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Update on Canadian Research Relevant to the 2016–2020 NPAFC Science Plan

by

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ABSTRACT

This document summarises Canada's scientific research activities in relation to the 2016–2020 NPAFC Science Plan. The focus is on research activities planned by Canada during 2019/20 and results from recent studies not previously documented to NPAFC.

INTRODUCTION

The Science Sub-Committee of the North Pacific Anadromous Fish Commission (NPAFC) developed a five-year Science Plan (2016–2020) (http://www.npafc.org/new/publications/Science%20Plan/SciPlan%202016-20/NPAFC_science_plan2016–2020.pdf) with five research themes intended to help understand variations in Pacific salmon productivity in a changing climate:

1. Status of Pacific Salmon and Steelhead Trout
2. Pacific Salmon and Steelhead Trout in a Changing North Pacific Ocean
3. New Technologies
4. Management Systems
5. Integrated Information Systems

This document updates earlier summaries of Canada's scientific research activities in relation to the 2016–2020 Science Plan (e.g., Irvine et al. 2018a, b). The focus is on research activities planned by Canada during 2019/20 that are relevant to the Science Plan. Recent studies not previously documented to NPAFC, including those reported on at this meeting are also included in the report. The list is not complete but provides an overview of major activities planned or recently completed.

Activities are organised according to the five major themes (1–5*)* listed above. It should be noted that research activities often cross over several components of the science plan, due to the inherent overlap associated with these themes.

1. Status of Pacific Salmon and Steelhead (including Biological Monitoring of Key Salmon Populations; Seasonal Migration and Distribution; Variation in Growth and Survival; Modeling the Future for Salmon)

Canada continues to monitor the status and important biological characteristics (e.g., salmon size, age composition, return timing, survival) for various key (important) salmonid populations. Time series information on catches, spawner escapements, and regional salmon production trends for hatchery and wild stocks are also obtained (Thiess et al. 2019).

A central problem in understanding how salmon respond to global changes is distinguishing between the effects of local drivers from regional and global drivers that are shared among many populations. Researchers in the Ecosystem Science Division are examining time series observations of annual production variations for sockeye salmon populations originating from

freshwater systems around the rim of the North Pacific Ocean (Hyatt et al. 2018). Historic production patterns are considered within a hierarchy of spatial scales including aggregated returns of adult sockeye salmon to (1) the entire north Pacific basin; (2) the north-central coast of British Columbia; (BC), (3) the south-coast of BC; and (4) disaggregated adult returns to several local-area watersheds representing southern, central, northern and Alaska transboundary areas of BC.

Adult returns aggregated at a Pacific basin scale indicated that between 1980–2015, total production of Sockeye Salmon in the Pacific was far above the 50-year average observed from 1925–1975. Almost half the average contribution to total Sockeye production for 1990–2015 was from Bristol Bay Alaska alone with BC stocks contributing the second largest proportion (Ruggerone and Irvine 2018). By contrast, sub-basin scale trends exhibited by aggregated returns of adult Sockeye to BC's north-and-central coast and BC's south coast areas revealed a relatively constant decadal-scale level of average production in 1950–1990 followed by a 30–40% decrease in average returns to both areas between the early 1990s and present (Connors et al. 2018). Return patterns to both sub-basin scale areas in BC were dominated by a few large Sockeye populations in the north-and-central coast area (i.e. Nass-Meziadin and Skeena-Babine) as well as in the south coast (i.e. less than a dozen large Fraser River populations such as Chilko, Adams and Quesnel) (Hyatt et al., 2018).

During the upcoming year we invite agency personnel studying data rich sockeye populations in Washington State and Alaska to collaborate with us by contributing observations on annual production, productivity indices and biological traits to supplement those currently assembled annually for sockeye Index stocks returning to B.C. International collaboration for annual assembly, analysis and reporting of the time series data on total production, productivity and biological traits would provide a cost effective means to facilitate the rapid identification of region-wide versus local area salmon production trends on an annual basis throughout the eastern North Pacific as a basis for improvements in timely advice to fisheries managers and stakeholders.

Fisheries & Oceans Canada's (DFO's) State of the Salmon Program's goal is to track and understand Canadian Pacific salmon population trends. It achieves this goal by developing tools and processes to foster collaboration among salmon-ecosystem experts. Two State of the Salmon meetings conducted in the last year integrated information on salmon and their ecosystem trends, and linkages between them. Global climate change projections in the Northeast Pacific Ocean and Western Canadian freshwater ecosystems over the next 30–80 years were also considered. Experts on salmon and their ecosystems participated and contributed their knowledge to these processes. Two publications are in preparation and will be published shortly. Outputs from this integrated work have been presented in various Canadian and international fora.

Another process led by this Program integrates science across Fraser Sockeye life-history stages, to categorise survivals (average, below or above average of 19 populations for the upcoming return year. Since salmon ecosystems are experiencing unprecedented changes, historical correlations are increasingly unreliable for forecasting; qualitative processes provide additional insight into salmon survival. This qualitative process provides information to inform quantitative forecasts and is published for 2018 returns (MacDonald et al. 2018). State of Salmon Program has also developed a synoptic status evaluation tool (SSET) using interactive data visualization methods to track and review salmon statuses annually in the Canadian Pacific. This enables

regular review and exploration of salmon data and trends. This Program's staff also participate in various initiatives to review case studies where ecosystem-based approaches are integrated into fisheries management actions at Canadian, national, and international levels.

The Hakai Institute continues its juvenile salmon observing program in the northern Strait of Georgia, Discovery Islands and Johnstone Strait (Johnson et al. 2019). This program has been operational since 2015 and obtains samples annually during the juvenile salmon outmigration to: evaluate the oceanographic controls of prey phenology, quantity and quality for migrating juvenile salmon in the northern Strait of Georgia, Discovery Islands and Johnstone Strait; determine stock-specific migration behavior of juvenile sockeye salmon, and co-migrating salmon species, through the region; determine juvenile salmon feeding biology and measure growth and condition across a spatial-temporal gradient of prey quantity and quality; determine juvenile salmon parasite and pathogen infection dynamics across the Discovery Island / Johnstone Strait region and; estimate mortality rates of juvenile salmon during their Strait of Georgia to Queen Charlotte Strait migration. In 2019, the Hakai Institute program will also begin experimental testing of the response of juvenile salmon to conditions of pCO_2, temperature and prey availability.

2. Pacific Salmon and Steelhead Trout in a Changing North Pacific Ocean (including Retrospective Salmon Studies; Linking Salmon Production, Climate and Ocean Changes)

In January 2019, Canada hosted an IYS workshop on Pacific and Atlantic salmon status and trends in Vancouver, BC. The primary goal of the workshop was to bring together salmon ecologists interested in working with others on representative times series of data and associated metadata to understand salmon status and trends. The specific objectives of the workshop were to: 1) identify a series of legacy datasets (and associated standards where possible), 2) look at broad temporal patterns for salmon data categories, and 3) link observed state changes and trends to potential drivers and mechanisms. Participants included scientists from Canada, USA, Japan, Korea, Russia, and France. Plans are to publish results from the workshop in the NPAFC Technical Report Series.

DFO continues to examine salmon ocean ecology on the continental shelf of Vancouver Island and the inside waters of the Salish Sea. Neville and King (2019) describe juvenile salmon research surveys planned in both offshore and inshore areas of the North Pacific Ocean by Canada for fiscal year 2019–2020. The inshore program will sample the Salish Sea (Strait of Georgia and Puget Sound) whereas the offshore program will sample along the continental shelf surrounding Vancouver Island (mid-summer) and the northern migratory corridor for Fraser River sockeye salmon, which includes Johnstone Strait, Queen Charlotte Strait and the continental shelf in southern Queen Charlotte Sound, (early summer and fall). These surveys are both part of long-term research programs that were initiated in 1997–1998, however in 2017 the offshore program began integrating with other pelagic research programs to develop a synoptic pelagic survey on the continental shelf off the west coast of Vancouver Island (King et al. 2019). This integrated survey will continue in 2019.

As part of the International Year of the Salmon Signature Gulf of Alaska Expedition in March 2019 documented elsewhere, Canadian scientists pursued various lines of research alongside the international team of researchers. For example, water samples from sixty stations were collected for environmental DNA to investigate species composition as well as preferences in salmon prey

species. Tissue samples from 255 salmon were collected to assess health and condition by means of tissue analysis on a high throughput multiplex qPCR platform. Finally, a novel approach in in-field genetic stock identification by single nucleotide polymorphism sequencing was performed onboard the research vessel in a world-first proof of concept experiment.

3. New Technologies

In 2018, Canada applied direct DNA sequencing to genotype Chinook Salmon and Coho Salmon. For Chinook Salmon, a panel of primers has been developed where approximately 390 amplicons are amplified via a highly-multiplexed single polymerase chain reaction, with at least one single nucleotide polymorphism (SNP) scored at each amplicon. For Coho Salmon, a panel has been developed to amplify 490 amplicons. Both panels are being used in an evaluation of whether parental-based tagging is a practical alternative to the present coded-wire tag program for Chinook and Coho salmon. In 2018, samples were collected from 100% of the Chinook Salmon broodstock (approximately 15,000 individuals) at hatcheries in British Columbia where CWTs are currently applied. Samples were also collected from Coho Salmon broodstock (approximately 7,000 individuals) at hatcheries where individuals are adipose fin clipped upon release. Canada genotyped these individuals using the SNP amplicon panels. Returning adults from prior hatchery releases were genotyped to identify returning Chinook and Coho salmon to specific hatchery parents sampled in 2013–2017, thereby providing a method to evaluate the accuracy of parental-based identification (PBT). Standard genetic stock identification techniques (GSI) were also used to determine the origin of individuals not assigned via parental-based identification. Accurate identification of returning individuals to specific hatchery parents provided the year and location of hatchery release, thereby providing a possible alternative to the current method of coded wire tagging (CWT). Initial applications of a PBT/GSI approach to stock identification for mixed-stock coho salmon samples analyzed in 2017 have proved very informative and have provided additional information relative to the existing CWT program. Very high accuracy and resolution of stock composition estimates of mixed-stock samples from coho salmon fisheries conducted in British Columbia during 2016 and 2017 have been obtained. The GSI estimates of coho salmon stock composition from mixed-stock fishery samples were obtained by applying a baseline of approximately 240 populations comprising about 41,000 individuals genotyped, with the populations surveyed ranging from southeast Alaska to Oregon (Beacham et al. 2019).

4. Management Systems (Cultural and Social Studies)

A management decision-support tool was developed to inform rebuilding plans for depleted Pacific salmon under various productivity regimes, with application to Fraser River Sockeye Salmon and Nass River Chum Salmon. This tool simulates population dynamics and evaluates impacts of various management actions under different hypothesis about climate driven changes in productivity. Implications of time-varying productivity on reference points for management were also evaluated. A publication describing this tool is being prepared.

5. Integrated Information Systems

Canada continues to lead the examination of the feasibility of applying a new information sharing technology to improve communication and collaboration between various parties involved in the management, assessment and harvesting of salmon. In January 2019 an IYS

International Salmon Data Laboratory workshop was held in Vancouver BC. Participants included Pacific and Atlantic salmon scientists and experts in a new generation of technology, tools, and practices for collecting, integrating, analyzing, and communicating information. The goal was to identify how the needs of salmon researchers can be better achieved through the application of modern technology for data processing, analysis, and presentation. Plans are to publish workshop findings in the NPAFC Technical Report Series. Proposals to apply these techniques to real data are being developed with a view to initiating a major initiative this coming year.

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