Pacific Salmon Foundation

Final Report
International Gulf of Alaska Expedition

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Gulf of Alaska Expedition

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A. Expedition Details

The expedition was the Signature Project of the International Year of the Salmon, a 5-year initiative to establish the conditions for resilience for salmon and people. Led by the North Pacific Anadromous Fish Commission, the partnership included the North Atlantic Salmon Conservation Organization (NASCO) and a number of NGO's, private sector, government and academic organizations.

B. Expedition Objectives

The primary scientific objective of the expedition was to uncover the fundamental mechanisms that regulate salmon in the North Pacific Ocean and to identify stock specific rearing areas for all five species of salmon, their abundances and their condition. This was the first comprehensive study of stock abundance, composition and condition of all stocks of all species of Pacific salmon at the end of their first ocean winter. This information will be used to test the hypothesis that the fish that survive to the end of the first ocean winter are the individuals that grew faster in the first few months in the ocean.

The secondary objective was to learn how to merge scientific cultures and practices from five countries. Over the years Russian, Canadian, American, and Japanese scientists have exchanged fishery scientists and run joint programs where several ships surveyed their respective zones using common methods but this is the first time they have all run a common program from a single ship. Russian scientists in particular have a 30-year history of studying salmon and the associated ecosystem. This is a tremendous opportunity to work directly with them to learn from them first hand.

C. Survey Schedule

Departure from Vladivostok	January 11, 2019
Survey of the Western Pacific Ocean	January 11 to 30, 2019
Transit from survey area to Vancouver	January 30 to February 16, 2019
Arrival in Vancouver (loading)	February 16, 2019
Departure from Vancouver	February 17, 2019
Return to Vancouver	March 18, 2019
Visit to Pacific Biological Station, Nanaimo, BC	March 19, 2019

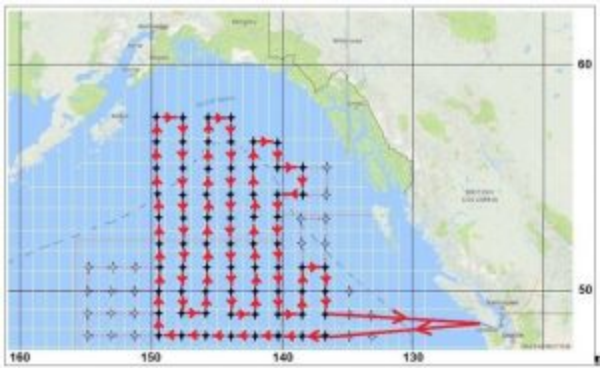
D. The Survey

The Russian research vessel the *Professor Kaganovskiy* travelled from Vladivostok to Vancouver to onboard 21 scientists and scientific equipment. During that trip some research was conducted in the western North Pacific by Russian scientists which will provide abundance estimates for Pacific salmon in that region to contrast and compare to data generated within the Gulf of Alaska.

The expedition left Vancouver, BC, on February 16, 2019, and over the course of the next month conducted sampling at 72 stations approximately 60 nautical miles apart from each other. Some of the stations were studied in the 1960's and 1970's by Japanese and Canadian researchers.

At each station several different types of gear were used to study the oceanography and the animals, including salmon in the upper 50m. A midwater trawl with a mouth opening of 50m collected fish and invertebrates during an hour-long tow. The animals caught were/will be identified and observations including length and sex were recorded to determine age structure, what freshwater stock it belongs to, its diet, what pathogens were carried and how physiologically healthy the fish were. Geneticists on board tested a new handheld genetic sequencer that allowed for stock identification at sea (a first). A live tank was tested in the trawl to catch fish that were tagged with satellite tags that when returned will tell researchers where the fish has been since it was tagged.

At each station probes were sent down 1,000m to measure how temperature, salinity, pH change with depth and plankton nets were used to sample the food for salmon in the form of primary producers like algae and secondary producers like krill that feed on the algae and are fed on in turn by salmon. All of the salmon were frozen and brought back for further study.



E. Scientific Equipment Used

Midwater rope trawl - a very large funnel-shaped fishing net with the front constructed from large hexagonal or rhombic mesh or near-parallel ropes. Trawling involved towing of nets behind the fishing vessel. Large trawl doors that are essentially "kites" pull the net open sideways (50m) and the mouth of the net 50m is held open vertically by floats on the top and a weighted lead line on the bottom. The net is towed at 2.5-3 knots and the fish are swept back in the narrow end of the net called the codend. It takes considerable power to fly the net with the headrope at the surface to catch salmon that tend to live in the top 50m.

Live fish box for midwater trawl - a large box which can hold up to 1,000 liters of water was used to keep live salmon (up to 70 cm) for further sampling. The box was inserted in the narrow portion of the midwater trawl and the fish were always in water as the net is brought back on board the ship.

Micronekton/plankton Bongo net – is comprised of two plankton nets mounted next to each other. The nets have a long funnel shape with a small mesh width (0.2336mm) used for collecting plankton. The bongo net can be configured to be towed vertically (up and down) or horizontally towed at 1-2 knots with a weight attached between the nets.

Plankton Juday net - a mesh net with a cone-like end that is towed vertically through the water column. The Juday net allowed for the sampling of zooplankton within different vertical water layers and is often used at different periods of the day (light and darkness).

Microplastic net with lifting bodies - a type of net that is towed behind the vessel with a mesh size small enough (300 um) to collect micro-plastics. This equipment allowed scientists to sample a layer of approximately 20cm at the water surface, where low density micro-plastics accumulate.

CTD (Conductivity, Temperature, Depth) – a device to detect how conductivity and temperature of the water column changes relative to depth. Conductivity is a measure of how well a solution conducts electricity, and it is directly related to salinity, or the concentration of salt and inorganic compounds in seawater. CTDs were attached to a metal frame which holds water-sampling bottles that collected seawater at different depths. The information generated from CTD data will be used to calculate the speed and direction of ocean current as well as to map the distribution of temperature and salinity throughout the survey area spatially as well as at depth.

MinION DNA sequencer – a miniaturized DNA sequencer that allowed scientists for the first time to determine within a day or two what stock it originated from. Future surveys could use this tool to study the finer scale distribution of stocks at sea.

F. Preliminary Findings

- International collaboration works! This collaboration involved several countries and differing generations and has the ability to significantly impact the future of ocean science;
- For the first time abundance estimates for salmon in the Gulf of Alaska were calculated with a very preliminary estimate of 55 million salmon in the survey area;
- Salmon species differed substantially in their distributions with some showing potential links to environmental conditions;
    - Sockeye in the north associated with cool water compared to pink salmon that were captured in the south and in warmer water;
    - Chum salmon were most broadly distributed and caught in a majority of the sets;
    - Coho salmon were the second most abundant salmon species caught in the expedition. This was a surprise as generally considered to be more coastal in distribution, however in this expedition they were caught over 1000kms offshore;
    - Pink salmon were in low numbers and mainly in the southern end of the survey area associated with warm waters. The low number were a surprise given this is a year when Pink Salmon are expected to be abundant;

    - A surprising difference was observed for chum salmon when fish of both good and poor condition would be captured in a set. DNA analysis will help determine if the variability is due to stock origin;
- Interesting north south differences in some species other than salmon including some abundant species of jellyfish and salps;
- At sea-genetic sequencing was successful providing real time stock composition. While at sea they were able to learn the stocks origin with 1-2 days. Coho caught were from SE Alaska to the Columbia River, with the majority originating from British Columbia;
- Development of the spring phytoplankton bloom was observed on the southern part of the survey during the expedition;
- Much more to come from laboratory analyses ashore;
- The first video to be recorded on adult salmon behavior within the trawl net on the high seas provided preliminary evidence that salmon exhibit schooling rather than solitary feeding behavior expected in the high seas winter;
- The Gulf of Alaska is a relatively free area from floating macro-plastic particles. Estimated macro-plastic occurrence ranged from 0 to 2.3 pieces per km2 based on twenty hours of observation. Samples were taken to document micro-plastics and results will be amiable when laboratory analyses are completed;

G. Subsequent Work

Work is continuing now that the samples have been brought back to shore and includes;

- genetic stock ID of all salmon and confirmation of on-vessel analysis (proof of concept);
- stock specific abundance estimates;
- fish health assessments;
- bioenergetics (energy density);
- otolith analysis for early marine growth dynamics;
- otolith analysis for thermal marks;
- stable isotope and fatty acid analysis of salmon, by-catch and zooplankton;
- eDNA analysis;
- integration of data and information; and
- spectral analysis for primary production.

H. Expedition Science Team

Country	Science Team Member
Canada	Brian Hunt, University of British Columbia
Canada	Christoph Deeg, Pacific Biological Station, Fisheries and Oceans Canada
Canada	Chrys Neville, Pacific Biological Station, Fisheries and Oceans Canada
Canada	Evgeny Pakhomov, University of British Columbia
Canada	P.S. Vishnu, University of Victoria
Canada	Svetlana Esenkulova, Pacific Salmon Foundation, Canada
Japan	Shigehiko Urawa, Hokkaido National Fisheries Research Institute
Korea	Hae Kun Jung, Gangneung-Wonju National Univerity
Russia	Albina Kazneparova, TINRO
Russia	Aleksandr Slabinskii, TINRO
Russia	Alexei Somov, TINRO
Russia	Anna Vazhova, TINRO
Russia	Anton Khleborodov, TINRO
Russia	Arkadii Ivanov, TINRO
Russia	Gennady Kantakov, TINRO
Russia	Igor Shurpa, TINRO
Russia	Mikhail Zuev, TINRO
Russia	Vladimir Radchenko, NPAFC
United States	Charles Waters, Alaska Fisheries Science Center, NOAA
United States	Gerard Foley Jr., Alaska Fisheries Science Center, NOAA
United States	Laurie Weitkamp, Northwest Fisheries Science Center, NOAA

I. Financial Information

Gulf of Alaska Scientific Expedition
From December 1, 2018 to April 30, 2019

Expenses	Amount
Charter	743,400
Communications	56,364
Data Management/Analysis	44,098
Travel	25,652
Equipment	22,780
Video	19,000
Material and Supplies	17,536
Total Expenses	**928,829**