing the historical average from 1977 to 2005 and 2005.

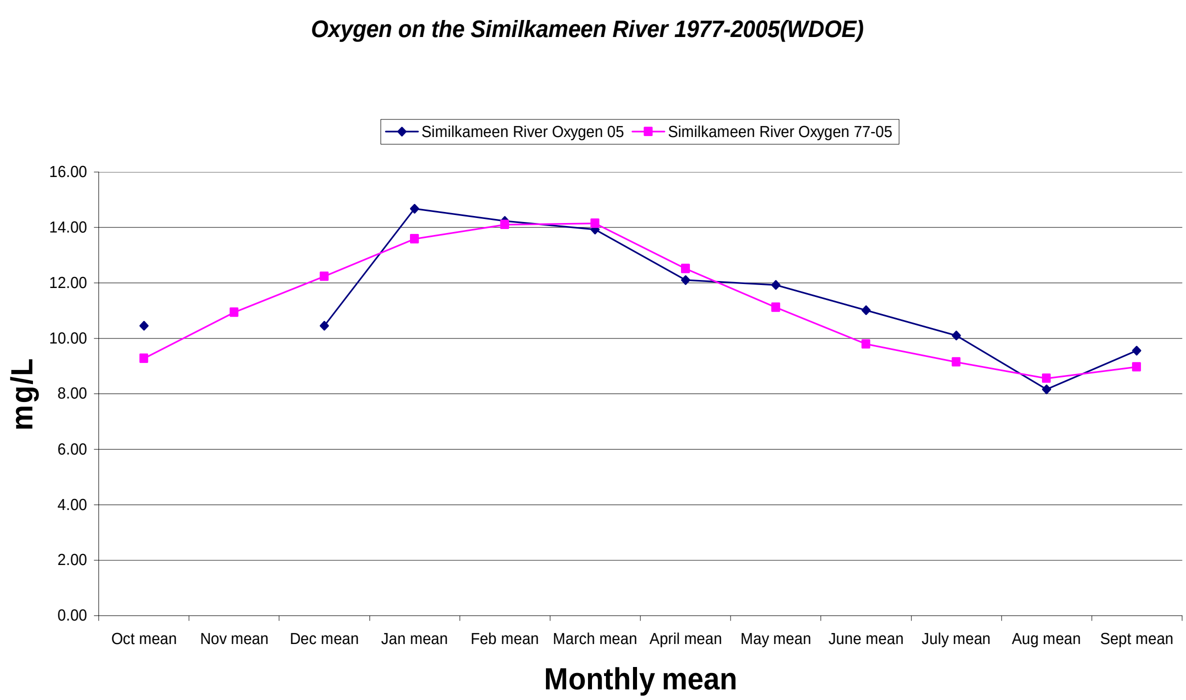

Figure 27: Grab sample data for dissolved oxygen collected by WDOE for the Similkameen River site located at the town of Oroville, Washington, comparing the historical average from 1977 to 2005 and 2005

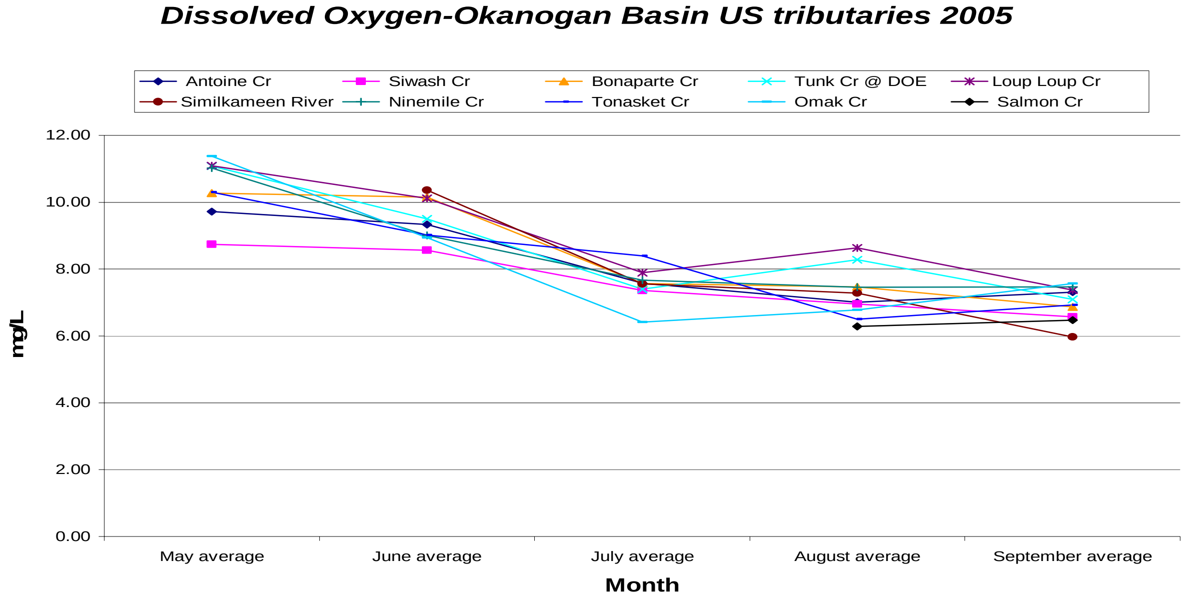

Figure 28: Grab sample data for dissolved oxygen collected by CCT for the tributary sites sampled in 2005.

Turbidity

In most streams, there are periods when the water is relatively turbid and contains variable amounts of suspended sediments (Bjornn and Reiser 1991). Turbidity, measured in nephelometric turbidity units (NTU), has been found to be linked to primary productivity (g O_2/m^2). An increase from 1 NTU to 170 NTU reduces productivity by 50%, and productivity can be reduced to zero at turbidities of 1,100 NTU or higher (LaPerriere et al 1983, VanNieuwenuyse and LaPerriere 1982). An increase of 25 NTU over normal background levels has been found to reduce primary productivity from 13 to 50% (Lloyd et al. 1987). Newly emerged salmon and steelhead fry show reduced growth and tend to emigrate from areas were turbidities ranged from 25-50 NTU (Sigler et al. 1984). Juvenile salmon avoid areas with turbidities above 70 NTU, whereas older fish appear to be little affected by ephemerally high concentrations of suspended sediments (Bisson and Bilby 1982, Sorenson et al. 1977).

In 2005, and historically, turbidities coming out of Canada were well below any threshold of biological importance. This is most likely due to the large lakes contained within this watershed that act as very effective sediment traps. Historical averages from the Okanogan and Similkameen Rivers show that turbidities typically occur at levels that would have no impact on salmonids as levels are below 25 NTU throughout the year (Figures 29 & 30). In 2005, ice damaged the Similkameen River site and thus data from February and March are missing.

We collected our own data on turbidity at EMAP tributary sites along the Okanogan River. Data at these sites was highly variable. We began collecting data in May of 2005. We took grab samples at the tributary sites three times a month (Figure 31). There were turbidity spikes in June and August at most sites. River turbidity levels jumped to 65 NTU. This level of turbidity had the potential to reduce primary productivity by perhaps 50% and reduce growth of newly hatched fish. This data may have been confounded by observers disturbing fine sediments shortly before collecting data. We have made modifications to our methodologies to measure and minimize potential observer impacts on data collected and look forward to a more complete data set next year.

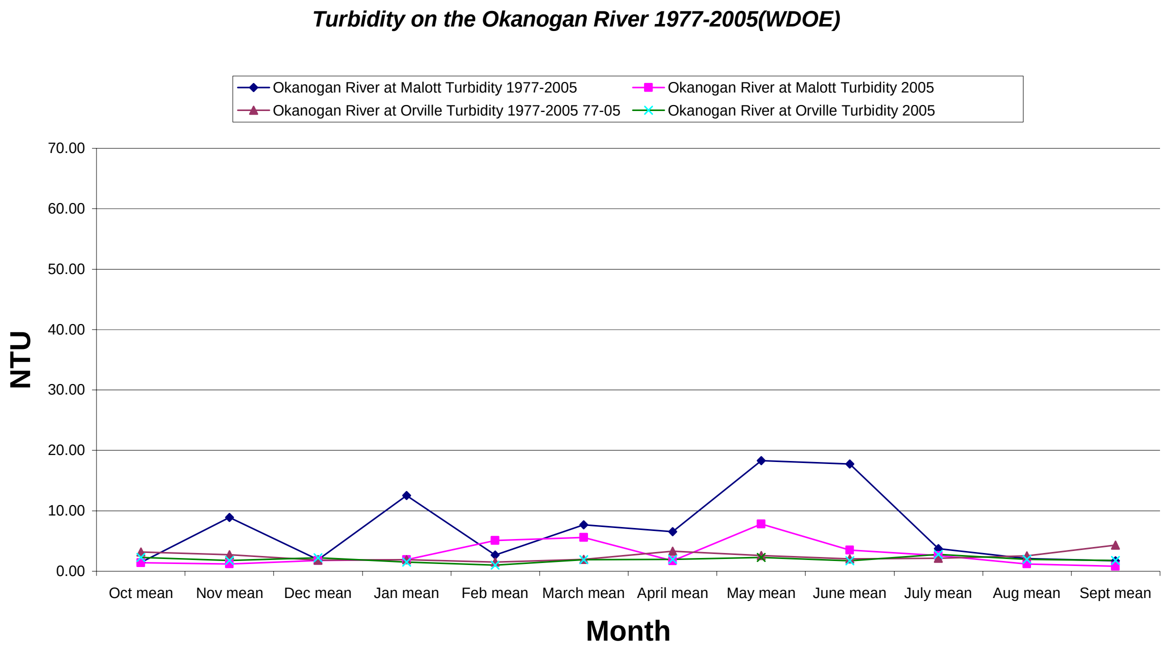

Figure 29: Grab sample data for turbidity collected by WDOE for the Okanogan River site located near the towns of Malott and Oroville, Washington, comparing the historical average from 1977 to 2005 and 2005.

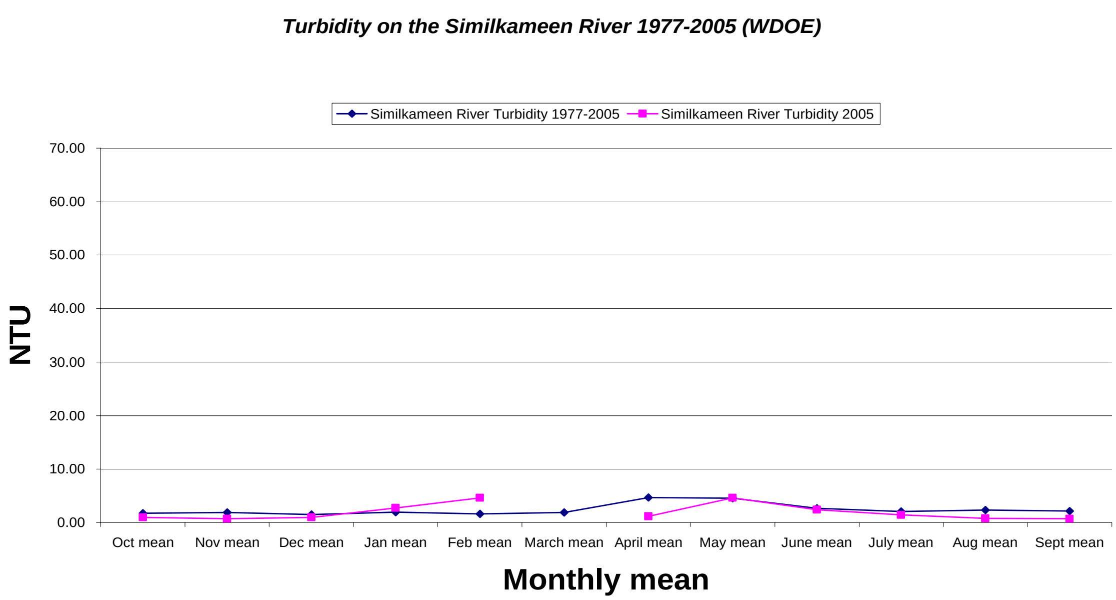

Figure 30: Grab sample data for turbidity collected by WDOE for the Similkameen River site located at the town of Oroville, Washington, comparing the historical average from 1977 to 2005 and 2005.

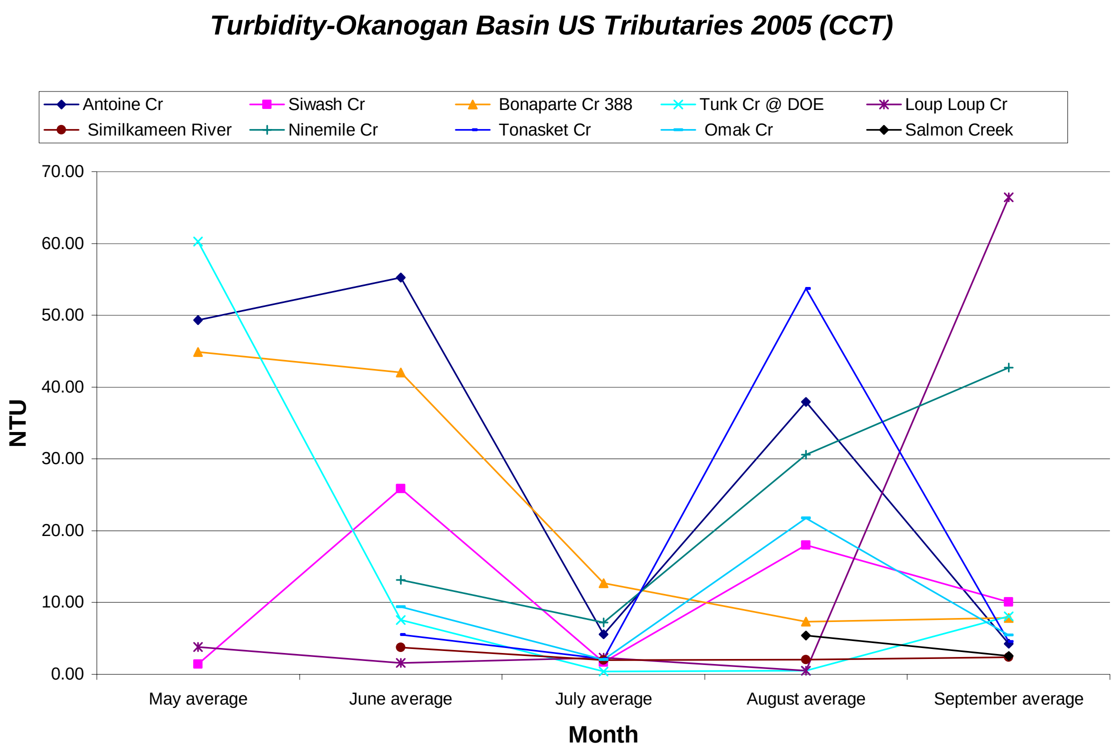

Figure 31: Grab sample data for turbidity collected by CCT for the EMAP tributary sites located throughout the Okanogan River basin, 2005.

pH

The sensitivity of fishes to extremes of pH varies; however, a range of 6.5-9.0 is recommended for salmonid species (Piper et al. 1982). Environmental pH affects the toxicity of ammonia, hydrogen sulfide, metals, and other pollutants. Alkalinity is a measure of the buffering capacity of water, therefore it has a major impact on the fluctuation of pH values. pH remained consistent in both the upper and lower Okanogan River sites and Similkameen River sites both in 2005 and when compared with the 1977-2005 average (Figure 32). The same was true for EMAP tributary sites surveyed by CCT (Figure 33). The lack of fluctuation between space and over time indicates that the Okanogan River basin has excellent buffering characteristics that protect it from fluctuating pH levels. With a stable reading for pH between 7.2 and 8.7 the water would be considered weakly basic and excellent for invertebrates and fish (Figures 32 & 33). The stability of pH values means that pH should be given a low level of importance when evaluating other water quality indicators.

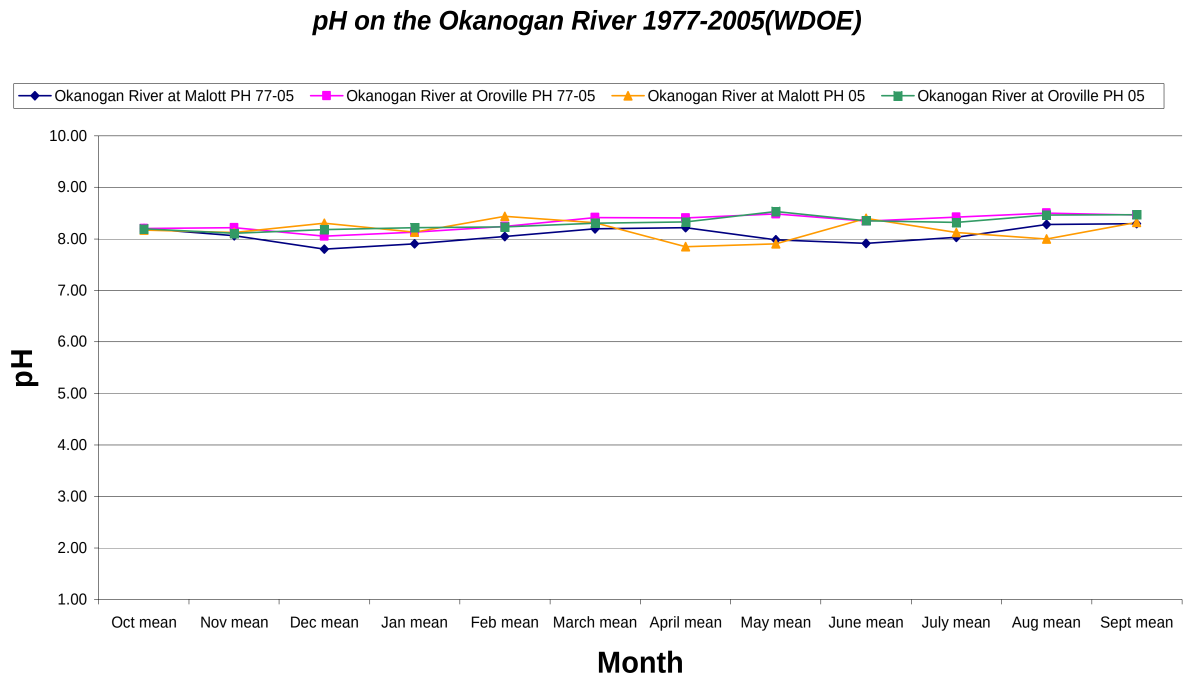

Figure 32: Grab sample data for pH collected by WDOE for the Similkameen and upper Okanogan River site located at the town of Oroville, WA, plus the lower Okanogan River site near the town of Malott, WA, comparing the historical average from 1977 to 2005 and 2005.

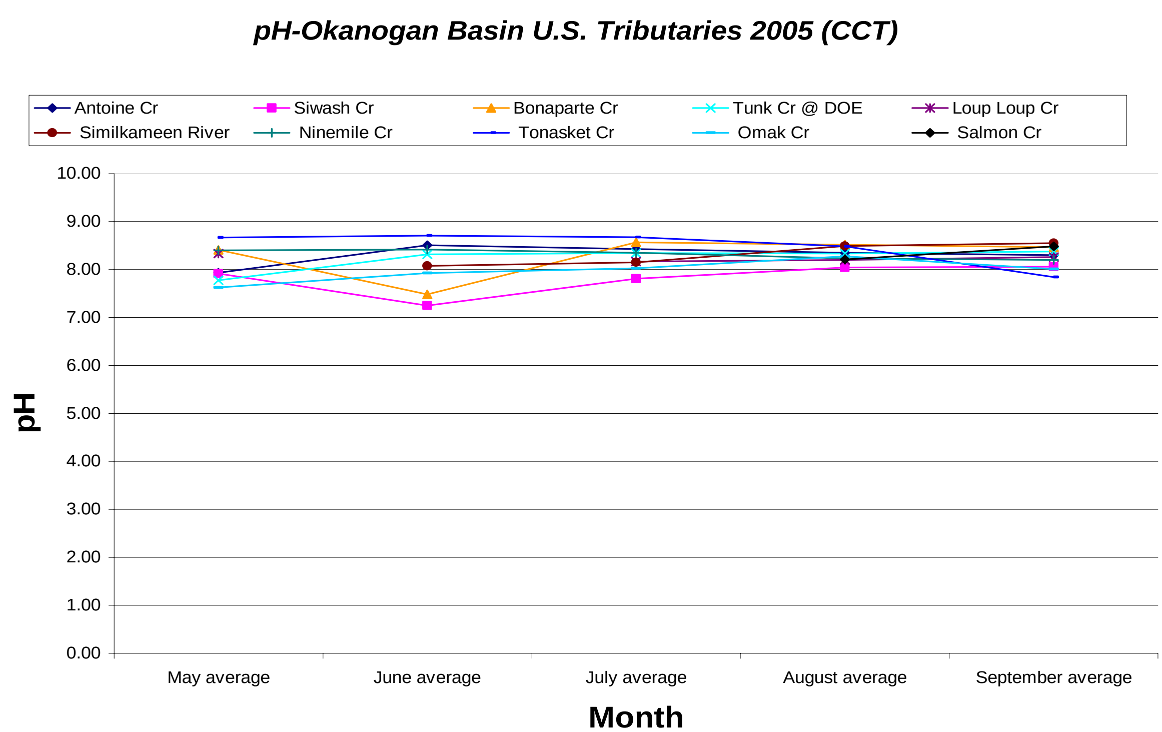

Figure 33: Grab sample data for pH collected by CCT for the tributary sites in the Okanogan River basin, 2005.

Ammonia

Ammonia in its un-ionized form (NH_3) is highly toxic to fish, but the ionized form (NH_4^+), usually referred to as ammonium, is not toxic. The amount of each form found in water is mainly influenced by the ionic concentration, pH, and temperature of the water. If the pH is below 7, no un-ionized ammonia exists. On the Okanogan River pH may reach 8.8 (Figure 32) and temperature can exceed 20°C (Figure 23) during the months of July and August, therefore as much as 20% of the ammonia-nitrogen measured could be in the un-ionized form.

Salmonids are known to be highly sensitive to ammonia (NH_3) toxicity and concentrations below 0.03 mg/l are considered optimal (Wedemeyer 1996). Ammonia concentrations between 0.05 and 0.2 mg/l are not typically considered lethal for salmonids but have been shown to significantly reduce growth (Wedemeyer 1996) and long-term exposures can cause physiological and histopathological effects along with gill hyperplasia that can result in indirect mortalities (Piper et al. 1982, Burrows 1964). The literature shows that rainbow trout have a minimum lethal level for ammonia (NH_3) of 0.2 mg/l (Norris et al 1991), however, the instantaneous mortality concentrations are more widely believed to occur at levels greater than 0.32 mg/l for salmonids (Summerfelt et al 2001).

Values recorded by WDOE are for ammonia-nitrogen which is a measure of total ammonia in both ionized and un-ionized form. Because only the un-ionized form has a bearing on fish health and given the information already documented for the Okanogan and Similkameen Rivers (pH, temperature) a maximum of 20% of the measured ammonium-nitrogen would be found in the un-ionized form (Piper et al. 1982). Concentrations of ammonia-nitrogen should not exceed 0.15 mg/l of optimum water quality (Piper et al. 1982). Ammonia-nitrogen levels below 0.25mg/l are unlikely to result in any adverse impacts to salmonids and levels below 1 mg/l are unlikely to have any impact during months outside of the June through September period.

Ammonia readings along the Okanogan River showed very minor variation at all sites and over time (Figure 34). The Similkameen River site located at the town of Orville, Washington, showed very comparable results to the lower Okanogan River site (Figures 34 & 35). The long-term data set collected by the WDOE illustrates that ammonia levels are well below any level that would have a biological impact, making continued monitoring of this indicator of questionable value in this watershed. The highest values for the Okanogan River for the period from June through September are below 0.03 mg/l both historically and in 2005 (Figure 34). The highest values for the Similkameen River for the period from June through September are below 0.03 mg/l both historically and in 2005 (Figure 35). The most common reading during all the hot summer months since 1977 is 0.01 or less as this is the lowest reading possible given the methodology employed by WDOE.

Ammonia on the Okanogan River 1977-2005(WDOE)

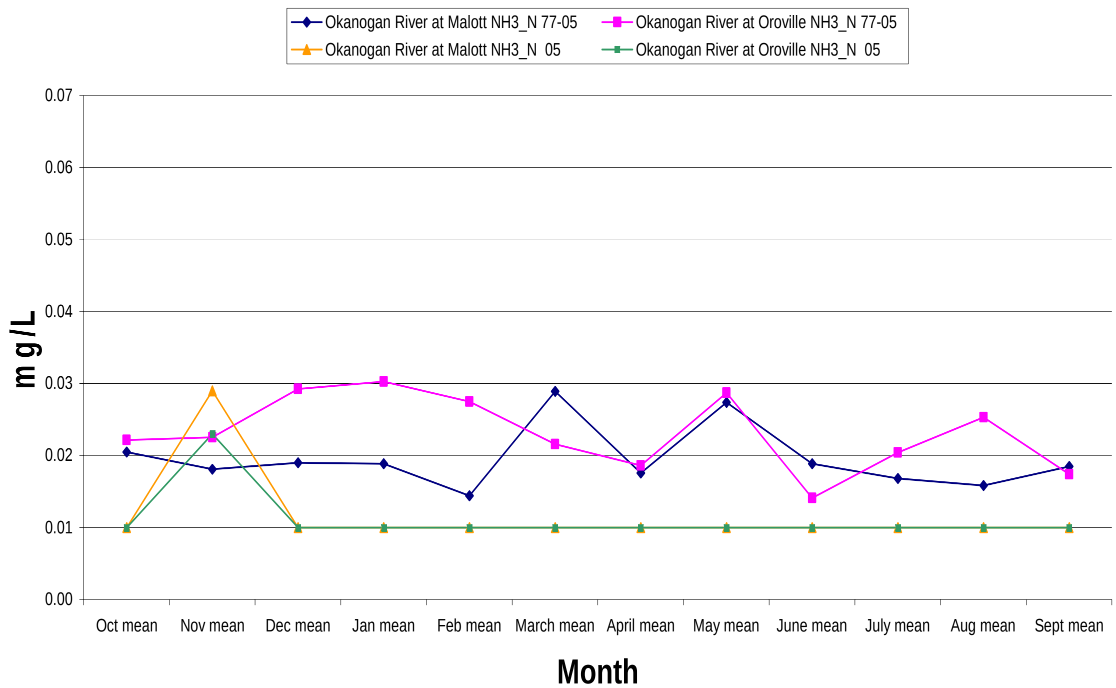

Figure 34: Grab sample data for Ammonia-nitrogen* collected by WDOE for the Okanogan River site located near the towns of Malott and Oroville, Washington, comparing the historical average from 1977 to 2005 and 2005. *The maximum of 20% of this value is un-ionized ammonia (NH_3).

Ammonia on the Similkameen River 1977-2005 (WDOE)

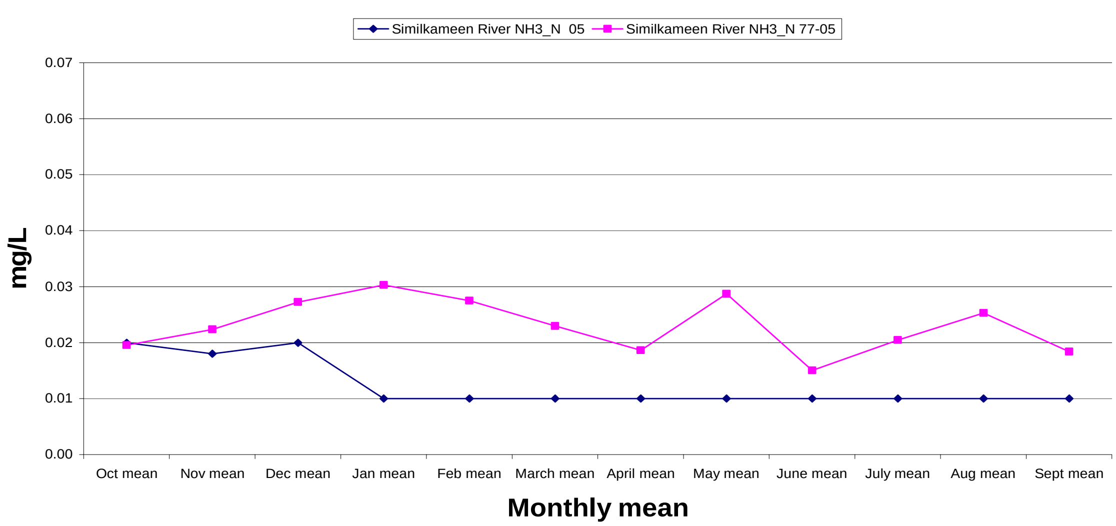

Figure 35: Grab sample data for Ammonia-nitrogen* collected by WDOE for the Similkameen River site located at Oroville, Washington, comparing the historical average from 1977 to 2005 and 2005. *The maximum of 20% of this value is un-ionized ammonia (NH_3).

Nitrogen and Phosphorus

Total nitrogen as measured by WDOE measures the amount of both Nitrite (NO_2), and Nitrate (NO_3). Nitrogen is an oxidation product of mainly ammonia in aquatic systems. The primary source of these nutrients is from fish waste, and both inorganic and organic fertilizers. Nitrogen nutrients are transformed by autotrophic bacteria from ammonia to nitrite to nitrate. Ammonia and nitrite are both toxic for fish but nitrate is not. For nitrite to be toxic it must be diffused across the gill membrane in the form of nitrous acid (HNO_2), which is found at pH levels above 6. Along the Okanogan River, only Nitrite is of possible concern and this form can only enter freshwater fish by the active chloride pump system (Summerfelt et al. 2001), wherein Nitrite oxidizes the iron in hemoglobin, reducing oxygen transport of blood. This can cause asphyxiation even when dissolved oxygen levels are not limiting (Russo and Thurston 1991). Nitrite toxicity is known as "brown blood disease" and is dependent on species, life stage, and the concentration of other ions, especially chloride and calcium (Russo et al. 1981, Russo and Thurston 1991, and Wedemeyer 1996). Nitrite is more toxic for salmonids than other fishes and can kill rainbow trout at concentrations above 0.2-0.4 mg/l (Wedemeyer 1996). The presence of dissolved chloride or calcium at concentrations of at least 50mg/l can increase fish tolerance to nitrite by 50 fold.

Phosphorus is not considered to be toxic for fish at levels that are likely to be found in aquatic systems. However, the ecological relationships between nitrogen and phosphorous can increase or hinder growth that results from increased algal growth by as much as 50%. The ratio of nitrogen and phosphorus (N:P) is used to determine which nutrient is limiting a given system. A ratio of 10 or less means that nitrogen is limiting while levels above 10 indicate phosphorus limited systems. Only the nutrient that is limiting is of biological value as the level of the other nutrient that is usable is limited by the limiting nutrient.

In the Okanogan basin, phosphorous levels are up to twice as high as nitrogen levels therefore N:P ratios are in all cases below 10 (Figure 36-39). Nitrogen is always limiting in the Okanogan and Similkameen rivers from the Canadian border to the confluence with the Columbia River. Future monitoring should continue to be focused on nitrogen levels and more specifically nitrite levels as these would have the most potential for biological impacts. Levels of nitrite as measured by WDOE are consistently from 2 to 10 times below potentially harmful levels and have been since 1977. However, WDOE measures the combined level of nitrite and nitrate so direct measurement of this indicator is not possible and the specific proportion of each can only be estimated at present (Figures 36 & 39). Specific nitrite levels are likely 4 to 20 times below the levels currently monitored (Figures 36 & 37).

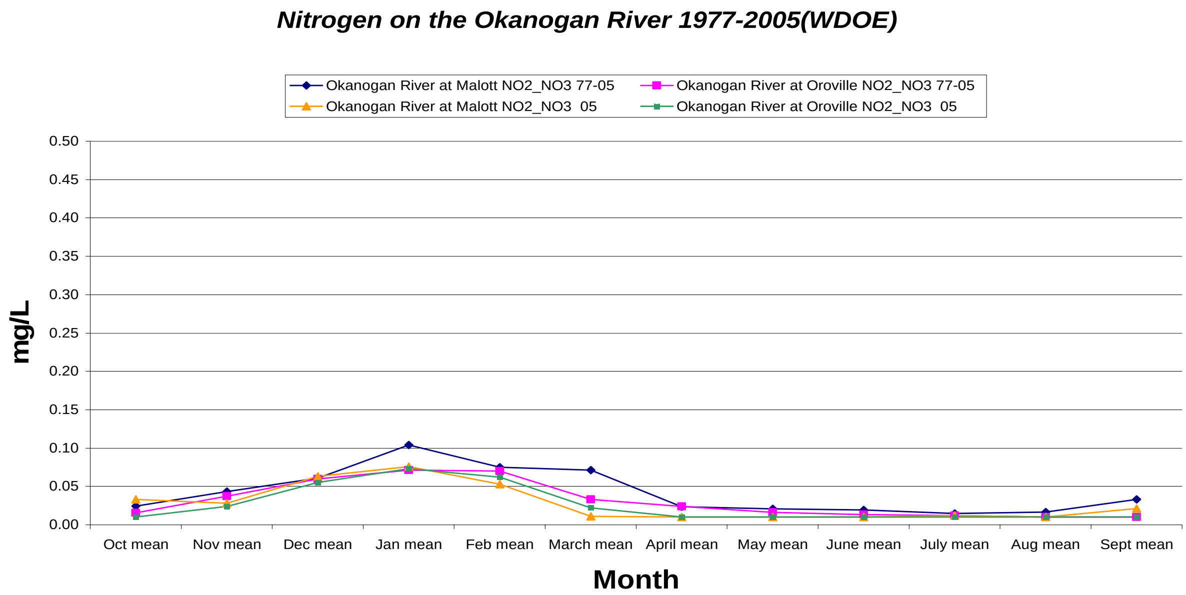

Figure 36: Grab sample data for total nitrogen (nitrate + nitrite) collected by WDOE for the Okanogan River site located at the town of Oroville, WA, plus the lower Okanogan River site near the town of Malott, WA, comparing the historical average from 1977 to 2005 and 2005.

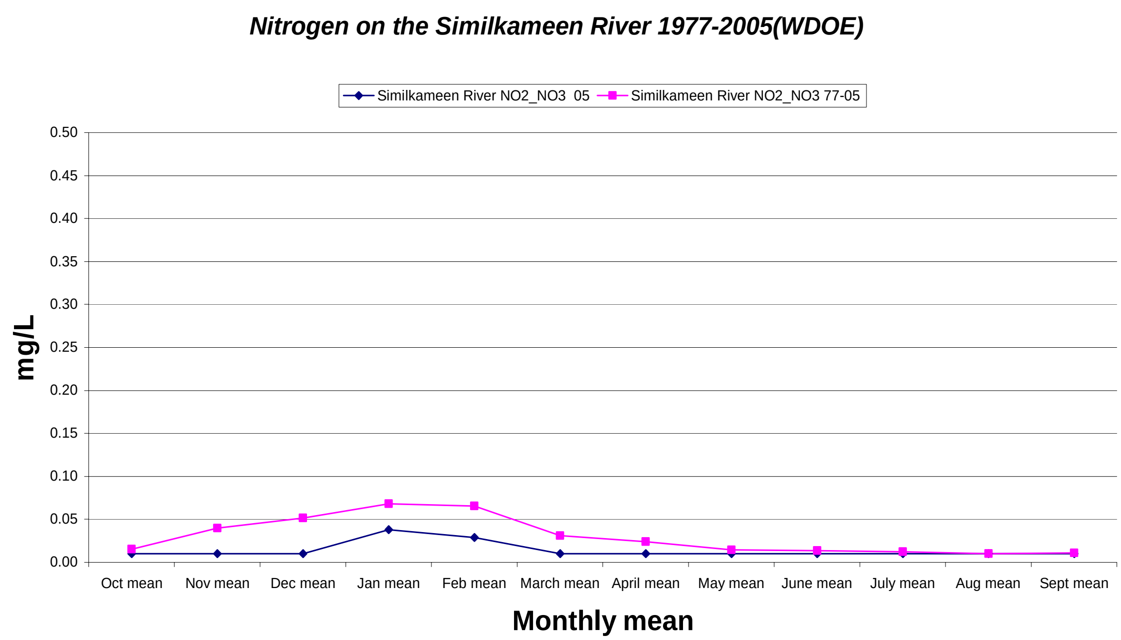

Figure 37: Grab sample data for total nitrogen (nitrate + nitrite) collected by WDOE for the Similkameen River site located at the town of Oroville, WA, plus the lower Okanogan River site near the town of Malott, WA, comparing the historical average from 1977 to 2005 and 2005.

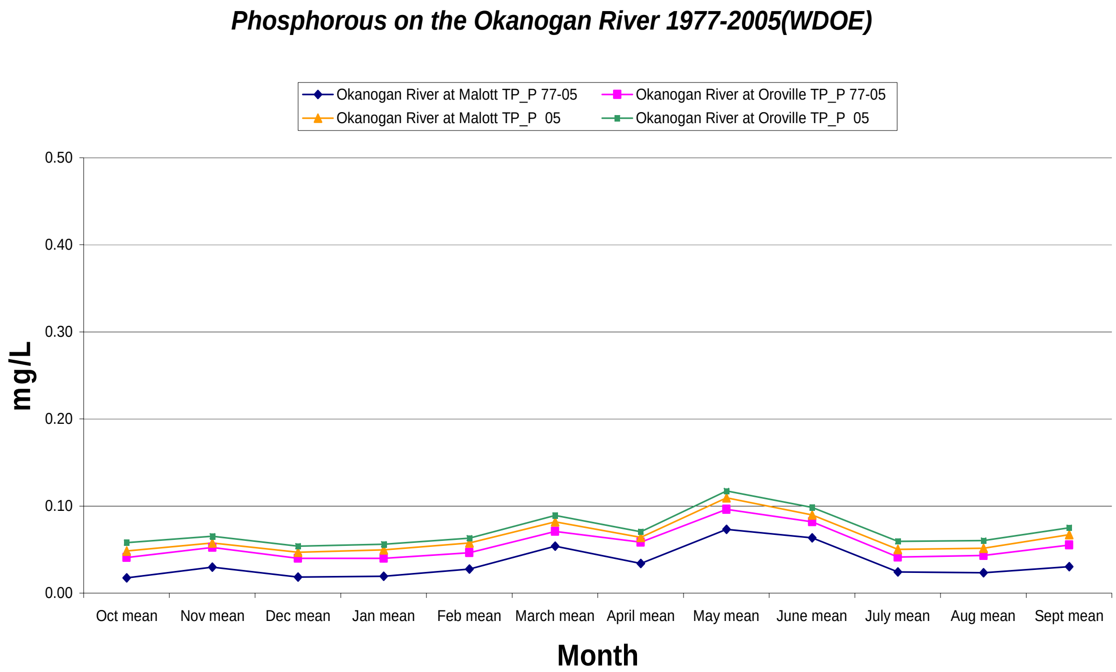

Figure 38: Grab sample data for total phosphorous collected by WDOE for the Similkameen River site located at the town of Oroville, WA, comparing the historical average from 1977 to 2005 and 2005.

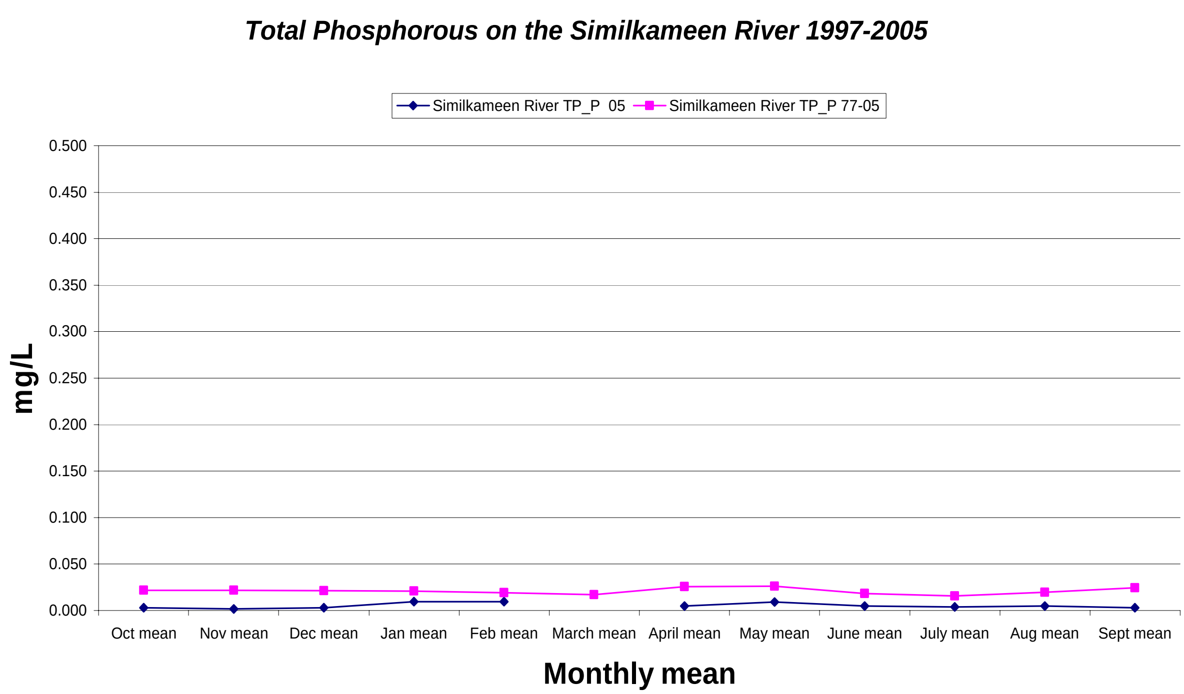

Figure 39: Grab sample data for total phosphorous collected by WDOE for the Similkameen River site located at the town of Oroville, WA, comparing the historical average from 1977 to 2005 and 2005.

Conductivity

Water conductivity is directly related to total ion concentration and increases with water temperature. Water containing mostly inorganic compounds conducts electricity better than water containing mostly organic compounds because the later are more likely to dissociate in solution (APHA 1992). Distilled water has very low conductivity (0.5-3.0 µS/cm), freshwater typically has conductivity ratings from 50 to 1,500 µS/cm, and seawater is typically 500 times more conductive (Reynolds 1996). "*Conductivity has been shown to have an effect on fish production, however, it's important to remember that these are only correlations,, they do not demonstrate cause and effect. I believe it is more than likely, both fish production and conductivity vary directly with some other covariate and that explains the effect on fish production*" (Hilman pers. com.). Water conductivity is the most important environmental factor that impacts electro-fishing. Extreme conductivity, whether low or high, exceeds the capacity of most electro-fishing power sources and reduces efficiency (Reynolds 1996).

Conductivity on the Similkameen River as measured near the town of Oroville was less in 2005 when compared to averages from 1977 through 2005 (Figure 40). The historical average readings ranged between 240 µS/cm in June and 270 µS/cm in December (Figure 40). In 2005, conductivity readings were consistently below the historical average and changes were far more dramatic with readings of 210 µS/cm in September to 110 µS/cm in November. During the fall of 2004 and the spring of 2005, Similkameen River conductivity remained very low (Figure 40). Okanogan River near Malott and near Oroville in 2005 varied closely with average readings from 1977 to 2005. 2005 readings on the Okanogan River varied from 140 µS/cm in May to 340 µS/cm in January (Figure 41).

We collected additional conductivity data on EMAP tributary habitats in 2005 (Figure 42). Specific conductivity was quite variable. Tonasket creek had the highest levels with a high reading of 820µS/cm in August. Omak Creek had the lowest readings with consistent readings near 100 µS/cm.

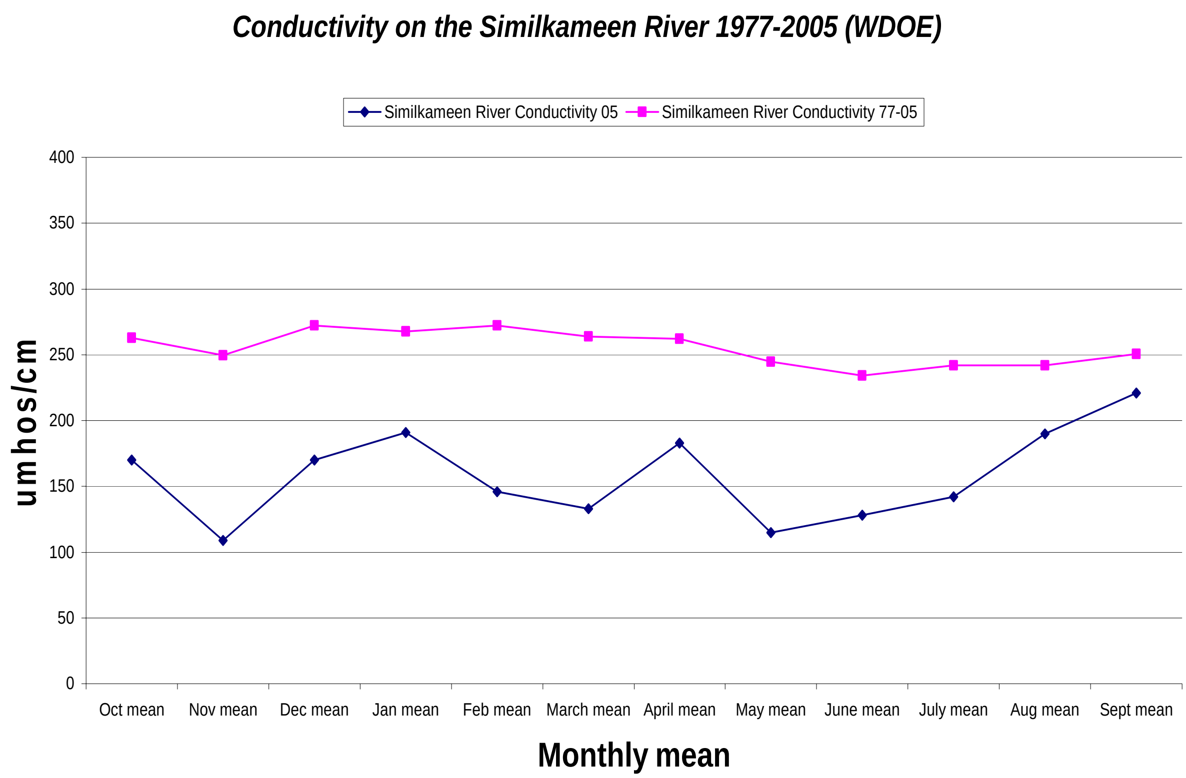

Figure 40: Grab sample data for conductivity collected by WDOE for the Similkameen River site located at the town of Oroville, WA, comparing the historical average from 1977 to 2005 and 2005.

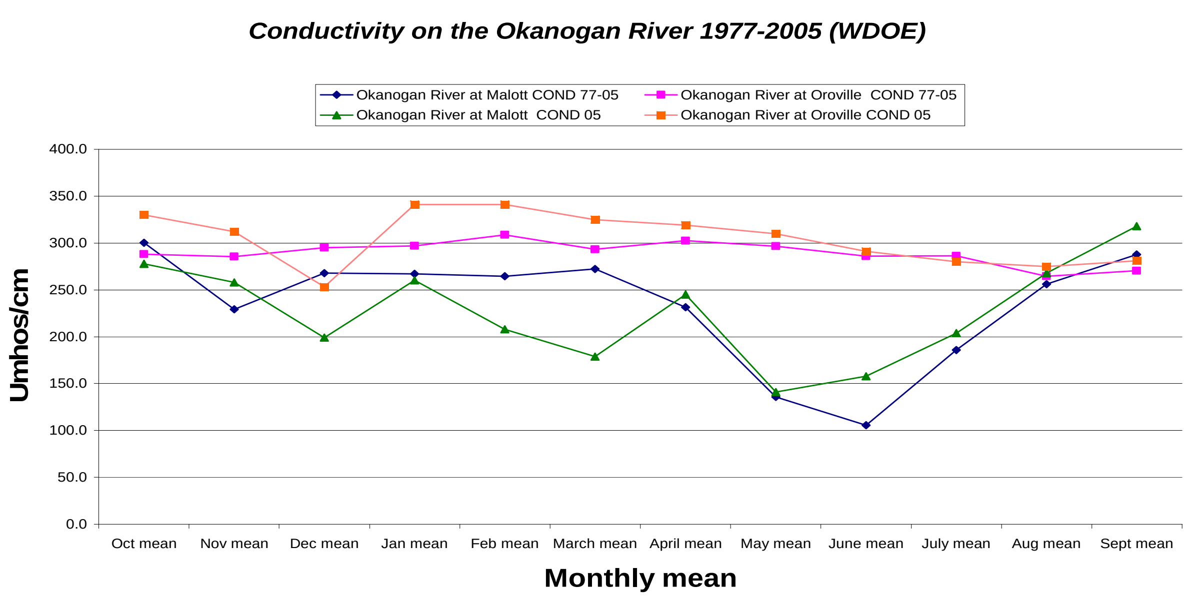

Figure 41: Grab sample data for conductivity collected by WDOE for the Okanogan River site located at the towns of Oroville and Malott, WA, comparing the historical average from 1977 to 2005 and 2005.

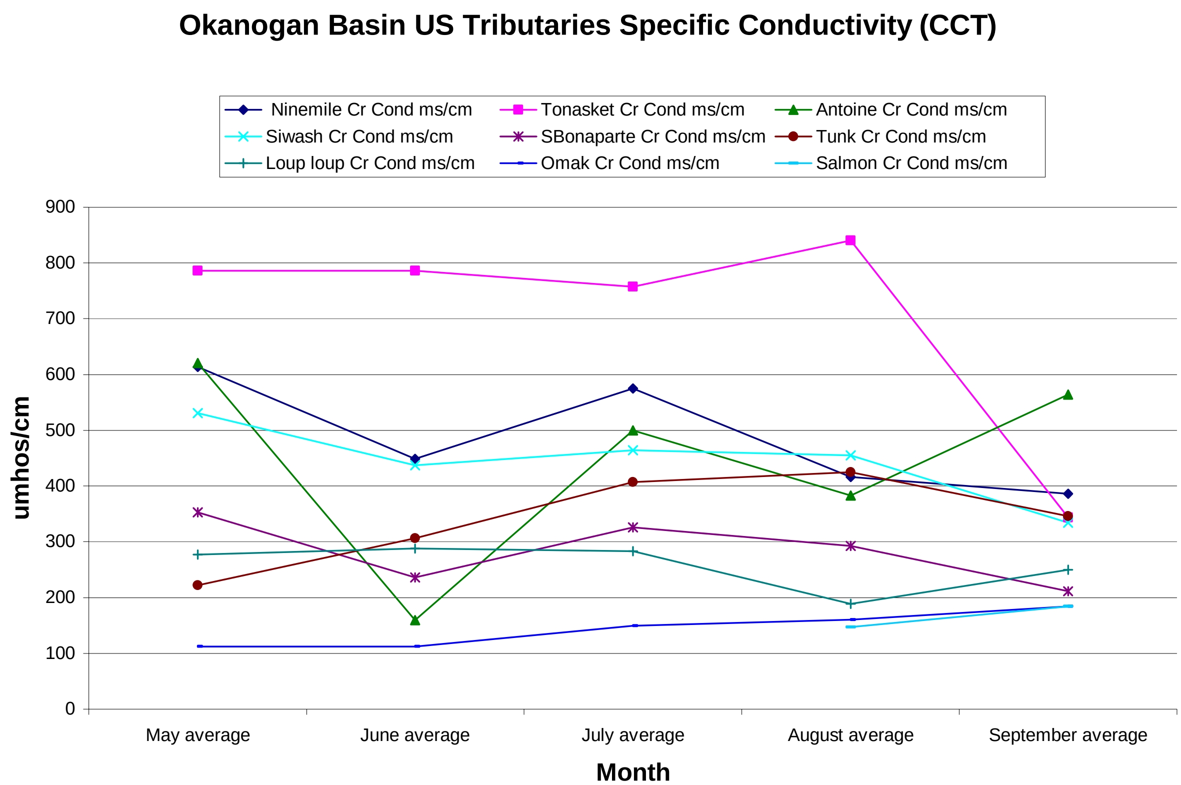

Figure 42: Grab sample data for conductivity collected by CCT for the Okanogan River tributary sites, 2005.

Habitat Data

We collected habitat data at 50 sites in the Okanogan Basin in July through early October. The Okanagan Nation Alliance also conducted barrier surveys on Canadian tributaries (see OBMEP web site).

The following summary graphs and tables (Table 5) (Figures 43-46) are data comparisons of selected parameters at sites we surveyed in 2004 and 2005. More detailed summary tables can be found on the OBMEP web site at: http://nrd.colvilletribes.com/obmep/Reports.htm The summary tables compare data within sites and are divided into tributary and mainstem Okanogan River sites. These tables represent only selected sites; the complete data set is contained on a server located at the Colville Tribes, Fish and Wildlife offices in Omak, WA. Specific information requests can be directed to the Colville Tribes, Fish and Wildlife Department, Anadromous Fish Division, 23 Brooks Tracts Rd., Omak, WA 98841.

In the following graphed parameters measured during our physical habitat surveys are compared between years. The sites analyzed were surveyed in both 2004 and 2005. We expected bankfull width, pool/riffle ratios, and canopy cover to be similar for specific sites between years (Figures 43-46). Some sites had differences that can be explained by flow. For example, site 27 had a pool/riffle ratio of 50% in 2004 and only 3% in 2005. This site had less discharge during the survey in 2005 and was confined to a much narrower channel and thus the habitat surveyed was more riffle than pool. This explanation also applies to canopy cover, especially on site 46 on the Similkameen River. The channel was limited to the thalweg in 2005, and thus, canopy readings were lower than when the channel was wider and closer to the bank in 2004. Percent substrate embedded and percent of fine sediment are estimated values based on observation. We are pleased to see that, for the most part, most values were consistent within sites between years (Figure 47). There was some variability in sites that were surveyed by the Colville Confederated Tribes in 2004 but were surveyed by the Okanagan Nation Alliance in 2005. We can solve any observer biases by having more training sessions and additional cross training of crews in 2006.

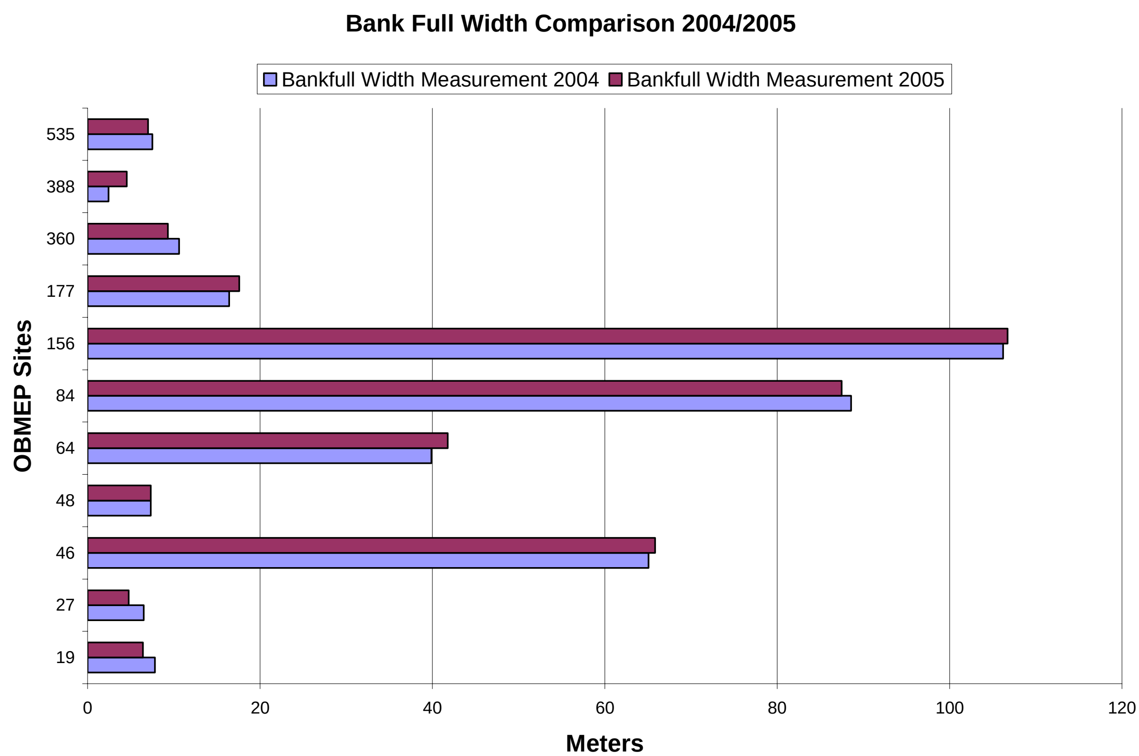

Figure 43: Bankfull width measurements within sites surveyed in 2004 and 2005. For the location of the OBMEP sites listed please refer to Figures 8 and 9 in this document.

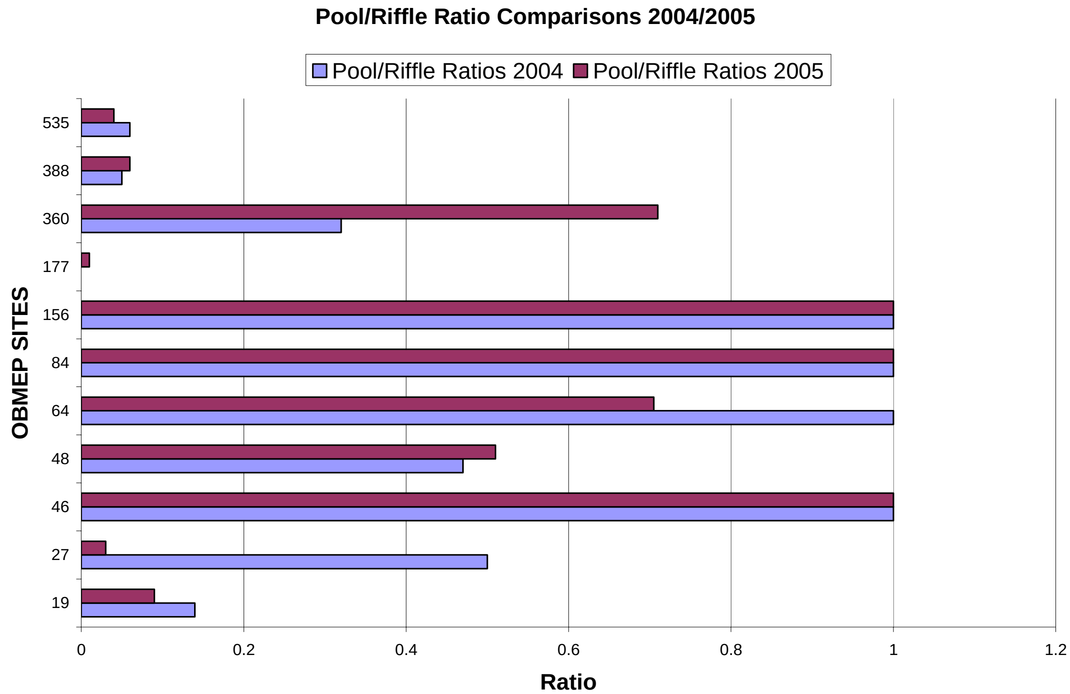

Figure 44: Pool/Riffle ratio within sites surveyed in 2004 and 2005. For the location of the OBMEP sites listed please refer to Figures 8 and 9 in this document.

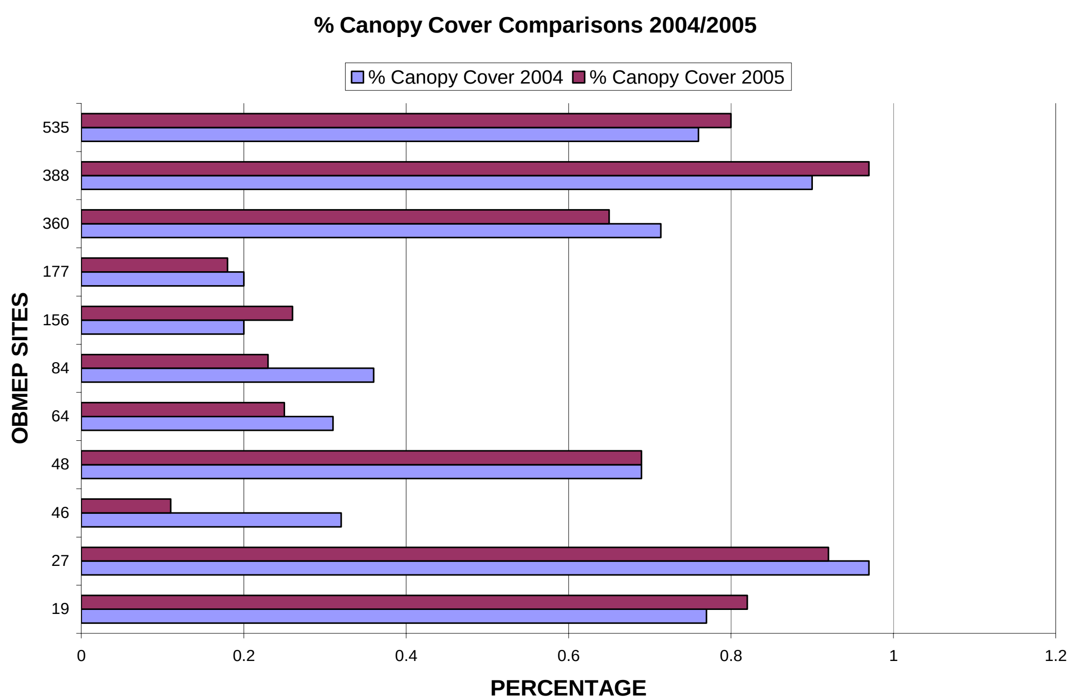

Figure 45: Canopy cover within sites surveyed in 2004 and 2005. For the location of the OBMEP sites listed please refer to Figures 8 and 9 in this document.

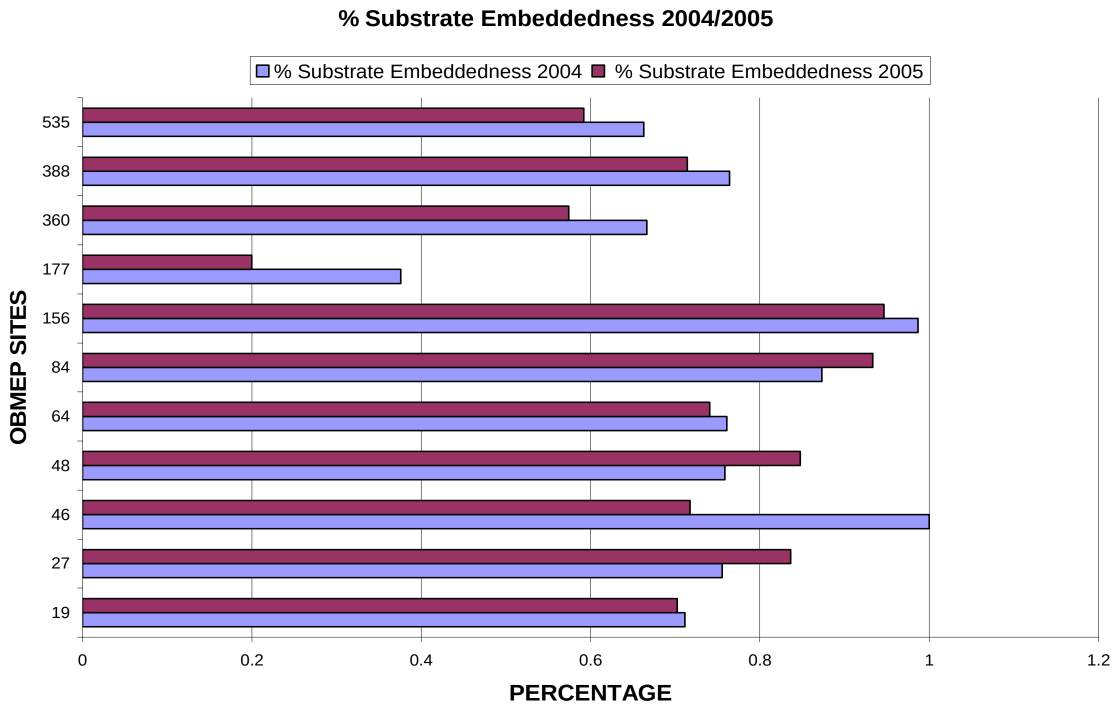

Figure 46: Percent substrate embedded and percent of small sediment present within sites surveyed in 2004 and 2005. For the location of the OBMEP sites listed please refer to Figures 8 and 9 in this document.

Table 3: Between year comparisons of select physical habitat indicators for OBMEP sites.

		PARAMETER				
OBMEP-EMAP Sites	**Site Numbers & year**	**Bankfull Width**	**Pool/Riffle Ratio**	**Canopy Cover Reach Average**	**% Embedded**	**Small Sediment %**
Okanogan River	**156 2004**	106.22	100%	**20%**	98.67%	100%
	156 2005	106.71	100%	**26%**	94.67%	99%
	84 2004	88.56	100%	**36%**	87.33%	100%
	84 2005	87.47	100%	**23%**	93.32%	99%
	64 2004	39.87	100%	**31%**	76.10%	71%
	64 2005	41.77	71%	**25%**	74.08%	83%
Salmon Creek	**360 2004**	10.62	32%	**71%**	66.65%	61%
	360 2005	9.32	71%	**65%**	57.44%	80%
Omak Creek	**19 2004**	7.81	14%	**77%**	71.14%	65%
	19 2005	6.41	9%	**82%**	70.24%	26%
	48 2004	7.32	47%	**69%**	75.87%	86%
	48 2005	7.33	51%	**69%**	84.78%	86%
Bonaparte Creek	**388 2004**	2.42	5%	**90%**	76.41%	50%
	388 2005	4.55	6%	**97%**	71.43%	59%

		PARAMETER				
OBMEP-EMAP Sites	**Site Numbers & year**	**Bankfull Width**	**Pool/Riffle Ratio**	**Canopy Cover Reach Average**	**% Embedded**	**Small Sediment %**
Ninemile Creek	**27 2004**	6.51	50%	**97%**	75.57%	39%
	27 2005	4.76	3%	**92%**	83.64%	75%
Inkaneep Creek	**535 2004**	7.52	6%	**76%**	66.29%	62%
	535 2005	7.00	4%	**80%**	59.19%	98%
Vaseux Creek	**177 2004**	16.41	0%	**20%**	37.58%	7%
	177 2005	17.60	1%	**18%**	19.99%	46%
Similkameen River	**46 2004**	65.06	100%	**32%**	100.00%	100%
	46 2005	65.82	100%	**11%**	71.76%	100%

Historical Juvenile Sockeye Data

Data has been collected by the Department of Fisheries and Oceans, Canada (DFO) and the Okanagan Nation Alliance on juvenile sockeye in Osoyoos Lake. Currently this is the only available rearing habitat for juvenile sockeye whose origin is in Canada. This data was collected from Osoyoos Lake using hydro-acoustic methodologies. A full report on this data is available on the OBMEP web site at: http://nrd.colvilletribes.com/obmep/Reports.htm.

Work Element 18: Disseminate Raw & Summary Data

Work Element Title: Workshop/conference attendance and publication.
Deliverable: Professional presentations, peer reviewed publication.

OBMEP staff biologists attended relevant workshops/conferences as scheduled within the region to exchange information with or provide presentations to other fisheries scientists. Peer reviewed publications have been developed that support the OBMEP program (see work element 6). During 2005, we also developed and posted these documents at our public web site (http:/nrd/colvilletribes.com/obmep/) to facilitate information dissemination. This site will be updated throughout 2006 and beyond with the most up-to-date information for this project and many references to this web-site will be made in future annual reports to reduce redundancy and duplication of efforts.

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