Southern Fund Projects 2004/05

The following is a descriptive list of the projects that are being funded by the Southern Boundary Restoration and Enhancement Fund Committee in 2004.

ENHANCEMENT

SOCKEYE SALMON

Evaluation and Reduction of the Impacts of Northern Pike-minnow Predation on Cultus Lake Sockeye Fry

Project Lead: Neil Schubert, Area Chief, Lower Fraser Stock Assessment, DFO.
Project Cost: $68,000 CAN $51,889 US

Predation by northern pikeminnow and other predators on juvenile fry and smolts may be a significant cause of freshwater mortality in Cultus Lake sockeye. In the 1930's, a 90% reduction in northern pikeminnow abundance resulted in a 3-fold increase in freshwater survival but later analysis questioned the sustainability of the benefits to sockeye.

The potential of predator reduction to increase sockeye survival needs to be thoroughly assessed by a comprehensive analysis of the effectiveness of previous control programs (in Cultus and elsewhere) and through the development of a model to determine the level and duration of the required reduction effort. Preliminary work funded by Fisheries and Oceans Canada and currently underway will form the basis of the proposed work: the development of a detailed study design (that is consistent with the results of the work underway) for the removal of northern pikeminnows in the lake prior to the emergence of the 2004 brood fry in the spring of 2005; the conduct of the field work; the evaluation of removal effectiveness; and the analyses and reporting of results.

Cultus Lake Northern Pikeminnow (Ptychocheilus oregonensis) Assessment and Removal Program in 2004 and 2005. *Final Report*

Monitoring and Evaluation of Sockeye Fry Released into Skaha Lake: Completion of Pilot Year Project for the Experimental Reintroduction of Sockeye into Skaha Lake

Project Lead: Deana Machin. Program Manager. Okanagan Nation Alliance Fisheries Dept.
Project Cost: $56,172 CAN $42,863 US

Okanagan Sockeye are one of the two remaining viable sockeye populations in the Columbia Basin and the last salmon stock returning to the Canadian portion of the Columbia Basin, via the Okanagan River. As it has been nearly 50 years since salmon had access into the upper Okanagan Basin (Skaha and Okanagan L.), it has been proposed to experimentally reintroduce sockeye back into Skaha Lake as a precursor to future reintroduction into Okanagan Lake. Reintroduction is feasible, based on a low-risk, high-benefit implementation strategy of sockeye fry introduction into Skaha Lake and will require a long-term monitoring and evaluation program. A limited Pilot Reintroduction Project commenced in October 2003 to assist in refining procedures for broodstock collection, egg take, incubation, and fry release and provided valuable information for the 12-Year Sockeye Reintroduction Management Plan. 250,000 sockeye fry Have been raered at Shuswap Falls Hatchery. The fry were thermally marked and adipose clipped prior to fry release at the end of May. The Monitoring and Evaluation Program for this long-term program has been developed by Okanagan Nation Alliance, Fisheries and Oceans canada and the provincial Ministry of Water, Land and Air Protection and is focused around the interactions of sockeye, kokanee and *Mysis relicta* since in-lake rearing capacity was identified as a major issue. Monitoring will include seasonal acoustic and trawl surveys, chemical and physical limnology, zooplankton and *M. relicta* sampling, gill netting for Skaha Lake kokanee (age structure), kokanee enumeration and biosampling, and sockeye smolt migration sampling out of Skaha and Osoyoos Lakes. The initial investment to this low-tech enhancement project will guide the way for increased natural production of Okanagan sockeye in the Columbia Basin. At the end of the 12-year Reintroduction Project, a decision can be made to open barriers into Skaha Lake to allow for natural production of sockeye, which will nearly double the rearing capacity for Okanagan sockeye and, since the Okanagan is a warm water system, provide adult over summer habitat (cool water thermal refuge).

Sockeye Reintroduction into SkahaLake: 2004/2005 Monitoring Program, 2003Broodyear. *Final Report*

HABITAT RESTORATION

GEORGIA BASIN

Cowichan River Chinook Incubation Assessment

Project Lead: Mel Sheng. DFO Restoration Unit. Nanaimo.
Project Cost: $10,000 CAN $7,631 US

In 2002, the first phase of the rebuilding strategy for Cowichan River chinook stocks was completed. This consisted of a literature review and preliminary assessment of non-fishing factors limiting production of these stocks. One potential issue identified relates to the quantity and quality of spawning gravel in the lower river (i.e., below Skutz Falls). While the upper river contains exceptionally high quality spawning gravel, gravel in the lower river is less widely distributed and contains a higher percentage of fines. Two major point sources of silt inputs have been identified. The most significant of these is Stoltz Slide located ~8 km below Skutz Falls. A secondary input is located in an area called Block 51 located ~5 km above Skutz Falls. During heavy rainfall events these sources contribute heavy silt loads to downstream habitats (e.g., 2002; see attachment). In some locations below Stoltz Slide, silt deposits have been observed forming a cement-like layer over top of chinook redds. Escapement monitoring by DFO has shown that a significant percentage of the chinook run spawns in the lower river in years when low flow is experienced during the migration period (up to 66% of the run in some years). Coincident with this spawning distribution is a trend towards lower egg-to-fry survival. In contrast, most Chinook spawn above Skutz Falls when flows are higher and experience higher survival. In addition, preliminary sampling of intergravel oxygen on spawning beds found extremely low DO levels in some of the lower river sites. Hence, it appears conceivable that incubation success may be poorer in years when more chinook utilize the lower river. This proposal outlines a study to determine whether the upstream sediment sources are adversely affecting chinook egg-to-fry survival, and if so, to quantify these effects in terms of suspended sediment transport, substrate composition, intergravel oxygen levels, and in situ measures of incubation survival. Sample sites above the silt sources will serve as study controls. The results of this work will be used to determine whether remedial action to eliminate/diminish these sediment sources is warranted to assist in the recovery of Cowichan River chinook salmon.

Cowichan River Chinook Salmon Incubation Assessment, 2004–2005. *Final Report*

Puntledge River High Temperature Study

Project Lead: Mel Sheng. DFO Restoration Unit. Nanaimo.
Project Cost: $15,000 CAN $11,446 US

Returning salmon adults are exposed to high water temperatures on many B.C. rivers including the Puntledge River. Although studies on the acute lethal effects of high temperatures on adult salmon have been reported (Berman, 1990; Servizi and Jensen, 1977), the effect of temperature on latter stages of egg maturation, fertilization success and egg development is complex and poorly understood. The high water temperatures recorded for the Puntledge River in the summer and early fall likely affect the productivity of salmon stocks that spend a portion of their adult life stage in this system (mainly summer chinook and pink salmon). A study on Puntledge River pink salmon in 2002 found that the adverse influence of high water temperature during the latter phase

of maturation significantly (P< 0.05) increased adult mortality, delayed maturation rate, and reduced gamete viability (Jensen *et al*., 2004; Can. Tech. Rep. Fish. Aquat. Sci. 2523). Chinook pre-spawning and incubation mortality in Puntledge River may be as high as 30%. A study is proposed to determine the potential impacts of high Puntledge River temperatures on the maturation rate, adult mortality, and subsequent gamete viability of summer-run chinook salmon. The project would entail exposing adult chinook salmon to 3 natural fluctuating temperature regimes commencing in mid-summer. Prior to hydro development in the watershed, it is likely that summer-run chinook would have ascended into Comox Lake to escape the warm river temperatures and then drop back downstream in the fall to spawn below the lake outlet. This project will provide new information on acceptable upper temperature limits for maintaining healthy salmon populations. This is critical for assessing strategies to mitigate the impact of low water flows and subsequent high water temperature.

Puntledge River High Temperature Study:Influence of High Water Temperature on Adult Summer Chinook Salmon in 2004 and 2005. *Final Report*

Puntledge River Summer Chinook Radio Telemetry Study

Project Lead: Mel Sheng. DFO Restoration Unit. Nanaimo.
Project Cost: $15,000 CAN $11,446 US

Following expansion of the hydro facilities on the Puntledge River in the 1950s, escapement levels of summer-run Chinook salmon declined from an average of 3,000 to a 10-year average of 430 during the 1990s. Through a hatchery based enhancement program the summer-run chinook genetic stock has been preserved. Lately, with the support of other conservation measures and increases in marine survival, recent returns have been above this 10-year average, but still short of escapement levels necessary to ensure a self-sustaining stock. The delay of returning adult summer chinook salmon at the tailrace pool of BC Hydro's generating facility has been a chronic problem in the Puntledge watershed since 1955. Prior to dam construction, it is likely that these fish would have ascended into Comox Lake to escape the warm river temperatures and then drop back downstream in the fall to spawn below the lake outlet. The high water temperatures recorded for the Puntledge River in the summer and early fall likely affect the productivity of salmon stocks that spend a portion of their adult life stage in this system (mainly summer chinook and pink salmon). Past radio telemetry studies on summer chinook in the Puntledge River were conducted to determine whether pulse flows released at BC Hydro's diversion dam stimulate summer chinook to migrate through the diversion reach or into Comox Lake. Results indicated a significant response in movement initiated by the pulse flow. During the Puntledge River Water Use Planning Process, the Consultative Committee agreed to pulse flow releases in light of these results. However, the Puntledge Water Use Plan will not likely be officially signed and implemented until the summer of 2005 at the earliest. Since it is expected to take 2-3 years to establish an optimum pulse flow for chinook migration, studies to determine these optimum pulse flows will not be completed until after peak returns from the Puntledge Hatchery Captive Brood Program which are anticipated in 2004 and 2005. This could potentially impact the overall spawning success of the returns and negate the benefits of this valuable captive brood program. Continuing radio telemetry studies in 2004 will provide further details regarding Chinook migration behavior and facilitate the establishment of an optimum pulse flow release strategy in the next 2 years such that potential impacts on chinook production during the anticipated peak returns are minimized.

Puntledge River Summer Run Chinook Radio Telemetry Study 2004. *Final Report*

Somenos Watershed Plan

Project Lead: Mel Sheng. DFO Restoration Unit. Nanaimo.
Project Cost: $22,000 CAN $16,787 US

The Somenos Basin is recognized as a key area for coho production in the Cowichan River watershed, but several problems exist. While winter and spring flows are good for salmon, they can cause flooding of adjacent farmland. In low summer and fall flows, Somenos Lake and Creek provide poor refuge for salmon, experiencing lethal temperature and oxygen levels. The proponents would like to develop a watershed plan with the Somenos Basin Steering Committee to improve low flows, water quality, adult access and rearing conditions during the summer and fall and reduce flooding impacts during the spring for farmers. The goal is to produce a plan that is mutually beneficial to all users of the watershed. Establishment of this type of relationship is key to future improvements and restoration of fish habitat, conservation of water and agricultural production in this watershed.

Somenos Watershed Plan. *Final Report 1* *Final Report 2*

FRASER BASIN

Ianson Channel Project

Project Lead: Patricia Carlson. Senior Project Engineer. DFO. Kamloops.
Project Cost: $30,000 CAN $22,892 US

The Ianson spawning and rearing channel on Lemieux Creek has been in operation for 15 years. This channel supports significant numbers of adult (single count in 2000 was about 70) and juvenile coho salmon. The existing channel is approximately 425 m in length with an average channel width of 1.5 m. The present spawning substrate has a high sand component and there are few pools and refugia for adult spawners and rearing juveniles. In addition, the existing smolt imprinting capability of the channel is inadequate as smolts from the Dunn Lake Hatchery (North Thompson Indian Band facility) must presently be held and released within only one week and in three separate groups rather then simultaneously held for four to six weeks that is the normal practice for most smolt imprinting facilities. This project entails widening the existing channel to an average of 3.5 m and providing refuge pools along its length.

The existing berm from the original construction will be pulled back to allow for the excavation of these pools. Additionally, gravel will be imported to improve the condition of the existing spawning material. Interior coho stocks in the North Thompson are exhibiting serious decline and have been identified under the federal Species At Risk Act. Lemieux Creek, a North Thompson tributary, experiences significant

habitat impacts from land and water uses resulting in loss of stream bank stability and vegetation, loss of groundwater off-channel habitats, reduced stable pool habitat, loss of side-channels, and increased sediment loading.

Lemieux Creek Ianson Channel Improvements. *Final Report*

Creighton Creek Stream Flow Recovery

Project Lead: Gay Jewitt. Whitevalley Community Resource centre Society. Lumby.
Project Cost: $18,000 CAN $13,735 US

Water use demands are surpassing supply in many areas of the Southern Interior of British Columbia. The climatic trend is for drier weather, with extended shoulder seasons that will increase the demand for irrigation and decrease the snow pack and supply of surface water during the summer months. Several dry years in a row have lowered the water table which has increased the need for irrigation causing poor water quality, increased predation and stranding / mortality of juvenile endangered Fraser River coho. The potential for conflicts between the agricultural community and fisheries is real and growing. This project would reduce or eliminate the threat of dewatering, fish kills and loss of species abundance at various trophic levels in Creighton Creek by working with the agicultural community to develop better water use strategies.

The project will help develop alternate water use strategies by:

- evaluating the water supply and demand, withdrawals, current irrigation systems and schedule efficiencies, soil types and crop demands,
- providing information and
- developing co-operative working relationships with the agricultural community that holds water licenses.

A major focus will be to identify water conservation shortfalls and develop a regime to optimize the water available. This project will also look at the possibility of storage in the upper watershed. The emphasis of this project is on applied recovery action that will result in the re-establishment of prime coho spawning and rearing habitat.

Creighton Creek Stream Flow Recovery. *Final Report*

Adams River Habitat Assessment

Project Lead: Timber Whitehouse, Program Head, Sockeye Stock Assessment, BC Interior, DFO.
Project Cost: $17,000 CAN $12,972 US

Sockeye salmon production potential in the Adams River has been gradually eroded over the past 15-20 years as a result of shifting bedload and hydrologic changes observed in the river. Channel morphology has slowly shifted over the years so that most of the discharge is directed down the now primary eastern channel. This flow distribution represents a major change from the recent past (as recent as the early 1990's) when most (~66%) of the Adams R. discharge flowed through the western channel. The upper and middle reaches of this channel are now dry during the sockeye spawning period and the persistent hydrologic shift to an eastern channel regime is resulting in the gradual dewatering of the lower west channel reaches. The result of this river

morphology shift has been that a large amount of previously accessible and optimal sockeye spawning substrate in the upper and middle reaches of the western channel has been completely dewatered and is no longer accessible to sockeye. Continuing hydrologic shifts in the lower reaches of the east and western channel are resulting in further sockeye spawning habitat loss due to dewatering. This pattern is not a new one; historically the IPSFC undertook substrate and channel/discharge management in the Adams R. to maintain flow in both of the channels. This work occurred on a semi annual basis, normally associated with the dominant and sub-dominant sockeye spawning years. It ceased with the termination of the IPSFC mandate in 1985. Given the great social and economic value of the Adams sockeye run we propose that a habitat assessment of the lower Adams River be undertaken to quantify sockeye production impacts associated with the channelization of the Adams system. Work would entail an assessment of historical/archival information regarding the Adams River including IPSFC engineering studies on hydrology, spawning ground capacity and substrate quality, and an assessment of production limiting factors. It would also entail detailed habitat mapping and assessment of the current status of the lower Adams River to quantify the amount of sockeye spawning habitat that has been lost due to dewatering. The comparative assessment would then be linked to an evaluation of current scientific knowledge regarding nursery capacity to determine if sockeye fry production potential from the accessible reaches in the lower Adams R. would fully utilize available rearing capacity. If habitat loss has resulted in predicted recruitment levels below those required to optimize lake fry output then options to manage this reduction could be identified. Given the changes in the system seen over the past 20 yrs this assessment is deemed critical to establishment of sustainable spawning escapement objectives for long term fisheries management purposes.

Adams River Habitat Assessment. Final Report

Shuswap Lake Sockeye Salmon Shore Spawning Atlas

Project Lead: Bob Harding. Habitat Technician. Salmon Arm.
Project Cost: $10,000 CAN $7,631 US

The Pacific Salmon Commission and DFO have conducted sockeye salmon enumeration programs on the Shuswap system for many decades. Shuswap Lake shoreline sockeye spawning enumeration has been completed with greater accuracy with the advent of GPS equipment over the past few dominate Adams run cycles. The raw data is available but not in a format which permits habitat managers and proponents to readily determine the location of proposed developments relative to sensitive spawning habitats. With the movement of governments towards best management practices or guidelines it is becoming increasingly important to be able to accurately identify the location of environmentally sensitive areas. Development of a digital spawning atlas would provide for production of hard copy and web-based maps for use by the public as well as by agency staff.

Please contact PSC for project maps.

Assessment of Restoration Projects and Prescriptions

Project Lead: Patricia Carlson. Senior Project Engineer. DFO. Kamloops
Project Cost: $125,000 CAN $95,383 US

In order to evaluate the success and productivity of habitat restoration works that have been developed directly by DFO or in conjunction with partners, it is essential to assess the physical integrity and the utilization by juvenile salmonids of these works, particularly use by threatened Thompson Basin Coho stocks. This information is critical to determining the function and success of existing works and, for future project consideration, by identifying those habitat restoration options and components that would be most productive and successful**.** This proposal is presented in two main parts: assessment of riparian stabilization and habitat improvement prescriptions; and assessment of off-channel habitat restoration projects and habitat features.

Riparian assessment:
There are a number of sites in the Bridge-Seton watersheds, Middle Shuswap watershed (Bessette, Duteau), Salmon, Nicola, Deadman, Bonaparte, and Raft River watersheds where riparian restoration and stabilization work has been undertaken within the last 15 years. It is proposed to assess and, when possible, quantify the utilization by juvenile salmonids of selected riparian restoration sites using a number of fish assessment and enumeration techniques (primarily netting and GEE trapping, using a mark-recapture technique for estimating rearing juvenile populations and calculating rearing densities, with the use also of electroshocking, if necessary).

Off-channel assessment:
A number of off-channel habitat restoration projects will be assessed to determine the utilization by juvenile salmonids of the channels and of the various habitat features within the channel (e.g. undercut banks, rock clusters, LOD complexity/placements). A comparison to mainstem habitats will be made.

PSC – DFO BC Interior Restoration Assessment
Final Report_1 *Final Report 2* *Final Report_3* *Final Report_4*

PUGET SOUND

Nooksack Basin Stream Restoration

Project Lead: Wendy Scherrer. Executive Director. Nooksack Salmon Enhancement Association
Project Cost: $85,183 CAN $65,000 US

The quality of aquatic habitats in the lower Nooksack watershed today is significantly diminished from times before Euro-American settlement. Lower gradient reaches of the Nooksack River and its floodplain were once complex and highly dynamic, with abundant logjams and beaver dams in the mainstem and tributaries. Channel movements and overbank flows, moderated by the presence of large woody debris (LWD), formed and maintained a network of diverse floodplain habitats. Habitat complexity and connectivity were maintained by an extensive forested floodplain. Over the past 140 years, many lowland areas of the Nooksack watershed, as well as mainstem and tributary channels, were cleared, ditched, drained and dredged. Today, many mainstem river reaches are hydrologically modified by riprap and dikes, lack functional large

wood, cover and pools, and exhibit impaired flow, thermal, and suspended sediment conditions. Agricultural and rural residential land uses now dominate the lowland landscape. This project will improve riparian and aquatic habitat along approximately 20,000 feet of stream channel.

The Nooksack Salmon Enhancement Association will increase the quantity, quality, and overall diversity of salmon habitat through LWD placement and riparian revegetation which will increase stream water quality, quantity and fish habitat by reducing erosion, increasing shade, providing detritus for macro-invertebrates, filtering pollutant inputs from adjoining agricultural lands, and providing a future source of LWD.

Nooksack Basin Stream Restoration Crew Project. *Final Report*

WASHINGTON

Pysht River Floodplain Assessment

Project Lead: Mike McHenry. Fisheries Habitat Manager. Lower Elwha Klallam Tribe
Project Cost: $31,452 CAN $24,000 US

The Pysht River is a 30,000 acre (12,100 hectare) watershed that drains primarily industrial forest lands on the north Olympic Peninsula. The Pysht River historically supported robust runs of Chinook, coho and chum salmon as well as steelhead and cutthroat trout. These runs, particularly mainstem dependent chum and Chinook populations, have declined as a result of the cumulative effects of reduced marine and freshwater survival. Tributary dependent populations such as coho have faired somewhat better with the Pysht retaining significant coho production (adult escapement of 4-7,000 in recent years). The primary causes of habitat degradation in the Pysht resulted primarily from historic logging as well as the degradation of the floodplain from highway construction, railroad grade construction and channelization. Some progress has been made in recent years with regards to improvements in forest management. Additionally significant efforts at habitat restoration have been initiated, beginning in 1993. Several large scale off-channel development, LWD additions and riparian reforestation have been completed or are planned in the next several years. These efforts have focused primarily on tributary habitats. What is needed to guide future restoration efforts on the Pysht is specific information on how to begin the restoration of severely degraded floodplain habitats. The floodplain of the Pysht River was historically very dynamic, flowing through approximately 12 miles of unconstrained valley, with large-diameter conifer forests. Logging beginning in the early 20th century eliminated these old-growth forests, and the Pysht was channelized in places to facilitate log transport (particularly in the estuary). A system of railroad grades was constructed adjacent to the Pysht River. Later a wagon road that paralleled the Pysht River was converted to a paved highway (State Highway 112) in the 1940's. None of these actions were built with consideration for fish habitat or fish passage. These actions not only restricted channel migration processes, but also isolated tributary habitats, associated wetlands, and off-channel areas critical to fish. These problems have been exacerbated by channel incision of 1-2 m in the lower mainstem. Channel incision is thought to be a direct result of historic imbalances in sediment supply, channelization and loss of channel

roughness through LWD depletion. We propose to inventory all potential floodplain habitats (including mainstem and estuary) in the Pysht River between river mile 0-11.5 to document passage barriers and identify human induced alterations to habitat in order to prioritize restoration actions for the Pysht River floodplain. Over the short term we expect to identify a number of projects that can be immediately acted upon by groups interested in conducting restoration in the Pysht River. This information will be used to guide restoration efforts through the Washington State Salmon Recovery Funding Board (SRFB) and other federal sources of restoration. Over the long-term we also hope to begin the long process of disconnecting floodplain infrastructure from the floodplain of the Pysht River. While this will not occur quickly or cheaply, planning must be initiated in order to have any hope of restoring natural processes in this river.

 *Pysht River Floodplain Habitat Inventory and Assessment.* *Final Report*

OREGON

Deschutes River Alder Re-establishment

Project Lead: Chris Brun. Fisheries Biologist. Confederated Tribes of the Warm Springs Reservation of Oregon.
Project Cost: $18,853 CAN $14,386 US

The objective of this project is to re-establish the dominant riparian hardwood trees species, white alder (*Alnus rhombifolia*), along the banks of the lower Deschutes River. The Deschutes River is a designated Wild and Scenic River and is managed to protect and restore native vegetation and fisheries. Flooding and wildfire have removed this tree along portions of the river that are key spawning and rearing areas for wild fall chinook salmon. Deschutes River fall chinook salmon are used by the U.S. Chinook Technical Committee of the Pacific Salmon Treaty as an indicator stock to assess the effectiveness of abundance based harvest management. They are a wild stock of Columbia River up-river bright fall chinook salmon. As such they depend on healthy streamside riparian vegetation particularly for post-emergent juvenile rearing. The CTWSRO, Bureau of Land Management and Oregon Department of Fish and Wildlife have made significant efforts to protect stream banks from disturbance. This has included construction of riparian fences to exclude livestock and recreation management to minimize human-caused stream bank trampling. These efforts have yielded positive results in the form of re-establishment of riparian grass and sedge communities. However, alder has been slow to re-generate. Mature alders are not being replaced by young alders as rapidly as one would expect. This project proposes to accelerate the re-establishment of alders by planting 14”-24” tall seedlings along portions of the river where once healthy alder stands existed.

 *Deschutes River Riparian Alder Tree Re-establishment.* *Final Report*

IMPROVED INFORMATION

SOCKEYE SALMON

Development and validation of the "Juvenile Growth" Stock-Recruitment Model for Cyclical Fraser River Sockeye Stocks

Project Lead: James C. Woodey, Fisheries Consultant
Project Cost: $66,952 CAN $51,089 US

We propose to develop and test a new spawner-recruit (S-R) model to describe and simulate production in cyclical Fraser River sockeye salmon stocks. Catch data and studies conducted since the early 1900's have established that several upper Fraser sockeye stocks show persistent cyclical patterns of abundance. In recent return years (1984-2003), stocks that display cyclical dominance accounted for 62% of the total Fraser sockeye production. The mechanism(s) behind cyclical dominance has been one of the most hotly debated subjects in British Columbia fisheries science and management for over 50 years. Scientists have proposed various mechanisms for the establishment and maintenance of cyclical dominance including density-dependent predation, genetic factors and fisheries. Many of the studies into cyclical dominance have depended on the widely used Ricker Stock-Recruitment (S-R) model. However, this model fails to correctly represent the population dynamics of cyclical Fraser sockeye stocks (i.e., it fails to capture the interaction between cycle lines). An alternate model, the Larkin S-R Model, explains historical recruitment in these stocks, but it fails to capture the mechanism(s) controlling recruitment. A new model (tentatively termed the "Juvenile Growth" Model) was introduced in conceptual form during Fisheries and Oceans Canada's (DFO) Fraser River Sockeye Spawning Initiative technical workshops. The potential effects of cycle line interaction on S-R model form and production under various scenarios was identified as the major source of uncertainty during the workshops. The proposed study will develop the conceptual model into a fully functional S-R model so that it could be implemented in the simulation model used in the Spawning Initiative. The model is based on cycle-line interaction wherein juvenile growth is inversely related to escapement abundances in the current and prior brood years. Combined with empirical relationships between juvenile size and rate of recruitment, the model serves to simulate future recruitment given spawning escapement inputs for analysis of potential management strategies. In conjunction with data on juvenile sockeye numbers and growth in Shuswap and Quesnel Lakes generated by the DFO Lake Survey Program, the model appears to identify the mechanism(s) that maintains cyclical dominance in Fraser River sockeye stocks.

Evidence for Cycle-line Interaction as a Mechanism for CyclicDominance in Fraser River Sockeye Salmon. *Final Report*

Sockeye Fry, Smolt, and Nursery Lake Productivity Assessment at Quesnel and Shuswap Lakes

Project Lead: J. Hume, DFO Science Branch, Cultus Lake
Project Cost: $110,000 CAN $83,937 US

Record sockeye escapements to Quesnel and Shuswap lakes in 2001 and 2002 have pushed abundance well beyond levels ever seen in these systems. Potential juvenile recruitment levels far exceed predicted optimal loading levels based on historic lake productivity assessments. These significant extensions in range of abundance must be assessed to update productivity relationships for production forecasting and to meet overall stock management objectives, including definition of sustainable escapement objectives. Results of these studies will influence decisions and strategies currently under development in the Fraser Sockeye Escapement Initiative. Whole system assessments are important to our ability to refine understanding of factors impacting lake productivity and smolt production. In conjunction with the historic time series these data will update scientific knowledge of rearing capacity, future production potential and forecasting capability. We propose to evaluate the affects of high escapements by sampling fry, smolt and whole lake responses. Fall fry populations will be assessed using hydroacoustic and trawl surveys in each lake. Estimates of abundance, size, distribution and diet for both juvenile sockeye and their competitors will be documented at both Quesnel and Shuswap lakes during the fall of 2004. Smolt out-migration will be sampled using downstream trapping methods during the spring of 2004 to obtain smolt size data from both systems. We are currently data poor regarding emigrant smolt size, this is particularly important because of the marine survival implications associated with reduced smolt size. The potential for intergenerational impacts will be evaluated by conducting detailed monthly limnological assessment at Quesnel Lake to evaluate the near and longer term sockeye production implications that are associated with an observed doubling of lake primary productivity in 2003. This major increase in lake productivity is the result of significant increases in marine derived nutrient levels from successive large sockeye escapements. These studies will build on current scientific understanding of sockeye salmon production limiting mechanisms, in addition to evaluating sockeye population parameters associated with historically high abundance levels. The opportunity to assess these conditions is unique in terms of the historic time series, but is particularly relevant given the likelihood of reduced ER's and larger terminal escapements in the future.

Sockeye Fry, Smolt, & Nursery Lake Monitoring of Quesnel & Shuswap Lakes in 2004. *Final Report*

Prediction of Migratory and Reproductive Success in Fraser Sockeye

Project Lead: Dr. Steve Macdonald, Head, Freshwater Habitat Science, DFO.
Project Cost: $105,000 CAN $80,122 US

The ability to forecast returns and achieve escapement and conservation goals can improve when in-season management tools consider the influence of environmental conditions. The current environmental management adjustment model (EMA) is reliant on accurate predictions of both the Fraser Rivers' water temperature and it's discharge. We intend to reduce the current temperature uncertainties surrounding outlet river temperatures from major lake systems by monitoring and modeling lake dynamics (i.e Quesnel, Shuswap and Kamloops Lakes). Furthermore, preliminary analysis has shown a close association between late season snow pack levels (May 15th) and mean discharge values in July and August. We propose to extend this

analysis, using climate, discharge, and temperature models, to make pre-season forecasts of migratory conditions (with confidence limits) for each run timing group. In addition, we will develop an in-season model to predict pre-spawn mortality (PSM), using a suite of physical and biological predictor variables. The final objective of this proposal is to link the model output information produced for resource managers with on going research initiatives to study the causal mechanisms between environmental conditions and spawning migration success. Significant predictor variables derived from both the EMA and a PSM model will be used to guide on going research (i.e. NSERC – early entry of late run fish). The effect of specific predictor variables (i.e. temperature or freshwater residency time) on the physiological condition of fish will be tested under controlled conditions. In the long term, the information gained from knowing how environmental conditions actually cause migratory or reproductive failure in salmon can be fed back to resource managers to predict the effects of long term environmental change on a population specific basis, which may help guide enhancement and/or rehabilitation efforts.

Prediction of Migratory and Reproductive Success in Fraser Sockeye. *Final Report*

Survival, Behaviour and Physiology of Migrating Adult Late-Run Fraser River Sockeye: Identifying the Cues and Causes of Abnormally High Mortality Prior to Spawning

Project Lead: Dr. Scott Hinch, Professor, University of British Columbia.
Project Cost: $96,000 CAN $73,254 US

This project, with partners from academia, government, First Nations and the private sector, will examine an early migration/high mortality phenomenon in late run Fraser sockeye, building on on-going work of the NSERC team led by Dr. Scott Hinch. Last year, using telemetry and physiological assessments of late-run Adams sockeye near spawning grounds, Hinch's team discovered unusual blood clotting and ionic balance problems in early migrants (which suffered high migration mortality). However, because sample sizes were low and the observational study opportunistic, the results to date are compelling but equivocal. We will mount a study using much higher sample sizes and a proper experimental design to determine:

a) what is causing the high bleeding and ionic distress,
b) the relationship with the natural kidney parasite – *Parvicapsula*, and
c) if these phenomena are causing the high mortality in early migrating late runs.

We will focus on the commercially valuable Weaver late run stock, which has experienced high levels of en route and prespawning mortality since 1995. The project has two parts:

1) Fish will be collected by beach seine in the Fraser River near the Weaver-Harrison (W-H) system from early and normal arrival timed migrants. Several hundred fish will be destructively sampled for relevant physiological, energetic, and disease measures. Approximately 120 fish will be non-invasively sampled for physiological and energetic status and implanted with either an acoustic or radio transmitter. Receivers will be deployed throughout the W-H to identify holding areas and confirm movements into spawning areas. These data will provide an assessment of timing based mortality patterns, and link mortality with water temperature, parasite infection, blood clotting ability, and ionic status. There is evidence that segments of the Weaver run spend time in Harrison Lake before spawning. Survival to spawn may thus rely on migrant's ability to occupy deep, cold water regions in the lake for a set period. Cooler temperatures would retard accumulation of degree-days, which would retard both energy expenditure and the development of *Parvicapsula* infection.

2) Approximately 40 fish from early and normal timed migrants will be captured as in (1), and held for 2-3 wks in freshwater tanks at West Vancouver Lab at either cool or warm temperatures to alter experimentally the rate of *Parvicapsula* infection. The cool temperature will be similar to those where sockeye are found holding in Harrison Lake and the warm temperatures would be similar to those of holding areas in the lower Harrison River. The upstream migrations of acoustic tagged fish will be monitored using a portion of the acoustic telemetry array provided by the POST project. This experiment will test hypotheses involving migration timing, encountered temperature, parasite infection, and enroute mortality.

Survival, Behaviour and Physiology of Migrating Adult LateRrun Fraser River Sockeye: Identifying the Cues and Causes of Abnormally High Mortality Prior to Spawning.
Final Report

A Biophysical Mechanism for the Early Entry of Late-Run Fraser River Salmon: Anomalous Oceanic Conditions Trigger an Accelerated Change in Fish Physiology

Project Lead: Dr. Richard Thomson, Head, Ocean Dynamics and Processes Section, Institute of Ocean Sciences, DFO.
Project Cost: $51,000 CAN $38,916 US

Recent research conducted by the Institute of Ocean Sciences reveals a significant correlation between lower than normal salinity in the upper layer of the southern Strait of Georgia during the summer and the post-1995 early entry of late-run sockeye salmon into the lower Fraser River. Using a combination of fish physiological assessments, troll test fishery data, and environmental time series records for coastal British Columbia, scientists at the Institute of Ocean Sciences, University of British Columbia, Simon Fraser University and the Pacific Salmon Commission will focus on the possible link between anomalous oceanic conditions and changes in the osmoregulatory behaviour of the returning fish. Funds will be used to:

1. Link sockeye distribution and timing behaviour with summer oceanic conditions in the Strait of Georgia, Juan de Fuca Strait and Johnstone Strait;
2. Examine the hypothesis that unusual and accelerated osmoregulatory changes (i.e. their preparedness for surviving in freshwater) are linked with the encounter of low salinity coastal water, providing the mechanistic link between oceanic conditions and the rapid early-entry response of returning late-run sockeye; and
3. Correlate fish distribution data and water property structure observed during the 2003 and 2004 PSC Troll Test Fisheries with long-term oceanographic time series data collected by the military at the Nanoose torpedo test range.

While the focus of the fish assessments will be on summer-run stocks because of low relative abundance of late-runs, it is of direct relevance to the late-run, early entry issue. This research will generate the relevant relationships between oceanographic and fish physiological conditions necessary to demonstrate that sockeye osmoregulatory status is affected by salinity and temperature patterns well away from the Fraser River mouth. In-kind support provided by the various investigators will include NSERC-funded personnel within the universities and loan of a $10,000 self-contained CTD-Oxygen probe by the Institute of Ocean Sciences.

The Brackish Layer Model: A Biophysical Mechanism for early entry of Late-Run Fraser River Salmon. *Final Report*

Investigating the Relationship Between Summer-Run Sockeye Abundance and Migration Timing, with Late-Run Sockeye River Entry Timing

Project Lead: Karl English, Vice-President, Western Operations of LGL Ltd.
Project Cost: $36,383 CAN $27,763 US

Given the large potential impact of changes in delay behavior on spawning success, a more detailed examination is warranted of the potential factors that could influence delay behavior and river entry timing for Late-run stocks. One possible explanation for major changes in delay behavior between years is the proposed "stay with the school" hypothesis. The hypothesis states that in years when the abundance of Summer-run sockeye is much larger than Late-run returns and there is high degree of overlap in the timing of Summer-run and Late-run migrations through coastal waters, a large portion of the Late-run sockeye would school with the Summer-run sockeye and enter the Fraser River in August. This hypothesis is supported by the following evidence:

1. sockeye have a strong affinity to remain in a school therefore the behavior of the school can affect the behavior of the individuals from different stocks (Freon and Misund 1999);
2. in 2000 and 2001, a small return of Late-run sockeye migrated through coastal fisheries with large numbers of Summer-run sockeye and 100% of the Late-run fish were estimated to have enter the river in August along with the Summer-run sockeye; and
3. in 2002 and 2003, 50-77% radio-tagged Late-run sockeye that were tagged in early and mid-August migrated through coastal waters and directly into the Fraser with large schools of Summer-run sockeye.

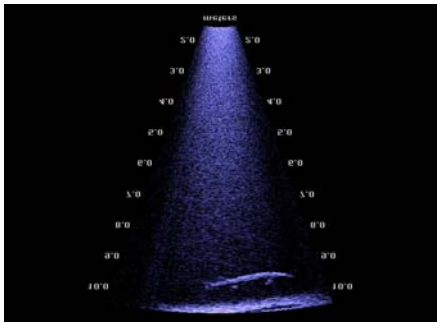
This project will analyze historical data and the 2002-03 radio-telemetry data to assess whether the portion of the Late-run fish entering the Fraser River in August is related to the relative timing and abundance of Summer-run stocks and will develop a model to provide pre-season and in-season forecasts of the portion of the Late-run return that will enter the Fraser River in August.

Influence of Summer-Run Sockeye on the River Entry Timing of Late-run Fraser Sockeye: "Stay with the School" Hypothesis. Final Report

Improving Escapement Estimates Using a DIDSON Acoustic Imaging System

Project Lead: Yunbo Xie, hydroacoustics scientist, Pacific Salmon Commission.
Project Cost: $157,000 CAN $119,802 US

At present, side-looking split-beam sonar is used to obtain in-season escapement estimates at Mission on the Fraser River and other rivers that are too wide or too turbid for other techniques. However, fish behaviour near the surface and the bottom and along the right bank at Mission have been identified as key uncertainties in the current enumeration system that cannot be resolved with split-beam sonar techniques. Recently, a new tool, the Dual-frequency Identification Sonar (DIDSON), has been developed. The DIDSON system is a high definition imaging sonar that produces near-video quality images of targets.



Because it is visual, specialized training is not needed for data collection, substantially reducing operating costs and the DIDSON can be used at sites in the upper Fraser watershed that are not suitable for split-beam sonar (e.g.,

shallow, bouldery bottoms). We propose the one-time purchase of a DIDSON system and its deployment at Mission early in the year to address key questions related to effects of fish behaviour on escapement estimates, followed by deployment further upstream to assess the feasibility of providing spawning ground escapement estimates or estimates of en-route losses through the Hell's Gate canyon.

Use of Dual-Frequency IdentificationSonar to Verify Split-Beam Estimates of Salmon Flux and to Examine Fish Behaviour in the Fraser River. *Final Report*

Observations of Avoidance Reactions of Migrating Salmon to a Mobile Survey Vessel in a Riverine Environment. *Final Report*

Feasibility of Deploying a DIDSON Acoustic Imaging System for Spawning Escapement Estimation

Project Lead: John Holmes, Research Scientist, Pacific Biological Station.
Project Cost: $100,000 CAN $76,307 US

The DIDSON (Dual-frequency Identification Sonar) is a high resolution acoustic imaging system that produces near-video quality images of fish targets. The DIDSON system is small, highly portable, monitors continuously, can be automated for data collection, and does not require extensive sonar expertise to operate. Experience in Alaska has demonstrated that the operating costs of a DIDSON are probably much lower than the operating costs of some of the techniques currently used to obtain spawning ground escapement estimates. At present, scientific knowledge of the effects of fish density on the accuracy and precision of fish counts produced by a DIDSON is limited, especially at the passage rates observed in the Fraser watershed. Furthermore, the site characteristics and ancillary equipment (e.g., weirs, tripods, pan and tilt mechanism) needed for successful operation of a DIDSON are not clearly known. Because of the design and operating characteristics of the DIDSON, site criteria may be less stringent than those required for the successful operation of a side-looking split-beam system. Although the mainstem Fraser River was surveyed as far as Lytton in the early 1990s for split-beam acoustic system sites, there is greater potential for improvements to current information as a result of deploying the DIDSON in tributary systems such as the Stuart-Nechako, Chilcotin-Chilko and Quesnel-Horsefly. Presently, knowledge of the hydroacoustic potential in these rivers systems is limited. Factors that may affect the performance of a DIDSON system include flow characteristics (laminar vs. turbulent, location of eddies), bottom profile (large boulders may create acoustic shadows), sediment loading (which reduces range through signal attenuation), river hydrology, and fish behaviour (shore-orientation is desirable since the maximum range of a DIDSON is 15 to 30 m depending on the frequency used.

Feasibility of Deploying a Dual-Frequency Identification Sonar(DIDSON) Imaging System to Improve Spawning Ground Escapement Estimation in the Fraser River.
Final Report 1 *Final Report 2*

Fraser River Fishwheels: In-season Abundance and Migration Assessment and System Wide Tagging Platforms

Project Lead: Timber Whitehouse, Sockeye Stock Assessment, BC Interior, DFO.
Project Cost: $172,981 CAN $131,996 US

Fishwheels operating in the mainstem of the Fraser River have served as effective tagging platforms for coho salmon assessment studies in recent years. An Interior Fraser-wide system escapement estimate was generated based on tag totals applied at the Siska site and recoveries from throughout upstream coho spawning sites. We propose to repeat the coho system wide tagging study in 2004, with extension of spawning grounds coverage into at least 8-10 previously un-assessed upper Fraser coho spawning streams in the upper watershed. A feasibility study to determine ability to establish extensive coho escapement indicators in the upper Fraser is also required. While fishwheels have fished for limited, non-peak, sockeye migration periods in the past, we propose to further evaluate their utility by extending operation into higher discharge periods and under the much higher abundance regimes associated with Fraser sockeye migration. Two and possibly three sites would be evaluated to determine the capacity of this gear type to fish effectively at higher discharge levels in June and July, as well as with the much greater abundance during sockeye migration. It is crucial to understand how changes in the physical characteristics of the migration environment will affect both vulnerability and catch-ability of different salmon species. Additionally, it is important to know whether abundance issues will result in gear saturation and a subsequent reduction in ability to sample representatively. The ability to demonstrate representative sampling across variable discharge levels may lead to the opportunity to develop reliable in-season indices of abundance at various points along the migratory route, similar to programs in both the Skeena and Nass River systems.

Development of this capacity can have a significant impact on in-season management decisions if the reliability of the catch data can be demonstrated. Issues such as discharge related migration delay or en-route mortality could be evaluated by using the gear type as an annual tagging platform for the application of conventional Petersen, radio, or acoustic tags. Developing confidence in this capacity will require multi year studies that inter-calibrate indices of run strength, catch and escapement.

Fishwheel Assessment of the 2004 Sockeye Salmon (Oncorhynchus nerka) Migration in the Fraser River at Siska Canyon. *Final Report*

Remotely Operated Vehicle (ROV) for Underwater Video Assessment of Sockeye Salmon Distribution on Lake Shore Spawning Grounds and in Migratory and Holding Areas

Project Lead: Timber Whitehouse, Program Head, Sockeye Stock Assessment, BC Interior, DFO.
Project Cost: $58,750 CAN $44,830 US

A highly portable, remotely operated underwater vehicle has been recently deployed on Fraser River sockeye spawning grounds to assess the presence/absence of carcasses in near terminal holdings areas (Shuswap Lake) and in the assessment of spawner distribution in deep water spawning areas that are inaccessible to surface based observers (Cultus Lake). The unit is easy to operate and video output can be viewed in real time, while simultaneously logging results to digital storage media on the surface. Multiple applications for this technology are proposed to provide improved or primary information for a number of stock assessment issues that are recurrent in Fraser sockeye migratory and terminal area assessment. We propose the purchase of a ROV for the development of underwater survey techniques to enumerate lake shore sockeye spawning populations.

Current assessment techniques fail to provide accurate means of enumerating lake spawning populations because the fraction of the population accessible to visual observers is variable and unknown, especially in deepwater systems like Quesnel & Shuswap, or in turbid systems like Chilko L., Middle R., or Seton L. The ROV would permit mapping of spawning distribution and density on deep water beach spawning areas, or in low visibility habitats so that the observable fraction of the population could be calibrated relative to the total spawner distribution and density which are out of surface based visual detection range. Application also extends to use in migratory and holding areas where survey techniques could be developed to monitor for the presence of sockeye carcasses associated with en-route mortality. High levels of sockeye die-off have been identified in recent years (e.g. Adams River 1999, 2002; Cultus Lake 2000, 2001, 2002; Weaver Creek 2001; Portage Creek 2001) often associated with no visible indications that fish died in migration or holding areas.

Development of an ROV based survey to identify and monitor sockeye migratory and holding areas for carcass presence would permit us to confirm and quantify en-route losses by survey reach, this capacity has not existed before. We have evaluated this technology over the past two years and recognize the significant potential it could provide in improving our lake assessments. We also feel there is a significant opportunity to conclusively address enroute losses in areas where surface carcass accumulations have been unable to corroborate the expected magnitude of die-off anticipated from in-season vs. terminal area estimate comparisons. We propose to develop survey techniques at various locations in the Fraser watershed this year (Weaver/Harrison, Chilliwack, Cultus, Tachie & Middle River, Seton) to begin to address gaps in current knowledge. These data will ultimately improve Fraser sockeye assessment quality and lead to improved resolution for in-season management purposes (mortality monitoring).

Evaluation of a Video Equipped Remotely Operated Vehicle (ROV) for the Underwater Video Assessment of Fraser River Sockeye Salmon Populations. *Final Report*

Increased DNA Analysis on Samples Taken from the Round Island Gillnet Test Fishery and the Johnstone Strait 10 Boat Gillnet Assessment Fishery to Improve Assessment Capabilities on Early Summer Run Fraser River Sockeye

Project Lead: Les Rombough, President, Area D Salmon Gillnet Association
Project Cost: $50,000 CAN $38,153 US

DNA samples taken from fish caught in the 2002 and 2003 Johnstone Strait 10 boat gillnet assessment fishery have not been analyzed. A component of this project is to have these samples analyzed and compared to samples taken from the Round Island gillnet test fishery and the upper Johnstone Strait purse seine test fishery during these two years. In addition there are efforts being made to incorporate a 90 mesh net into the gillnet test program at Round Island for 2004. A second component of this project is to collect and analyze DNA samples from both the 60 and 90 mesh nets in this test fishery as well as DNA samples from the 10 boat gillnet assessment fishery in Johnstone Strait. A third component of the project is to compare the DNA results from the Round Island gillnet test, the 10 boat gillnet assessment fishery, the full fleet gillnet fishery and the upper Johnstone Strait purse seine test fishery. The overall goal is to improve our assessment capabilities in Johnstone Strait for Early Summer Run Fraser River sockeye.

DNA Analysis from Johnstone Strait Gillnet Assessment & Test Fisheries. *Final Report*

Alternate Fraser River Test Site DNA Sampling

Project Lead: Ken Connolly, Manager, Area E Gillnetter's Association.
Project Cost: $45,000 CAN $34,338 US

This project will provide DNA sampling at the new test sites established in 2003. We would use this opportunity to provide information to the Pacific Salmon Commission and Dept. of Fisheries and Oceans when requested. If so required we could use an alternate test site closer to the confines of the Pitt River for DNA sampling. Area E Gillnetters Assoc. still requests the use of the Brownsville Bar and Wing Dam sites with the possible use of an alternate site as in Douglas Island drift site.

2004 Area E Gillnet Fraser Sockeye Gill Net Assessment Fishery. *Final Report*

Develop Techniques for Upper Fraser River In-Season Salmon Run Size Assessment Using DNA Stock Identification Procedures

Project Lead: Dr. David Levy, Fisheries Consultant, Lheidli T'enneh Band
Project Cost: $36,000 CAN $27,470 US

The Lheidli T'enneh Band Agreement in Principle (July 26, 2003) contains provisions for involvement of the Lheidli T'enneh in future management of Upper Fraser River fisheries, in partnership with Canada and British Columbia. The Upper Fraser In-Season Run Size Assessment Project has been funded under a Treaty Related Measure (TRM) to develop a methodology for assessing sockeye run size in the Lheidli T'enneh Fish Area and further upstream. Development of this capability will be critical to identifying sockeye stock conservation concerns; to better identify stock migration timing; to meet escapement targets; and to implement and manage commercial and FSC fisheries under the Lheidli T'enneh Final Agreement, and identify the existence of fish "surpluses". Similar requirements are also needed for in-season assessment of Upper Fraser chinook populations (e.g., Stuart/Nechako River systems). This project is proposed to complement quantitative assessment feasibility work planned for summer, 2004. Stock ID utilizing DNA analysis is now a proven technique for Fraser sockeye and chinook, and, in conjunction with an accurate enumeration system, would permit the estimation of upriver salmon stock abundance estimates in near-real time. The planned TRM project will deploy a fish wheel and set nets in summer 2004 and will therefore provide the necessary source of DNA samples. Funding is requested under the SBREF to pay for the analysis of 1200 DNA samples by PBS, DFO at a cost of $30 per sample. All costs for sample collection and data analysis will be borne by the TRM project, and all collected data will be made available to any interested parties.

Application of DNA Stock Identification for Estimating Chinook and Sockeye Salmon Run Size in the Upper Fraser River. *Final Report*

CHINOOK SALMON

Validation of a Long-Range Dual Frequency Identification Sonar (DIDSON-LR) for Fish Passage Enumeration in the Methow River

Project Lead: Peter Galbreath, Senior Fisheries Scientist, Columbia River Inter-Tribal Fish Commission.
Project Cost: $233,653 CAN $178,293 US

The Columbia River Inter-Tribal Fish Commission (CRITFC) proposes to conduct a field assessment of the DIDSON-LR, for counting returning summer Chinook salmon in the Methow River, Okanogan County, Washington. This test will be performed in concert with an ongoing project from the ADF&G managed Southeast Sustainable Salmon Fund (SSSF; Title - CRITFC: A Stock Assessment and Research Plan For Mid- Columbia River Summer Chinook, Project No. 45060). The objectives of the SSSF project are to obtain abundance and genetic analysis data for summer Chinook salmon in this mid-Columbia River, in support of the US-Canada Pacific Salmon Treaty which regulates ocean harvest using an abundance based management approach. The aggregate stock of Mid-Columbia summer Chinook salmon, which includes a portion which home to the Methow River, has been identified by the Pacific Salmon Commission as an

exploitation rate indicator stock. Because abundance data for this stock is of questionable accuracy, the SSSF project was designed to install and operate a counting tower to furnish improved data on escapement. The tower is located at a site just upstream of the confluence of the Methow River with the Columbia River. We propose in this project to purchase and install a DIDSON-LR at the same site and collect data simultaneously with the counting tower. In periods of modest flow and high clarity typical during the summer-fall migration season, the counting tower data will be highly accurate, and the accuracy of the corresponding DIDSON-LR data can be assessed. Conversely, during occasional periods of poor visibility (high flow and turbidity), the tower counting will underestimate fish passage, and comparison with the DIDSON-LR counts may be used to (partially) readjust the counting tower data. Additionally, a controlled range limitation experiment will be performed to validate readings from the DIDSON-LR against passage of a target fish over the entire width of the river.

Validation of a Long-Range Dual Frequency Identification Sonar(DIDSON-LR) for Fish Passage Enumeration in the Methow River. *Final Report*

DNA Based Determination of Stock Composition of Catch and Release Chinook Salmon for Comparison to Coded Wire Tag (CWT) Estimated Composition

Project Lead: Wilf Luedke, Acting Area Chief, South Coast Stock Assessment, DFO
Project Cost: $151,000 CAN $115,223 US

DNA will provide information to supplement and contrast with CWT data regarding stock group specific impacts of the WCVI troll fishery. This is important in the current WCVI troll fishery because it operates during parts of the year where little CWT data exists. In addition, the low sample rate associated with the regular mark recovery program (MRP) for CWT may not have the capability to identify impacts in new fisheries, especially on the monthly time scale required. Consequently, DNA is used to supplement the CWT information to provide the best available estimate of impact on stocks.

Available DNA information suggests a non-random distribution of chinook in the ocean. Stocks have different behaviours (e.g. WCVI chinook are near shore oriented), likely rear in schools of similar stock origin, and likely have different migration pathways. This patchy distribution of fish may result in a patchy distribution of chinook catch. Due to logistic considerations the chinook troll fisheries have been sampled using the boat as the basic unit. Consider this to be "clustered" random sampling. If the catch is also patchy then the current method of expanding CWT to the entire fishery may be inappropriate and result in considerable imprecision in the result. Statistical uncertainties in the current CWT sampling program, and the subsequent analyses using CWT, will be explored in 1-2 discrete fisheries. In these 1-2 fisheries the sample rates will be increased from 20% to 80+% for CWT, and from 100 DNA samples/opening to 1000+ DNA/opening to evaluate the effects of patchy fish distribution, clustered sampling rather than simple random sampling, and stratification by area and gear. This will provide insight into both accuracy and precision of CWT and DNA information.

DNA Determination of Stock Composition for Catch and Release Chinook. *Final Report*

Evaluation of the Magnitude of Hatchery Chinook Straying Into Natural Spawning Areas from Otolith Marks

Project Lead: Jeff Till, Salmon Technician, Thermal Marking Coordinator
Project Cost: $50,000 CAN $38,153 US

We do not fully understand the extent to which hatchery fish stray into natural spawning areas in their rivers of origin and other rivers. Preliminary data from recent years indicates that there may be extensive straying of chinook along the West Coast of Vancouver Island (WCVI). For example, otolith analysis from the Gold River on the WCVI in 2002 and 2003 indicates the majority of the chinook there originated from Robertson Creek hatchery. This project will expand our knowledge of the extent to which hatchery stocks stray through sampling and examination of otoliths in a number of rivers. Complicating this analysis is the fact that initial comparisons of thermal mark and coded wire tag (CWT) data from Robertson Creek Hatchery and Stamp River have indicated differences in hatchery contribution findings between the two methods. Hatchery contributions based on CWT have been considerably lower than otolith based estimates. This project will allow continued sampling and analysis of otoliths in rivers along the WCVI and elsewhere. A time series of repeatable results will provide the necessary evidence and certainty to make conclusions about biases in CWT results. These biases may be important in current assessment methods, assumptions of mark mortality, and may alter our management processes. The implications of this work are significant to the evaluation of hatchery operations and hatchery impacts on wild salmon. It is even more important in the evaluation of CWT which we use as the basis for most of our chinook and coho assessments. The results from CWT are the basis for calculating exploitation rate, stock composition, and survival rates as well as providing the data for stock status determination, escapement targets, and other assessments. Due to the potential significance of the results to the way we do business, this should be viewed as an ongoing requirement for the development of potential alternatives to CWT. This work has been developmental and will not be funded within the DFO core operational work. However, this work is agreed to be a high priority because of its potential implications to past and future assessments, enhancement policies, and management models.

Magnitude of Hatchery Chinook Straying from Otolith Mark. Final Report
Please contact PSC for report appendices.

COHO SALMON

Development and Documentation of a Coho Mixed Stock Model (FRAM Component)

Project Lead: Wilf Luedke, Acting Area Chief, South Coast Stock Assessment, DFO
Project Cost: $50,000 CAN $38,153 US

Estimates of stock group abundance and fishery specific exploitation rates are required to calibrate the coho Fishery Regulation Assessment Model (FRAM). These estimates, if routinely available for all years, would also allow post-season evaluation of model performance and the impact of U.S. and Canadian fisheries. A suite of tools on a variety of platforms and programming languages have been employed to generate the FRAM base (1986-1991); however, these estimates need to be made annually for assessment as well as for the generation of alternative FRAM base years. Placing these tools on a PC platform as components in a Visual Basic (VB) program will have the benefit of addressing some contemporary analytical needs,

facilitating the analyses and making the procedures accessible to all parties. An important component is the Mixed Stock Model (MSM) whose mission is to estimate production expansion factors (PEF) from CWT recoveries. The PEF estimates combined with estimated CWT recoveries provide stock composition estimates. Currently, MSM resides on a main frame computer and is coded in C. Besides difficulty of access to the tool, stocks with similar distributions in fisheries cause collinear problems. The solution is to combine stocks for the purposes of estimation or to remove stocks by assuming the associated PEF's are known. Also, we anticipate problems with sparse fishery information in unevaluated and future years and the need to combine GCI and CWT recovery information to generate the PEF and stock composition estimates. This project will improve MSM operation, extend the current methodologies to improve the PEF estimates, develop new VB code on a PC platform to improve access to users and document the procedures. The MSM component will have the ability to identify collinear stock problems, to allow the user to redefine fisheries, to specify fishery related weights to be used in the least squares estimation, and to include prior information (e.g., from GCI stock composition) on the PEF's.

 *Coho Mixed Stock Model.* *Final Report*

Joint FRAM Coho Model Development – US Component

Project Lead: Jeffrey Haymes, Coho species specialist & James Packer IT specialist, WDFW, Olympia
Project Cost: $320,656 CAN $244,682 US

Successful implementation of the Southern Coho Management Plan depends on development of planning tools used to evaluate performance of fisheries regimes adopted by the parties to the Pacific Salmon Treaty. This project represents the U.S. portion of essential tasks that have been defined by the bilateral Coho Technical Committee and Southern Panel, intended to produce necessary components of the agreed planning tools (specifically the Fishery Regulation Assessment Model – FRAM) and the data needed as input for application of those planning tools and documentation of those products. Goals are: (1) the programming specialist will convert existing UNIX based programs to PC-based programs structured in Visual Basic resulting in the integration of four computation modules into a single program used to perform a complete cohort analysis; (2) he programming specialist will develop PC-based command files and test performance of programs with simulated input data; (3) a historical database will be created containing products of annual cohort reconstruction and analysis of CWT data for Puget Sound and Coastal Washington management units.

 *FRAM Coho Model Development & Support Final Report.* *Final Report*

Development and Documentation of an Expanded Canadian FRAM Base Period for Coho

Project Lead: Arlene Tompkins, DFO Biologist, Pacific Biological Station, Nanaimo.
Project Cost: $15,000 CAN $11,446 US

FRAM requires that current fisheries be scaled to historic fishery specific exploitation rates to predict impacts. The current version of coho FRAM uses exploitation patterns derived from CWT recovery data from 1986-1991 catch years as a base period. We propose to compile the necessary data from regional and area-specific databases and records to expand the base period to better represent current fishery patterns and stock distributional profiles. Priority would be givens to the years: 1) 1992 to 1997; 2) pre 1986; 3) 1998 to current. All data sources and procedures will be documented. The objective of this project is to provide the fishery managers with a number of base period options that can be selected depending on annual fishing plans and predicted stock distributions. A contractor will be hired to work with agency staff to compile agency data.

Canadian Coho FRAM Base Period Expansion Project. *Final Report*
Please contact PSC for report attachments and data.

Development of Southern BC Fishery Management Modules for Coho (FRAM Component)

Project Lead: Wilf Luedke, Acting Area Chief, South Coast Stock Assessment, DFO
Project Cost: $10,000 CAN $7,631 US

A common method to project fishery specific exploitation rates in the simulated year is by specifying an effort scalar relative to a base (1986-1991 mean). The scaling is usually accomplished by relating base effort measures to that predicted for the year to be modeled. Where effort predictions are not available catch ratios (predicted to that observed in the base year) can be used. We will assume that net fisheries are not directed at coho; thus, effort scalars are straightforward because the underlying catchability does not change. For hook-and-line fisheries, the effort directed at coho depends on what other salmon species are available (relative catchabilities and value to the user) and ant time/area closures. The objective of this work component is to assist the FRAM user in establishing the exploitation rate scalars. Specific work tasks for implementation of this component are as follows:

1. Compile directed effort for BC hook-and-line and net fisheries and time periods as defined for FRAM over the base years (1986 to 1991). Use the multi-species algorithms developed for the hook-and-line management models to partition effort directed at coho.
2. Develop an algorithm to approximate coho directed effort for hook-and-line fisheries based on predicted run of all salmon species and effort by time period. Implement the algorithm using application VB macros inside an Excel spreadsheet.
3. Assemble preseason effort predictions from net planning models (e.g., PSC Sockeye Planning Model). Where not available use catch expectations in comparison to the base years to compute a pseudo effort scalar.
4. Document algorithms and procedures in a memorandum format.

Final Report of the Southern BC Fishery Management Module. *Final Report*
Please contact PSC for report appendices and attachments.

Terminal Management Framework & Modeling for Cowichan River as a Pilot for Canadian TAMM's

Project Lead: Wilf Luedke, Acting Area Chief, South Coast Stock Assessment, DFO
Project Cost: $35,000 CAN $26,707 US

The Cowichan River has been selected as the first implementation of a Terminal Allocation Model (TAM) in Canada. Southern coho are managed on an abundance-based (ABM) approach. The FRAM model is the main tool for managing impacts in marine fisheries. In the US, TAMs provide the framework for managing terminal fisheries. Both models are required to implement ABM. To date, no terminal models have been developed for Canadian coho stocks. The Cowichan River drains one of the largest watersheds on Vancouver Island. The river supports coho, chinook and chum salmon populations. There are multiple stakeholders using the salmon resources and there is typically conflict over competing use of these stocks. Stakeholders include First Nation bands, recreational fishers and a well-developed commercial sport fishery as well as the local enhancement society and habitat users (e.g. forestry companies, municipality). To develop the model three main tasks need to be initiated. First, the best available stock and habitat data need to be assembled and synthesized to develop habitat-based escapement targets. Second, an annual assessment plan to estimate coho population abundance needs to be generated and implemented. Third, a formal process needs to be developed for managing the terminal allocation and coordinating enhancement and re-mediation activities towards reduced user conflict and long-term sustainability of the salmonid populations.

Final Report of the Cowichan River Terminal Allocation and Management Framework. *Final Report Please contact PSC for report appendices.*

Joint Development of a Standardized DNA Baseline for Coho Salmon, Washington and BC

Project Lead: Terry Beacham, DFO Molecular Genetics Lab, Pacific Biological Station, Nanaimo.
Project Cost: $40,000 CAN $30,523 US

An ongoing data need for managing coho salmon fisheries and harvests throughout the Southern Boundary area is estimating stock contributions (and exploitation rates) for major mixed-stock fishery harvests in southern B.C. and Washington. While allozyme (protein) analysis can provide informative estimates of contributions of groups of genetically similar populations it does not have the resolving power necessary for stock-specific analyses. Based on preliminary studies of coho and other species of Pacific salmon, microsatellite DNA shows considerable promise for increasing the resolution of such analyses to the level of individual stocks. However, the absence of a standardized approach for DNA analysis by DFO and WDFW (the two agencies with primary fishery management responsibility in this region) has prevented the development of a shared DNA baseline for addressing PST-level issues between Canada and the U.S. This project will provide a basis for applying the high resolving power (and non-invasive sampling) of DNA-based mixed-stock analysis to address international (and domestic) information needs for chum salmon fishery management and conservation. We propose to implement for coho salmon the same general approaches and mechanisms currently being utilized to achieve coast-wide chinook microsatellite DNA standardization. The starting points will be locus screening protocols and methodologies currently being independently employed by the DFO (Nanaimo) and WDFW (Olympia) Genetics Laboratories for studies of coho populations within their respective jurisdictions. Through a process of independent genetic analysis of shared tissue from 192 fish,

exchange and review of electropherograms and processed data, and standardization/coordination meetings we will first identify a suite of 20-30 candidate loci (and share the lab-specific protocols for their analysis). Next, each lab will screen a common set of 96 new samples for all candidate loci and rank each locus. This will lead to the identification of a potential core set of the best 12-18 loci. The third step will be to screen a new set of 192 fish to assess (and refine) allele scoring/binning to assure standardization among laboratories at all core loci. Once standardization has been achieved, the initial DNA baseline data set will have to be assembled in future years by screening approximately 100 representative coho salmon stocks.

Development of a Standardized Suite of Microsatellite Loci to be Used in the Establishment of a Coho Salmon Baseline for Southern B.C. and Washington.
Final Report

Joint Development of a Standardized DNA Baseline for Coho Salmon in Washington and BC. Standardization of Loci and Allele Scoring Between Labs

Project Lead: James Shaklee, Genetics Laboratory, WDFW, Olympia.
Project Cost: $39,315 CAN $30,000 US

An ongoing data need for managing coho salmon fisheries and harvests throughout the Southern Boundary area is estimating stock contributions (and exploitation rates) for major mixed-stock fishery harvests in southern B.C. and Washington. While allozyme (protein) analysis has provided informative estimates of contributions of groups of genetically similar populations it does not have the resolving power necessary for stock-specific analyses. Based on preliminary studies of coho and other species of Pacific salmon, microsatellite DNA shows considerable promise for increasing the resolution of such analyses to the level of individual stocks. However, the absence of a standardized approach for DNA analysis by DFO and WDFW (the two agencies with primary fishery management responsibility in this region) has prevented the development of a shared DNA baseline for addressing PST-level issues between Canada and the U.S. This proposal (and its counterpart from the DFO Nanaimo Molecular Genetics Lab) to standardize DNA marker classes, loci, and alleles for coho salmon is a first step in developing a shared Washington – British Columbia coho DNA baseline that will overcome this obstacle.

Development of a Standardized Suite of Microsatellite Loci to be Used in the Establishment of a Coho Salmon Baseline for Washington and Southern B. C.
Final Report

DNA Based Determination of Stock Composition of Catch and Release Coho Salmon for Comparison to Coded Wire Tag (CWT) Estimated Composition

Project Lead: Wilf Luedke, Acting Area Chief, South Coast Stock Assessment, DFO
Project Cost: $23,500 CAN $17,932 US

With non-retention of wild (non-adipose fin clipped) coho, CWT do not provide the utility for estimating stock composition which they once did. Stock composition of released wild coho can be estimated using DNA stock ID techniques. In jurisdictions where total escapement is estimated (most US and interior Fraser) exploitation rates can be determined using estimated fishing mortalities from stock specific catch estimates such as those derived using DNA. Canada specifically uses DNA to estimate exploitation of interior Fraser coho to evaluate whether

domestic exploitation rate caps have been met. Canada has indicated that annual reviews of exploitation rate compliance through direct measurement should be conducted. The mixed stock model (MSM) used to populate the coho fishery regulation assessment model (FRAM) has been based on CWT to estimate catch by stock. DNA is a viable alternative which perhaps can be used in future versions of MSM. The project to update MSM will incorporate the capability to use DNA information. Shaping of fisheries can be achieved to provide fishing opportunities while conserving stocks of concern through increased knowledge about distribution patterns and migration behavior of these stocks.

DNA Stock Composition Estimates for Catch and Release Coho. *Final Report*

CHUM SALMON

Joint Development of a Standardized DNA Baseline for Chum Salmon, Washington and BC

Project Lead: Terry Beacham, DFO Molecular Genetics Lab, Pacific Biological Station, Nanaimo.
Project Cost: $45,000 CAN $34,338 US

An ongoing data need for managing chum salmon fisheries and harvests throughout the Southern Boundary area is estimating stock contributions (and exploitation rates) for major mixed-stock fishery harvests in southern B.C. and Washington. While allozyme (protein) analysis can provide informative estimates of contributions of groups of genetically similar populations it does not have the resolving power necessary for stock-specific analyses. Based on preliminary studies of chum and other species of Pacific salmon, microsatellite DNA shows considerable promise for increasing the resolution of such analyses to the level of individual stocks. However, the absence of a standardized approach for DNA analysis by DFO and WDFW (the two agencies with primary fishery management responsibility in this region) has prevented the development of a shared DNA baseline for addressing PST-level issues between Canada and the U.S. This project will provide a basis for applying the high resolving power (and non-invasive sampling) of DNA-based mixed-stock analysis to address international (and domestic) information needs for chum salmon fishery management and conservation. We propose to implement for chum salmon the same general approaches and mechanisms currently being utilized to achieve coast-wide chinook microsatellite DNA standardization. The starting points will include some collection of Canadian representative chum stocks, and initiation of locus screening protocols and methodologies currently being independently employed by the DFO (Nanaimo) and WDFW (Olympia) Genetics Laboratories for studies of chum populations within their respective jurisdictions. Through a process of independent genetic analysis of shared tissue from 192 fish, exchange and review of electropherograms and processed data, and standardization/coordination meetings we will first identify a suite of 20-30 candidate loci (and share the lab-specific protocols for their analysis). Next, each lab will screen a common set of 96 new samples for all candidate loci and rank each locus. This will lead to the identification of a potential core set of the best 12-18 loci. The third step will be to screen a new set of 192 fish to assess (and refine) allele scoring/binning to assure standardization among laboratories at all core loci. Once standardization has been achieved, the initial DNA baseline data set will have to be assembled in future years by screening approximately 100 representative chum salmon stocks.

Development of a Standardized Suite of Microsatellite Loci to beUsed in the Establishment of a Chum Salmon Baseline for Southern B.C. and Washington.
Final Report

Joint Development of a Standardized DNA Baseline for Chum Salmon in Washington and BC. Standardization of Loci and Allele Scoring Between Labs

Project Lead: James Shaklee, Genetics Laboratory, WDFW, Olympia.
Project Cost: $39,315 CAN $30,000 US

An ongoing data need for managing chum salmon fisheries and harvests throughout the Southern Boundary area is estimating stock contributions (and exploitation rates) for major mixed-stock fishery harvests in southern B.C. and Washington. While allozyme (protein) analysis has provided informative estimates of contributions of groups of genetically similar populations it does not have the resolving power necessary for stock-specific analyses. Based on preliminary studies of chum and other species of Pacific salmon, microsatellite DNA shows considerable promise for increasing the resolution of such analyses to the level of individual stocks. However, the absence of a standardized approach for DNA analysis by DFO and WDFW (the two agencies with primary fishery management responsibility in this region) has prevented the development of a shared DNA baseline for addressing PST-level issues between Canada and the U.S. This proposal (and its counterpart from the DFO Nanaimo Molecular Genetics Lab) to standardize DNA marker classes, loci, and alleles for chum salmon is a first step in developing a shared Washington – British Columbia chum DNA baseline that will overcome this obstacle.

Development of a Standardized Suite of Microsatellite Loci to be Used in the Establishment of a Chum Salmon Baseline for Southern B.C. and Washington.
Final Report

MULTI-SPECIES

Increase Observer Accuracy on Species Identification and Data Collection on the Test Boats for the FSC Coordinated Fishery

Project Lead: Natalie Nelson, Coordinator, First Nations Marine Society, Nanaimo.
Project Cost: $14,000 CAN $10,683 US

In 2003 observer accuracy in estimating numbers of sockeye and pink salmon during the FSC coordinated fishery resulted in some inconsistencies with in-season off-loads at the delivery plants. For 2004 observers will be trained at the Fisheries Observer course offered by Malaspina College in Nanaimo. Once trained the observers would be deployed on the Test Fishing vessels participating in the 2004 FSC Coordinated Fishery. Funding is required for the training course and to pay for observer coverage during the FSC Coordinated Fishery.

Increase Observer Accuracy on Species Identification and Data Collection on the Test Boats for the FSC Coordinated Fishery. *Final Report*