

Management Plan for Experimental Reintroduction of Sockeye into Skaha Lake

Proposed Implementation, Monitoring, and Evaluation

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Management Plan for Experimental Reintroduction of Sockeye into Skaha Lake

Proposed Implementation, Monitoring, and Evaluation

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EXECUTIVE SUMMARY

Okanagan River sockeye salmon, which spawn near the town of Oliver, B.C., have their farther upstream migration limited by several water control and diversion dams. Stock numbers have been declining for many years and the Okanagan Native Alliance Fisheries Department (ONAFD) has been the principal advocate of a program to restore their numbers and range by reintroducing them into upstream waters where they may once have occurred in substantial numbers

Some investigators have warned that without effective intervention Okanagan sockeye are at considerable risk of extinction. Among a host of threats, the quality of water in the single nursery areas in Osoyoos Lake is deteriorating and a sanctuary such as that afforded in larger lakes higher in the system could be essential.

Because the proposed reintroduction upstream has implications for other fish species, (particularly kokanee, the so-called "landlocked sockeye" which reside in many Okanagan lakes), the proponents undertook a three-year investigation, with funding from the Bonneville Power Administration and the Confederated Tribes of the Colville Reservation, to identify possible problem areas, and they committed to an interim experimental reintroduction to Skaha Lake where any problems could be worked out before a more ambitious reintroduction, (e.g. to Okanagan Lake) could be formally considered.

The three-year investigation was completed in the spring of 2003. It included an assessment of risks from disease or the possible introduction of unwanted exotic species. It also considered the present quality and quantity of sockeye habitat, and opportunities for expanding or improving it. Finally ecological complexity encouraged the development of a life history model to examine interactions of sockeye with other fishes and their food organisms.

While some problem areas were exposed in the course of these studies, they appeared to be manageable and the concept of an experimental reintroduction was largely supported but with the proviso that there should be a thorough evaluation and reporting of progress and results. A 2004 start on implementation and monitoring has now been proposed.

The Canadian Okanagan Basin Technical Working Group (COBTWG), with research and other expertise from participating agencies has, since 1997, provided guidance in moving toward a comprehensive implementation and monitoring program. (Much of the technical input from COBTWG is by a sub-committee of fisheries experts from federal, provincial and Okanagan Nation member agencies.)

Participants reviewed several introduction options and concluded that capture of mature adults on the spawning grounds, and extraction and fertilization of eggs gave the least risk, and offered the greatest learning opportunities - for instance for studies of sockeye-kokanee interactions at various life stages. Eggs would be incubated in a local hatchery and known numbers of fry would be planted in the river from which point they would be expected to move downstream and into Skaha Lake.

Planned studies are also expected to expand knowledge of sockeye and kokanee interactions with food organisms, particularly the ubiquitous shrimp *Mysis relicta* which

represents a food supply for growing sockeye and kokanee, and at the same time competes with them for planktonic forage organisms. While there is uncertainty about the weight which should be assigned to each of these disparate roles, modelling results suggest that mysids may be a greater hazard for lake-dwelling kokanee than sockeye.

As the program moves forward, conservation measures for the existing stock are being built in. For instance yearly escapement records from Wells Dam on the Columbia River permit a forecast of corresponding run sizes on the spawning grounds, and investigators have proposed that no fish should be removed for brood stock purposes, when runs are smaller than 10,000 sockeye at Wells.

Modeling results were instructive when considering levels for fry plants: Simulated fry introductions ranging from 200-7500 fry/ha suggested that numbers as high as 1000 fry/ha would have little effect on survival of either kokanee or mysis, and that stepped increases as high as 5000 fry/ha would generate increases in sockeye fry survivals, but that survival would begin to decline above that level.

Fry cultured for the Skaha Lake reintroduction will be distinctively marked so their behaviour, growth and survival can be measured at successive life stages. Marking will also help in distinguishing them from kokanee fry of similar size and appearance. Unique marks will be selected so as to readily identify the bearers if mixed with fish from any other marking programs in the Columbia Basin.

The central question in this investigation relates to the performance of the resident kokanee population during the reintroduction of their anadromous counterparts. Investigators must decide how great a change in growth and survival of kokanee (particularly juveniles), and over how long, should be accepted as clear evidence of success or failure of the reintroduction experiment.

To get at this question a series of hypotheses will be tested and suitable performance measures are now being developed. There will be several levels of fry introduction over the years, and a comparison of both sockeye and kokanee population responses, such as growth rates, will be measured. Kokanee response data will be compared with like data from years when there were no sockeye in Skaha L.

The ONAFD seeks efficiency, and year-to-year consistency in the critical task of obtaining brood stock and to this end it is developing a detailed Procedures Manual for fieldwork. This draws upon the extensive experience of government agency culturists and others and can be upgraded after each year's work experience.

A detailed workplan has been developed, featuring essential tasks, and setting down procedures and processes designed to maximize both performance and efficiency.

ACKNOWLEDGEMENTS

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Thanks to members of the Canadian Okanagan Basin Technical Working Group: Elmer Fast, Dr. Kim Hyatt and Dave Smith of Fisheries and Oceans Canada, Steve Matthews and Andrew Wilson of Water, Land and Air Protection for their support, input, and review. In addition, the COBTWG Sub committee: Howie Wright, Paul Rankin, Andrew Wilson and Tom Johnston contributed significantly.

Thanks to Doug Lofthouse of Fisheries and Oceans Canada for assisting in broodstock collection and hatchery expertise and information. Szczepan Wolski and crew at Shuswap Falls Hatchery – assisting in 2003 broodstock collection, egg-take and incubation and for helping to develop field procedures.

Chris Bull of Glenfir Resources and the Confederated Tribes of the Colville Reservation, especially Jerry Marco and Chris Fisher, have also provided valuable guidance in the development of Okanagan sockeye reintroduction planning.

Finally, Howard Smith contributed substantially in terms of compiling and capturing information provided by the COBTWG, primary author, and COBTWG sub-committee.

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1.0 INTRODUCTION

The Okanagan Nation has been promoting the reintroduction of sockeye salmon to historic habitats in Skaha and Okanagan lakes for several years (Fig. 1). Reintroduction is not only seen as a return of salmon to the upper reaches of the Okanagan, but it will also address Okanagan Nation cultural objectives. Fisheries authorities, following the precautionary principle, have agreed that the first step in the process should involve an experimental reintroduction into Skaha L. alone where the benefits, costs and risks of the program could be worked out.

Three years of preparatory investigations have been carried out for the Skaha sockeye reintroduction. This paper briefly reports the results of those studies, and then recommends a strategy for implementing and monitoring. Although the total program is reviewed briefly, the focus of this paper is Year 1 of the monitoring and evaluation. The Okanagan Nation Alliance have targeted Year 1 of the program for September 2004 but preparatory work for a pilot introduction was completed in the fall and winter of 2003.

2.0 BACKGROUND

Dams and their management have prevented sockeye and other anadromous salmon from entering their native habitats in Skaha and Okanagan lakes since about 1915. The Okanagan Nation intends to restore salmon access while conserving the existing sockeye population and re-establishing the tribal fishery. They will concentrate on sockeye salmon initially. Okanagan sockeye are one of only two remaining viable sockeye salmon populations in the entire Columbia River. They are in decline and without effective intervention they are at high risk of extinction within the next twenty years (Hyatt 2003, personal communication). Life history modelling results based on cumulative anthropogenic impacts also suggest extinction within twenty years (Parnell et al. 2003). Reintroduction to Skaha and Okanagan lakes could provide access to: essential cool holding areas for migrating adults; additional spawning area; and critical lake rearing habitat for fry. Osoyoos L., presently the only Okanagan sockeye nursery lake, is exhibiting some water quality problems and rearing space could be limiting there if the sockeye population increases.

A workshop was held in 1997 to examine options for reintroducing sockeye to Okanagan L. (Peters et al. 1998). Participants felt that since salmon had not been in Okanagan L. for about 80 years; that resident kokanee were declining; and that knowledge of growing conditions in the upper lakes was sparse a precautionary approach should be taken. It was therefore agreed that an experimental reintroduction should be tested in Skaha L. to examine the opportunity for sockeye production and the risks, if any, for the kokanee population. The Skaha experiment would provide valuable information for assessing the wisdom of reintroducing sockeye into Okanagan L.

As a further precaution, the risks involved in the Skaha experiment were thoroughly evaluated. With funding from Bonneville Power Administration, and the Confederated Tribes of the Colville Reservation (CCT), the Okanagan Nation Alliance Fisheries Department (ONAFD) undertook a three-year study entitled "Evaluation of an Experimental Reintroduction of Sockeye Salmon into Skaha Lake".

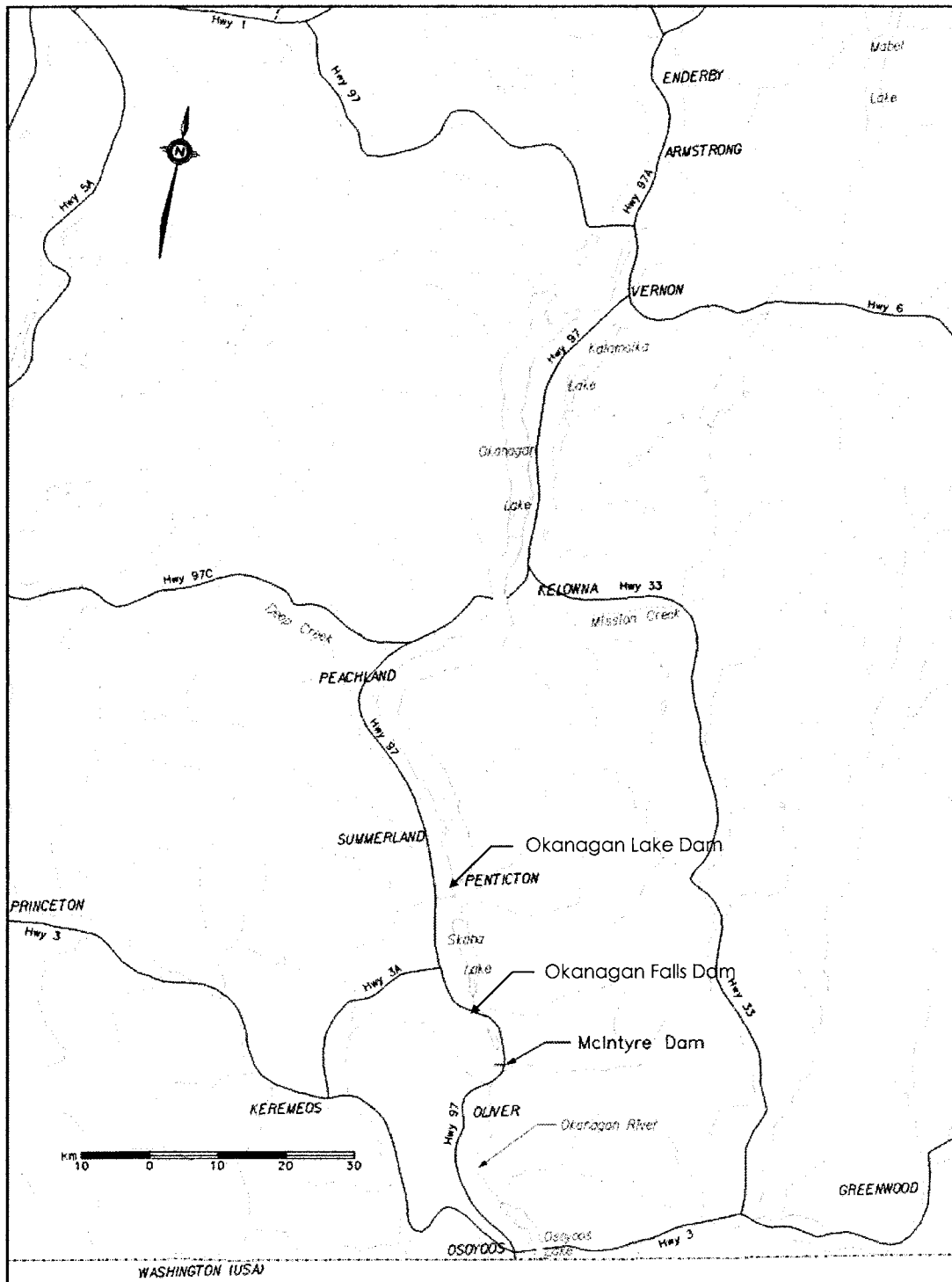


Fig. 1: Okanagan Basin

3.0 RESULTS OF THE EXPERIMENTAL REINTRODUCTION EVALUATION

The “Evaluation of an Experimental Reintroduction of Sockeye Salmon into Skaha Lake” study consisted of six objectives:

1. Disease Risk Assessment;
2. Exotic Fish Species Risk Assessment;
3. Assessment of sockeye spawning and lake rearing habitat;
4. Development of a life-cycle model to further understand interactions among sockeye, kokanee and the opossum shrimp *Mysis relicta*;
5. Options for Experimental Design and Monitoring program; and,
6. Development of an Implementation Plan.

Objectives 1-5 are complete. A technical summary that summarizes potential risks and a recommended implementation approach has also been completed (Smith 2003). Outlined below is a summary of identified risks.

3.1 Disease Risks

The only significant known disease risk appears to be the parasite *Parvicapsula*. This has recently been found in Okanagan River sockeye but to date it is not known to occur upstream from McIntyre Dam (the present limit of sockeye migration). *Parvicapsula* is believed to be linked to prespawning mortality in a Fraser River summer sockeye population (Adams River). Recent studies suggest that the parasite is transmitted to sockeye by an intermediate host that occupies a marine or brackish water habitat in the vicinity of the river estuary (Jones et al. 2003), but little is known about its possible impacts. Further studies are needed before permitting adult sockeye in the upper Okanagan system; direct adult reintroduction is considered a high risk but reintroduction of fry is considered acceptable provided appropriate precautionary measures are taken (Evelyn & Lawrence 2003).

3.2 Exotic Species Risks

The main exotic species risk to reintroduction is walleye (*Stizostedion vitreum*) but this fish is not known to occur further upstream than Mallot, Washington on the Okanagan River (Alexis et al. 2003; Smith 2003).

3.3 Habitat Risks

Long & Newbury (2003) have identified some potential problems when sockeye and kokanee use the same spawning beds but risks appear low provided overlaps are monitored and the affected spawning habitat is rehabilitated and/or increased as required.

Temperature and oxygen conditions in Skaha L should be better for juvenile sockeye than in their present rearing area in Osoyoos L. However, if sockeye fry are planted in Skaha there will likely be some risk of competition among sockeye, the planktonic *Mysis relicta*¹ and the existing kokanee population.

Smith (2003) suggests that sockeye reintroduction is feasible but should be carefully monitored. Parnell et al (2003) agree. They note that in other British Columbia lakes sympatric sockeye and kokanee dominance corresponds to known phosphorus concentrations as follows:

- <5µg/L sockeye out-compete kokanee (coastal lakes)
- >5µg/L<10µg/L sockeye or kokanee will be the major pelagic species, and
- >10µg/L sockeye and kokanee apparently co-exist.

Currently readings of total phosphorus in Skaha L. are at least 10µg/L suggesting that there is a low competitive risk to Skaha kokanee (Wright & Lawrence 2003).

3.4 Modelling

Modellers have raised three issues of particular interest in regard to the reintroduction of sockeye. These are: risks to sockeye, risks to kokanee and opportunities for learning. They also recommended that a number of general hypotheses should be tested (Parnell et al. 2003). Their general hypotheses statements were used to generate the specific hypotheses statements to be found in Section 4.4.4.

4.0 DEVELOPMENT OF AN IMPLEMENTATION PLAN

4.1 Workshop to Identify Options

In October 2002, the ONAFD convened a Canadian Okanagan Basin Technical Working Group (COBTWG) workshop to review a sockeye-kokanee-mysid interactions model and to identify and discuss potential reintroduction methods and their risks. Three options for methods of reintroduction have been suggested (Parnell et al. 2003):

1. Open up barriers to migration and allow natural re-establishment.
2. Capture and transport adult sockeye into Skaha L. (the so-called “trap and truck” method).
3. Capture adults during spawning, fertilize and incubate eggs and release only juveniles into Skaha L..

Some of the major pros and cons of these options are as follows:

¹ *Mysis relicta* was introduced into Okanagan L. in 1966 as a forage organism for fish. It subsequently spread to downstream lakes and is now thought to be a factor in the decline of some Okanagan basin kokanee stocks as they compete with juveniles for planktonic food organisms.

4.1.1 Barrier Removal

Opening the McIntyre, and Skaha L. outlet dams at this time could cause an unacceptable risk to both kokanee and sockeye. (The operation of both dams could be adjusted to allow fish to pass). First kokanee might prove to be vulnerable to the parasite *Parvicapsula*. Secondly, significant numbers of sockeye would likely migrate farther upstream than is possible now, and utilize untested spawning areas. (See map, Fig.1)

Another problem with barrier removal is that it would reduce the opportunity to maximize learning from a Skaha L. introduction; numbers of fry would not be controlled and marking would be extremely difficult.

Removal of one or both migration barriers may be a desirable option at a future date when the benefits and the risks of a sockeye population in Skaha L. have been thoroughly assessed. Until then the option has risks with minimal learning benefits. Here it is noted that complete barrier removal might allow some exotic species found downstream, into upstream portions of the basin, and that any dam modification would likely require steps to ensure that they were restricted to their current ranges.

4.1.2 Adult Capture and Transport

Capturing adult sockeye, and transporting them to Skaha L. using the truck and transport option would place a known number of sockeye into Skaha, and spawning and lake rearing interactions could be readily investigated. However, as with Option 1, unknowns associated with the *Parvicapsula* parasite present unacceptable risks and the number of sockeye that might need to be removed from the present spawning areas is worrisome. As noted by Parnell et al (2003) at least 3000 female sockeye and an equal number of males would likely be required to produce a sufficient number of juvenile sockeye for effective monitoring in Skaha L.

4.1.3 Juvenile Release

Introduction of juvenile sockeye directly into Skaha L. is the option with least risk and the greatest learning benefit: there is no risk of exotic species or fish diseases being introduced; there is an ability to mark a controlled number of fry which facilitates monitoring of in-lake kokanee and sockeye interactions and; it permits an assessment of the growth, development and survival of the treated fish. Furthermore, this option requires the use of the least number of sockeye (about 300 females as compared to 3000 in trap and transport) - an important feature in efforts to conserve the existing population.

4.2 Proposed Implementation Framework

The COBTWG concluded that Option 3 – introducing fry – was the best method of reintroduction, and in the fall of 2003 the ONAFD collected broodstock and incubated eggs in a hatchery as part of a Pilot Reintroduction Project. This effectively tested

methodologies, and hatchery survival rates, and provided a firm basis for a workplan and budget for year 1 of the reintroduction (See Appendices B and C).

A 12-year phased program planned around Option 1 is expected to begin in 2004, spanning 3 sockeye, and 4 kokanee cycles, and featuring adult capture, egg incubation and juvenile release.

This will include collection of six years of SAR (Smolt to Adult Return) data to test the expectation that juvenile sockeye released into Skaha L. will survive as well or better than they would have in Osoyoos L. When more is known of the behaviour of the parasite *Parvicapsula*, and if introduction risks are found to be minimal, a program of adult capture and transport may be used to assess the interaction of kokanee and sockeye on selected spawning grounds.

Also, because Skaha L. sockeye will begin returning during the fourth year of the program there can be, by removing the McIntyre Dam, or by moving fish above it, an evaluation of their migration behaviour, and selection of spawning beds in the river between Osoyoos and Skaha lakes. If and when sockeye are provided access through the Skaha L. dam there may be need to assess their behaviour and interaction with kokanee on spawning pads in the river below Okanagan L. Lastly, the returning Skaha adults can if needed, supplement the egg take from the Osoyoos L. stock and at the end of Year 12, a decision can be made on whether to remove one or both barriers to migration into Skaha L.

Results from modelling suggest that the *Mysis* shrimp poses a greater threat to both Osoyoos and Skaha lakes kokanee populations than sockeye do. While a mysid harvest program might be a risk-averse method of creating more space for kokanee and sockeye juveniles it is proposed for the present to monitor future changes in mysid density with a view to possible action as a better understanding of sockeye-kokanee-mysis interactions emerge.

The proposed Years 1 – 4 Workplan is appended as Appendix C.

4.3 Adult Capture, Egg Incubation And Juvenile Release

To guard against any harmful effects to existing sockeye salmon stocks, caused by taking too many fish for broodstock, removal will be limited to a maximum of 10% of spawning ground counts or 5% of Wells Dam counts, and as an added conservation measure no fish will be taken at escapement levels below 10,000 sockeye past Wells Dam (This corresponds to about 250 fry/hectare in Skaha L - See Appendix A).

When possible it would be useful to plant at least 1000 fry/ha to strengthen observations on interactions among sockeye, kokanee and mysids. Approximately 1000 sockeye females (and an equal number of males) would be required for this.

Assuming a 50/50 sex ratio, and observing the guidelines above, this would correspond to 40,000 sockeye at Wells Dam (1000 females plus 1000 males with a 10% exploitation rate and a 50% loss between Wells and the Okanagan R. spawning grounds.)

Such a large escapement has only occurred ten times in the last 34 years of Wells Dam counts (www.fpc.org 1967-2001). Viewing this possibility from the minimum escapement requirement (10,000 above Wells Dam), and given the history of Wells Dam counts, broodstock collection would not have been acceptable in five of the last 34 years.

Options for making more fish available for egg takes, for instance by trap and transport of mature adults from lower in the system, or by reducing the commercial fishery should be considered but are beyond the scope of the present dissertation.

Other restrictions to fry supplementation exist in the form of capacity and cost effectiveness of the selected hatchery. Currently the Shuswap Falls Hatchery (where eggs for the Pilot Reintroduction Project are being incubated) has a capacity of 2,000,000 eggs while the existing Skaha L. hatchery has a capacity of 1,000,000.

Incubation methods will follow recommendations for Alaska sockeye fish culturists, emphasizing water quality, disinfections and compartmentalization (McDaniel et al. 1994). Implementation will also be reviewed with Canadian agency experts, particularly those familiar with sockeye enhancement on the Upper Adams River (Wolski & Lofthouse 1997, 2002). Most details presented below which are not specific to the Okanagan situation have been adopted from Wolski & Lofthouse (1997; 2002).

4.3.1 Facility Preparation and Personnel Training

The best location for an egg incubation and rearing facility has yet to be identified, but it should have at least a five million egg capacity, and be capable of rearing fry to 1.5 g for spring release thus permitting a maximum Skaha L. plant of approximately 1750 fry/ha annually.

Among current options would be building a new hatchery, or upgrading either Skaha L. or Shuswap Falls hatcheries to a five-million egg capacity.

Experienced professionals will be contracted to assist with the fish culture conservation program and a call for proposals will be sent to qualified contractors. The successful applicant will assist with property and building security, provision of virus free water and staff training. ONAFD expects that staff will need fish health training and certification at (for instance) Malaspina University College and to apprentice under a qualified instructor

A preliminary analysis has identified three potential areas for facility location:

Site 1. Skaha L. Hatchery – this site was used by the British Columbia provincial government for kokanee incubation in the early 1980's but was discontinued a few years later. The hatchery is privately owned but leased yearly by the BC Freshwater Fisheries Society for rainbow trout rearing and the Province holds the water license. The water originates in springs, volume is continuous and consistently at 10 °C, so thermoregulation would be required. Plumbing would likely need refurbishing and buildings either updated or replaced. Current capacity is 1,000,000 eggs but water quantity for rearing to 1.5-gram fry may be an issue.

Site 2. Penticton Indian Band Lands – a large portion of the west side of Skaha L. abuts the Penticton Indian Band reserve and two or three possible sites have been identified along the northwest side of the lake. In addition, an area on the west side of the Okanagan River Channel (between Okanagan and Skaha lakes) where wells could provide water has been considered.

Site 3. Shuswap Falls Hatchery – this site was used for Okanagan sockeye egg incubation in the 2003 pilot year. It is owned by Fisheries and Oceans Canada and is currently managed under contract by Wolski Environmental Consulting Ltd. It has been used in previous years for sockeye culture for the Upper Adams River population and for chinook and coho enhancement projects. Current capacity is 2,000,000 sockeye eggs with an adequate water supply to rear fry to 1.5 grams. However, there are plans to use the facility for Upper Adams sockeye in 2005.

Following agreement on implementation requirements a feasibility study will help to decide on the most appropriate site. Fisheries and Oceans Canada has indicated that they will help in this evaluation.

3.2 Numbers of Fry

Modeling undertaken by ESSA Technologies Ltd. of Vancouver has provided useful insights into the interactions among sockeye fry, kokanee fry and mysids under various treatment regimes, and this assists in deciding appropriate levels of reintroduction. Fig. 2 shows model generated survival rates for these three organisms as sockeye fry density was increased from 200 – 5000 fry/ha.

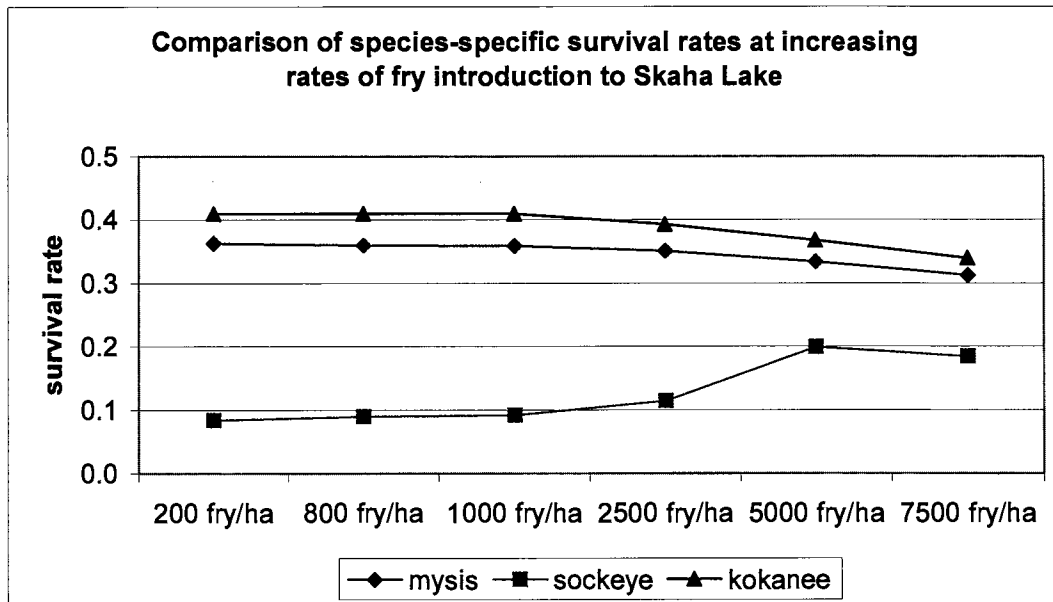


Fig. 2: “Sensitivity of survival rate performance measures to increasing rates of sockeye fry introduction.” Reproduced from ESSA Technologies Ltd. report *Evaluate Alternative Experimental Strategies for Reintroducing Sockeye Salmon to Skaha Lake*, Fig. 4.7

The data suggest that sockeye fry-smolt survival rises as introductions increase over this range, but as densities increased above 5000 fry/ha survival began to fall off (Parnell et.al. 2003). Modelling also indicated that kokanee underyearling survival would be unaffected by increasing sockeye fry stocking densities up to 1000 fry/ha but that it would gradually decline thereafter.

The kokanee fry-age 0 survival rate was 0.40 when 200-1000 sockeye fry were reintroduced and declined to 0.34 when sockeye were present at 7500 fry/ha (Parnell et al, 2003). The model results suggest that the maximum fry introductions proposed (1750/hectare – see Section 4.3.1) are expected to affect kokanee survival to some measurable degree but will not be detrimental to the long-term persistence of the population.

4.3.3 Broodstock Collection

In the past some Okanagan R. sockeye have been intercepted at Wells Dam to provide broodstock for the Cassimer Bar Hatchery. While Wells would also be a convenient location for collecting broodstock for Skaha L., mortality would likely be high due to the length of holding required to bring fish to spawning readiness, and the likely complications in transporting the fish across the British Columbia-Washington border. Therefore, collection will be, as in 2003, by seining on the spawning grounds of the Okanagan R. below McIntyre Dam.

Following capture, adults will be held in pens in the river until ripe (usually a maximum of 12 hrs.). Egg take, fertilization, transport, and disinfection and incubation will be according to procedures used in the initial 2003 work by ONAFD staff and advisors and as recommended to culturists in Alaska and by DFO.

To assist field crews and to encourage consistency over the life of the program, a “Procedures Manual” has been drafted and is attached here as Appendix B. Some modifications will no doubt occur as experience deepens, and crews hone their skills in this important operation.

4.3.4 Marking and Fish Release

All reintroduced sockeye fry will be identified with both an adipose fin clip and a thermal mark². Adipose clips can be discerned in trawl samples, during smolt monitoring, in adults migrating past Wells Dam video counters (Klinge 2003, personal communication), and during broodstock collection on the spawning grounds.

Fish from the Wenatchee River system will be similarly fin clipped but the additional thermal mark on Okanagan sockeye fry originating in Canada will enable workers to

² A thermal mark is a technique used during the developmental stages of sockeye fry where temperatures are varied that will produce a detectable banding in the sockeye otoliths. This is an efficient method of mass marking cultured salmon with a distinct banding or ‘bar code’ to determine fish culture facility origin and brood year.

separate specimens from the two populations during smolt biosampling and elsewhere as the fish mature. It will also be an important means of differentiating between sockeye and kokanee fry during monitoring and evaluation in Skaha L.

Fry will be released in the Okanagan River Channel between Okanagan and Skaha lakes and timed to coincide with kokanee emergence there, and before lake surface and river water temperatures exceed 17 °C.

4.4 Monitoring and Evaluation

4.4.1 The Role of COBTWG

The Canadian Okanagan Basin Technical Working Group (COBTWG) is a tripartite working group consisting of federal Fisheries and Oceans Canada (DFO), the Okanagan Nation Alliance (ONA), and the provincial Ministry of Water, Land and Air Protection (WLAP). COBTWG deals with salmon and resident fish population issues in the Canadian portion of the Okanagan basin (www.obtwg.ca). The members of COBTWG have been involved with this initiative since the first workshop in 1997 (Peters et al. 1998). They participated in the review, development, and recommendations for the evaluation phase of the project from 2000-2003, and, jointly with the ONAFD, in planning and developing essential features of the Year 1 incubation and fry rearing phases.

A workshop was called by COBTWG on November 24, 2003 to discuss the Implementation, Monitoring and Evaluation plans. It was decided that technical input to plan development would thereafter be by a sub-committee of members from DFO, WLAP and ONAFD.

The COBTWG sub-committee will provide historical data input, an initial program review monitoring and evaluation parameters, and recommend to the parent committee. It will act as a technical advisory body on the implementation strategy and arrange for annual, and other reports to be provided to both COBTWG representatives and funding agencies. The sub-committee will be provided with technical assistance as required

At a meeting of the sub-committee on November 25, 2003 and during a teleconference on December 22, 2003 members developed the monitoring and evaluation plan and the year one workplan. In addition, a subsequent discussion at the January 15, 2004 COBTWG meeting was held prior to development of this report to be sent out for final comment.

4.4.2 Key Features

Large scale experiments such as the Reintroduction of Sockeye Salmon to Skaha L. outlined here will always have some monitoring and evaluation limitations and generate uncertainty about the quality of certain baseline information. (In the present case the historic data were sometimes collected under uncertain circumstances and by many different investigators working with several resource agencies over several decades).

Program success or failure from a sockeye stock perspective can be measured simply in terms of the number of successful anadromous returns to Skaha L. However, the sockeye reintroduction could also affect the well being of other Okanagan fish species with possible negative impacts on kokanee being the most significant. A critical question to be answered is:

What rates of growth and survival of kokanee juveniles, relative to their historic or “baseline” performance will be convincing evidence of either program success or program failure?

The difficulty in setting a satisfactory level for statistical tests, and accumulating test values over a satisfactory number of years may be reduced through the expertise of agencies who have participated and learned from similar large scale experiments concerned with British Columbia *O. nerka* populations such as those in the Great Central L., Okanagan L., and in Kootenay L. (Andrusak et al. 2001; Ashley & Thompson 1993; O'Neill & Hyatt 1987; Stockner 1987). Examination of performance measures used in those studies, and the level of success enjoyed in those and other similar ventures should be instructive when evaluating the approach taken here.

4.4.3 Performance Measures

Performance measures will need to address production, growth and survival of key organisms, and at least four such measures are considered:

1. Failure in Biological Persistence: i.e. when kokanee are unable to maintain themselves in the presence of increasing numbers of sockeye.
2. Impacts on Existing Utilization: i.e. when there is a persistent decrease in CPUE in kokanee, or indirectly on predators such as rainbow trout (for the latter a change in size at age may also be apparent).
3. Statistically significant change in kokanee stock performance (in response to successive sockeye introductions) relative to some base period for which acceptable data exists.
4. Changes in kokanee and other stock performance as sockeye fry are introduced in varying numbers in successive years.

In the present investigation an hypothesis similar to that suggested by Parnell et al (2003) may be tested:

Hypothesis: “failure in biological persistence of Skaha L. kokanee can be attributed to reintroduction of sockeye salmon”

The main thrust of the investigation is to quantify variations in kokanee stock performance caused by introduction of sockeye. However demonstrating cause and effect will be challenging, and the problem will be exacerbated by variations in numbers of mysids interacting with the fish populations. For each of these 3 taxa, (sockeye, kokanee, mysis) a baseline, a range of values and a mean and variance will be needed. Both the nature and

magnitude of variations in abundance, and what drives them will be sought as will variations in zooplankton food organisms.

The effects on the existing sockeye population of the reintroduction to Skaha will be watched with great interest. It will be required to track a known number of marked sockeye fry to at least the smolt stage, to monitor kokanee population trends and to partition the mysid stock into a) an energy source;(i.e. as food for organisms higher in the food chain), and b) an energy sink;(by consuming food sought by other species).

Comparative measures of sockeye production in Osoyoos and Skaha lakes will be required as reintroduction to Skaha takes hold, and because tertiary waste water treatments began to affect Skaha L. trophic levels about 20 years ago lacustrine baseline data should not begin earlier than about 1980.

Indicators of production variation in kokanee include the following:

- numbers of spawners on the spawning grounds
- biomass in Skaha L.
- change in density dependent growth
- change in survival rate (only in a modeling sense as needed baseline data are not available)

There is a curvilinear relationship between kokanee size at age 1.0, and the pelagic biomass. Using this as a baseline it will be possible to measure changes in yearly performance beginning with the year of sockeye introductions. Confidence in assessing relative success or failure can be expected to improve as data are gathered.

It is apparent that a great deal of careful monitoring of both physical and biological features of the aquatic ecosystem will be needed during the next dozen years. A period of uninterrupted work will be required initially, but it is expected that there should be a thorough review of progress at the end of (for instance) each 4-year period when any required re-alignment of effort can be undertaken.

Skaha L. was selected as an experimental environment in which to evaluate the long term goal of reintroducing sockeye back into Okanagan L. (Peters et al. 1998). While the experiment should proceed, there is also need to establish an acceptable level of risk for both sockeye and kokanee. With risk in mind strict conservation measures have already been set for broodstock collection. In the more difficult case of fry reintroduction, there is a need to balance the risk to kokanee against anticipated important learning benefits. A question arises as to the size and duration of an observed negative impact (for example reduced growth rate) before deciding that sockeye reintroduction is detrimental to Skaha kokanee? This question should be reviewed on both a technical and general public level at the conclusion of each 4-year period.

4.4.4 Hypotheses to be Tested

Concerns implicit in the hypotheses given below, and in the information needed to test them comprised the rationale for the workplan presented in Appendix C. The list of information needs serves as a check against requirements of the workplan, ensuring that no essentials are missed and that no unnecessary expenditures of human or material resources occur. The hypotheses are similar in intent to those proposed by Parnell et al (2003). Although the sub-committee of the COBTWG has had input into the development of the workplan, the formal review by COBTWG of both the workplan and this report will not be in time for present reporting purposes.

4.4.4.1 Kokanee Related Hypotheses

Hypothesis 1: There is no difference between brood year-return ratios in adult Skaha L. kokanee in the 1989-2003 base period and the experimental reintroduction period.

Information needs: Standardized adult escapements in the baseline period; yearly escapement numbers during the experimental period; kokanee biosamples.

Hypothesis 2: There is no difference between predicted and observed density related growth of age 0⁺ Skaha L. kokanee at various levels of sockeye fry introductions during the experimental reintroduction period.

Information needs: Results of four-season Acoustic and Trawl Survey (ATS); general chemical and limnological conditions; zooplankton (including Mysis) abundance; numbers of sockeye fry introduced.

Hypothesis 3: There is no difference between predicted and observed survival rates of age 0-1.0 Skaha L. kokanee at various levels of sockeye fry introduction during the experimental period.

Information needs: Calibration of spring ATS surveys by estimated numbers of emerging fry; four-season ATS results; biosamples; numbers of sockeye fry introduced.

4.4.4.2 Sockeye Related Hypothesis

Hypothesis 4: There is no difference between Osoyoos L. and Skaha L. Smolt to Adult Return (SAR) ratios during the sockeye fry reintroduction period.

Information Needs: Annual Okanagan R. sockeye escapement; and for **both** Osoyoos and Skaha lakes, ATS data; smolt timing and age composition; general chemical and physical limnological conditions; zooplankton (including Mysis) abundance.

4.4.5 Model Refinement Needs

A model developed by Peters and Marmorek (2003) will be used to generate predictions for comparison with observed variations in kokanee production. As with most models, there are limitations. Most notable here are assumptions respecting density dependent in-lake carrying capacity. Our phosphorus to fish biomass estimates are based on lakes where the major limnetic fish are juvenile sockeye (Hyatt & Rankin 1999) whereas in Skaha L. there are kokanee and *Mysis relicta* populations and both are pelagic feeders. To overcome this limitation the model uses '0⁺ equivalents' for other than 0⁺ age classes of kokanee and for *M. relicta* (Peters & Marmorek 2003). The concern is whether these really are equivalents. For instance do sockeye out-compete kokanee, or do kokanee out-compete sockeye and are mysids primarily an energy sink or primarily a source of food? More information is needed as to interactions between these taxa and their food sources. Lines in Fig. 3 suggest a complex of possible interactions.

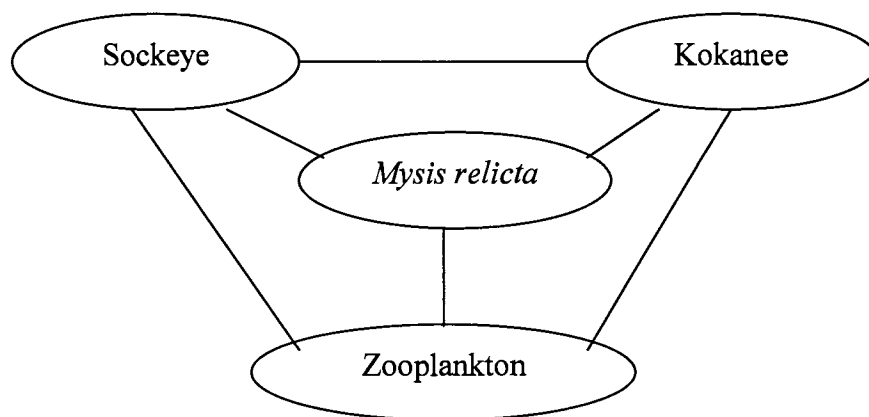


Fig. 3: Sockeye-Kokanee-Mysid Interactions

As an added complication, there are two whitefish species (Lake Whitefish - *Coregonus clupeaformis* and Mountain Whitefish – *Prosopium williamsoni*), which are also limnetic in Skaha L. and which utilize the same general food source to some degree as the three animals identified above.

To improve our understanding of the various species interactions, an analysis similar to that provided by the 'Wisconsin' bio-energetics model by Stockwell and Johnson (1997) and developed by Fisheries and Oceans Canada for another British Columbia lake will be conducted (Hyatt et al. 2004). It is expected that at the end of the 12- year experimental period, our knowledge of these interactions will be much improved and will enable us in a future project to develop a refined model to evaluate reintroduction of sockeye into Okanagan L.

5.0 NEXT STEPS

Due to time constraints, the Canadian Okanagan Basin Technical Working Group has had input through the COBTWG sub-committee and workshops, but not the opportunity to formally review this final draft of the experimental management plan. The COBTWG will have the opportunity and endorse the outlined approach in 2004. Because the COBTWG has made significant contributions into the development of the experimental management plan and the associated monitoring and evaluation design, we anticipate minor changes to this document and the detailed workplan (Appendix C).

There are a number of public and government operated hydro-electric facilities operating on the Columbia River that have a requirement to mitigate for uncontrollable losses of sockeye salmon at their facilities. The ***Management Plan for Experimental Reintroduction of Sockeye into Skaha Lake: Proposed Implementation, Monitoring, and Evaluation*** is a project that the operators of those hydro-electric facilities could finance to meet their specific mitigation requirements associated with their Federal Energy Regulatory Commission (FERC) operating license. Potential funding partners could include:

- Bonneville Power Administration;
- Douglas County Public Utility District;
- Chelan County Public Utility District; and
- Grant County Public Utility District.

This experiment is targeted to being in September 2004 and is expected to continue for twelve years. To implement this experiment, the Okanagan Nation Alliance will continue to work closely with the Confederated Tribes of the Colville Reservation to coordinate with government agencies and to secure funding and partnerships.

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APPENDIX A

Selected Wells Dam sockeye salmon counts with
acceptable levels of removal for egg takes

Selected Wells Dam sockeye salmon counts with acceptable levels of removal for egg takes

Wells Dam Counts	Spawning ground count equivalents ¹	Females available for broodstock ²	Number of Eggs Available. ³	No. fry/ha in Skaha L. ⁴
10,000	5,000	250	650,000	250
12,000	6,000	300	780,000	300
16,000	8,000	400	1,040,000	400
20,000	10,000	500	1,300,000	500
24,000	12,000	600	1,560,000	600
28,000	14,000	700	1,820,000	700
32,000	16,000	800	2,080,000	800
36,000	18,000	900	2,340,000	900
40,000	20,000	1000	2,600,000	1000
48,000	24,000	1200	3,120,000	1200
56,000	28,000	1400	3,640,000	1400
64,000	32,000	1600	4,160,000	1600
72,000	36,000	1800	4,680,000	1800
80,000	40,000	2000	5,200,000	2000
100,000	50,000	2500	6,500,000	2500
120,000	60,000	3000	7,800,000	3000
200,000	100,000	5000	13,000,000	5000

¹ Assume 50% survival between Wells and spawning grounds

² Assume 50:50 sex ratio and broodstock collection of 5% of Wells counts or 10% of spawning ground counts.

³ 2,600 eggs per female - see Parnell et. al. (2003)

⁴ Skaha L. area 2,000 ha. See Parnell et.al, (2003) for conversion.

APPENDIX B

Detailed Procedures for Sockeye Broodstock Collection,
Egg Removal, Fertilization and Incubation

Detailed Procedures for Sockeye Broodstock Collection, Egg Removal, Fertilization and Incubation

PREAMBLE:

Procedures described here are based on the pilot year experience in 2003. This should be considered a 'working' document to be revised as needed after each year of operation. In the long term a condensed version is planned as a manual for field workers but at present it has been most valuable in developing parts of the workplan and budget.

CONTENTS

- 1. Background and Equipment**
- 2. Seining Procedures**
- 3. Calculating Daily Egg Take**
- 4. Making a Set**
- 5. Extracting and Fertilizing Eggs**
 - a. Sanitation**
 - b. Removing Eggs**
- 6. Incubation**
- 7. Rearing Fry**

1. BACKGROUND AND EQUIPMENT

This manual describes procedures to be followed in obtaining and fertilizing sockeye eggs from the Okanagan River, and incubating and culturing fry in a hatchery for planting in Skaha L.

In what follows we refer to "seine crews" that capture the fish, and "egg take crews" that process them.

Fish capture could take place at a barrier such as McIntyre Dam, or somewhere near there by means of a beach seine. With the former, it is frequently difficult to find the requisite number of "ripe" fish - i.e. fish that are mature enough that they need not be held for long periods before eggs can be extracted. Seining, particularly for fish already distributed on the spawning grounds, can be effective but it has shortcomings. First among these is the frequent need for seine crews to walk on spawning redds, thus risking significant egg destruction. Secondly, there is inevitably a substantial catch of partially, or even completely spawned fish. Under some circumstances fish schooled in pools will offer opportunities with little fish damage, but it may result in catching too many "green" fish.

Whatever strategy is employed, crews need experience and sensitivity to become effective seiners, maximize use of time and to minimize damage to the spawning stock.

Capture and processing of 1000 fish or more will usually require two crews; one seining in the natural stream channel above the Highway 97 bridge; the other in the channelled portion below it.

Experience gained in 2003 suggests that the seine crew should begin work about 4hrs prior to those taking eggs. After a seine collection has been made, seiners select fish considered ready, or nearly ready to spawn, separate them according to sex, and place males and females in separate holding pens in the river.

Holding pens will be constructed of lumber and soft nylon mesh netting as described by (Wolski & Lofthouse 2002). Broodstock will be held for a maximum of 12 hours, and any that die during the holding period will be removed and disposed of downstream of the holding area. Seine crew leaders will endeavour to have eggs taken throughout the duration of the run, and as nearly as possible proportional to numbers entering the capture area.

Ten people are required for broodstock collection; six-member seine crew during an 8hr (6a.m - 2p.m) shift and beginning about 4hrs ahead of the four-member egg take crew. A list of routine gear requirements follows:

- truck with livewell
- portable livewell for holding fish in the river
- totes for transporting fish between livewells
- zodiac or other water transport for moving seines and other equipment
- beach seine about 200' in length with a bunt end of about 15' using 1^{3/4}' mesh
- large dip nets (2)
- paddles or other items for herding fish
- safety equipment - i.e. preservers, first aid kit, spare parts, cell phones
- field forms for recording data
- camera and throwbag

2. SEINING PROCEDURES

The best seining sites are free of debris and brush, and have high concentrations of spawners. Because much of the river at suitable seining sites is quite shallow, deeper areas with modest numbers of fish may be the best choice when available (The best sites can usually be identified by the technicians who are also conducting spawning counts on the river and know where spawner concentrations can be found). Ideally seine sites either start above, and end within a riffle area; start in a deep riffle and end at a bar; or start in a deep

riffle and end in another deep riffle. The seine should usually be closed on the side of the river that has the least debris.

Seining is for green or ripe females from 7 -10 am but only in the channelled section of the river below the Highway 97 bridge, starting near the bridge and working toward the egg take site. A zodiac is used to transport the beach seine between sets, and a live well is moved along with the operation to hold selected females.

On the set made nearest to 10am the seine crew will likely be near the egg take site, and at that time will collect both mature females and (likely) all males available. There are two holding pens at the egg take site - one for females and one for males. Seining continues below the egg take site until 1pm or until the specified number of females has been caught.

Selected fish will need to be closely examined to determine their ripeness, or spawning readiness. This should be done visually, or at most with a light touch to the fish's belly to see if eggs are loose in the skein. Rough handling, or excessive pressure can damage the mature fish or her eggs, or in the case of males it may expel sperm.

3. CALCULATING DAILY EGG TAKES

The 2003 experience suggests that the egg take crew can, based on fish density and with basic outfitting, readily take about 70 females/day, but this can be increased to 100 or more by adding additional transportation totes. Daily catch requirements vary according to 3 general run phases with the year's total made up of 25% early phase fish; 50% from around the peak of spawning, and 25% from the late phase.

The target for the daily maximum number of females is 2.5% of the then current Wells Dam accumulative count (assuming a 50% ratio of males:females), captured over a ten day seining period.

Example:

Wells Dam accumulated count: 20,000 sockeye

Targeted no.of females: 500 females

Distribution of take for females: 125 early, 250 peak, 125 late phase

When the target for a particular time period (early, peak, late), is reached, seining is discontinued until the next run phase. Such a pause is most likely to occur during the early run as later spawning fish are apt to move in and spawn most quickly

4. MAKING A SET

Before making a set, the six-member seine crew divides equally into "anchors" and "herders". "Anchors" deploy the seine net and move downstream toward the "herders". The 3-person anchor crew will need the zodiac, beach seine and rope. Other essential equipment includes the crew truck, field data sheets, the river live-well, two dip nets, and oars or paddles for 'herding. The three "herders" (individuals who will encourage the fish to move toward the net) take positions about equally spaced across the river (and mindful of the need to stay off redds) at the downstream end of the seine site - usually where there are no large concentrations of spawners.

To begin, Anchor #1 holds one end of the net on the side of the river from which the net is to be deployed. The other two anchors carefully walk across the river, leading the zodiac boat containing the seine net, and letting out part of the net as required. Once across the river, Anchor # 2 will remain at the other end of the net and slightly downstream of Anchor #1, and holding the cork line.

The Anchor #3 designated as the leader, moves with the boat downstream ahead of the two anchors letting out the net but leaving approximately one half of net in the zodiac (about 100'). While letting out the net the Anchor#3 will also 'herd' sockeye found near the bank side he is walking on into the middle of the river. This can be achieved by using a stick and hitting the water surface close to the bank. Once the net is deployed, the cork line should approximate the shape of a hockey stick with the 'blade' across the river, and the handle downstream, the three-person crew will walk downstream towards the herders. (Figures 1 and 2).

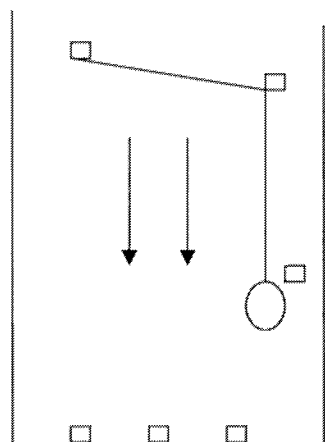


Fig. 1 - diagram of deployed seine net. Note: Squares represent people; the oval represents the zodiac boat; arrows show river flow; and the connecting line show the general position of the seine.



Fig. 2: photo of seine net deployed

Anchor 1 will stop approximately two thirds of the length of the beach seine upstream of the herders. Once the leader is near them, the herder closest to the leader (herder 1) will herd sockeye upstream followed by the second and third herders walking upstream at a slight angle with herder 1 farthest upstream (Fig. 3). Each of the herders will slap the surface of the water with a paddle or oar to encourage the fish to move upstream and into the seine.

The leader (Anchor #3) will walk behind the herders and cross the river as fast as possible deploying the remaining length of net from the zodiac until reaching the opposite bank. Once there the leader will sit on the bank and pull in the net by the lead line as fast as possible and keeping hands close to the river bottom to ensure that the catch does not escape under the net.

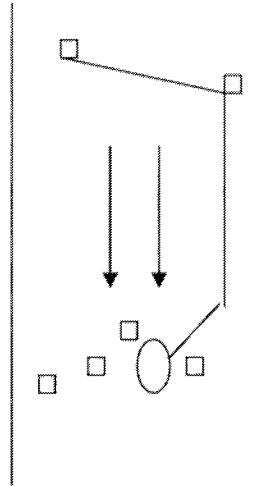


Fig. 3 –Positioning of crew members as leader moves across the river

Here it is critical to prevent the net from moving downstream past the pull-in site as the current may then make it too difficult to retrieve. (see comments below). If this happens, all is not lost; fish can still be collected. Herder 3 (now closest to the leader) will move the boat out of the way and help the leader by piling the seine on shore (Fig. 4).



Fig. 4 – photo showing crew pulling seine net in

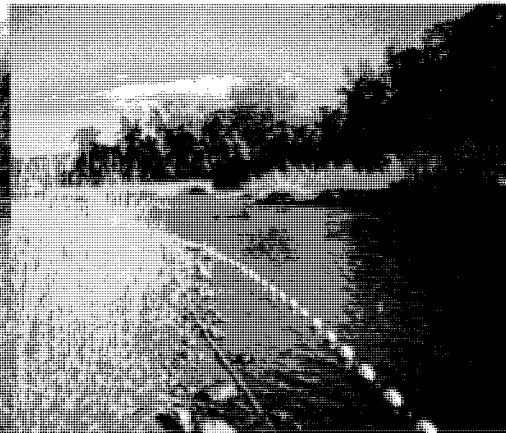


Fig. 5 net seined on shore

Anchor 1 will also assist in bringing in the net while ensuring that the fish remain in it. The goal at this point is to purse the net and ensure that the lead line is completely grounded, otherwise fish will readily find 'holes' for escape. Anchor 2 will still hold on to the cork line and ensure that the lead line is on the river bottom. Herders 2 and 3 should keep moving the fish upstream because the upper end of the net is less likely to have holes caused by earlier snagging etc. Since crews are working within the river, it will be a long shoreline seine and as it moves closer to shore, the herders will begin pulling in the leadline. It can be kept low by pulling on it rather than cork line, and sometimes by

standing on it when feasible. When all the leadline is on shore, the seined fish can be collected and placed in the river livewell.

If it appears that the net cannot be pulled in and a 'purse' begins developing downstream of the lower pull in site, the goal will be to still bring the net in, but also to assist the current to bring the two ends of the leadline together (Fig. 6). These types of sets biased sets where a large portion of the fish have likely escaped should not be used for biosampling purposes (e.g. determining sex ratio). In addition, processing of fish will take longer as it is more difficult to remove them.



Fig. 6 – photos showing net pursing downstream and leadlines pursed together

The person designated Anchor 1 is also the recorder and monitor for the upstream end of the net. In order to improve the process there should be a post-haul discussion on the effectiveness of the set – whether people saw fish escape, how well the leadline was on the ground, and whether the leader was able to pull in the net without a large portion of the net being downstream of his pull-in point.

It is very important that the crew members know when and how to shout out the information to the recorder. This should be reviewed prior to beginning a day of beach seining. The leader monitors the downstream end of the seine and the live well. The other four people will work in groups of two starting at either end of the seine. As they move towards each other, the net area already checked will be moved onshore and the size of the purse will be slowly increased. Each group of two will have one dip net for ripe or green females. One person will have the dip net and the other will remove fish from the seine area. The person with the most experience in distinguishing ripe from green fish should remove them from the net.

The fish processing person will call out to identify females immediately, as either “post-spawned”, “green” or “ripe” fish and will count the males in multiples of ten. All spawned females and all males will be released. On seine sets completed closer to the egg-take site, the seine crews will keep all male. Some fish other than sockeye will be caught and their species and numbers will be called out to the person with the dip net.

All salmon other than sockeye and rainbow trout should be kept in the seine until biosampling is complete. e.g. in this process a large rainbow would be DNA punched, sexed, photographed, and scale sampled. Once biosampling is complete, the net will be readied for transport to the next site, or to run out again if the crew has already reached the next seine set location.

The foregoing description applies to the crew located in the diked section below the Highway 97 road crossing and above the Oliver bridge on the west side of the river. For larger egg takes, e.g. those requiring 500 or more females, a second crew of six can be deployed in the natural section upstream of the Highway 97 Bridge.

This second seine crew (Crew # 2) would have the same shift timing as crew #1, i.e. start seining by 7am. However access to the natural river section is difficult, the egg take crew should set up immediately below the Highway 97 bridge along the west side of the dike area as it is immediately downstream of the natural area. Meanwhile, the seine crew will conduct only one float through the natural section and the egg take crew will start at 11 am instead of 10 am. On reaching the second egg take site, the seine crew will use the egg take crew truck to return to pick up their own vehicle. From 11-1pm, the egg take crew would work the set back section below the bridge in the set back section collecting females only, or if time permits, to do a second run on the natural section. The same equipment would be required. The seine crew of six would drop off the zodiac, beach seine, and paddles with two people at Deer Park Estates where the sockeye enumeration also begins. They would then float down to the first beach seine site. The rest of the crew will drive down to the first seine site and pick up the two large dip nets, live-well, and recording information. From this point they will seine down to the egg take site immediately below Hwy 97 bridge at the end of the natural section.

5. EXTRACTING AND FERTILIZING EGGS

The egg take crew will be divided into two units with emphasis on compartmentalization at the fish selection and kill area, and the disinfected egg handling area. In addition to routine disinfection procedures, compartmentalization will reduce the potential for disease transfer between stations.

A minimum of four people will be required for egg takes, with an additional person if biosampling is also conducted (scale and otolith, length, weight and sex). The egg take crew will be on site at 10am to begin setting up (11am if there is a second crew working on the natural section). Setting up takes approximately one hour on Day 1 and half an hour on subsequent days. The egg take crew will work in conjunction with the disease sampling crew. Crew members have responsibilities as follows:

(Crew members identified as CM1 – CM 4 thereafter)

- Crew member #1 – selects mature fish of both sexes
- Crew member #2 – disinfects and transports individual fish
- Crew member #3 – culls selected female and male fish as necessary and collects ovarian fluid for disease assessment
- Crew member #4 – selects fish for *Parvicapsula* detection

The egg take crew will work with 16 female fish at a time. A maximum of 72 females could be processed daily by the egg take crew, and depending upon the success of the seine crew, this could be increased to 100. Sorting and killing will follow standard fish culture procedures. A one-to-one fertilization ratio will be used when feasible. However a few

more males than females will be collected in case some of the milt samples are too small or appear infertile.

Eggs and milt will be extracted from ripe sockeye at the egg-take site along the river, to be transported to the hatchery and fertilized there. Gamete transport, surface egg disinfection, egg incubation, and fry marking will occur at a hatchery located on or adjacent to Skaha L. Disinfectant footbaths will be used by crews moving between work areas.

a. Sanitation

It is extremely important to maintain sanitary conditions in the areas of fish handling and egg extraction.

If a crew-member is required to change tasks during egg-takes, proper disinfection of gloves and rain gear will be required prior to the change. Every fish handled will be treated as though infected and will not be allowed to contact other fish, their containers or solutions used to prepare them. After each fish handling, all implements and hands will be disinfected. Only virus-free water will be used in any egg contact and if ice is required to control water temperature or for disinfection solutions, it too will be kept virus free. Disinfectant solutions will be a buffered (pH of 7.0) 1:100 iodophor in water kept below 10 °C.

There will usually be fish to process after setting up the egg take site. CM 1 will check females for maturity at commencement of each broodstock collection period. Partial egg release and/or a soft underbelly will be an indication of spawning readiness.

After killing, each fish will be passed to CM3 who will wrap a looped string around the tail for hanging, with the loop centered on the caudal peduncle in front of the caudal fin. It will then be taken ashore and submerged in iodophor solution for a minimum of 5 seconds. CM2 (who will be disinfected from head to toe with iodophor solution) will remove the female from the solution and hang it on the drying rack by the string, head down (Fig. 7). CM 2 will bleed the fish by cutting its gills. This procedure will be repeated until there are sixteen females on the rack or there is no remaining ripe female. Each female will be hung for a minimum of fifteen minutes prior to egg removal.

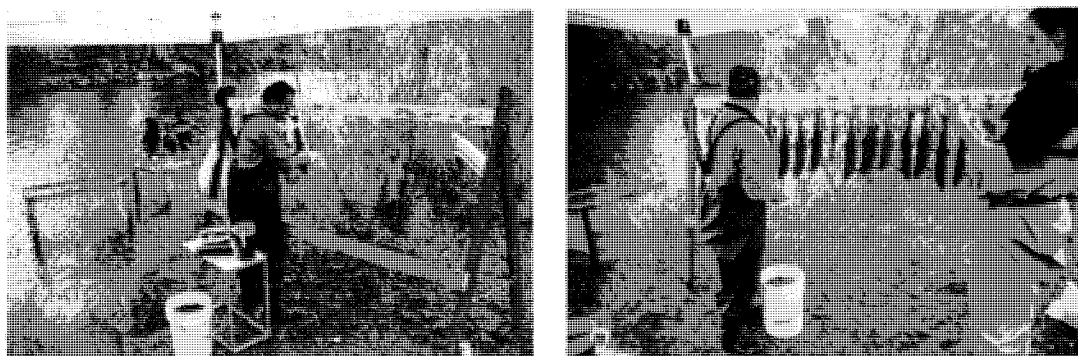


Fig. 7 – Egg Take Site – fish selection and kill area

During that interval, males can be processed. CM3 will take males one at a time from the livewell and kill them with a sharp blow to the head. They will then be transferred to shore

where they will be submerged in iodophor solution for a minimum of 5 seconds. CM1 and CM2 will be on shore and thoroughly disinfected. CM1 will remove the males from the solution one at a time, dry the belly with paper towel, and eject the milt from the belly by running a finger down each of its sides from the head toward the cloaca, without touching the cloaca or any of the milt. Each male will be spawned into a separate "Whirl-pak" bag, held by CM2. The first squirt of milt will be discarded to preclude contamination. The bag will then be sealed with approximately 99% of the air retained, and placed in a separate, dry, plastic disinfected container with a tightly closed lid and placed in a cooler with a mixture of water and ice.

Each bag of eggs or milt will be viewed for quality, and any eggs or seminal fluids that look questionable as determined by colouring will be discarded. When enough males are collected, the crew will revert to working on females.

b. Removing Eggs

Each female will be wiped dry with clean paper towels, and more clean paper towels will be stuffed in the gills and mouth to absorb any blood thus preventing it from being transferred to the eggs and/or other females. CM2 will transport the females one at a time to a covered egg collection station nearby. CM1 will be in the egg collection station, which will be disinfected before and after each female's eggs are extracted. A dry, disinfected plastic container will be placed on a bench by CM1 and numbered. CM2 will hold the female over the container tail downwards. Eggs will be removed by CM1 through an incision beginning at the ovipositor and moving downward to the anterior end of the body cavity using a clean, dry and disinfected spawning knife. Care will be taken to ensure the disinfection solution does not drip into the container. CM1 will remove the eggs and egg skeins from the fish, CM2 will then transfer the female to a clean area for disease sampling by CM4. If any impurities, such as bile are introduced into the eggs, CM1 will remove them with a clean paper towel. The container full of eggs will then be sealed with a tight fitting lid and placed in a padded cooler for transport on disinfected ice to the hatchery.

CM3 will then hand a clean, unused disposable pipette to CM 1 for ovarian fluid collection. CM 1 will extract the fluid and hand the pipette back to CM3, who will transfer the fluid into a clean tube, seal it, and label it with the corresponding fish number.

CM 4 will remove the females from the egg collection station and place them on a tray covered in newspaper for *Parvicapsula* testing. He or she will use instruments that have been disinfected by either (1) soaking them in 95% isopropyl alcohol and then flaming them, or (2) soaking them in 10% bleach for a minimum of 10 minutes, rinsing them in distilled water, dipping them in 95 % ethanol, and then flaming them. The tools will be then be placed on a clean surface.

The blunt end of a scalpel will be used to remove the swim bladder from the kidney. The sharp end will then be used to cut a portion of the posterior kidney, approximately 2cm² and to tease away the thin membrane enclosing the kidney. A pair of clean forceps will then be used to remove the underlying kidney and place it in a Whirl-pak. Any visual external or internal abnormalities will be noted by CM4. The female will then be

discarded along with the newspaper, and clean newspaper will be placed on the tray prior to the next sampling.

Each sample will be labelled with the corresponding fish number. Both the ovarian fluid and the kidney samples will be stored on ice and either frozen or shipped immediately in dry ice to the lab in Nanaimo for processing. If any of the samplers note any abnormalities in the ovarian fluid or kidney, the eggs of that fish will be discarded but the samples will still be sent to the lab to confirm whether or not they are diseased.

This process will continue until all females are removed from the rack, at which time the sequence will be repeated. During the killing and hanging of the next 16 females, CM4 will probably need the intervening time to complete the kidney sampling.

6. INCUBATION

At the egg incubation facility the vehicle will be parked at the outdoor disinfection station and egg containers and milt bags will be wiped with disinfection solution and moved to the egg receiving station and left for a minimum of 10 minutes. Egg containers will be wiped dry and individually weighed and transferred to the egg fertilization bench. Each day 2-3 egg containers will be randomly selected for individual egg counts in order to calculate number of eggs collected. Sperm bags will also be wiped dry and transferred to an egg fertilization bench.

Assuming matched numbers of egg and sperm containers, the contents of sperm bags will be poured into the egg containers and stirred by hand. After 2-3 minutes, 500 ml of incubation water will be added to induce sperm activation and gently stirred for 15-30 seconds. Remaining sperm bags will then be distributed among egg containers following the same fertilization procedure to ensure that egg batches are not lost because of non-viable sperm from the first batch. The fertilized egg containers will be washed three to four times with disinfectant solution, then covered with fresh solution and left for one hour for water hardening, replacing the solution once.

Prior to transfer to the incubation unit, the area will be properly disinfected. Each incubation unit will have a separate virus free inlet and outlet water line. In addition, egg temperature and incubation water temperature will be within 3-4 °C of each other.

All fertilized eggs at this point will be considered a 'lot' and will range between 20-50 females per lot for each incubation unit. This translates into approximately 60,000-150,000 fertilized eggs per lot (assuming 3,000 eggs/female). Small lots will be incubated in stacks of Heath trays and larger lots in Kitoi boxes. Virus free water flows will be 55 litres per minute (lpm) for Kitoi boxes and 12-13 lpm for Heath trays. During incubation the cooling system will not be used until river temperatures fall below virus free water temperatures.

Approximately one week after eggs are well 'eyed', they will be shocked and picked. This will involve siphoning off eggs from each incubation unit into a disinfected 20l bucket (half filled with clean water) and poured back into freshly disinfected incubation units (either Kitoi or Heath). The next day the eggs will be sorted electronically to remove dead

eggs. After this process, each unit with eyed eggs will be flushed with disinfection solution.

After an additional 7 days the eggs will be shocked and picked a second time and placed into freshly cleaned Kitoi boxes with clean and disinfected substrate to no more than a maximum of 30cm substrate depth (bio-rings or saddles) and enclosed in plastic mesh bags.

Throughout the incubation period floors will be cleaned with disinfectant weekly. Equipment will be disinfected prior to any transfers between incubation units. Water temperature and dissolved oxygen levels will be monitored daily. Each incubator will be checked on a regular basis for early signs of IHNV outbreaks (eg. oil droplets on surface, or early emergent sac fry). If there are suspected cases the hatchery manager will discuss their destruction with fish pathology experts

7. REARING FRY

The goal will be to rear fry to the 1.5gram stage for marking and release. Attempts will be made to have releases coincide with emergence of kokanee fry from the Okanagan River channel near Penticton.

Incubation units will be monitored until approximately 95% of the alevins are at stage 5 of development (the 'buttoned up' stage) when they will be transferred to fry rearing containers.

Fry rearing container dimensions will be at a minimum ratio of 10 to 1, length to width, and carefully cleaned and disinfected prior use. Each rearing unit will have separate virus free water and inlet and outlet sources and be no closer than two feet from any other unit. Rearing densities will be maintained at less than $6.3\text{kg/m}^3/\text{cm}$. Baffles will be used to clean out excess waste. Rearing units will be cleaned twice daily and mortalities will be removed and numbers recorded.

Fry will be fed a high quality semi-moist diet. Initially, they will be fed two to three times per hour. Later the frequency will be lessened to reduce gill problems. After initialization, fish will be fed only what they consume.

The fish manager will regularly monitor fish during the morning feeding, looking for any behavioural abnormalities, and removing dead or moribund fish. If disease is suspected, the hatchery manager, through consultation with a fish pathology specialist, may destroy the suspect group of fry. Moribund fish from the suspected batch will be removed for disease analysis. If IHNV is confirmed, other rearing containers will be sampled to ensure there has not been horizontal transmission

APPENDIX C

Proposed Workplan for:
Experimental Reintroduction of Sockeye into Skaha Lake:
Implementation, Monitoring, and Evaluation Years 1-4

EXPERIMENTAL REINTRODUCTION OF SOCKEYE SALMON INTO SKAHA LAKE							
PROPOSED WORKPLAN (YEARS 1-4) FOR EVALUATION AND MONITORING OF SOCKEYE, KOKANEE, MYNIS AND OTHER LIMNETIC FISHES IN SKAHA AND OSOYOOS LAKES							
Workplan	Task	Information Yield	Rationale	year 1	year 2	year 3	year 4
Monitoring							
Juvenile Rearing (sockeye, kokanee)	RST Estimate of fry Abundance	abundance, size, timing, egg to fry survival	Calibration of ATS fry survey; egg-fry survival	Yes	Yes	Yes	No
	3 x 7 m Acoustic and Trawl Survey (ATS)						
	May ATS	density and size, ratio of sk/ko, diet		Yes	Yes	Yes	Yes
	Summer (Aug) Survey	density and size, ratio of sk/ko, diet, growth		Yes	Yes	Yes	Yes
	Fall Survey	density and size, ratio of sk/ko, diet, growth, survival		Yes	Yes	Yes	Yes
	Winter Survey	density and size, ratio of sk/ko, diet, growth, survival, pre-smolt estimate		Yes	Yes	Yes	Yes
Older Age Classes of Kokanee and other Limnetic Fishes (e.g. Whitefish)							
	Additional trawling with 3 x 7 m net in Skaha only to coincide with summer ATS	size, ratios of relative abundance, age structure	estimate biomass of larger limnetic fish, partitioning mechanism	Yes	Yes	Yes	Yes
	Gill netting in Skaha only to coincide with summer ATS	size, ratios of relative abundance, age structure	estimate biomass of larger limnetic fish, partitioning mechanism	Yes	Yes	Yes	Yes
Sockeye Migration							
	RST for Skaha smolts	age and size information, timing		Yes	Yes	Yes	Yes
	RST for Osoyoos smolts	age and size information; ratio of Osoyoos to Skaha smolt numbers	ratio will suggest whether to invest in Pit tags to measure survival through Vaseux Lake	Yes	Yes	Yes	Yes
Adult Monitoring							
Kokanee	Calibrate and Standardize WLAP escapement monitoring in Penticton Channel & increase frequency	escapement estimate, residency timing	used to develop a standardized dataset of adult escapement of WLAP 1989-present	Yes	Yes	Yes	Yes
	Biosampling	fecundity, size at age, sex ratio, residualization of sk		Yes	Yes	Yes	Yes
	Shingle Creek	escapement estimate, residency timing		Yes	Yes	Yes	Yes
	Biosampling	fecundity, size at age, sex ratio, residualization of sk		Yes	Yes	Yes	Yes
Sockeye	Annual enumeration – standardized	adult escapement and no. of marked fish returning		Yes	Yes	Yes	Yes
	Biosampling of broodstock collection	fecundity, size at age, sex ratio		Yes	Yes	Yes	Yes
General Lake Limnology							
	Chemical limnology during ATS			Yes	Yes	Yes	Yes
	Physical limnology (secchi and TDO) during ATS			Yes	Yes	Yes	Yes
Mysis relicta	Sample 10 sites at time of ATS to reduce cost.	Biomass, size and numbers at different life stages		Yes	Yes	Yes	Yes
Zooplankton	Sample 10 sites at time of ATS and Mysis surveys to reduce cost	genus density, biomass, size		Yes	Yes	Yes	Yes
Baseline data development							
Juvenile Rearing	ATS surveys 1999-2003	partitioning of age 0 ⁺ Sk (Osoyoos) and Ko (Skaha) and larger limnetic fishes. Determine baseline growth & survival from 2002 trawl work	baseline estimates of total limnetic fish biomass and growth rates and survival when available	Yes	No	No	No
Adult Monitoring	Review WLAP escapement 1989-present and compare with 2004-06	standardized dataset of adult escapement of WLAP 1989-present	Part of CNAT analysis/publication on Okanagan River kokanee	Yes	No	No	No
Biosampling	Compile WLAP historical data 1989-present	baseline estimates of size at age	Part of CNAT analysis/publication on Okanagan River kokanee	Yes	No	No	No
Mysis relicta	Compile historical data 1999-2002, and process 2003 samples	Baseline estimates of density by life stage (adult, sub-adult), plus size and biomass		Yes	No	No	No
	Egg counts (1999-2003) and current for productivity analysis	production changes in mysid	understand the resource partitioning, sink or source, trophic triangle information	Yes	No	No	No
Zooplankton	Compile historical data 1999-2002 and process 2003 samples - check WLAP information	baseline estimates genus density, biomass, size		Yes	No	No	No
	Egg counts (1999-2003) and current for productivity analysis	production changes in major zooplankton genus	understand partitioning mechanisms i.e. energy sink or energy source, and trophic triangle dynamics.	Yes	Yes	No	No
Chemistry	Spring P level 1989-pres.	baseline P levels	For fish biomass/TP production estimate	Yes	No	No	No
Baseline Data Summary	Prepare data for yearly & long term comparisons			Yes	Yes	Yes	Yes
Hatchery Operations							
	Hatchery preparation			Yes	Yes	Yes	Yes
	Broodstock collection (6 people per crew for 10 days)			Yes	Yes	Yes	Yes
	Egg take (4 people per crew for 10 days)			Yes	Yes	Yes	Yes
	Egg picking and Inventory			Yes	Yes	Yes	Yes
	Disease Screening (2 crews of 2 people)			Yes	Yes	Yes	Yes
	Fry ponding, rearing and release, Mar-May			Yes	Yes	Yes	Yes
	Fry marking (adipose clip-sub contract)			Yes	Yes	Yes	Yes
	Overall hatchery management	Year end hatchery report		Yes	Yes	Yes	Yes
Reporting/Analysis							
Part 1. Hatchery report				Yes	Yes	Yes	Yes
Part 2. M&E report				Yes	Yes	Yes	Yes
	Chemical and Physical limnology, Adult enumeration, ATS, Smolt sampling, Data synthesis	Report with analysis, results and interpretation, and progress on hypothesis testing provided to COBTWG. Year end report will include Feb. smolt estimates for presentation at annual April meetings		Yes	Yes	Yes	Yes
Year end meeting	Coordinate and communicate information to COBTWG			Yes	Yes	Yes	Yes
Implementation quarterly meeting	Coordinate and communicate information to COBTWG and public			No	No	No	Yes
ABBREVIATIONS USED IN WORKPLAN CNAT - Core Numbers and Traits ATS - Acoustic, and Trawl Surveys RST - Rotary Screw Trap (for juvenile fish) WLAP - Ministry of Water, Land and Air Protection TP - Total Phosphorous T/DO - Total Dissolved Oxygen Sk-Sockeye;Ko-Kokanee. COBTWG - Canadian Okanagan Basin Technical Working Group							