

“Ocean Science and the United Nations Decade of ocean science for Sustainable Development”

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NPAFC contribution to Part I of the UN Secretary-General report on
“Oceans and law of the sea”

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Executive Summary:

1. NPAFC efforts in advancing the ocean science
2. NPAFC initiatives and projects related to the UN Decade of ocean science for Sustainable Development
3. Emerging ocean science technologies at the service of NPAFC
4. Science-policy interface in the NPAFC
5. Integration of traditional knowledge in the NPAFC research and outreach programmes

1. One of the main NPAFC objectives is to coordinate and assess scientific studies of anadromous stocks and ecologically related species in the Convention Area, to review and coordinate the collection and exchange of scientific data and specimens, other scientific exchanges, and to review proposed scientific research programs. Every five years, the NPAFC adopts a Science Plan for cooperative scientific research. The present Science Plan is for the period of 2016–2020.

In 2014, NPAFC started planning the International Year of the Salmon (IYS) project to facilitate the NPAFC Science Plan implementation and attract the public attention to problems of anadromous fish conservation. Then, the project's scope expanded to address ocean climate change impacts to human and salmon ecosystems and possible societal responses to emerging challenges.

The IYS is an international framework for collaborative outreach and research. Through outreach efforts, the IYS will raise awareness of what humans can do to better ensure salmon and their varied habitats are conserved and restored against the backdrop of increasing environmental variability, and thus the overall theme is *‘salmon and people in a changing world’*. The IYS will stimulate an investment in research and leave a legacy of knowledge, data/information systems, tools, and a new generation of scientists better equipped to provide timely advice meant to inform rational management of salmon and build resilience for salmon and people.

In 2016, the IYS planning phase was launched by NPAFC and the North Atlantic Salmon Conservation Organization (NASCO), together with other partners. In July 2018, NPAFC and NASCO presented the IYS project at the 7th Regional Fishery Body Secretariats' Network (RSN) meeting in Rome. The IYS was also presented in several articles in the RSN Newsletter in 2015-2018. The IYS focal year will be 2019, with projects and activities continuing into 2022.

2. The IYS implementation timeline foresees several important steps, which are planned for 2021-2022, the first years of the UN Decade of ocean science for Sustainable Development

implementation. The IYS outcome should underpin development of new NPAFC Science Plan and other multiyear scientific programs in the future. Expected IYS outcomes by themes include:

- **Status of Salmon:** The present status of salmon and their environments is understood.
- **Salmon in a Changing Salmosphere:** The effects of natural environmental variability and human factors affecting salmon distribution and abundance are understood and quantified.
- **New Frontiers:** New technologies, analytical methods, ideas and ways of thinking are advanced and applied to salmon research. Research is carried out to fill gaps in poorly studied regions of the salmosphere.
- **Human Dimension:** Communities, Indigenous Peoples, youth, harvesters, scientists and resource managers across the Northern Hemisphere share knowledge and collaborate in the development of new tools and approaches to restoring, managing and sustaining salmon.
- **Information Systems:** Information systems that house and mobilize historic and current data about salmon and their environment are freely available.
- **Outreach and Communication:** People understand the value of healthy salmon populations and engage to ensure salmon and their varied habitats are conserved and restored against amidst increasing environmental change.

Substantive discussion on the IYS outcome and further steps will take place at the IYS Wrap-Up Symposium preliminary planned for autumn 2022.

The IYS field research program will be also continued with integrated surveys of the entire North Pacific Ocean that will allow NPAFC to address the largest gap in understanding of salmon ocean ecology—winter high seas distribution and factors affecting their survival. This requires five research vessels per time period at a cost of C\$1.2M per vessel to charter or use vessels from the NPAFC States' government agencies. This Signature IYS Pan Pacific Survey is planned to occur in February-March 2022 and beyond. Many partner organizations including the North Pacific Fisheries Commission (NPFC), North Pacific Marine Science Organisation (PICES), and Pacific Salmon Commission (PSC), expressed great interest in participating in the planning and conducting of such an expedition. Potentially, its results can be of interest for tuna RFMOs operating in the North Pacific.

The Gulf of Alaska expedition is perceived to be a pre-cursor of the IYS Pan Pacific Survey. It will demonstrate the feasibility and importance of future international cruises for better understanding of Pacific salmon ecology of the ocean phase of their migration. This expedition will be performed in February-March 2019 aboard the Russian research trawler, *Professor Kaganovskiy*, as a collaborative project with 20 scientists representing all five NPAFC member countries on-board. The expedition's funding was provided by the governments of Canada and the Province of British Columbia, British Columbia Salmon Farmers Association, Pacific Salmon Foundation, and private donors. Research will provide a comprehensive understanding of the abundance, condition, country of origin, and location of stocks from salmon producing countries. An enormously wide sampling program will be completed. This information is needed as forecasts are limited in predicting how climate and the changing ocean environment affect salmon production and their resilience to climate change impacts.

3. Several new technologies will be used in the 2019 marine expedition and will then be brought on board by the IYS Pan Pacific Survey.

First, documenting health conditions of the migrating Pacific salmon in the ocean will be started on this cruise. It will include aseptic tissue collection for histopathological analysis and systematic recording of pre-determined clinical signs as well as other related observations. A multiplex PCR (m-PCR) method will be used for the detection of epidemically important fish pathogens. A baseline for the health state of foraging Pacific salmon populations will be created. Obtained scientific data will heavily contribute to solve disputes around salmon net-pen farming in the coastal waters, where wild salmon stocks migrate.

Second, the nanopore sequencing technology will be applied for express-identification of salmon stocks on-board of the research vessel. This technology has several advantages, such as, amplification bias is eliminated; single stranded DNA molecule (ssDNA) fragment lengths (and hence read lengths) are not limited by the processivity of a polymerase enzyme; PCR-free library preparation saves time, compared to PCR-based methods; methylation and other modifications are retained. Various Pacific salmon populations including coho and Chinook salmon belonging to endangered populations have hypothetically different potential foraging habitats and hot spots for in the northeastern Pacific. Testing this hypothesis is critically important for further studies on the changing environmental conditions' impact on the sustainability of salmon stocks.

RAFOS Ocean Acoustic Monitoring (i.e., ROAM) is a new concept for salmon tracking proposed by Atlantic salmon researchers. The concept proposes using existing SOFAR (Sound Fixing and Ranging) technology to track salmon in the high seas. It works in reverse to existing approach, so that instead of drifting tags emitting 'pings', which are identified by moored receivers, drifting tags identify 'pings' emitted from moored sound sources. Some advantages of this new method include increased ability to accurately track salmon through the most part of their marine migration with cheaper tags. In October 2017, the NPAFC Secretariat hosted the ROAM webinar for interested participants in the Pacific basin. A workshop was hosted by Tim Sheehan (U.S. NOAA National Marine Fisheries Service) in Woods Hole from March 13–15, 2018 to further explore the concept. There is a great amount of interest from both the Atlantic and Pacific basins to explore the use of this technology. While this approach is still under development, it provides with enhanced potential for basin-level scientific collaboration.

Among scientific projects listed on the IYS website (<https://yearofthesalmon.org/projects>), several projects use new methodological approaches. The scope of a new project developed by the University of Liverpool, UK is to employ zooarchaeological data to reconstruct the past ecology, abundance and distribution of the seven species of Pacific salmonids (*Oncorhynchus* spp.) on the Pacific coast of North America. Accurate identification of species, using fish remains, will be achieved via cutting-edge scientific identifications techniques: Geometric Morphometrics (GMM) - a digital tool based on detailed morphological shape analysis, and ZooMS - a biomolecular 'fingerprinting' technique enabling the identification of animal bones to species using extracted collagen. Suitable baselines for the pre-industrial/contact status of salmonids in the region will be established. Further, these baselines can be deployed as models for assessing *Oncorhynchus* resilience during times of rapid climate change (i.e. Little Ice Age/Medieval Climatic Anomaly). The results of this research will be used to inform climate change studies in the northeastern Pacific, modern salmonid conservation/fisheries policies and subsistence-based economies of modern indigenous communities along the Pacific coast, both of whom still rely on these species.

4. The NPAFC has consistently taken specific steps to strengthening the science-policy interface on anadromous stocks conservation and fisheries enforcement. All the Commission's decisions are made based on the best available scientific data and recommendations.

In 2012, NPAFC initiated preparation of comprehensive review on the ocean ecology of Pacific salmon and anadromous steelhead trout instead of twenty-year old existing book. The book Beamish, R.J. (ed.), "*Ocean ecology of Pacific salmon and trout*" was published in April 2018. Currently, this is the most comprehensive summary and interpretation of the research published on the ocean ecology of six species of Pacific salmon, steelhead, and coastal cutthroat trout. Forty-one authors representing four NPAFC member countries contributed to this 1090-page volume. This review establishes a background for the new NPAFC Science Plan development as well as for other research programs and plans.

Within NPAFC, the Committee on Scientific Research and Statistics (CSRS) closely cooperates with the Committee on Enforcement (ENFO). Joint ENFO/CSRS sessions take place at every annual meeting of the Commission. Scientists present new scientific data on salmon distribution and migration timing depending on thermal conditions that allow the of reveal potential IUU fishing hot spots and adjust the Parties' patrol efforts in the NPAFC Convention Area in the most efficient manner. In 2018, two committees decided to improve the information exchange and established a new working group that will facilitate collaboration, aiming at enhancing of mutual activities.

5. NPAFC actively involves traditional knowledge into the IYS research and outreach programmes. Traditional knowledge holders participate in the IYS North Pacific Steering Committee activities, the IYS opening events in 2018, several projects and events listed on the IYS website, e.g. Skeena Salmon Art Fest, Yukon Salmon Resiliency Conference with presentation from Simpcw First Nation, who manage the Dunn Creek Hatchery producing coho salmon, etc. Traditional knowledge is very important piece of information for the IYS outreach programs that delivers knowledge about salmon to primary school classrooms across the North Pacific Ocean coast. Such programs are developed in Canada, Japan, Russia, and in the Pacific Northwest of the U.S.