SALISH SEA MARINE SURVIVAL PROJECT
CANADIAN BACKGROUNDER
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BACKGROUND CONTEXT

In 2009, the Pacific Salmon Foundation (PSF) was asked to investigate why the production of chinook and coho salmon within the Strait of Georgia crashed during the 1990s and has not recovered (Figure 1). The Strait of Georgia is British Columbia's (BC) inland sea located between Vancouver Island and the provincial mainland. The Georgia Basin and tributaries are home to three-quarters of the population of BC, many of whom use the area for a wide variety of recreational and commercial activities. In the past, these fisheries were amongst the most valuable in Canada, but that changed dramatically in the mid-1990s. Catches that annually had numbered in the hundreds of thousands to a million fish decreased to a mere tenth or less of those levels and have not recovered despite continued investments in hatchery programs and significant reductions in fishing pressures. Regrettably, these losses have not been explained or addressed[1]; and the public is increasingly concerned about the future of salmon, the health of our inland sea, and the continued economic impacts on local communities. Monitoring of hatchery salmon released into the Strait of Georgia and Fraser River has clearly demonstrated a

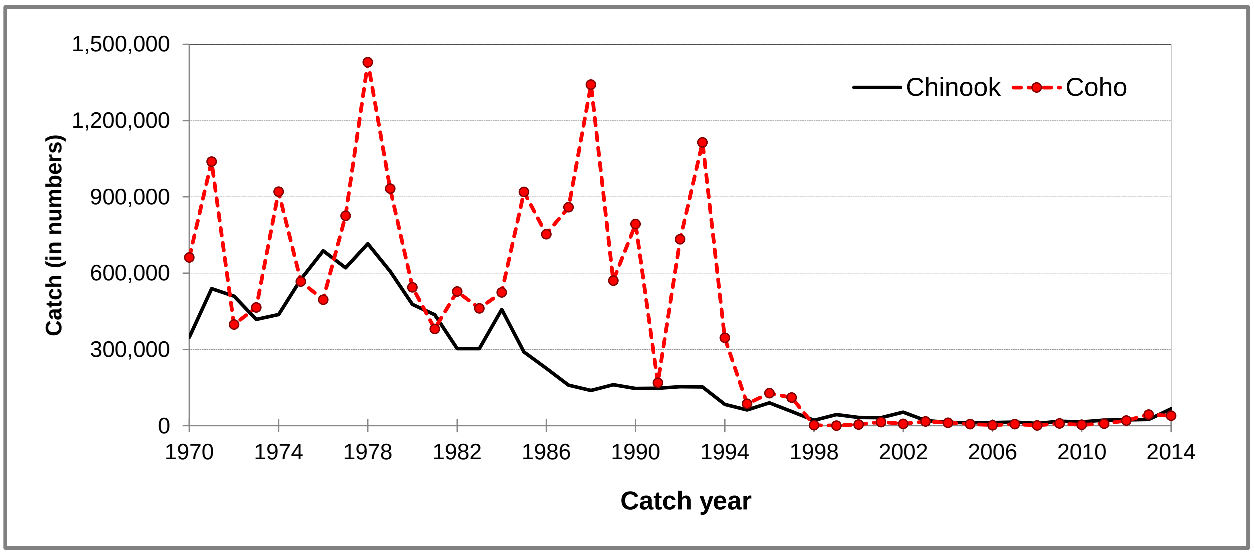

Figure 1. Landed catch of Chinook and coho salmon in the Strait of Georgia and Strait of Juan de Fuca, 1970 to 2014. Previous to 1995, catches included recreational fishing and commercial troll; but following is limited to recreational catch as troll gear is prohibited for Chinook and coho in this region.

significant decrease in the survival rate of these fish but the cause of this decline has not been determined. The PSF developed a scientific program[2] to determine what presently limits the production of Chinook and coho salmon and what mitigation actions may be undertaken to

[1] The most recent effort to examine the Strait of Georgia and it biodiversity has been reported in the scientific journal Progress in Oceanography (2013), volume 115; and the book "The Sea Among Us, the amazing Strait of Georgia", by RA Beamish and G. MacFarlane. 2014. Harbour Publishing.

[2] The Strait of Georgia Chinook and Coho Salmon proposal (2009). Available at: www.marinesurvivalproject.com

increase production. Promoting the restoration of these fisheries could be invaluable to British Columbia and studies of the early marine life of Pacific salmon is a natural extension of the Foundation's core programs working in freshwater streams and with local communities.

However, the Strait of Georgia is also part of a larger ecological zone contiguous with the Puget Sound and the Strait of Juan de Fuca; in combination this region is referred to as the Salish Sea. As in Canada, the American portion of the Salish Sea is also a human population center with extensive development, and many similar problems for Pacific salmon. Many fisheries in these joint waters are considered under the Pacific Salmon Treaty (1985) between the United States and Canada (www.psc.org). Decreased production of salmon in the Salish Sea has severely limited fishing opportunities and presents numerous issues under the Treaty. To address these issues, in October 2013, an endowment fund under the Treaty agreed to fund 25% of an international research program modelled after the Strait of Georgia program … the Salish Sea Marine Survival Project (SSMSP). The SSMSP has been developed to identify the factors determining annual production of Chinook, coho salmon, and Steelhead[3] trout in the Salish Sea. It was initiated in response to the declines in Chinook, coho and steelhead production, but also because of other ecological changes in the Salish Sea, and increasing evidence that the overall survival of juvenile salmon at sea is largely determined in the first few months after entry to the marine environment.

The SSMSP has been designed as a 5-year, $20 million ecosystem-based, interdisciplinary study involving government, universities, private consultants, local communities, and not-for-profit groups. The Project is coordinated by nonprofits, Seattle-based Long Live the Kings (LLTK) and Vancouver-based Pacific Salmon Foundation (PSF).

Objectives

The primary objectives of the Salish Sea Marine Survival Project is to determine the principal factors affecting the survival of juvenile salmon and steelhead in the Salish Sea. In Canada these studies are intended to:

- Re-build production of wild Pacific salmon and steelhead through a program that is ecosystem-based, considers hatchery effectiveness, and engages communities.
- Promote sustainable fisheries and increase their value to B.C. communities, and
- Provide a foundation for long-term monitoring of Salish Sea and salmon health.

Ultimately, the research results and subsequent management actions may also benefit other marine life in the Salish Sea, such as the southern resident killer whales[4].

[3] The original focus in Canada was on the loss of Chinook and coho catches, but in Puget Sound, Steelhead trout are also a significant concern. Production of steelhead trout in southern BC has also declined in recent decades but has not received the attention of Chinook and coho salmon. All three species will be included in the project.

[4] The Southern Resident Killer Whale population is listed as 'endangered' under Canada's Species at Risk Act (http://www.registrelep-sararegistry.gc.ca/default.asp?lang=En&n=A9748209-1).

Scope and Geographic Range of the Study

The geographic range of this project includes the entire Salish Sea, the body of water that extends from the north end of the Strait of Georgia and Desolation Sound to the south end of the Puget Sound and west to the mouth of the Strait of Juan de Fuca (i.e., the inland marine waters of southern British Columbia, Canada and northern Washington State[5]).

The interaction between salmonids with environments in the Salish Sea is complex. This study is being approached from an ecosystem context requiring experts from multiple disciplines. Chinook, coho and steelhead are the species of greatest concern given significant declines in their smolt[6]-to-adult survival (the primary measure of marine survival) since the mid-1990s. However, chum, pink and sockeye will be included to the extent practicable given potential for shared survival determinates; inter-species competition; the recent extraordinary variation in survival of these species, and the associated effects on local fisheries.

The Project's focus will be on factors affecting juvenile salmon and steelhead while they are in the Salish Sea. Understanding the condition of fish entering the Salish Sea marine environment will also be included to assess whether conditions prior to their marine residence affect survival in the Salish Sea. Resident Chinook and coho salmon will be studied as these fish stay within the Salish Sea through adulthood and may provide a clue to how salmon respond to variations in marine conditions. However, it will be more difficult to determine whether conditions in the Salish Sea and the impacts on juvenile salmon, also affect the survival of salmon in the open north Pacific Ocean after they leave the Salish Sea (i.e., Is survival in the North Pacific contingent on the conditions these salmon encounter in their earlier life phases?). Conditions in the North Pacific will not be included other than the large scale environmental indices that have been developed.

Within the Salish Sea, a number of changes over time have contributed to the decline in catch of these Chinook and coho. Before the decline in catches (1980s and into 1990s), fishing pressures exceeded those sustainable for Chinook and coho salmon produced from natural habitats. Compounding this, the marine survival rates of hatchery and natural Chinook and coho declined steadily through that period. The combination of excessive fishing pressures and declining survival rates accelerated the decline in abundance of Chinook and coho salmon. However, reductions in fishing pressure and significant investments in hatchery production during the past 20 years within the Strait have failed to recover local natural populations or sustain associated fisheries.

While scientific and public consultations identified many changes in the Salish Sea over past decades, there was little agreement or understanding on the causes of the salmon declines. It was also apparent that we lack scientific consensus in Canada or the United States on processes presently determining the annual production of Chinook and coho salmon in the Salish Sea.

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[5] See map: http://staff.wwu.edu/stefan/SalishSea.htm

[6] A "smolt" is the stage of a juvenile salmon's life when it is physiologically capable of adapting to saltwater. In this stage, the juvenile becomes silvery (losing it dark bars) and begins migration out of freshwater habitats.

However, in preparing for this research, a short list of the primary concerns and knowledge gaps has been identified:

- Causes of early marine mortality are largely unknown (there is consensus that mortality rates are highest in the first few months in the sea but little agreement on the mechanisms);

- Changes in the marine ecosystems of the Salish Sea have been numerous, widespread, and significant;

- Lack of understanding as to why hatchery-produced salmon were also showing poor survival and not sustaining local fisheries. It is likely that production from the major hatcheries is competing with wild fish.

- Information collected through annual oceanographic surveys have seldom been linked with data on Pacific salmon production or its' variability; and

- Research to-date has lacked a conceptual foundation or plan designed to understand the production of Pacific salmon within the Salish Sea (despite an abundance of researchers, laboratories, and ships).[7]

Conceptual Development of the Study

The lack of consensus on causation could have been anticipated when attempting to assess changes in just a few specific species within a complex natural ecosystem. However, we know that two broad categories of effects will have to be studied. In ecological jargon, these categories are referred to as "**bottom up**" (the annual variation in environmental conditions) versus "**top down**" (biological factors). But in reality, these categories interact in natural ecosystems to generate the annual variations that we observe in salmon abundance, distribution, and growth.

'Bottom-up' control simply means the food that the young fish need is a determining factor. The mechanism involves annual weather conditions and effects mediated through the lower levels of the biological production chain. Initially environmental conditions influence the timing, intensity, spatial extent, and duration of phytoplankton blooms (e.g., winter wind and spring sunlight determine the timing of spring blooms of phytoplankton). Once the primary production (phytoplankton) is initiated, energy is passed through to higher levels (zooplankton and ichthyoplankton (fish eggs and larvae)), upward to small forage fishes and onward to juvenile salmon.

[7] A comprehensive source for publications related to the Strait of Georgia and Pacific salmon can be accessed at the Strait of Georgia Data Centre (www.sogdatacentre.ca) containing over 10,800 references.

'Top-down' control refers to a variety of biological factors that directly limit survival of salmon and therefore their abundance (i.e., what kills juvenile salmon in the Salish Sea). Mortality likely occurs through predation, pathogens and disease expression, competition for food, and human developments including habitat loss, shore-line modifications, and aquaculture. Each of these factors may act singularly but usually the effects involve multiple factors that vary in time, space, and opportunity.

While none of these factors are new insights, they are recurring concerns, and most have not been thoroughly explored for Pacific salmon within the Strait of Georgia and Juan de Fuca.

The challenge then in developing the SSMSP was how to separate the effects of multiple factors to identify the primary determinants of salmon production and, subsequently, what mitigation measures may be possible to improve annual production.

If environmental conditions and bottom-up processes primarily control Chinook and coho production, then recommendations for how to restore and sustain production <u>will be fundamentally</u> different than if top-down biological processes are the primary controls.

Further, biological interactions may have very different consequences depending on what the productivity of the environment is during a particular time and place. This point is not widely appreciated but could be very important. For example, the consequences of interactions between hatchery and natural juveniles may vary widely depending on the abundance and availability of food for juvenile salmonids (i.e., competition for food would be much greater during poorer environmental conditions with resultant poor food production).

Setting Goals for Salmon Recovery

If the marine environment in the Strait of Georgia has changed dramatically over the last 30 years, it is unclear whether the abundances in the 1970/80's are reasonable expectations for future recovery goals. Modeling studies at the University of BC have suggested that recovery may only be possible to about one half of past levels[8,9].

Such models can be an informative representation of natural processes and can identify key sensitivities or unknowns in the development of mitigation plans. However, given our state of knowledge and the numerous interactions possible, it is inappropriate to use them to recommend specific recovery goals at this time. *The SSMSP should more appropriately be*

[8] Source: Martell, S.J., Beattie, A.I., Walters, C.J., Nayar, T., Briese, R., 2002. Simulating fisheries management strategies in the Gulf of Georgia ecosystem using Ecopath with Ecosim. In: Pitcher. T., Cochrane, K. (Eds.), The Use of Ecosystem Models to Investigate Multispecies Management Strategies for Capture Fisheries. Fisheries Centre Research Reports 10(2), pp. 16–23

[9] Recovery to 50% of the past production would still be a very successful program and provide for sustainable fisheries operating at lower but appropriate harvest rates.

considered the beginning of an adaptive management process to restore salmon production over time. The process would include: establishing interim actions and production targets, monitoring responses at a level of detail required to assess actions, and adapting to what is learned. Such a process will likely be more immediately informative for coho salmon but is also important for Chinook salmon, though it may take longer due to their older ages at maturity. This course of action will also directly engage communities and user groups in establishing targets and making key decisions.

Hypotheses for SSMSP

Science advisors to the SSMSP broadly agree that the primary hypotheses to investigate include, in order of significance:

A. Bottom-up processes — annual environmental conditions that determine the food for salmons and therefore result in the variation in size and growth rate of juvenile salmonids.

B. Top-down processes - biological processes that directly determined the survival of salmonids. Predation is likely the direct cause of mortality, but fish condition may be compromised by other biological factors, increasing their susceptibility to predation (e.g., disease, hatchery versus wild competition).

C. Additional in-direct factors exacerbating these ecological processes, including habitat loss, and contaminants.

In actuality, each of these factors interact each year but to differing degrees. Consequently, to explain the annual variation we observe, requires monitoring each of the factors each year. The Project will build out from the condition of juvenile salmon in-river, to estuary environments and habitats used by salmon, and into the near-shore waters in order to identify very local effects occurring within more global factors. The differentiation of where effects are most influential will be important to identify mitigation opportunities versus longer-term adaptation of Pacific salmon to environmental conditions that are changing over time. Identifying the latter is equally important to sustaining future salmon production and may limit production resulting from mitigation actions taken under future environmental conditions.

The SSMSP will build from extensive past research, identify hypotheses presently under consideration (see www.marinesurvivalproject.com), and develop research and monitoring programs to test these. By measuring many factors simultaneously, the SSMSP will allow consideration of multiple hypotheses within and between years. The Project proposes three years of comprehensive and integrated research and analysis, followed by the development of adaptive management actions to rebuild salmon production and sustainable fisheries.

Research Planning

The important differences of the SSMSP from previous efforts is the scope of topics considered simultaneously and the breadth of collaboration involved. The SSMSP benefits from a depth of past research (literally thousands of studies and report, see www.sogdatacentre.ca). But this history covers almost one hundred years of projects and has failed to provide an understanding of the ecological controls/mechanisms that determine the annual production of Pacific salmon within the Strait of Georgia (also true for the geographic area encompassed by the Salish Sea). This is not a comment about the quality of research conducted but the context within which it was conducted. Many individual studies address specific species in a particular time/area and for short periods of years. In a complex and open ecosystem such as the Salish Sea, studying a species without consideration of its broader environment will naturally limit the inferences and understanding that can result. This limitation is the fundamental observation that the Science Team addressed in developing the scope of the SSMSP. Put simply, the SSMP will endeavor to study everything at once that could be hypothesized to impact the annual production of Pacific salmon within the Salish Sea (Figure 2).

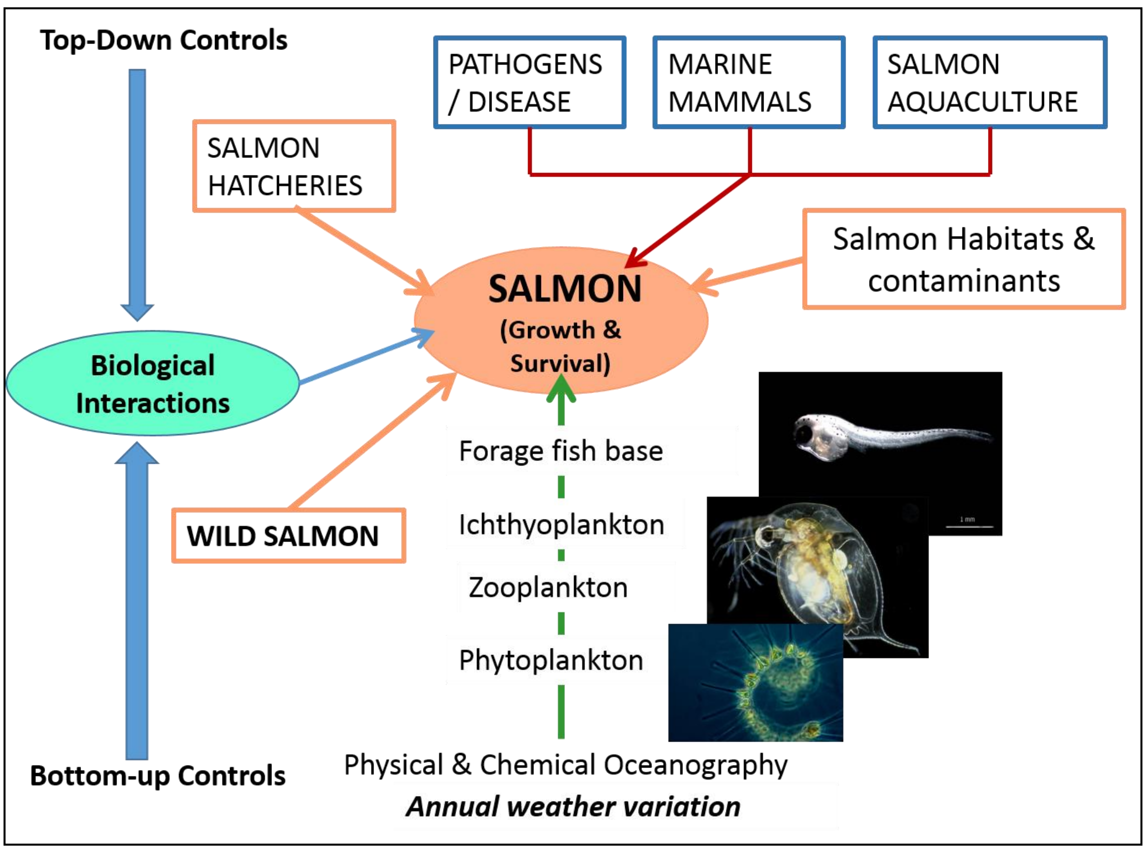

Figure 2. A schematic of the factors addressed annually within the Salish Sea Marine Survival Project. In aggregate, studies within each of these components makes up the SSMSP.

Details of the individual studies within each component cannot be provided in this backgrounder but will be documented in each annual report of the SSMSP and will be available on the SSMSP website (www.marinesurvivalproject.com). But, a project of this scope obviously creates issues of its own issues, for example:

1) Duration of the Project;
2) Building the collaboration to conduct the studies and sustain that effort over time, and
3) Coordination of each program within the overall Project (domestic and international).

While undertaking the breadth of studies is necessary to understand the mechanisms that determine salmon production in a year, we acknowledge that the scope of work cannot be sustained for many years due to the costs and commitment of many researchers; however, this is also a unique attribute of this Project. The SSMSP is a five-year project including one year of planning and testing methods, three years of research intended to cover the full scope of study, and one year for completion of analyses and initial reporting. The Pacific Salmon Foundation has secured the funds for the five years but we fully acknowledge that restoration and management actions will require more time. However, a major objective of this effort is to ensure that ecological monitoring within the Salish Sea continues after the SSMSP so that the health of these ecosystems are no longer neglected.

The ability to undertake the scope of this initiative required building a research network with government laboratories (with Science Branch, Dept. Fisheries and Oceans, Canada), First Nations, universities, non-government organizations, and local communities. The network has been built over the past few years and is based on the common objective of promoting sustainable fisheries and salmon production within the Salish Sea. Organizations with the expertise to deliver specific components of the Project were invited to participate and prepare research proposals for technical review and subsequent funding. The SSMSP did not use an open solicitation of research proposals in order that we could ensure the greatest coverage of the study components within the available funds.

Possibly the greatest challenge in managing the project will be in the coordination of these many projects both within Canada and with U.S. participants. The analogy of the weakest link in a chain is appropriate. While this issue is recognized, minimizing the impact of it falls to the Project managers to track progress by each organization and, where possible, to foresee problems. For example, ensuring comparability of sampling has been addressed by developing sampling protocols for specific tasks; communication between researchers has been addressed through workgroups, internet communication sites, and annual international workshops; and Project managers are in weekly communication throughout the year.

At the international level, the primary concern has been alignment of the research programs. Alignment has been monitored under three broad categories:

1. **Bottom-up Sampling Program and Individual Studies**
   - A fully integrated sampling program examines the condition of salmon and steelhead as they out-migrate while simultaneously evaluating the physical and biological (plankton) characteristics of the Salish Sea. This includes identifying critical growth periods and understanding the primary mechanisms affecting growth.

<u>U.S. – Canada alignment is high</u>

- Individual bottom-up studies build off of this sampling framework to hone our understanding of the relationship between salmon and their prey, and to build out from the fish and their prey to the factors driving prey availability, such as temperature, habitat availability, ocean acidification, runoff, and wastewater. Many of these studies are to test specific mechanisms, new ideas and may focus on particular areas/issues of interest. Thus, a distributed approach among U.S. & Canadian scientists is applied to cover more ground.

U.S.-Canada alignment is moderate

2. **Top down Studies -** Targeted studies evaluate predation (what eats salmon and steelhead) and other potential contributing factors, including disease, toxic chemicals, competition between hatchery and wild fish, harmful algae, and aquaculture impacts. A distributed approach among U.S. and Canadian scientists is applied to address unique/local issues and cover more ground depending on local issues/areas of interest, although we are working to align the contaminant studies, and there is overlap with approaches to assess marine mammal predation.

   U.S.-Canada alignment is moderate

3. **Trend Analyses and Modeling -** Existing and new data are brought together to analyze and model relationships between salmon and their ecosystem, to evaluate the cumulative effects of multiple factors, and to model factors ultimately driving survival over time. This work establishes the platform for integrated data analyses for the entire project. The work includes survival trends, ecosystem indicators development and ecosystem modeling.

   U.S. – Canada alignment is moderate-high

In summary, the fundamental differences of the SSMSP from past research are:

a) The scope and integration of individual studies (essentially do everything, everywhere);
b) The collaboration of researchers and organizations to facilitate the scope of studies (building collaboration and research network); and
c) The integration of individual studies into an understanding of the mechanisms determining the survival of Pacific salmon in our near-shore marine waters.

Project Management

There are three levels of management within the SSMSP. The base level of consideration is a Science Team composed of local experts (Table 1) who advised on the factors to be considered and reviewed the research proposals prepared before any individual project is funded.

Drs. Riddell and Pearsall will be responsible for tracking research activities, monitoring progress, producing overviews for the science team and the Foundation's Oversight Committee, and providing feedback to the various scientists, First Nations and community groups involved. The Pacific Salmon Foundation will provide administrative and financial services to the project.

Table 1. Science Team for Canadian portions of SSMSP.

Brian Riddell (Project Lead)	CEO/President, Pacific Salmon Foundation	Background, Research Scientist in salmon assessment and genetics, and fisheries management.
Isobel Pearsall (Project Coordinator)	Research Scientist, Pacific Salmon Foundation	Responsible to oversee the project, managing staff and volunteers, science coordination and planning. Lead for Strait of Georgia Data Centre, UBC
Richard (Dick) Beamish, Fisheries Research	DFO Science (retired)	Extensive experience in fish, fisheries, and the Strait of Georgia[10].
Ken Denman, Oceanography and Climate	DFO Science (retired)	Adjunct Professor, School of Earth and Ocean Sciences at University of Victoria, and past Chief Scientist with Ocean Networks Canada.
Ian Perry, Fisheries Oceanography	DFO Science, Research Scientist	Head of Zooplankton Ecology and Ecosystems, DFO Science, and Adjunct Professor, UBC
Andrew Trites, Marine Mammologist	Professor, UBC	Director, Marine Mammal Research Unit at UBC, and Research Director of the North Pacific Universities Marine Mammal Research Consortium.
Tony Farrell, Fish Physiology	Professor, UBC	Canada Research Chair in Fish Physiology, Culture and Conservation (since 2010)
Carl Walters, Fisheries & Modelling	Professor Emeritus, UBC	Zoology and Fisheries, specialist in fisheries stock assessment, adaptive management, and ecosystem modeling
Marc Trudel, Fish Ecology	DFO Science, Research Scientist	Head, Salmon Marine Interactions Section at the Pacific Biological Station. Adjunct Department of Biology, UVic
Kristi Miller-Saunders, Molecular Genetics	DFO, Research Scientist	Head, Molecular Genetics Laboratory at Pacific Biological Station, and an adjunct Professor in the Department of Forest Sciences at UBC
Mel Sheng	DFO, Salmonid Enhancement Program, Biologist	Operations Section Head for DFO's South Coast Area, Salmon Enhancement Program

[10] Author "The Sea Among Us, the amazing Strait of Georgia", by RA Beamish and G. MacFarlane. 2014. Harbour Publishing.

At the second level of management, the PSF's Board of Directors (list available at www.psf.ca) has formed a SSMSP Oversight Committee to monitor the conduct and administration of the project. Terms of reference for this committee have been set as:

- Provide financial oversight of the use and accountability of funds used in the project, and monitor fund raising and cash flow during this project;
- Report annually on the progress of this research on achieving its stated objectives as presented within the original project description, and recommend corrections to actions or objectives as determined by this committee;
- Communicate effectively on results to funders, government agencies, and the public as appropriate; and
- Support the integration of programs between PSF and Long Live the Kings (US host agency) as this project proceeds.

Periodic meetings with the science team will allow for information exchange with the Oversight Committee and allow feedback on direction of research and funding.

The third level of project management involves the coordination of research planning and projects between countries. The responsibility for the coordination rests with the Pacific Salmon Foundation (Canada) and Long Live the Kings (U.S.). Coordination has been facilitated by development of sampling protocols and data standards, development of secure websites for communication and data sharing (BaseCamp software), creation of a Project website for document sharing, research up-dates, and public access (www.marinesurvivalproject.com), and annual workshops to review research progress and planning for future works.

Information Management and Infrastructure

Complex research projects are often deficient in allocating resources for knowledge management. Knowledge management includes the organization of new information, the integration of current knowledge, and the development of an analytic framework for the testing of competing hypotheses (i.e. decision support). Further, models of ecosystem behaviour need to be designed to account for variation in both space and time. Only recently has increased computing power been combined with analytical and visualization tools (e.g., Google earth, HectaresBC) to provide for calculations at meaningful resolutions and within reasonable time frames.

Another function of the infrastructure system is to create communication products. When communications are made to politicians and the public, the messages must be clear and understandable. A well-structured knowledge management infrastructure and an effective presentation system will significantly enhance the credibility of project presentations.

To this end, we have adopted a number of guidelines and activities around data sharing and infrastructure. These include:

1. Data will be stored to allow open access and peer review.
2. A 'core' collection of data sets will be made available for use by all members of the research teams (e.g., historical catch or spawning escapement data, hatchery releases).
3. Open source software will be encouraged.
4. UBC provides the server "hub" and programming support for the project via the Strait of Georgia Data Centre (www.sogdatacentre.ca). Other open-access data systems in use include Oceans 2.0 at the University of Victoria, and BaseCamp, a project management site where photographs, videography and researcher observations are freely available for use by all project participants. Other open access data systems may be used by the US side.
5. Data will be stored outside of government systems to enable open access and reduce costs.
6. All data will be spatially referenced with attached metadata.

Data Sharing and Publications

With many researchers involved in an international project, the topic of data sharing and publication rights has been an interest. One goal of the Salish Sea Marine Survival Project is to make ecosystem data developed through this effort comparable across the Salish Sea and readily available and usable for a variety of analyses, with a life extending beyond this project. Therefore, all relevant datasets produced via the SSMSP have been requested as deliverables (in addition to technical reports, manuscripts or other types of reports) from individual projects**.** All data collected within the SSMSP will be open to all participants with the exception that some specific agreements require time allowances for first publication.

All data and reports from the SSMSP will be made available to the public via the Strait of Georgia Data Centre and the SSMSP website (www.marinesurvivalproject.com). Guidance has been provided to researchers with respect to how to acknowledge the SSMSP, and reports will be numbered sequentially so that all the products from the program can be tracked over time.

DELIVERABLES AND TIME-LINES

The SSMSP is designed as a five-year project involving one year for planning and evaluation of methods (2014), up to three years of research and analyses (2015-2017, duration will vary with activity), plus a minimum of one year for project reporting, dialogue, and recommendations.

How to build a salmon restoration plan depends on accepting or rejecting the primary hypothesis. If environmental factors have primary control of annual variation in juvenile production, then resource managers will have very little direct control. Under such environmentally driven uncertainty a diversified set of actions would be an appropriate strategy. For example, small scale diversified enhancement plans involving numerous streams would be preferred to investing in a few large production hatcheries. The outcome of such a diversified plan may be a lower sustainable harvest with less annual variation - as opposed to a "boom or bust" outcome from large production hatcheries.

If biological factors are the primary factors, then the SSMSP includes factors of common public concerns, are practical to address, and can lead to restoration actions. Predation and competition could be controlled through predator control and alteration of hatchery practices. Disease may be more difficult to control and is more controllable in hatcheries than in the wild through the screening of broodstock, prophylactic treatments of eggs, reduction of rearing densities, and inoculation. Moreover, if disease is controlled, its incidence in co-mingling wild fish would likely also be reduced.

LINKAGES

The development of this project has renewed interest in collaboration within the Strait of Georgia and for taking action to restore Chinook and coho salmon production. The real value of linkages will be those developed between the organizations, universities, and the communities involved in planning and execution of these projects. As of August 2015, fifteen organizations (Figure 3) plus several community groups are participating in the research network coordinated by the Pacific Salmon Foundation to deliver the Salish Sea Marine Survival Project.

Figure 3. Research collaborations as of August 2015. This network representation does not include the numerous individuals and corporations that have enabled PSF to raise $8 Million in funds to support the SSMSP activities. Activities can be tracked at the SSMSP website: www.marinesurvivalproject.com and at www.sogdatacentre.ca .

In August 2015, Genome Canada, Simon Fraser and Laval Universities became collaborators with the announcement of a new research project to assess genetic diversity in Coho salmon and the impacts of hatchery practices on their fitness. Each linkage involves numerous other benefits including researchers and their personal contacts, access to other research funds to leverage PSF funding, logistical supporting including vessels and laboratory equipment, and numerous students. The value of these in-kind contributions to the SSMSP has not yet be fully quantified but over the five years are expected to equal the $10 Million raised by the Pacific Salmon Foundation.

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