HOW COLLABORATIVE ECOSYSTEM RESEARCH ADDRESSED A MAJOR IMPEDIMENT TO SALMON RECOVERY

SALISH SEA
MARINE SURVIVAL PROJECT

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LONG LIVE THE KINGS

PACIFIC SALMON FOUNDATION

marinesurvivalproject.com

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Cover photo: Jeremy Koreski

"Ideally, bringing different stakeholders together will create a result greater than the sum of its parts. This is the goal of the Salish Sea Marine Survival Project: it involves stakeholders from a variety of backgrounds sharing information, labor, and money to tackle a problem at a scale far beyond individual capabilities, both scientifically and socially." – Stonecipher 2017

INTRODUCTION

The salmon lifecycle takes them from riverbeds to estuaries and then through thousands of miles of ocean habitat before returning to their natal rivers to reproduce and start the lifecycle all over again. Survival during the marine (estuary and ocean) phases plays a critical role in determining the number of salmon that return to be caught in fisheries or reproduce (Pearcy 1992).

The Salish Sea is the combined waters of Puget Sound, the Strait of Georgia and the Strait of Juan de Fuca. Chinook, coho and steelhead abundance from populations in the Salish Sea region has declined substantially over the past 30+ years (Coronado and Hilborn 1998, Scott and Gill 2008, Beamish et al. 2010, Irvine and Fukuwaka 2011) in some cases leading to federal protections. This has had a significant impact on the ecosystem, fisheries, treaty rights, our economy, and the way of life of many local communities. For example, Strait of Georgia Chinook and coho fisheries were once among the most valuable in Canada. Catches that annually had numbered in the hundreds of thousands to a million fish now are merely a tenth or less of those levels (Pearsall and Schmidt et al. 2021).

Salmon recovery efforts that began in the late 1990s had focused on understanding and addressing harvest, freshwater and estuary habitats, and hatchery impacts; however, little emphasis had been put on impacts in the marine ecosystem. Concerns regarding the limited focus on the Salish Sea marine environment began mounting between 2000 and 2010. Relationships between Puget Sound Chinook early marine growth and marine survival were documented (Duffy and Beauchamp 2011), declines in Strait of Georgia coho marine survival were found, with performance in the Strait of Georgia a particular concern (Beamish et al. 2010), and studies showed high mortality of juvenile steelhead as they migrated through the Puget Sound marine environment (Moore et al. 2015). Further, the Strait of Georgia Ecosystem Research Initiative (Perry and Masson 2013) documented substantial changes in the Strait of Georgia marine environment since the 1980s. These changes included increased temperatures of both seawater and river water, declines in deep water oxygen levels, sea level rises, and changes in the timing of the Fraser River freshets (Riche et al. 2013), culminating in major regime shifts that occurred in the late-1970s and mid-1990s, with a major shift in the zooplankton community in 1998–1999 (Li et al. 2013) and mean vertebrate trophic level decreasing since the 1980s (Preikshot et al. 2013). However, through to 2010, there were no comprehensive studies of mechanisms that were regulating the production of Chinook, coho, or steelhead salmon in the Salish Sea.

In 2012, the Pacific Salmon Foundation (PSF, Vancouver, BC) and Long Live the Kings (LLTK, Seattle, WA) initiated the Salish Sea Marine Survival Project (SSMSP). This multidisciplinary, ecosystem-based research effort focused on a specific question: what are the primary factors in the Salish Sea environment that affect salmon and steelhead marine survival?[3] Here, we provide an overview of how this complex project was designed, operated, and managed. We also provide insights into its strengths and limitations and how the work has changed the local landscape for salmon and ecosystem research and recovery.

1. Marine survival, also called smolt-to-adult survival, is the survival rate from when juvenile salmon migrate downstream to the marine environment to when they become adults and are captured in fisheries or return to rivers and hatcheries to spawn.

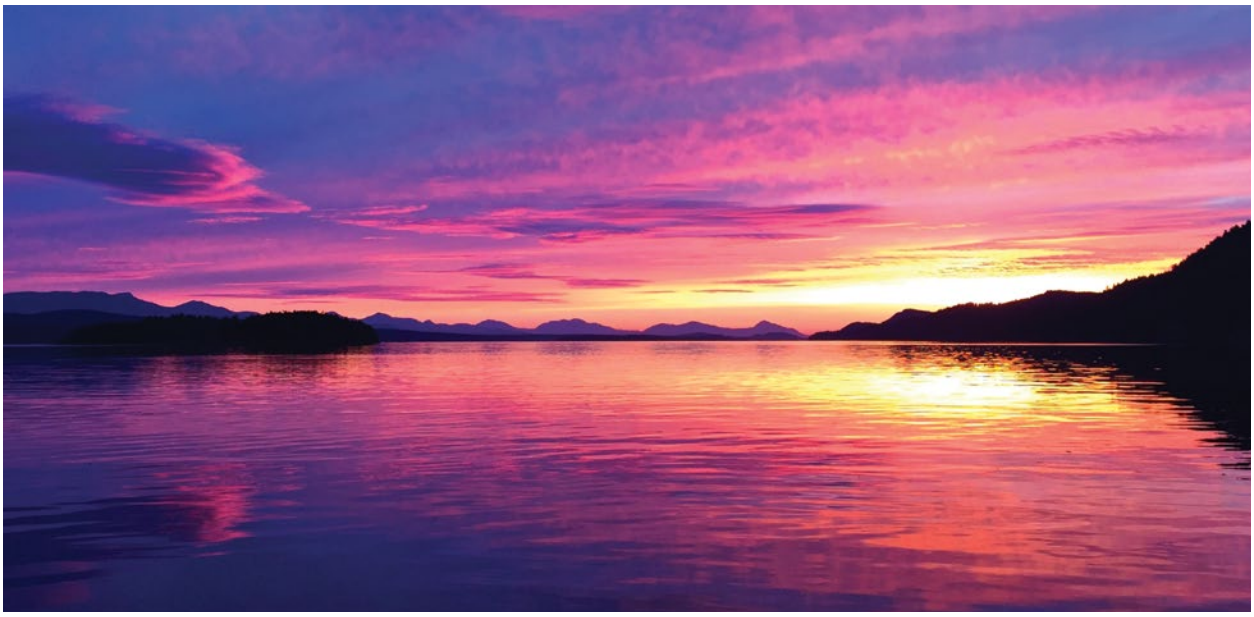
THE BEGINNING

The study of factors affecting juvenile salmon and steelhead in Salish Sea marine waters was occurring prior to the SSMSP. However, our ability to attribute causation within the Salish Sea to reduced adult abundance was very limited. Most studies evaluated the total marine survival rate (smolt survival to adult age) and could only roughly attribute causation to large-scale environmental effects (Beamish et al. 2007, Araujo et al. 2013, Ruggerone and Goetz 2004). In particular:

- The interaction between salmon and the Salish Sea was largely a black box, and its complexity required a more thorough understanding of how salmon are affected by the physical, chemical, and biological characteristics of the marine environment. For over 100 hundred years, the vast majority of studies have focused on single species, times and locations, and topics.
- Coordination and information sharing among marine survival researchers and research programs varied and was considered inadequate given the perceived regional scale of the problem.
- Research efforts were designed independently and often limited geographically and/or at a population-specific level, without being integrated into a larger context (e.g., common framework, questions or shared hypotheses).
- Marine survival research was limited by funding, a majority of which had been focused on research, management, and recovery efforts in the freshwater environment where human impacts to salmon survival are most visible and where implementation of mitigation actions are more obvious.

The SSMSP originated from work of the PSF. In 2009, the PSF convened a group of Canadian scientists to propose a multidisciplinary approach to determine what limited the production of Chinook and coho salmon and what mitigation actions could be undertaken to increase production (Riddell et al. 2009). The following year, LLTK facilitated a Salish Sea focused session at the State of the Salmon Conference in Portland, Oregon. Here, attendees called for a broader, more coordinated effort to address how changes to the Salish Sea impact salmon survival. In response to this need, the PSF and LLTK combined efforts and create an international endeavor.

In 2012, the PSF and LLTK held the first Salish Sea Marine Survival Workshop with 90 U.S. and Canadian participants and a 15-member advisory panel to present the state of science and receive feedback from the broader scientific community regarding critical elements of a transboundary research project (Schmidt et al. 2013). The workshop was a jumping off point for the project and resulted in preliminary research recommendations, fundraising and formal research planning in 2013. The five-year, exploratory research phase commenced in 2014 and continued through 2018.



APPROACH

In 2017, Grace Stonecipher interviewed 22 project participants and assessed the project from the general standpoint of participation in research and landscape conservation (Shirk et al. 2012, Bucchi and Neresini 2007, Cornwall 2008). From the participant responses, she surmised that, "…the Salish Sea Marine Survival Project is successful because the factors that unite participants, a common goal and a skilled facilitator, overpower those that create differences" (Stonecipher 2017).

The PSF, LLTK and participating scientists sought to develop a project configuration that addressed the constraints described in the previous section. Early on, it was determined that a highly structured, Salish Sea-wide research design was intractable due to differences in participant, funding, and management arrangements by nation. Instead, a common framework was established, including a primary goal; focal species, geography, and life-history range; and shared hypotheses. Multidisciplinary science teams were identified by nation, and national and international collaboration, project management, communications and fundraising were led by the PSF and LLTK. Within this framework, scientists were provided an environment that enabled research implementation and promoted international and interdisciplinary collaboration.

Other ocean ecosystem endeavors contributed to the design of the project. For example, NOAA's Northwest Fisheries Science Center had been leading California Current and Gulf of Alaska salmon ocean ecosystem programs. Further, the Department of Fisheries and Oceans was just completing their Strait of Georgia Ecosystem Research Initiative when the Salish Sea Marine Survival Project began. Leads from each of these projects provided guidance via a steering committee at the 2012 workshop to kick off the project. While these other efforts did share a common framework, operationally, none of them necessitated the level of collaboration required in the Salish Sea region, which comprises a large number of distinct entities involved in salmon research, management, and policy. Ultimately, over 60 government, tribal, academic, nonprofit and private entities were involved in the Salish Sea Marine Survival Project (Appendix A).

A Common Framework

The goal of the project was to identify the most significant factors affecting the marine survival of Chinook, coho and steelhead, focusing on the juvenile phase of these three species within the Salish Sea. The fish would be assessed migrating downstream as well as throughout the Salish Sea to determine whether freshwater conditions influence performance in the marine environment. Given our limited understanding of the Salish Sea ecosystem, the group agreed to be as holistic as possible and focus on high-grading these to a suite of factors most influential to juvenile salmon survival as compared to endeavoring to define one primary factor.

Three primary hypotheses were created:

1. Bottom-up ecological processes including weather, water, plankton and forage fish abundance that control food availability for salmon have changed affecting salmon size, growth and ultimately survival.
2. Top-down ecological pressures like predation have increased and may be exacerbated when fish are compromised by contaminants or disease.
3. Other factors (limited salmon diversity, increased competition, habitat loss) could be contributing to these ecological shifts.

Twenty-four sub-hypotheses were also established to describe the specific factors being assessed (Pearsall and Schmidt et al. 2021).

Strong Collaboration

The PSF and LLTK coordinated efforts in Canada and the US, respectively, and jointly executed international collaboration. Multidisciplinary technical teams and workgroups were established in each country, comprised of lead scientists selected for the effort. They met several times a year to develop and implement the research. Steering committees were also established: higher-level management representatives of the primary entities involved. These committees ensured project efforts remained focused on the objectives, approved funding allotments for the various research elements, helped maintain the project as a priority for the entities engaged, and facilitated the transfer of knowledge to those who are responsible for managing the salmon resource.

International collaboration occurred primarily via annual, US-Canada workshops where lead scientists from each nation convened to review and update the hypotheses being tested, align and coordinate study methods, share and interpret results, and discuss how findings would inform the next steps in research. Late in the research phase, a US-Canada Synthesis Committee was established to provide guidance regarding how to synthesize the diversity of results. Further, topic-oriented workshops with broader participation were held in 2019 and early 2020 to ensure all the relevant data were presented and discussed for synthesis.

The numbers of team and committee participants and annual workshop participants were deliberately limited to facilitate decision-making. Committees and teams were typically kept to groups of less than 20 in attendance at any given time, and workshops limited to 50. Decision-making was generally done by consensus. Where consensus could not be reached, especially for research and funding prioritization, a ranking process or majority vote was used.

Across the project, scientific expertise was broadly represented in both topic (e.g. oceanography, plankton, salmon physiology, disease, contaminants, predation) and approach (e.g. empirical research, modeling, correlative analyses). As one participant stated, "this (diversity in approaches) provided checks and balances against going too deeply into one particular approach where it may not bear as much fruit as doing a combination of things where you can really generate some synergy" (Stonecipher 2017). Innovation was emphasized with many new ecosystem assessment approaches developed over the course of the project (see Bagley et al. 2020). Experimental approaches were weakly represented in this effort, in part due to the difficulties of performing experiments in complex ecosystems. Also, traditional ecological knowledge (TEK) was not heavily relied upon nor formally collected. Attempts were made to gather qualitative information from stakeholder communities; however, it was more to validate or refute perspectives versus a formal role in the research itself. This was in part because the timescale under review spanned only the past 40 years during which time generally adequate environmental data were available; meanwhile, TEK likely has higher utility for understanding longer term changes as well as periods for which no quantitative data exist.

Tribal, federal, and state government representatives for both the technical teams and steering committees were sought because they have shared authority to manage salmon and their ecosystem but also have varied management responsibilities and goals, different constituent bases, and often oversee different geographic areas. Engaging these management entities from the beginning was expected to facilitate early and shared buy-in on the approach and ultimately agreement on the research findings. This increases the chances that the findings will affect management. The academic representatives often brought a more independent perspective but spoke more to the next steps in science versus management. This is not surprising as academics are inherently influenced by academic pursuits versus an urgent need to manage the resource (Stonecipher 2017).

Tribal and First Nations representation was limited. This is of concern because indigenous people are arguably the most marginalized resource users in the region but also carry significant weight as to how salmon are managed: in Washington State, tribes have legal authority to co-manage our salmon. There are 17 tribes[2] with fishing rights in Puget Sound alone, and each may have different management priorities based on many factors. Of those, eight were periodically represented and only four were actively engaged.[3] While there was an open-door policy for tribal participation, engagement was limited because tribal staff are often overworked with many priorities to address. Further, like many resource limited environmental resource management entities, tribes are wary of collaborative efforts as they often require significant resources and sadly all too often have little impact on the status quo: the continuing decline of environmental resources.

2. www.nwifc.org/member-tribes/
3. Tulalip, Nisqually, Lummi, and Port Gamble S'Klallam were more actively engaged, and Squaxin, Muckleshoot, Upper Skagit, Stillaguamish, and Jamestown S'Klallam participated to some degree.

Additionally, few tribal scientists were sought out initially as experts. Instead, the tribes were primarily engaged through data collection activities and by providing funds directly or advocating for and partnering on funding requests. A limited number of tribal scientists in the region engage as principal investigators in traditional western science. This may be because of: a) an acknowledgement by tribes that the experts already exist and can be contracted, b) tribes prioritize hiring experts in policy and resource management versus science, c) tribes prioritize work that is tied to addressing issues in their specific Usual and Accustomed Areas versus questions about broader regional impacts to salmon, and d) tribes have historically had limited ability to attract skilled scientists due to lower positional salary allocations relative to other entities.[4]

Thoughtful Execution

The PSF and LLTK initially sought to execute a five-year research phase (2014-2018), with an estimated fundraising need of $20 million dollars. This short but intense timeline was deemed reasonable to make significant progress on the research question and ensure broad commitment by researchers while remaining within the limits of funding amounts and length of funder interest that could be sustained as nonprofits. Ultimately, this five-year period was considered the exploratory research phase given no experiments were performed or solutions tested.

Research was developed in an iterative fashion. This was partially a consequence of the timing of funding, which did not come in all at once or from a single source; however, it provided the opportunity for early results to inform later research. In Canada, the PSF and participating scientists began with a pilot effort around the Cowichan River and Bay region and then expanded to more areas throughout the Strait of Georgia in 2015. In the United States, LLTK and participating scientists split efforts between Chinook/coho and steelhead, and implemented research prioritization processes to narrow scopes of work to the funding available at the time. Ultimately, over 90 studies were implemented via the SSMSP throughout the Salish Sea.

An initial seed funder and persistent fundraising played a critical role in the effort. The essential 'seed funder' was the Pacific Salmon Commission's Southern Endowment Fund[5] that invested $5 million dollars to help initiate the effort, which was split between the two nations. The PSF and LLTK then raised the remaining funds for each of their respective nations, exceeding the $20 million dollar goal. In the US, participating state and tribal entities provided funds directly, and participating scientists also contributed to fundraising via competitive research grants. Well over 30 public and private funding sources were leveraged over the course of the project. Participating scientists from the US and Canada also contributed significant in-kind resources but these values are not included in the fundraising totals. Government staff salaries were predominantly covered and/or ongoing efforts that could contribute valuable data were aligned with needs of the project.

Managing research separately by nation facilitated decision-making and fund distribution, but it limited the ability to assess how some factors affect marine survival Salish Sea-wide. Some key datasets were compared across the US-Canada border, including marine survival trends, zooplankton biomass and composition, and seal predation. Assessments of impacts to Puget Sound coho and Strait of Georgia steelhead were limited compared to Chinook throughout the Salish Sea, Puget Sound steelhead, and Strait of Georgia coho. This was partially due to difficulties obtaining adequate sample sizes and partially because Puget Sound coho are not listed under the Endangered Species Act and therefore less of a management priority. Research on steelhead in BC has been much more limited than for Chinook and coho salmon, partly because steelhead are a provincial, rather than federal, responsibility and have not been a focus of stock assessment or research within the Department of Fisheries and Oceans, Canada.

4. This is influenced by the findings of Stonecipher 2017 and the general perspective of the authors as facilitators.

5. Many fisheries in the Salish Sea are considered under the Pacific Salmon Treaty (1985) between the United States and Canada. Decreased production of salmon in the Salish Sea has severely limited fishing opportunities and presented numerous issues under the Treaty. The endowment fund under this treaty is used to address joint issues. We acknowledge the key effort of the late Mr. Larry Rutter (U.S. Commissioner) who leadership enabled the support from this endowment.

CHANGING THE SALMON RECOVERY LANDSCAPE

The SSMSP was limited to five years but has lasting impacts. New collaborative research that began during the project continues. The PSF's Strategic Salmon Health Initiative and LLTK's Hood Canal Bridge Ecosystem Impact Assessment were formed in 2013 and 2015, respectively, to focus on specific factors affecting marine survival. In 2019, following the exploratory research phase, the PSF established legacy projects in the Strait of Georgia, and the Washington State legislature funded next steps in marine survival research. New work includes testing new hatchery rearing and release strategies to increase Chinook and coho survival, assessing new technology to reduce seal predation, evaluating Pacific herring recovery approaches, BC-wide expansion of Salish Sea PIT tag studies to assess bottlenecks to Chinook survival, development of a Climate Adaptation Plan for nearshore habitat recovery, and focused studies to implement soft shores approaches to improve forage fish habitat. The project also influenced the development and implementation of International Year of the Salmon: a northern hemispheric wide effort to study Atlantic and Pacific salmon and communicate their plight to the public.[6]

In Puget Sound, LLTK and participating scientists have contributed to the Puget Sound Ecosystem Monitoring Program and other forums to ensure the work of the project has lasting impacts to our ecosystem monitoring infrastructure. For example, the zooplankton monitoring program initiated through the project is now integrated into the Puget Sound Ecosystem Monitoring Program. Zooplankton biomass is also now considered a vital sign of Puget Sound health.[7] Further, the Puget Sound Atlantis ecosystem model developed through the project is now broadly recognized as a regional tool for assessing various ecosystem issues.

In Canada, the Salish Sea Marine Survival Project has resulted in the expansion of many SSMSP monitoring programs and creation of new ones, including: a continued DFO focus on seal and sea lion diet analysis throughout the Canadian Salish Sea; an augmented DFO zooplankton sampling program (a critical development to assess annual variation); adoption of the PIT tag methodology and Biomark© array by DFO for Cowichan stock assessment and by the BCCF and the Province for steelhead studies; a new program for forage fish monitoring in the Strait of Georgia through the World Wildlife Fund and Vancouver Island University; and a significant expansion of nearshore habitat restoration, monitoring and marine debris removal through Coast Restoration Fund support to Seachange, Project Watershed (Comox), and Raincoast Conservation in the Fraser River estuary. The PSF also continues to collect detailed oceanographic information via the PSF Oceanography Citizen Science program, as well as ecosystem information from an angler-based adult coho and Chinook diet study.

Finally, efforts have been made to integrate the findings of the project into the region's ecosystem recovery framework. In British Columbia, project findings are helping guide efforts for a major marine risk assessment process for the West Coast of Vancouver Island, as well as influence hatchery release practices. In Washington, over 20% of the recent recommendations of the Washington State Governor's Southern Resident Orca Task Force were influenced by the project (Task Force 2019). Low abundance of Salish Sea Chinook salmon limit the productivity of southern resident orca whales. Recommendations included novel hatchery management approaches, a focus on estuary habitat restoration, an ecosystem approach to predation management, forage fish recovery, zooplankton monitoring and revised NPDES permitting for wastewater treatment to include flame retardants. NOAA's Recovery Plan for Puget Sound steelhead, listed as threatened under the Endangered Species Act, includes several actions to improve early marine survival (NMFS 2019). Further, LLTK is working with the Puget Sound region to update Chinook recovery plans to reflect the findings of the project.

6. https://yearofthesalmon.org/
7. https://www.pugetsoundinstitute.org/tag/puget-sound-vital-signs/

CONCLUSION

The SSMSP is a powerful example of how ecosystem-based research and management can benefit from collaborations led by nonprofit organizations. Nonprofits have the independence and flexibility to work across public and private entities, across disciplines, and across diverse perspectives. We have the agility to adjust quickly and keep collaborative efforts on course. We also have the capacity to raise and manage public and private funding. And we attract talent skilled at both understanding science and managing diverse groups.

The SSMSP research effort was a short-term success that continues to inspire greater collaboration and increased focus on understanding and addressing impacts to juvenile salmon and steelhead in the Salish Sea marine environment. Efforts must continue, and our longer-term success will be measured by how this work leads to actual change in salmon management such funding and implementing the actions proposed in the previous section. Ultimately, our true metric will be whether we can recover salmon and steelhead in the Salish Sea. We are optimistic but recognize this is a decades-long effort and we still have much to learn.

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APPENDIX A: SALISH SEA MARINE SURVIVAL PROJECT PARTNERS LIST

Project Managers

Long Live the Kings

Pacific Salmon Foundation

Tribes

Cowichan Tribes

Jamestown S'Klallam Tribe

Lummi Nation

Muckleshoot Indian Tribe

Nisqually Indian Tribe

Port Gamble S'Klallam Tribe

The Puyallup Tribe of Indians

Skagit River System Cooperative

Squaxin Island Tribe

Tulalip Tribes

Academic

University of British Columbia

University of Washington

University of Victoria

Simon Fraser University

Nonprofit

Genome British Columbia

Ocean Networks Canada

Kwiáht

Trout Unlimited

Pacific Northwest Salmon Center

YMCA Camp Orkila

International

Southern Endowment Fund of the US-Canada Pacific Salmon Treaty*

Federal

National Oceanic and Atmospheric Administration

Fisheries and Oceans Canada

US Geological Survey

Environmental Protection Agency

US Fish and Wildlife Service

National Fish and Wildlife Foundation

Washington Sea Grant

Northwest Association of Networked Ocean Observing Systems (NANOOS)

State

State of Washington**

Washington Department of Fish and Wildlife

Washington Department of Ecology

Puget Sound Partnership (including the Puget Sound Salmon Recovery Council)

Northwest Indian Fisheries Commission

Salmon Recovery Funding Board

Puget Sound Recreational Fisheries Enhancement Fund

Local

King County

Seattle City Light

City of Bellingham

Port Metro Vancouver

Port of Seattle

Private

Pacific Salmon Endowment Fund Society

The Boeing Company

Goldcorp

Sitka Foundation

Vulcan

Canfisco

Pacific Crest Seafoods

Integral Consulting

Northwest Marine Technology

Finest at Sea

Eagle Wing Tours

Kintama

Prince of Whales Whale Watching

Vancouver Whale Watch

Orca Spirit Adventures

Keurig Canada

Methanex

PEETZ Fishing & Outdoors

Sonora Resort Canada

Smith-Root

Aqueduct Foundation

Knelson Family Foundation

Mary and Gordon Christopher Foundation

Lagniappe Foundation

Wolrige Foundation

Fairbairn Foundation

Raven Foundation

Vancouver Foundation

Vancouver International Airport

The Ritchie Family Foundation

Stuart Wolfe

Dick Bradshaw

Rudolph North

Tony Allard

Rocky Mountaineer

Cenovus Energy

Kinder Morgan

BC Conservation Foundation

BC Salmon Farmers Association