

## Fish and Water Management Tool Project Assessments: Okanagan Adult Sockeye Salmon (*Oncorhynchus nerka*) Abundance and Biological Traits in 2005

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Salmon Index Data System Reports (SIDS SRe.'s) facilitate timely exchange of information and results on assessments of salmon abundance, their biological traits and associated habitat variables, in response to requests from a variety of "clients" both within and external to the Department of Fisheries and Oceans. Information contained in status reports is often preliminary in nature and contact with the authors is recommended to clarify any uncertainties associated with interpretation or use of status report contents.

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**Survey Type:** [ ] acoustics and trawl, [X] spawning ground, [X] other.

**Survey Rationale:** Annual production variations of both Okanagan River sockeye salmon (*Oncorhynchus nerka*) fry and Okanagan Lake kokanee (*O. nerka*) are influenced significantly by water regulation decisions at a series of low-head dams built at lake outlets (Okanagan, Skaha, Vaseux, Osoyoos) in the headwaters of the Okanagan River. Dams and diversions are operated to meet flood control, fisheries and other water use objectives (Hourston et al 1954; Alexander et al. 2005) in Canadian portions of the Okanagan basin. Water management decisions influence fish production through effects on:

- 1) seasonal water level variations at Okanagan Lake beaches where kokanee spawn,
- 2) discharge, water level, and flows downstream in natural and channelized sections of the Okanagan River, where sockeye salmon spawn; and
- 3) water quality in the rearing-habitat of sockeye fry in Osoyoos Lake.

The Fish-and-Water Management Tools (FWMT) Project was initiated in 2001 by the Canadian Okanagan Basin Technical Working Group and Douglas County Public Utility District No. 1, (Hyatt et al 2001, Hyatt and Machin 2005). The goal was to develop, test and apply decision-support models to improve water management decisions affecting production variations of Okanagan sockeye and kokanee salmon (*O. nerka*). Detailed descriptions of the design and functional properties of the FWMT System may be found in Alexander and Hyatt (2005) and Alexander et al. (2005) respectively. However, of particular relevance here, the FWMT sockeye sub-model (Hyatt et al. 2005) simulates production outcomes for three cohorts of sockeye salmon from the time of spawning in October through egg incubation, emergence, and rearing to the end of the following November. During this interval, the sockeye sub-model supports simulations on daily to weekly time steps as required to reflect mortality processes known to control Okanagan sockeye production variations. Key mortality events occur in both spawning (e.g. flood-and-scour

or drought-and-desiccation events in the Okanagan R.) and lake rearing habitats (e.g. density-dependent or density independent growth survival and production in Osoyoos L.). The sub-model provides estimates of sockeye egg, alevin, fry and “smolt” abundance from the time of initial egg deposition in October to the following winter just prior to the time of seaward migration by smolts. Adult spawner abundance, sex ratio, timing of egg deposition, and age-specific fecundity are required to initialize sub-model simulations for the fish-and-water management cycle associated with a sockeye salmon brood year. Daily water temperature values are used in the sockeye sub-model to help identify the date of peak spawning by sockeye salmon and to determine the elapsed time from egg-deposition to egg-hatch and fry emergence. Daily water temperature values are automatically imported into the FWMT model from the Water Survey of Canada Station 08NM002 maintained at Okanagan Falls.

Sockeye salmon abundance and biological traits associated with 2005 brood year adults were determined through field survey work at the Okanagan River during mid-Sept to early-Nov. Comparisons of observations of seasonal water temperatures recorded by WSC at Okanagan Falls versus those obtained from independent “Tidbit” data loggers deployed in spawning gravel below Vaseux Creek were completed in each of 2002, 2003 and 2004. These data sets indicate that Okanagan Falls values are biased high relative to incubation sites during late fall and winter (Hyatt et al., unpublished data) such that a bias correction must be applied to FWMT System water temperatures (i.e. WSC Okanagan Falls daily temperature) to improve the reliability of 100 % hatch date estimates. Accordingly, daily water temperature recordings were retrieved and compared from both sites again during 2005 to provide an appropriate bias correction for application of the FWMT sockeye sub-model during the 2005-06 fish-and-water management cycle (see detailed comments below).

#### Survey Resources:

Surveys to determine abundance and biological traits of Okanagan sockeye salmon during 2005 involved cost-sharing and collaborative efforts among Fisheries and Oceans Canada (PST funding), the Okanagan Nation Alliance and Washington State Public Utility Divisions serving as “co-sponsors” for either the Fish and Water Management Tools (FWMT) Project (Douglas County Public Utility District No. 1 ) or the Skaha Sockeye Reintroduction (SSR) Project (Chelan Public Utility District). Public Utility Division contributions to costs in support of 2005 escapement surveys were shared equally between the FWMT and SSR projects because information regarding adult sockeye abundance and biological traits is required by both projects. Fisheries and Oceans Canada leads the FWMT Project while the Okanagan Nation Alliance leads the Skaha Sockeye Project. Both groups and their partners (e.g. BC Ministry of Environment) participate in coordination of internal and external arrangements for agency, tribal or “contract” technicians and biologists to execute surveys in addition to subsequent biological sample and data processing activities.

**Survey Subjects:** Field crews conducted surveys for: (1) Seasonal abundance and biological traits (sex ratio, peak spawn time, age-specific fecundity, timing and magnitude of egg deposition) of adult sockeye on the spawning grounds in the Okanagan River near Oliver, B. C., (2) Daily observations of seasonal (September-05 to March-06) water temperature recorded at WSC-Okanagan Falls and in the sockeye index reach of the Okanagan River below McIntyre Dam near the confluence of Vaseux Creek.

**Survey Dates:** Twelve spawner enumeration surveys were completed between 13-Sep-2005 and 3-Nov-2005. Eleven seine sets were completed between 11-Oct-05 and 21-Oct-05 to determine proportions of male and female sockeye on the spawning grounds. In addition, 2 dead-pitch surveys were conducted on 20-Oct-05 and 26-Oct-05. Biosampling was conducted on a daily basis between 12-Oct-05 and 20-Oct-05 in conjunction with brood stock collection. Otoliths were sent to the PBS aging lab for reading; results were received 20-Jan-06. Dates for each survey or sampling operation are identified in the attached tables. WSC-Okanagan Falls provided continuous observations of water temperature throughout 2005-06. Temperature data loggers deployed in the sockeye spawning area below McIntyre Dam have provided independent observations of incubation environment temperatures throughout the period of egg deposition (early Oct-06 ) and incubation (Oct-present).

**Survey Crew(s):** Okanagan Nation Alliance Fisheries Department personnel under the direction of Howie Wright and Karilyn Long (250-707-0095).

**Survey Status:** Summary tables attached include observations of: sockeye spawner abundance by survey date and spawning location; estimates of adult sockeye abundance; sex composition from seine sets and dead pitch surveys; age composition by sex; and female fecundity. Summary tables are assembled from field notes and raw data sheets provided to Margot Stockwell by Karilyn Long, Jillian Tamblin, and Michelle Walsh of the ONA Fisheries Department (received 2-Dec-05). Seasonal assessments of sockeye abundance and biological traits (sex ratio, size, age and fecundity) of adult spawners are expected to continue on an annual basis to provide start-up parameters for annual application of the FWMT System in support of “fish friendly” water management decisions.

**Status of Samples:** Adult abundance records, biological samples and survey observations will be incorporated (yes [X], no [ ]) into sample inventories or the FWMT Core Numbers and Traits Database (program contact, Margot Stockwell) maintained by the Salmon in Regional Ecosystems Program at PBS to meet ongoing monitoring and evaluation requirements.

**Status of Sample Analysis:** Completed

**Status of Data Analysis and Reporting:** Additional data analysis and/or reporting will be completed (yes [X], no [ ]). Estimates of environmental conditions (e.g. temperature), salmon

abundance and biological traits are provided here as a citable source of startup values required as inputs for application of the FWMT System in support of Okanagan fish-and-water, management decisions during 2005-06. Values reported here have been used to initialize application of the FWMT sockeye sub-model to predict fry production for 2005 brood year adults and as such have been reviewed carefully for obvious bias or error. An annual record of FWMT startup values is required for future evaluation (in year 2012-13) of multiyear, sockeye salmon production benefits attributable to operational use of the FWMT System. Although values adopted here should be “near final”, they may still be subject to some revision pending more complete analysis, reporting and/or entry into regional data systems of Fisheries and Oceans Canada.

### **Preliminary Observations and Conclusions:**

#### **1. Estimates of 2005 Okanagan Sockeye Abundance**

**1.1. Wells Dam Estimates:** Personnel from Douglas County Public Utility and the U.S. Army Corps of Engineers have monitored the daily numbers of adult salmon migrating through fish ladders at Wells Dam (Figure 1) since the dam first became operational in 1967.

Enumeration methods pertaining to this monitoring program are outlined in Stockwell and Hyatt 2003. Daily sockeye counts for 2005 were obtained from the Columbia River D.A.R.T.<sup>1</sup> website at <http://www.cbr.washington.edu/dart/dart.html> (last accessed 2-Dec-05). Significant numbers (> 100) of adult sockeye began passing through Wells Dam on approximately June 25; passage was 95% complete by August 1. The total, annual sockeye count past Wells for this year was 55,553 fish. Wells Dam counts may be regarded as an absolute estimate of the number of sockeye potentially available to reach the Okanagan spawning grounds. However, these counts do not reflect any pre-spawning mortalities that most likely occur during the 3-4 month period between passage at Wells Dam and the commencement of spawning in the Okanagan River.

**1.2. Terminal Spawning Ground Estimates:** Personnel from the ONA Fisheries Department conducted 12 weekly to biweekly (13-Sep-05 to 3-Nov-05) float and stream walk surveys of the Index and Channel sections of the Okanagan River spawning grounds (Figure 2). Field survey methods are detailed in Stockwell and Hyatt 2003. A peak live plus dead count of 24,161 sockeye was observed on 19-Oct-05. Peak counts provide a relative index of abundance estimates but are biased low in comparison with Wells counts (over the last 10 years peak counts are on average 40% of Wells counts; Hyatt and Stockwell 2006). Variation in abundance estimates between Wells Dam and the terminal spawning grounds are likely due to differences between survey techniques, pre-spawn mortality, or a combination of both.

<sup>1</sup> Columbia River Data Access in Real Time (D.A.R.T.), Columbia Basin Research, School of Aquatic & Fishery Sciences, University of Washington, Seattle, WA.

**1.3. Area-Under-the-Curve Estimates:** An area-under-the-curve (AUC) estimate of sockeye abundance was derived from the standard trapezoidal approximation method as described in Hillborn et al 1999. We did not include any correction for observer efficiency ( $v$ ) as no defensible estimates of observer efficiency have been obtained during any Okanagan sockeye enumerations (i.e.  $v$  is assumed to equal 100% in Okanagan AUC estimations). Because no specific stream life measures were completed for Okanagan sockeye in 2005, a stream life ( $s$ ) value of 11 days was assumed to be applicable. The rationale for this value is that Early Stuart sockeye salmon exhibit an average stream life of 11 days (Perrin and Irvine 1990) and Okanagan sockeye salmon adults are similar to Early Stuart sockeye with respect to average body size, migration distance, and migratory timing.

In 2005, live sockeye counts were obtained during 12 float-surveys of the Index section and 11 stream-walk surveys of the Channel section. Surveys were conducted at intervals of 3 to 7 days (Table 1) throughout the spawning period. In calculating the AUC for the complete spawning area of the river, daily live counts for the Index and Channel were added together. No Channel survey was conducted on Oct. 10. Therefore, to prevent a low bias estimate for this date, the mean of the preceding (Oct. 4) and subsequent (Oct. 13) survey counts was calculated and then added to the Oct. 10 Index count. The AUC estimate of sockeye abundance for the Okanagan River is 31,536 fish.

**1.4.** A summary of 2005 Okanagan sockeye escapement estimates derived from separate survey and analytical methods is presented in Table 2. The  $AUC_{river}$  value of 31,536 represents our current “best estimate” of the total number of adult sockeye present at the Okanagan River spawning grounds during 2005. Other values summarized in Table 2 are presented only for historic and comparative purposes i.e. various metrics (counts through Wells Dam, peak counts of sockeye adults in the Okanagan river or a smaller index area) have been used in earlier intervals to follow annual changes in adult sockeye escapement.

## **2. Estimation of Peak Spawn Timing / Peak Egg Deposition**

**2.1.** Peak abundance alone does not provide sufficient information to reliably establish time of peak spawning and subsequent egg deposition. Historical observations indicate that Okanagan sockeye may be present on the spawning grounds for more than a month before active spawning commences. This is may be due to unfavourable, warmer water temperatures that delay the initiation of spawning. Behavioural observations of adult salmon (holding, pairing, spawning) by survey crews in combination with abundance data provide a more accurate estimate of the true peak spawn date. Table 1A indicates peak abundance in the Index section coincides with a time period where all live sockeye were observed to be actively spawning. As such, 19-Oct-05 should be regarded as the date of peak sockeye spawning. Abundance and behavioural observations in the Channel Section (Table 1B) are more unpredictable than those from the Index area. Accurate observations are more difficult in the channel due to poor visibility caused by turbulence in the pools below the vertical drop structures where the fish tend to congregate. However because > 95% of total spawners were present in the Index section throughout the entire month of

- October, the above peak spawn date is considered to be applicable to the entire Okanagan population.
- 2.2. Peak spawn may also be characterized as the date when the abundance of carcasses is  $\geq 3\%$  and  $\leq 10\%$  of the total fish observed on the spawning grounds (Hyatt and Rankin 1999). On the enumeration survey of Oct. 19, 7.5% of sockeye counted in the Index section were carcasses; 4.7% of the fish in the Channel section were carcasses (Figure 3 a & c). That is, the carcass “rule” confirms that peak spawning is on or near Oct. 19.
  - 2.3. Peak spawn date may also be defined as the date on which declining water temperatures in Okanagan River spawning areas reach  $12^{\circ}\text{C}$ , the historical average temperature at which peak spawning activity normally occurs (Hyatt et al 2005; Stockwell and Hyatt, unpub. data). Figure 4 confirms that water temperature is at or near  $12^{\circ}\text{C}$  on 19-Oct-05. Thus, the water temperature “rule” implies that Oct. 19 is the date of peak spawning activity.
  - 2.4. Redd counts lagged behind adult counts and, although variable among dates, suggested a peak egg deposition date of Oct. 23<sup>rd</sup> (Figure 3b) rather than Oct. 19<sup>th</sup>. However, redds are more difficult to resolve visually, given variable water clarity in the spawning area, so the low redd-count recorded on Oct. 19<sup>th</sup> (Figure 3b) is more likely a function of low water clarity than of reduced spawning activity.
  - 2.5. Three of four independent sources of observation confirm Oct. 19 as the peak spawn/egg deposition date for the 2005 brood year. Additionally, FWMT allocates the temporal distribution of egg deposition to 3 weekly cohorts, such that 40% of spawning occurs during the peak spawn week and 30% each in the weeks immediately before and after the peak week (Hyatt et al 2005). Thus, the 2005-06 FWMT spawn dates are set as: 12-Oct-05 for cohort 1; 19-Oct-05 for cohort 2; and 26-Oct-05 for cohort 3.
3. The proportion of females in the 2005 Okanagan sockeye population was determined from fish collected in seine samples and from dead pitches conducted on the spawning grounds.
    - 3.1. A total of 18,507 sockeye were caught in 11 seine nets sets between Oct. 11 and Oct. 21. The proportion of samples composed of female sockeye varied between 20.9% and 39.7% among dates but there were no obvious trends for changes in female proportion across dates. The overall sex ratio indicated an unusually small proportion of females (31.9%) (Table 3). However, seine-net sampling may be numerically biased towards male sockeye because their behaviour of holding higher off the bottom than females, their slightly larger size and the presence of canine teeth all predispose them to a higher probability of capture than females. Indeed, direct observations by field crews suggest small fish and especially females (which remain closer to the bottom than males) readily escape from under the lead line of seine-net hauls during retrieval.
    - 3.2. Dead pitches were also conducted on Oct. 20 and Oct. 26 in two major spawning areas of the Okanagan River (Table 4) to determine sockeye sex ratios. Sockeye females comprised a much larger proportion of sockeye in dead pitch (53.7 %) than in seine

samples (31.9%). Female proportions varies significantly between both locations (higher female ratios in the principal spawning area than in channel areas further downriver) and dates (higher female proportions in both sampling areas during later sampling dates). Both of these trends are consistent with general behavioural patterns observed for spawning sockeye (i.e. greater fidelity of females to spawning sites and tendency for females to guard redds and thus persist in upstream spawning areas longer than males as die-off progresses). For the combined dates, the natural section of river between McIntyre Dam and Highway 97 Bridge yielded samples composed of 65.5% females; the main spawning section between Highway 97 Bridge and VDS 11 contained adults comprised of 49.4% females. This represents an abundance of approximately 10,000 female sockeye from both locations at peak spawn (Table 5). Samples from dead pitches are not subject to the sampling biases imposed by physical and behavioural traits on seine-set samples and are considered to more accurately represent female proportions in the population.

4. More than 95% of all sockeye obtained from seine samples ( $n = 276$ ) between Oct. 12 and Oct. 20 were classified as age 1.2 (Table 6). Although four-year-olds undoubtedly dominated returns of Okanagan sockeye in 2005, concerns persist that both sex-ratio and age composition of bio-samples obtained from seine hauls reflect biases associated with several factors. Firstly, we have noted concerns and evidence (i.e. differences in sex ratios of seine-caught versus dead-pitch samples) regarding non-random sampling and retention of sockeye during seine-net retrieval. Secondly, seined fish are also used as a source of brood-stock for hatchery culture of Okanagan sockeye fry so inadvertent selection of larger and older fish during sampling remains a possibility. Finally, there is evidence that otolith readers may misclassify ages of Okanagan sockeye adults in at least 5 % of all cases as suggested by subsequent comparisons of length frequency distributions of sockeye assigned ages as either three-year-olds or four-year-olds (i.e. assignment of adult ages are incompatible with body size observations). This may also serve to explain differences in the age structure assigned to samples of sockeye obtained from samples in the Columbia River main-stem (by Columbia Intertribal Fisheries Commission) versus those obtained for the FWMT Project in terminal spawning areas (M. M. Stockwell observations).
5. Brood year 2005 fecundity estimates were higher (2602) than observed in previous years. Although based on a small sample size ( $n = 20$ ), estimates should be relatively reliable because all females were of one age group (1.2) and were selected to include only unspawned, green fish that had intact egg skeins (Table 7).
6. The OFWMT model incorporates daily mean water temperature data in “real-time” from Water Survey of Canada (WSC) monitoring stations in the Okanagan River (<http://scitech.pyr.ec.gc.ca/waterweb/main.asp>). Water temperatures are used in the sockeye sub-model to predict the developmental stage and hence the vulnerability of eggs, alevins and emerging fry to changes in flow rates (scour and desiccation). FWMT considers 100% egg hatch to have occurred when all cohorts exceed 525 accumulated thermal units (ATU's); fry

emergence is 100% complete at 875 ATU's. Originally, Real-Time WSC Station 08NM085 (Okanagan River at Oliver) was selected as the water temperature source for the model because of its close proximity to the main spawning grounds. However, errors, inconsistencies and continually high temperature bias in the data from this station over the last 3 years have compelled the FWMT Steering Committee to recommend the alternate WSC Station 08NM002 (Okanagan River at Okanagan Falls; Figure 2) as the source of water temperature data to support sockeye sub-model applications. Additionally, ONAFD and DFO install Tidbit temperature loggers at key sockeye spawning locations in the Okanagan River throughout the incubation period. Comparison between the WSC and Tidbit temperatures indicates that daily temperatures recorded at Okanagan Falls also exhibit bias (Figure 5). Although the average daily difference is less than 1°C, the additional thermal units accumulated by employing Okanagan Falls temperatures can advance hatch times to several weeks earlier than the true date (M. Stockwell, unpub.data). We have not implemented new code within the FWMT System yet to deal directly with the effect of the high bias in winter temperatures at Okanagan Falls on egg-hatch predictions. However, as an interim measure it is possible to anticipate the average extent of bias observed in recent years and then to adjust the accumulated thermal unit (ATU) threshold considered to trigger egg hatch. Accordingly, we have increased the ATU threshold for sockeye egg hatch from an average of 525 degree-days to 595 degree-days as the preferred "startup" value for FWMT use during the 2005-06 in-season management cycle. We have not adjusted the ATU threshold for fry emergence because seasonal changes appear to produce compensatory changes in Okanagan Falls temperatures relative to incubation temperatures during the spring interval of emergence (Figure 5.).

## 7. Recommendations:

- 7.1. Reliable estimates of the time of egg deposition are critical for predicting the windows of vulnerability of eggs, alevins and fry in the FWMT model. Therefore, annual spawning ground surveys should continue to include assessments of seasonal changes in the abundance of: live sockeye holding, live sockeye spawning (i.e. engaging in redd digging and territorial defence), sockeye redds and dead sockeye.
- 7.2. Dead pitches should be continued in future years as the preferred means of determining sex ratios.
- 7.3. In addition to recording sex of individual fish during dead pitch procedures, individual length measurements (fork length or post-orbital hypural length) should be recorded. These will serve as a source of supplemental observations to establish the age structure of annual sockeye returns. Review of historic length at age information for Okanagan sockeye indicates that males and females returning as three-year-old "jacks and jills" may be readily distinguished from other ages (i.e. principally ages four and five) on the basis of length (Authors unpublished data).
- 7.4. Information on individual fish size should also be supplied along with each otolith sample to aid personnel in the PBS ageing laboratory to reliably classify Okanagan "jacks and jills" (i.e. three-year-old sockeye).

- 7.5. Sample sizes of 50 females with intact ovaries should be obtained generally each year before the peak of spawning to ensure that fecundity samples accurately reflect the age and size composition of spawning females.
- 7.6. Deployment of data loggers to monitor average daily water temperature on Transect 2 below McIntyre Dam should be continued for additional years in order to provide an adequate data set to reliably calibrate daily observations of water temperature from the WSC Okanagan Falls station with those observed on the spawning grounds located near Transect 2.

**Completed By:** Kim Hyatt and Margot Stockwell

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**References:**

- Alexander, C.A.D., B. Symonds and K. D. Hyatt, Eds. 2005. The Okanagan Fish/Water Management Tool: Guidelines for Apprentice Water Managers (v.1.0.001). Prepared for the Canadian Okanagan Basin Technical Working Group (COBTWG) and Douglas County Public Utility Division (DCPUD), Draft report submitted to COBTWG and DCPUD, Sept. 2005.
- Alexander, C. A. D. and K. D. Hyatt, Eds. 2005. The Okanagan Fish-and-Water Management Tool (Ok-FWMT) Record of Design (v. 1.0.001). Prepared for the Canadian Okanagan Basin Technical Working Group (COBTWG) and Douglas County Public Utility Division (DCPUD), Draft report submitted to COBTWG and DCPUD, Sept. 2005.
- Hilborn, R., B. G. Bue, and S. Sharr. 1999. Estimating spawning escapements from periodic counts: a comparison of methods. *Can. J. Fish. Aquat. Sci.* 56: 888-896.
- Hyatt, K. D., C. Peters, C. Alexander, and P. Rankin. 2005. The sockeye submodel of the Okanagan Fish Water Management (OKFWM) Tool. Chapter 6 *In* The Okanagan Fish Water Management (OKFWM) Tool Record of Design. *Can. Manuscr. Rep. Fish. Aquat. Sci. in prep.*
- Hyatt, K. D. and D. P. Rankin. 1999. A habitat based evaluation of Okanagan sockeye salmon escapement objectives. PSARC Working Paper S99-18. Department of Fisheries and Oceans, Pacific Science Advisory Review Committee, Pacific Biological Station, Nanaimo, British Columbia. 59 p.
- Hyatt, K. D., E. Fast, M. Flynn, D. Machin, S. Matthews and B. Symonds. 2001. Water management tools to increase production of Okanagan sockeye salmon. Fish-Water Management Proposal (June 21, 2001) submitted to Douglas County Public Utility Division No. 1, Wenatchee Washington. Canadian Okanagan Basin Working Group Secretariat. 24 p.

- Hyatt, Kim D. and Deana Machin. 2005. Okanagan Fish and Water Management Tool (FWMT): Operational Deployment & Assessment of the FWMT System to Support 2005-06 Fish-and-Water Management Decisions: Year 1 of 8. Proposal (Sept. 2005) submitted to Douglas County Public Utility Division No. 1, Wenatchee Washington. Canadian Okanagan Basin Technical Working Group Secretariat. 34 p.
- Hyatt, K. D. and M. S. Stockwell. 2006. A detailed audit and reconstruction of Okanagan sockeye salmon escapement estimates from 1961-2003. Pacific Science Advisory Review Committee Working Paper S04-XX: *in prep*. Fisheries and Oceans Canada, Pacific Biological Station, Nanaimo, B.C.
- Hourston, R., C. H. Clay, E. W. Burrige, K. C. Lucas, D. R. Johnson, H. T. Heg, W. R. McKinley, J. T. Barnaby, L. A. Fulton, and A. A. Gentry. 1954. The salmon problems associated with the proposed flood control project on the Okanagan River in British Columbia, Canada. A report prepared by the technical staffs of the United States Fish and Wildlife Service, The Washington Department of Fisheries and The Department of Fisheries, Canada. Vancouver, B.C. Canada, April, 1954. 109 p.
- Perrin, C. J. and J. R. Irvine. 1990. A review of survey life estimates as they apply to the area-under-the-curve method for estimating the spawning escapement of Pacific salmon. Can. Tech. Rep. Fish. Aquat. Sci. 1733: 49 p
- Stockwell, M. M. and K. D. Hyatt. 2003. A summary of Okanagan sockeye salmon (*Oncorhynchus nerka*) escapement survey observations by date and river segment from 1947 to 2001. Can. Data Rep. Fish. Aquat. Sci. 1106: 34 p + data CD-ROM.

Table 1. Visual counts of Okanagan sockeye spawners and redds by date and section (Figure 2) during 2005.

A. Index Section (McIntyre Dam to Vertical Drop Structure 12)

Date	Holding	Spawning	Total Live	Dead	Total L+D	Redds
13-Sep	43	0	43	0	43	0
20-Sep	212	0	212	0	212	0
27-Sep	788	0	788	0	788	0
04-Oct	4,020	2,479	6,499	0	6,499	87
10-Oct	350	13,765	14,115	13	14,128	1,842
13-Oct	0	17,370	17,370	189	17,559	645
16-Oct	0	16,041	16,041	496	16,537	3,033
19-Oct	0	21,787	21,787	1,778	23,565	1,488
22-Oct	0	7,759	7,759	2,690	10,449	3,281
25-Oct	0	5,356	5,356	4,150	9,506	2,734
28-Oct	0	1,758	1,758	7,153	8,911	864
03-Nov	0	319	319	1,699	2,018	489

B. Channel Section (Vertical Drop Structure 12 to Vertical Drop Structure 1)

Date	Holding	Spawning	Total Live	Dead	Total L+D	Redds
13-Sep	3	0	3	0	3	0
20-Sep	7	0	7	0	7	0
27-Sep	151	0	151	0	151	0
04-Oct	555	42	597	0	597	33
10-Oct		no channel counts on this date				
13-Oct	576	179	755	1	756	235
16-Oct	182	473	655	6	661	310
19-Oct	129	439	568	28	596	310
22-Oct	372	342	714	96	810	311
25-Oct	139	123	262	149	411	280
28-Oct	0	145	145	115	260	133
03-Nov	0	70	73	55	123	85

Table 2. Estimates of Okanagan sockeye salmon abundance for the return year 2005 as derived from separate survey and analytical methods.

Method	Estimate
Wells Dam Count	55,553
PLD <sub>Index</sub>	23,565
AUC <sub>Index</sub>	29,883
PLD <sub>River</sub>	24,161
AUC <sub>River</sub>	31,536

Table 3. Sockeye sex composition from seine sets to obtain brood stock in the Okanagan River, October 2005.

Date	# of Sets	# Males	# Females	% Female
11-Oct-05	1	413	109	20.9
12-Oct-05	8	2,010	685	25.4
13-Oct-05	10	1,960	1,029	34.4
14-Oct-05	7	1,379	778	36.1
15-Oct-05	6	1,315	704	34.9
16-Oct-05	6	955	536	35.9
17-Oct-05	7	917	604	39.7
18-Oct-05	9	1,059	392	27.0
19-Oct-05	8	1,106	539	32.8
20-Oct-05	8	897	347	27.9
21-Oct-05	7	588	185	23.9
Totals		12,599	5,908	31.9

Table 4. Sockeye sex composition from dead pitches in the Okanagan River, October 2005.

A. Northern section of spawning grounds (Transect 1 to Hwy 97 Bridge)

Date	Males	Females	Unknown	% F
20-Oct-05	86	115	0	57.2
26-Oct-05	119	285	6	69.5
Totals	205	400	6	65.5

B. Southern section of spawning grounds (Hwy 97 Bridge to channel)

Date	Males	Females	Unknown	% F
20-Oct-05	219	116	0	34.6
26-Oct-05	615	704	7	53.1
Totals	834	820	7	49.4

C. All locations combined.

Date	Males	Females	Unknown	% F
20-Oct-05	305	231	0	43.1
26-Oct-05	735	989	13	57.0
Totals	1,039	1,220	13	53.7



Table 5. Estimated number of Okanagan River female sockeye spawners as calculated from dead pitch samples, October 2005.

A. Northern section of spawning grounds (Transect 1 to Hwy 97 Bridge)

Date of Enumeration	Date of Dead Pitch	Total Number of Fish	Percent Female	Number of Female Sockeye
19-Oct-05	20-Oct-05	4,522	57.2	2,586
25-Oct-05	26-Oct-05	1,216	65.9	845
All dates		5,738	65.5	3,758

B. Southern section of spawning grounds (Hwy 97 Bridge to channel)

Date of Enumeration	Date of Dead Pitch	Total Number of Fish	Percent Female	Number of Female Sockeye
19-Oct-05	20-Oct-05	19,043	34.6	6,589
25-Oct-05	26-Oct-05	8,290	53.1	4,402
All dates		27,333	49.4	13,503

C. All locations combined

Date of Enumeration	Date of Dead Pitch	Total Number of Fish	Percent Female	Number of Female Sockeye
19-Oct-05	20-Oct-05	23,565	43.1	10,157
25-Oct-05	26-Oct-05	9,506	57.0	5,418
All dates		33,071	53.7	17,759

Table 6. Sex and age composition from biosampling 12 to 20 October, 2005. Otoliths were removed during biosampling at the Okanagan River spawning grounds; ages were determined by the Aging Lab at the Pacific Biological Station, Nanaimo.

Sex	Age 1.1		Age 1.2		Age 1.3		Age 2.2		n	Not Read
	#	%	#	%	#	%	#	%		
F	1	0.7	138	97.2	3	2.1	0	0.0	142	9
M	0	0.0	127	95.5	5	3.8	1	0.8	133	5

Table 7. Egg retention in sockeye sampled at the Okanagan River spawning grounds 14 to 18 October, 2005.

	Value
n	20
age	1.2
mean # eggs	2602
min # eggs	2022
max # eggs	3357

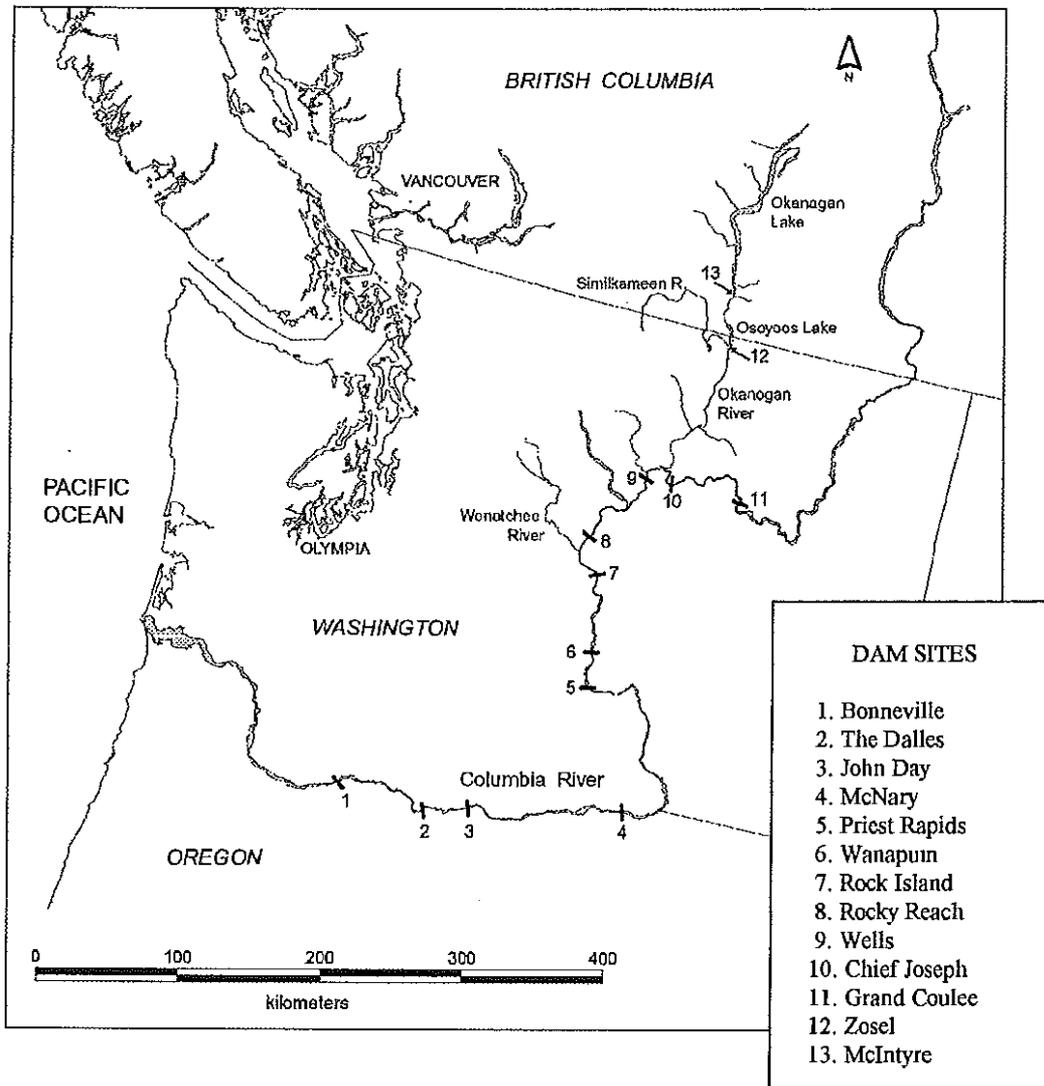
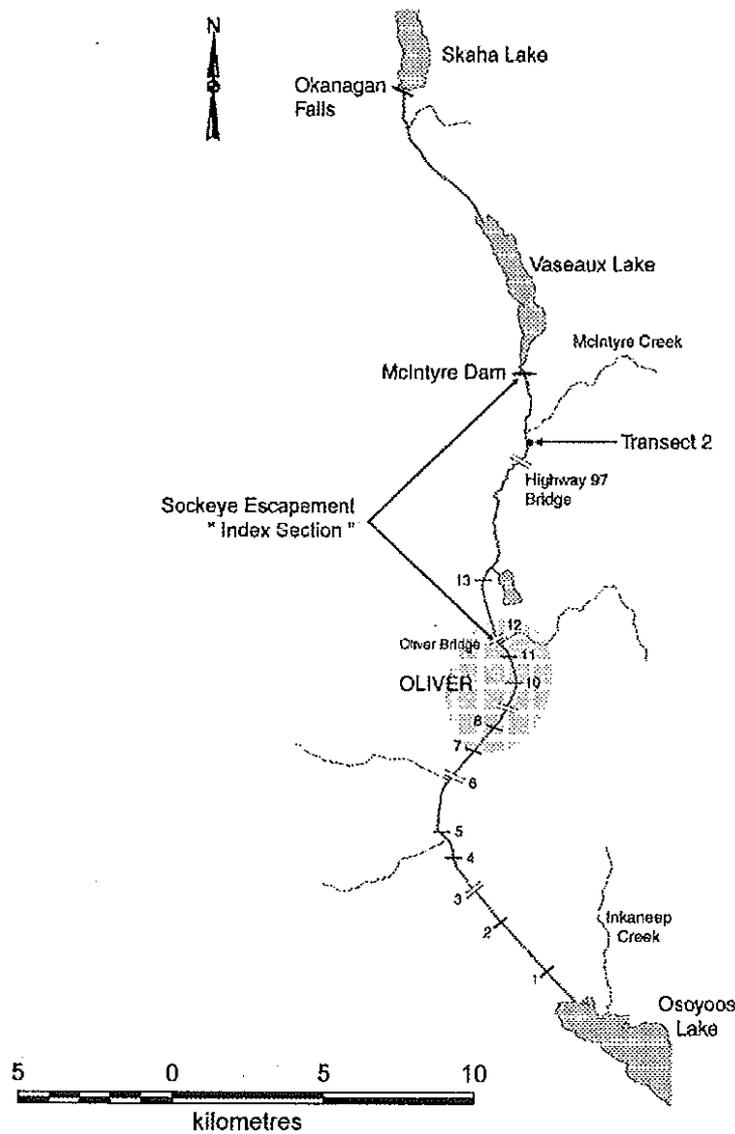


Figure 1. Locations of the sockeye salmon migration route through the Columbia and Okanogan Rivers.



#1 to #13 are vertical drop structures

Figure 2. Okanagan River sockeye spawning grounds. The Index section supports approximately 75% of spawners while the Channelized sections (VDS1 to VDS12) supports approximately 25% of spawners.