North Pacific Anadromous Fish Commission

Established to promote conservation of anadromous stocks in the North Pacific Ocean.
Members are Canada, Japan, the Republic of Korea, the Russian Federation,
and the United States of America.

Newsletter

New Year Message From the President

Dear NPAFC Colleagues, I hope this New Year's Message finds you safe and well. As we begin 2022, we find ourselves in the midst of a global pandemic that is seemingly without end. The uncertainty, changing guidance, travel restrictions, and remote working environment have been stressful and challenging, to say the least. And if the challenges posed by an unprecedented global health crisis weren't enough, we have seen extreme impacts of a changing climate being visited on salmon and many of our communities. It is worth saying that all of us need to divert at least some of our attention to our own health and wellness in these difficult times.

Despite all this, there are some positive things we can reflect on as we look back and look forward to 2022. For example, in spite of all the challenges, the NPAFC has demonstrated a high degree of resilience in maintaining a positive outlook, embracing technology, and finding solutions. The end result was an exceedingly productive 2021 and what is shaping up to be a landmark year for the NPAFC with a Pan-Pacific Expedition and an IYS Synthesis Symposium to conclude the International Year of the Salmon (IYS).

I would like to commend the work of the NPAFC Secretariat in conducting an effective virtual annual meeting in 2021 using web-conferencing technology complete with interpretation. Staff and NPAFC members have become proficient in the use of web-conferencing tools to conduct work intersessionally,

Doug Mecum has served as the Deputy Regional Administrator for NOAA Fisheries Alaska Region since September 2005. He is currently the Acting Alaska Regional Administrator. Doug started his career as a fisheries biologist for the Wyoming Game and Fish Department. He moved to Alaska in 1981 to pursue his graduate education. In 1983, he began work with the Alaska Department of Fish and Game where he served in various research and management positions culminating as the Director of the Division of Commercial Fisheries. Doug has also served on many fisheries-related commissions and committees, including the North Pacific Fisheries Management Council (NPFMC), North Pacific Research Board (NPRB), Pacific Salmon Commission (PSC), North Pacific Anadromous Fish Commission (NPAFC), North Pacific Fisheries Commission (NPFC), Pacific States Marine Fisheries Commission (PSMFC), and the Exxon Valdez Oil Spill Trustee Council (EVOS). The University of Wyoming graduated Doug with Honors and a Bachelor's degree in wildlife conservation and management. He later earned a Master's degree in fisheries science from the University of Alaska School of Fisheries and Ocean Sciences. Doug resides in Juneau with his wife Barbara, daughter Brianne, son Bryce, and granddaughter Sage. He has served as United States Head of Delegation to NPAFC since 2006 and was elected to be the President of NPAFC on May 20, 2021.

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hosting everything from cruise planning meetings to a seminar series on the upcoming expedition. The Third NPAFC-IYS Workshop was also conducted virtually with over 300 registered participants and was published in NPAFC Technical Report 17. It was unfortunate that this workshop could not have been held in person in Hakodate, Japan, to provide an appropriate backdrop for a remarkable topic session on *Resilience for Salmon and People: Lessons from the Great East Japan Earthquake in 2011*.

In addition to the NPAFC-IYS Workshop, the International Year of the Salmon (IYS) made stellar progress in securing funding and support for our signature project, the Pan-Pacific Expedition that will take place from February to April 2022. This was accomplished through the extreme efforts of staff, Commission members, our IYS Steering Committee partners, and funders including the North Pacific Research Board, the British Columbia Salmon Restoration and Innovation Fund (BC SRIF), the Pacific Salmon Foundation, the NPFC, and all of the NPAFC Parties/agencies. Over the past year, dozens of scientists from NPAFC countries have participated in planning this expedition that is larger in scope than any high seas research effort conducted in the past. Even in advance of setting out to sea, this project has succeeded in demonstrating the ability to collaborate internationally. We know going into the future that no single country or entity will be able to do this work alone.

I was very pleased that in 2021 the Commission recognized the contributions of two long-standing members of the NPAFC—Dr. James Irvine and Dr. Shigehiko Urawa by awarding them the NPAFC Award. The award is in recognition of their sustained scientific contributions to the Commission's mission to conserve and manage anadromous salmon and steelhead stocks in the North Pacific Ocean and its adjacent seas.

We have seen some changes over the past year in staff and I would like to acknowledge the contributions of Aidan Schubert our IYS Coordinator and MacKenzie Kermoade our NPAFC intern who both joined us in 2021, as well as Stephanie Taylor who held several positions with the IYS team and has a new position with Canada's DFO. I would also like to thank and recognize our NPAFC interns Andrew Chin and Minje Choi, who completed their internship last year.

In 2021, all NPAFC members became Parties to the FAO Agreement on Port State Measures to strengthen their efforts in combating illegal, unreported, and unregulated (IUU) fishing. The Committee on Enforcement (ENFO) successfully completed its patrol season and held twelve bi-weekly conferences to exchange information between the Parties. Canadian sighting reports highlighted a high incidence of vessels not transmitting an Automatic Identification System (AIS) signature or vessels transmitting incorrect AIS information as well as a noticeable trend where fishing vessels do not appear to be flying a state flag to indicate their registration. These findings can be discussed by ENFO at the Annual Meeting as well

The second meeting of the FAO Agreement on Port State Measures (PSMA) Open-ended Technical Working Group on Information Exchange took place in May 2019 in Seoul, Korea. Photo credit: FAO

Basin-scale Events to Coastal Impacts (BECI) infographic. Photo credit: Camille Jasinski

as with our partners in the North Pacific Fisheries Commission (NPFC). In July, ENFO members attended the First Global Fisheries Enforcement Training Workshop held by FAO and the International Monitoring Control and Surveillance (IMCS) Network. Finally, Draft Terms of Reference for the NPAFC IUU Vessel List was considered together with the South Pacific Regional Fisheries Management Organization (SPRFMO) and North Pacific Fisheries Commission (NPFC) experts and endorsed to present to the Commission at the 2022 Annual Meeting.

The year ahead will be one of reflection and change as the IYS concludes and we consider what we have learned and what actions we will take as a Commission building on the IYS. The IYS will conclude with a Synthesis Symposium in Vancouver from October 4–6, 2022. I am pleased to learn that planning for this symposium is proceeding well in partnership with our Atlantic Ocean partner, the North Atlantic Salmon Conservation Organization (NASCO). It will not only synthesize what we have learned over the course of the IYS but also forward looking in setting a roadmap for future research through 2030. This work will inform our new five-year Science Plan.

One significant opportunity the Commission will be presented with this year is the UN Decade of Ocean Science for Sustainable Development project called Basin Events to Coastal Impacts (BECI). It was developed by staff and partners including the Pacific Salmon Foundation in response to the UN call last January and in August it was endorsed by the UN. This is a significant achievement. The objective of BECI is to build on IYS expeditions conducted in 2019, 2020, and 2022 and test an international ocean intelligence system of monitoring, research, and analytical approaches that provide timely knowledge and advice to decision-makers about the impact of current and future climate on ocean conditions in high seas and coastal socio-ecological systems. Salmon will be an exemplar species but a modular approach will ultimately include all species of interest. Staff and partners are working on developing a BECI science plan that should be completed for the NPAFC annual meeting in May. If successful this may well be the most significant legacy of the IYS.

While the virtual meeting environment has been key to our success over the past two years, I hope we are able to meet in person soon. I look forward to what I know will be a most interesting year for the NPAFC. In the meantime, please stay safe and well.

Best Regards,
Douglas Mecum

Are There Too Many Salmon in the North Pacific Ocean?

By Gregory T. Ruggerone (Natural Resources Consultants, Inc.),
James R. Irvine (Fisheries and Oceans Canada, Pacific Biological Station),
and Brendan Connors (Fisheries and Oceans Canada, Institute of Ocean Sciences)

Greg Ruggerone has investigated the ecology, population dynamics, and management of Pacific salmon since 1979. He is a former Project Leader of the Alaska Salmon Program, University of Washington, and former President of Natural Resources Consultants, one of the oldest fisheries consulting firms in the United States. His interest in salmon abundance trends in Asia and North America stems from his interest in the interactions of pink salmon with other species and his research with Professor Don Rogers, who created the first dataset of Pacific salmon abundance returning from the North Pacific Ocean. Over the recent decade, Greg has collaborated with Jim Irvine and Brendan Connors on investigations of pink salmon interactions with other salmon species, oceanographic effects on salmon, and salmon abundance trends.

At the Third NPAFC-IYS Virtual Workshop on *Linkages between Pacific Salmon Production and Environmental Changes* that took place in May 2021, we hypothesized that an overabundance of salmon, combined with effects of recent marine heat waves, may have been responsible for unexpectedly low returns of all five species of Pacific salmon across the North Pacific in 2020 (Ruggerone et al. 2021). We were subsequently invited to provide this updated summary of our report for the NPAFC Newsletter so that our findings could reach a broader audience. We hope that our article, which includes updated and preliminary estimates of commercial catch for 2021, will stimulate further discussions about the interactions of salmon at sea, especially in light of the dynamic and shifting ocean environment in which they live.

Since everyone wants more salmon, the question "*Are there too many salmon in the North Pacific Ocean?*" might seem odd. However, it is worth considering the potential effects of healthy and abundant salmon populations that often migrate 1,000s of kilometers at sea where they intermingle and compete with distant depleted populations for prey. It is not surprising that fishery managers are primarily concerned with maintaining those populations that return to regions they manage with little consideration for how these populations might adversely affect other salmon. Likewise, hatchery managers release large numbers of juvenile salmon to maximize harvests in nearby salmon fisheries, often with little consideration for, or understanding of, potential competition effects on other distant salmon populations that compete for the same common pool of resources at sea (Holt et al. 2008).

The numbers of Pacific salmon surviving to adulthood increased following the 1977 ocean regime shift, peaking in 2018 when approximately 950 million pink, chum, and sockeye salmon returned from the ocean (Figure 1). This increase was likely the result of favourable ocean conditions combined with the release of large numbers of hatchery-origin juvenile salmon. Releases of hatchery salmon into the North Pacific reached approximately 5.5 billion juvenile salmon in 2019, a sharp increase since the 1960s when approximately 0.6 billion hatchery salmon were released each year (NPAFC 2021a). Approximately 40% of the total salmon biomass in the Pacific during 1990 to 2015 was made up of hatchery salmon, especially chum and pink salmon (Ruggerone and Irvine 2018). Clearly hatchery salmon are now key components

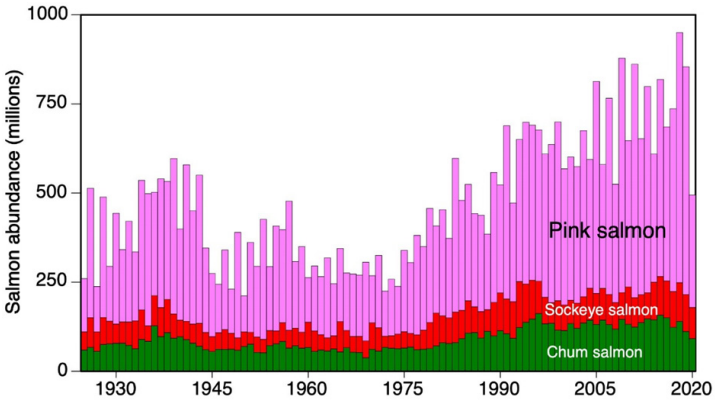

Figure 1. *Total abundance of adult pink, chum, and sockeye salmon (catch plus spawning escapement) returning from the North Pacific Ocean to streams in North America and Asia, 1925–2020. Ruggerone et al. 2021 (updated from Ruggerone and Irvine 2018).*

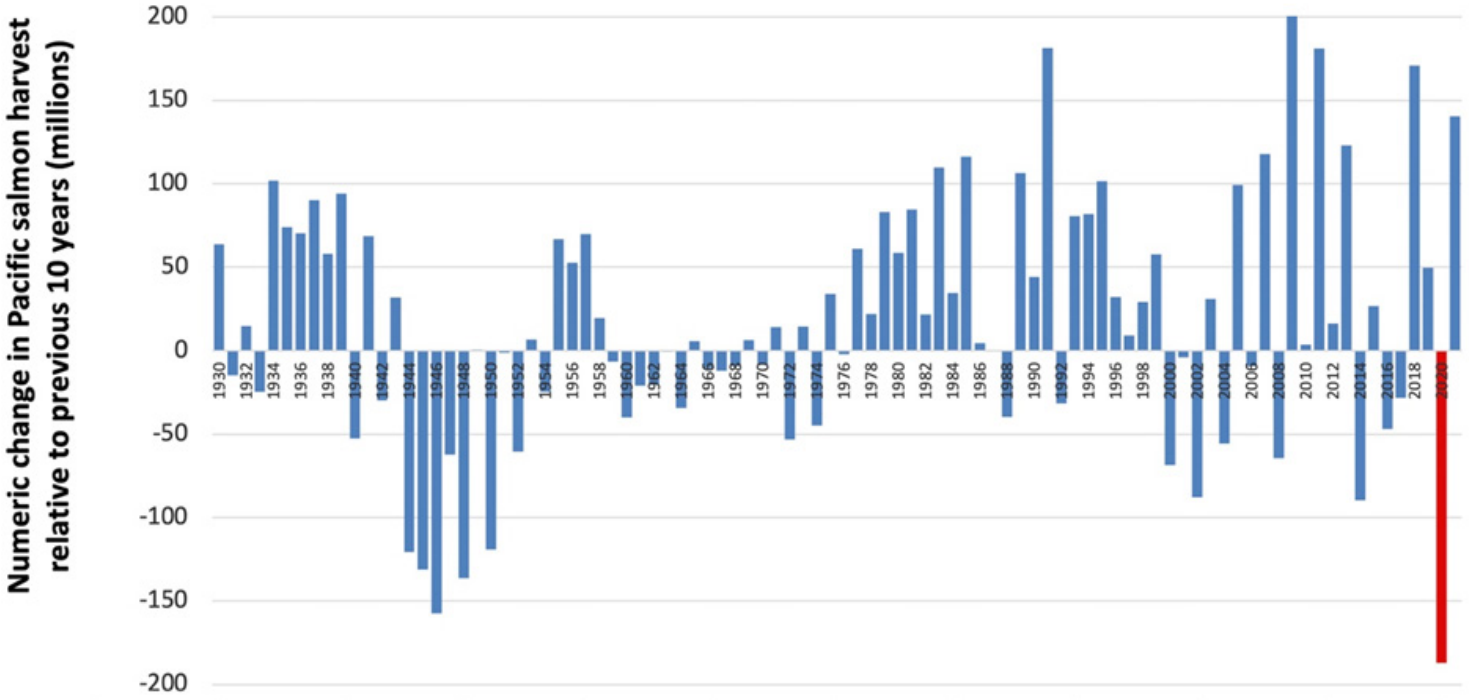

Figure 2. *Change in the commercial catch of Pacific salmon (pink, sockeye, chum, coho and Chinook) relative to the average catch during the previous ten years, 1930–2021. Catch includes both Asia and North America. Updated from Ruggerone et al. 2021 using data from NPAFC (2021b) and preliminary 2021 catch data. The rebound in 2021 is primarily due to pink salmon and Bristol Bay sockeye salmon.*

Table 1. Total abundance of pink, chum, and sockeye salmon (catch plus spawning escapement in millions) returning from the North Pacific Ocean to streams in Asia and North America, 2016 to 2020. These values extend the 1925 to 2015 salmon abundance database (Ruggerone and Irvine 2018; Irvine et al. 2021).

	Asia			North America			Total			
Year	Pink	Chum	Sockeye	Pink	Chum	Sockeye	Pink	Chum	Sockeye	Total
2016	335	110	24	97	39	79	432	150	104	686
2017	287	74	21	226	49	79	513	123	101	737
2018	614	98	23	87	42	86	701	140	109	950
2019	435	74	24	203	37	81	639	111	104	854
2020	205	68	17	110	23	71	315	92	87	494

of the epipelagic North Pacific Ocean. Then in 2020, the harvest of Pacific salmon unexpectedly and precipitously declined. We wanted to know why.

In 2019, salmon abundance remained exceptionally high (~854 million salmon). Together the 2018/2019 period was the highest two-year period of salmon abundance on record since 1925, nearly 20% greater than the previous two-year high in 2009/2010, and more than 3.2 times higher than average abundance during relatively low salmon production years from 1960 to 1975.

Pink salmon dominate the abundance of Pacific salmon returning from the North Pacific, reaching approximately 700 million maturing fish in 2018 and nearly 640 million fish in 2019 (Figure 1). The exceptional return in 2018 was highly unusual because pink salmon abundance is typically highest in odd-numbered years (Irvine et al. 2014). Approximately 88% and 68% of the total pink salmon abundance were from Asia in 2018 and 2019, respectively (Table 1). In contrast, peak abundance of pink salmon in North America occurred in 2013 and 2015 (more than 300 million fish per year). Overall, pink salmon represented approximately 74% of total salmon abundance in 2018/2019. Most pink salmon are of natural origin, but abundance of hatchery pink salmon during 2005 to 2015 was greater than abundance of wild chum salmon and approximately equal to abundance of wild sockeye salmon. Total chum and sockeye salmon represented only 14% and 12%, respectively, of total salmon abundance in 2018/2019. These values exclude Chinook and coho salmon, whose combined reported commercial catch was 1.5% of total salmon catch from the North Pacific during 2018/2019 and approximately 5% of total salmon catch, on average, during 1925 to 2020 (NPAFC 2021b).

The high abundance of Pacific salmon in recent decades came to an abrupt end in 2020. Commercial catch statistics for all salmon species indicate Pacific salmon harvests, which provide an index of abundance, declined more in 2020 than in any other year on record since 1930 (Figure 2). Commercial salmon catch declined by approximately 187 million fish compared with average catch during the previous 10 years (2010–2019; Figure 2). Although the COVID-19 pandemic likely reduced commercial catch to some extent in some regions, most fishery reports and preliminary escapement estimates indicate that low abundance rather than harvest reductions from the COVID-19 pandemic were primarily responsible for the unusually low catch in 2020.

The following details illustrate the issue of commercial catch declines in 2020 for each species. Harvests of each species of Pacific salmon declined 35%, on average, in 2020 when compared with the previous 10-year average. Harvests of Chinook salmon in 2020 were the lowest on record since 1925, declining 54% compared with the previous ten years. Chum salmon harvests in 2020 declined 42%, followed by pink (-40%), coho (-27%), and sockeye salmon (-10%). Sockeye salmon harvests declined relatively little because returns to Bristol Bay in the southeastern Bering Sea remained robust and offset the exceptionally low harvests of sockeye salmon in the Gulf of Alaska, British Columbia, Washington, and the Columbia River. The decline in sockeye harvests in regions beyond Bristol Bay and the Alaska Peninsula, which intercepts many Bristol Bay sockeye salmon, was 44%. Pink salmon returning to the Norton Sound region in northern Alaska in 2020 continued with relatively high returns that began in 2016 (J. Menard, jim.menard@alaska.gov, personal communication), providing evidence for the beneficial effects of the warming ocean on some salmon species in the extreme north.

We hypothesized that a tipping point was reached in the North Pacific Ocean, leading to the substantial decline of all five species of Pacific salmon in 2020 (Ruggerone et al. 2021). We suggested that the tipping point was caused by the combined effects of unusually frequent marine heatwaves since 2014 (Krovnin et al. 2019; Gupta et al. 2020; Litzow et al. 2020) and exceptionally abundant pink salmon during 2018 and 2019 (Figure 1). This hypothesis is partially supported by recent research on the combined effects of sea surface temperature (SST) and pink salmon abundance on productivity (return per spawner) of 47 sockeye salmon populations (brood years 1976–2009) ranging from the Fraser River in British Columbia to Bristol Bay, Alaska (Figure 3) (Connors et al. 2020). This research found that a 1.5°C increase in SST (1 standard deviation) was associated with a 23% increase in sockeye productivity in the Bering Sea, a 9% productivity increase in the Gulf of Alaska, but with a 12% decline in productivity in the southern region (British Columbia and Southeast Alaska). Frequent heatwaves following the period considered by Connors et al. (2020) likely contributed to the growing abundance of pink salmon in the north while also contributing to a northward shift in the adverse effects of high SST on production of other salmon species.

The research by Connors et al. (2020) also found that a 119 million increase in pink salmon abundance (i.e., 1 standard deviation) was historically associated with a 9% decline in sockeye productivity in the Bering Sea and the Gulf of Alaska, and a 21% decline in British Columbia (Figure 3). This finding is consistent with a trophic cascade caused by abundant pink salmon (Batten et al. 2018) and other studies indicating adverse

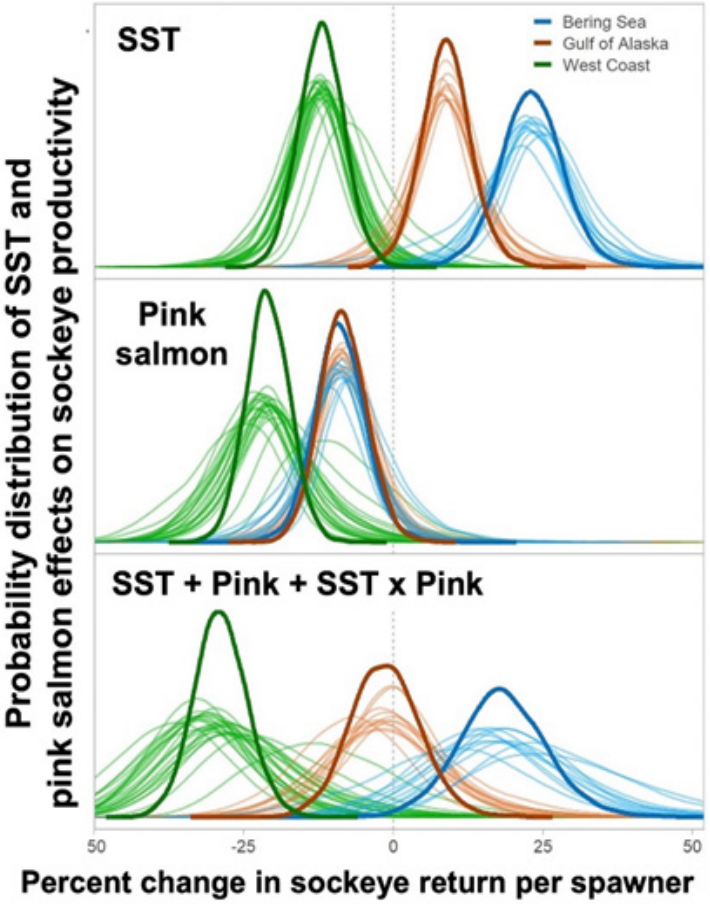

Figure 3. *Effects of a 1 standard deviation increase in both SST (1.5°C) and pink salmon abundance (119 million fish) and the combined effect of both variables on the percentage change in sockeye salmon return per spawner. Empirical model based on 47 sockeye salmon populations (1976 to 2009 brood years) spanning the Bering Sea, Gulf of Alaska, and West Coast (Southeast Alaska through British Columbia) of North America. Thin lines represent each stock; thick lines represent mean of 47 stocks. Source: Connors et al. 2020.*

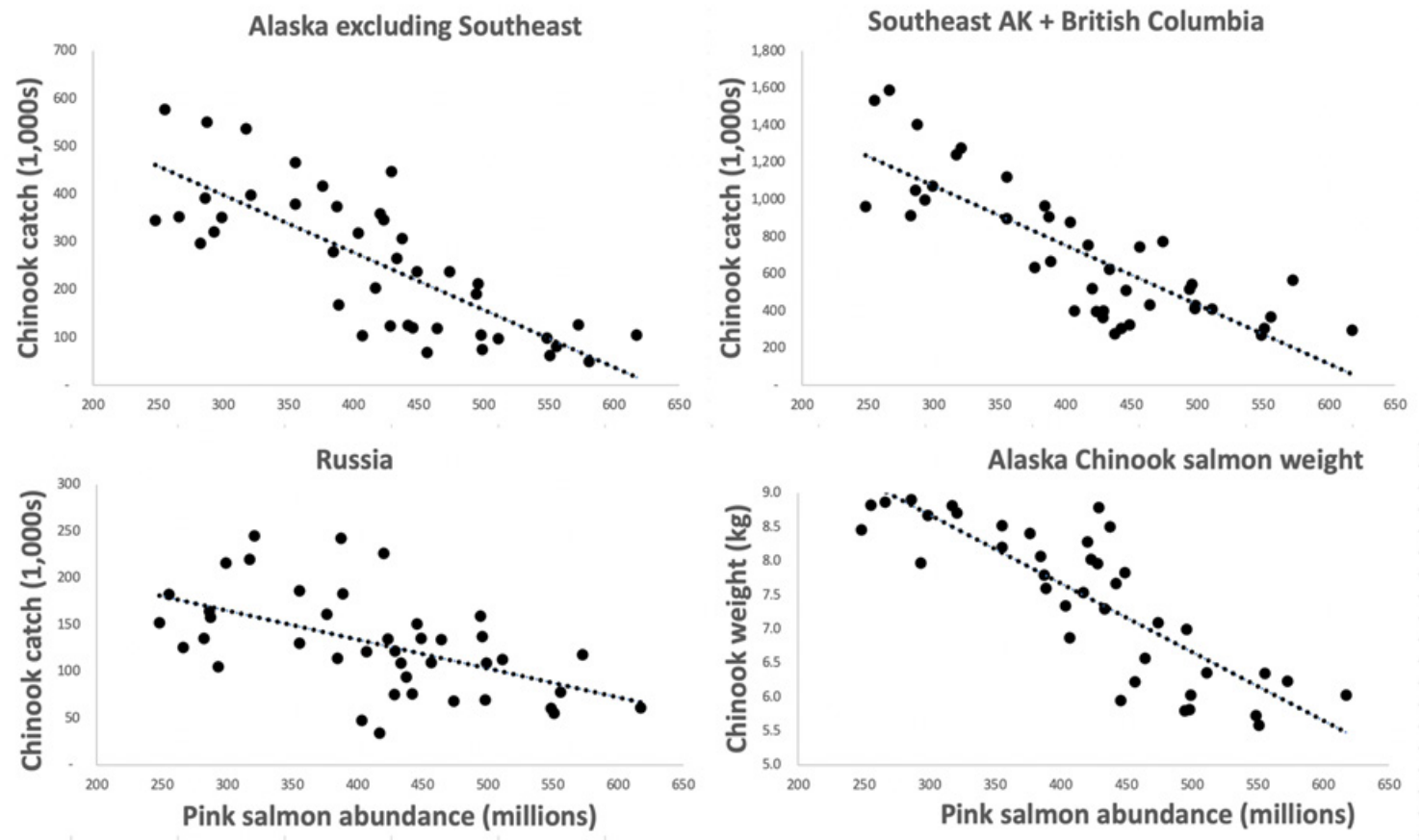

Figure 4. *Relationships between the three-year running average of pink salmon abundance (catch and escapement) returning from the Pacific Ocean and the commercial catch of Chinook salmon in Alaska (excluding Southeast), British Columbia and Southeast Alaska, and Russia, and the average weight of Chinook salmon in Alaska, 1980 to 2020. Values updated from Ruggerone et al. (2016a).*

effects of pink salmon on the growth, age-at-maturation, survival, and abundance of sockeye salmon, Chinook salmon, coho salmon, chum salmon, marine fishes, seabirds, and potentially southern resident killer whales (Ruggerone and Nielsen 2004; Ruggerone and Irvine 2018; Ruggerone and Connors 2015; Ruggerone et al. 2019). Additional evidence of adverse interactions between pink salmon and other species is shown by the biennial patterns in marine species that are consistent with the biennial pattern in pink salmon; a pattern that cannot be explained by physical oceanography alone.

The adverse effect of numerous pink salmon on vital rates of other salmon species has the potential to be far-reaching because salmon migrate long distances. For example, 11–38% of Chinook salmon sampled on the southeastern Bering Sea shelf during 2005–2010 originated from the west coast of the contiguous United States (Larson et al. 2013). Furthermore, commercial catch of Chinook salmon in Alaska, Russia, and British Columbia (which includes many southward migrating Chinook salmon), and the average weight of Chinook salmon in Alaska are negatively correlated with pink salmon abundance during the three years in which Chinook salmon overlap with pink salmon at sea (Figure 4). The diets of Chinook and pink salmon can significantly overlap, especially when pink salmon are in their second year at sea, as both species consume small fishes, squid, and zooplankton (e.g., Davis et al. 2009).

The tipping point hypothesis stems from the record-setting back-to-back-year abundances of pink salmon and unique ocean conditions leading up to the salmon decline in 2020. Both pink salmon abundance and SST were relatively high leading up to the salmon decline in 2020, and more extreme than considered in the Connors et al. (2020) study, which ended with the 2009 sockeye salmon brood year. Furthermore, pink salmon abundance in 2018 did not decline as in past even-numbered years. This hypothesis is consistent with research that has uncovered non-stationary effects of ocean temperatures on salmon catch in the Gulf of Alaska, including negative effects of recent heatwaves on catch (Litzow et al. 2020) and the interactive effect of climate and competition among wild and hatchery pink salmon (Ohlberger et al. 2021).

Preliminary 2021 commercial harvest data indicate a tremendous surge in pink salmon from

Sockeye salmon spawning in Lake Iliamna, Alaska. Photo credit: Greg Ruggerone

Sockeye salmon swimming in Lake Iliamna, Alaska. Photo credit: Greg Ruggerone

the low numbers observed in 2020, despite the ongoing COVID-19 pandemic. Commercial harvests of pink salmon in Alaska and Russia rebounded and led to the largest harvest of pink salmon on record since 1925 (~515 million pink salmon, all regions combined). Sockeye salmon abundance in Bristol Bay, Alaska, set a record high in 2021 [66 million fish (catch and escapement); Sands et al. 2021], apparently in response to favorable early marine growth in the Bering Sea (e.g., Ruggerone et al. 2005, 2007), relatively few pink salmon returning from the North Pacific in 2020 (Ruggerone et al. 2016b), and few pink salmon in the Bristol Bay region. Pink salmon and Bristol Bay sockeye salmon are the primary reason for the resurgence of total salmon in 2021 (Figure 2).

In contrast, overall commercial harvests of Chinook, chum, and coho salmon, as well as non-Bristol Bay sockeye salmon, remained low throughout Asia and North America during 2021. Relative to harvests during 2010 to 2019, chum salmon harvests declined the most (-38%), followed by Chinook (-33%), coho (-25%) and sockeye salmon beyond the Bristol Bay and the Alaska Peninsula management area (-27%). In British Columbia, harvests of all five species appear to have been very low in 2021, with preliminary estimates of total commercial harvest being less than 10% of the average harvest during 2010–2019.

The jury is still out on the validity of our tipping point hypothesis in which the combined effects of high back-to-back pink salmon abundance (2018 and 2019) and frequent marine heatwaves led to large reductions in the abundance of all species in 2020. The record high harvest of pink salmon in 2021 represented approximately 81% of all salmon harvests, and approximately 87% of all harvests if the large harvest of Bristol Bay sockeye salmon are excluded. In contrast, harvests of other salmon species in most regions of the North Pacific remained very low relative to 2010 to 2019. Given the sudden and widespread decline in salmon abundance in 2020, we suspect that factors during late marine life were important to the widespread decline in addition to factors during early marine life and freshwater residence. The exceptional abundance of pink salmon in 2021 raises the concern for rapid recovery of salmon in many regions, but it is difficult to predict whether high pink salmon abundance will exacerbate poor feeding conditions for other salmon species in the near future or partially offset the benefit of favorable ocean conditions if conditions improve. Regardless, with such high abundances of pink salmon returning from the North Pacific as it warms and their effect on the growth and survival of other salmon species, we ask: are there too many salmon in the ocean and if so, should hatcheries continue to release up to 5.5 billion salmon each year of which nearly 1.5 billion are pink salmon?

References

Batten, S.D., G.T. Ruggerone, and I. Ortiz. 2018. Pink Salmon induce a trophic cascade in plankton populations around the Aleutian Islands. Fish. Oceanogr. 27: 548–559.

Connors, B., M.J. Malick, G.T. Ruggerone, P. Rand, M. Adkison, J.R. Irvine, R. Campbell, and K. Gorman. 2020. Climate and competition influence sockeye salmon population dynamics across the Northeast Pacific Ocean. Can. J. Fish. Aquat. Sci. 77: 943–949. (Available at https://cdnsciencepub.com/doi/full/10.1139/cjfas-2019-0422)

Davis, N.D., A.V. Volkov, A.Ya. Efimkin, N.A. Kuznetsova, J.L. Armstrong, and O. Sakai. 2009. Review of BASIS salmon food habits studies. N. Pac. Anadr. Fish Comm. Bull. 5: 197–208. (Available at https://npafc.org)

Gupta, A.S., M. Thomsen, J.A. Benthuysen, A.J. Hobday, E. Oliver, L.V. Alexander, M.T. Burrows, M.G. Donat, M. Feng, N.J. Holbrook, S. Perkins-Kirkpatrick, P.J. Moore, R.R. Rodrigues, H.A. Scannell, A.S. Taschetto, C.C. Ummenhofer, T. Wernberg, and D.A. Smale. 2020. Drivers and impacts of the most extreme marine heatwave events. Sci. Rep. 10: 19359. doi: 10.1038/s41598-020-75445-3.

Holt, C. A., M. B. Rutherford, and R. M. Peterman. 2008. International cooperation among nation-states of the North Pacific Ocean on the problem of competition among salmon for a common pool of prey resources. Marine Policy 32: 607–617.

Irvine, J.R., G.T. Ruggerone, and B. Connors. 2021. Were the largest salmon returns on record in the North Pacific during 2018/2019 responsible for low returns in 2020? pp. 117–121. *In* State of the physical, biological and selected fishery resources of Pacific Canadian marine ecosystems in 2020. *Edited by* J.L. Boldt, A. Javorski, and P.C. Chandler. Can. Tech. Rep. Fish. Aquat. Sci. No. 3434. (Available at https://publications.gc.ca/collections/collection_2021/mpo-dfo/Fs97-6-3434-eng.pdf)

Irvine, J.R., C.J.G. Michielsens, M. O'Brien, B.A. White, and M. Folkes. 2014. Increasing dominance of odd-year returning pink salmon. Trans. Am. Fish. Soc. 143: 939–956.

Krovnin, A.S., N.V. Klovach, and K.K. Kivva. 2019. Unprecedented far east salmon catches in 2018: what should we expect in future? N. Pac. Anadr. Fish Comm. Tech. Rep. 15: 7–12. (Available at https://npafc.org)

Larson, W.A., F.M. Utter, K.W. Myers, W.D. Templin, J.E. Seeb, C.M. Guthrie III, A.V. Bugaev, and L.W. Seeb. 2013. Single-nucleotide polymorphisms reveal distribution and migration of Chinook salmon (*Oncorhynchus tshawytscha*) in the Bering Sea and North Pacific Ocean. Can. J. Fish. Aquat. Sci. 70: 128–141.

Litzow, M.A., M.J. Malick, N.A. Bond, C.J. Cunningham, J.L. Gosselin, and E.J. Ward. 2020. Quantifying a novel climate through changes in PDO-climate and PDO-salmon relationships. Geophys. Res. Lett. 47(16): p.e2020GL087972.

North Pacific Anadromous Fish Commission (NPAFC). 2021a. NPAFC Pacific salmonid hatchery release statistics (updated August 2021). NPAFC, Vancouver. [Accessed December 2021]. (Available at https://npafc.org)

North Pacific Anadromous Fish Commission (NPAFC). 2021b. NPAFC Pacific salmonid catch statistics (updated September 2021). NPAFC, Vancouver. [Accessed December 2021]. (Available at https://npafc.org)

Ohlberger, J., E.J. Ward, R.E. Brenner, M.E. Hunsicker, S.B. Haught, D. Finnoff, M.A. Litzow, T. Schwoerer, G.T. Ruggerone, and C. Hauri. 2021. Non-stationary and interactive effects of climate and competition on pink salmon productivity. Global Change Biology. doi: 10.1111/gcb.16049.

Ruggerone, G.T., and J.L. Nielsen. 2004. Evidence for competitive dominance of pink salmon (*Oncorhynchus gorbuscha*) over other salmonids in the North Pacific Ocean. Rev. Fish Biol. Fish. 14: 371–390.

Ruggerone, G.T., E. Farley, J. Nielsen, and P. Hagen. 2005. Seasonal marine growth of Bristol Bay sockeye salmon (*Oncorhynchus nerka*) in relation to competition with Asian pink salmon (*O. gorbuscha*) and the 1977 ocean regime shift. Fishery Bulletin. 103(2): 355–370.

Ruggerone, G.T., J.L. Nielsen, and J. Bumgarner. 2007. Linkages between Alaskan sockeye salmon abundance, growth at sea, and climate, 1955–2002. Deep-Sea Res. II 54: 2776–2793.

Ruggerone, G.T., and B.M. Connors. 2015. Productivity and life history of sockeye salmon in relation to competition with pink and sockeye salmon in the North Pacific Ocean. Can. J. Fish. Aquat. Sci. 72: 818–833.

Ruggerone, G.T., B.M. Connors, B.A. Agler, L.I. Wilson, and D.C. Gwinn. 2016a. Growth, age at maturation, and survival of Yukon, Kuskokwim, and Nushagak Chinook salmon. Final report to Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative, Anchorage, Alaska. (Available at www.aykssi.org)

Ruggerone, G.T., B.A. Agler, B. Connors, E.V. Farley, Jr., J.R. Irvine, L. Wilson, and E.M. Yasumiishi. 2016b. Competition between pink and sockeye salmon at sea and its influence on Bristol Bay sockeye salmon forecast error. N. Pac. Anadr. Fish Comm. Bull. 6: 349–361. (Available at https://npafc.org)

Ruggerone, G.T., and J.R. Irvine. 2018. Numbers and biomass of natural- and hatchery-origin pink, chum, and sockeye salmon in the North Pacific Ocean, 1925–2015. Mar. Coast. Fish. Dyn. Manage. Ecosyst. Sci. 10: 152–168. doi: 10.1002/mcf2.10023.

Ruggerone, G.T., A.M. Springer, L.D. Shaul, and G.B. van Vliet. 2019. Unprecedented biennial pattern of birth and mortality in an endangered apex predator, southern resident killer whales in the eastern North Pacific Ocean. Mar. Ecol. Progr. Ser. 608: 291–296.

Ruggerone, G.T., J.R. Irvine, and B. Connors. 2021. Did recent marine heatwaves and record high pink salmon abundance lead to a tipping point that caused record declines in North Pacific salmon abundance and harvest in 2020? N. Pac. Anadr. Fish Comm. Tech. Rep. 17: 78–82. (Available at https://npafc.org) (PowerPoint: https://npafc.org/workshop-presentations-2021/).

Sands, T., T. Elison, and A. Tiernan. 2021. 2021 Bristol Bay salmon season summary. Alaska Dept. Fish and Game, Anchorage, Alaska. (Available at https://www.adfg.alaska.gov)

Trying to Hit a Moving Target: Challenges with Pink Salmon Stock Assessment

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Figure 1a. *Construction of the Hells Gate fishways along the Fraser River mainstem in the 1940's in response to the Hells Gate landslide of 1913. Photo credit: PSC & IPSFC Archival Collection*

Pacific Salmon Commission Background

Canada and the United States have been formally engaged in bilateral management of Pacific salmon and their fisheries since the creation of the International Pacific Salmon Fisheries Commission (IPSFC) in 1937 (Roos 1991). The IPSFC was responsible for some of the earliest research efforts conducted on Fraser River sockeye salmon (*Oncorhynchus nerka*) populations. Most notably, the IPSFC coordinated the creation of the world's first vertical slot fishways—erected in the Fraser River mainstem at Hells Gate, British Columbia in response to a massive rockslide in 1913, which threatened the survival of salmon spawning in the upper Fraser River (Thompson 1945). (Figure 1a). Fishway construction began in the mid-20th century as a collaborative effort between Canadian and American governments, biologists, and engineers, and in 2013 a plaque was erected at the site to commemorate 100 years of international co-management of Fraser River salmon (Figure 1b). While initially focused on the commercially vital Fraser sockeye salmon run, in 1957 the IPSFC expanded its mandate to also include research and bilateral management of pink salmon (*Oncorhynchus gorbuscha*).

In 1985, the Pacific Salmon Treaty was ratified between the governments of Canada and the United States (Figure 2), leading to the dissolution of the IPSFC and the establishment of the Pacific Salmon Commission (PSC) (Figure 3) as the newly formed regional fisheries management body responsible for upholding the terms of the Treaty (Amended Annex IV of the Treaty between the Government of

Canada and the Government of the United States of America concerning Pacific Salmon. Entry into force 11 February 2021). The goals of the Treaty are to prevent overfishing and to provide for the optimum production and fair sharing of the harvest of Pacific salmon. To achieve these goals, the Treaty provides a framework through which both countries interact to establish, implement, and monitor science-based fishery management regimes applicable to their respective jurisdictions (https://www.psc.org). With this transition, the scope of the collaboration between the two countries extended beyond the Fraser River, to populations from Alaska to Oregon and to all species of Pacific Salmon.

The PSC is administered through a Secretariat headquartered in Vancouver, British Columbia—just down the road from the NPAFC office! The Secretariat staff are administrative and scientific professionals who facilitate meetings, provide scientific assessments, run field programs, and maintain extensive archives dating back to the early 20th Century. Most Secretariat staff members are biologists that provide technical and analytical support to the Fraser River Panel, the PSC body responsible for in-season management of Fraser River sockeye and pink salmon. Biological staff manage test fisheries, collect and analyze Scale and DNA samples for stock identification, operate a hydroacoustic program in the lower Fraser River (e.g., PSC 2021), and update stock assessments throughout the fishing season.

Figure 1b. *A plaque located at Hells Gate, commemorating 100 years of bilateral co-management of Fraser River salmon by the United States and Canada. Photo credit: PSC*

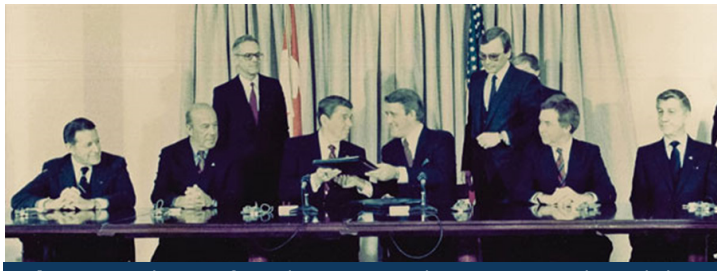

Figure 2. *The Pacific Salmon Treaty between Canada and the United States was ratified at the so-called Shamrock Summit in Quebec City the day after St. Patrick's Day (March 18) in 1985 by Canadian Prime Minister Brian Mulroney and U.S. President Ronald Reagan. Photo credit: PSC & IPSFC Archival Collection*

Assessment of Fraser River pink salmon

Despite representing one of the most data-rich and most intensely managed salmon fisheries in the Pacific, recent changes to the productivity (DFO 2021) and migration behaviour (Folkes et al. 2018) of the Fraser River pink salmon run has confounded in-season assessments. For example, in 2019, the timing of the pink salmon return to the waters off of the Fraser River was the earliest recorded in the 63-year time series. As a result, PSC biologists have been actively exploring new relationships and potential covariates to improve estimates of the Fraser River pink salmon return, and assist the Fraser River Panel in making timely fisheries management decisions.

Pink salmon return to the Fraser River on an odd-year cycle (Heard 1991), typically with peak arrival timing in marine approach fisheries at the southern and northern ends of Vancouver Island (Figure 4) occurring in the third week of August (PSC 2021). Many of the assessment tools originally developed for sockeye salmon do not perform well for pink salmon due to slower and more variable migration speeds. In addition to small and highly variable

Figure 3. *Pacific Salmon Commission logo, representing the areas where salmon are subject to bilateral management under the terms of the Pacific Salmon Treaty.*

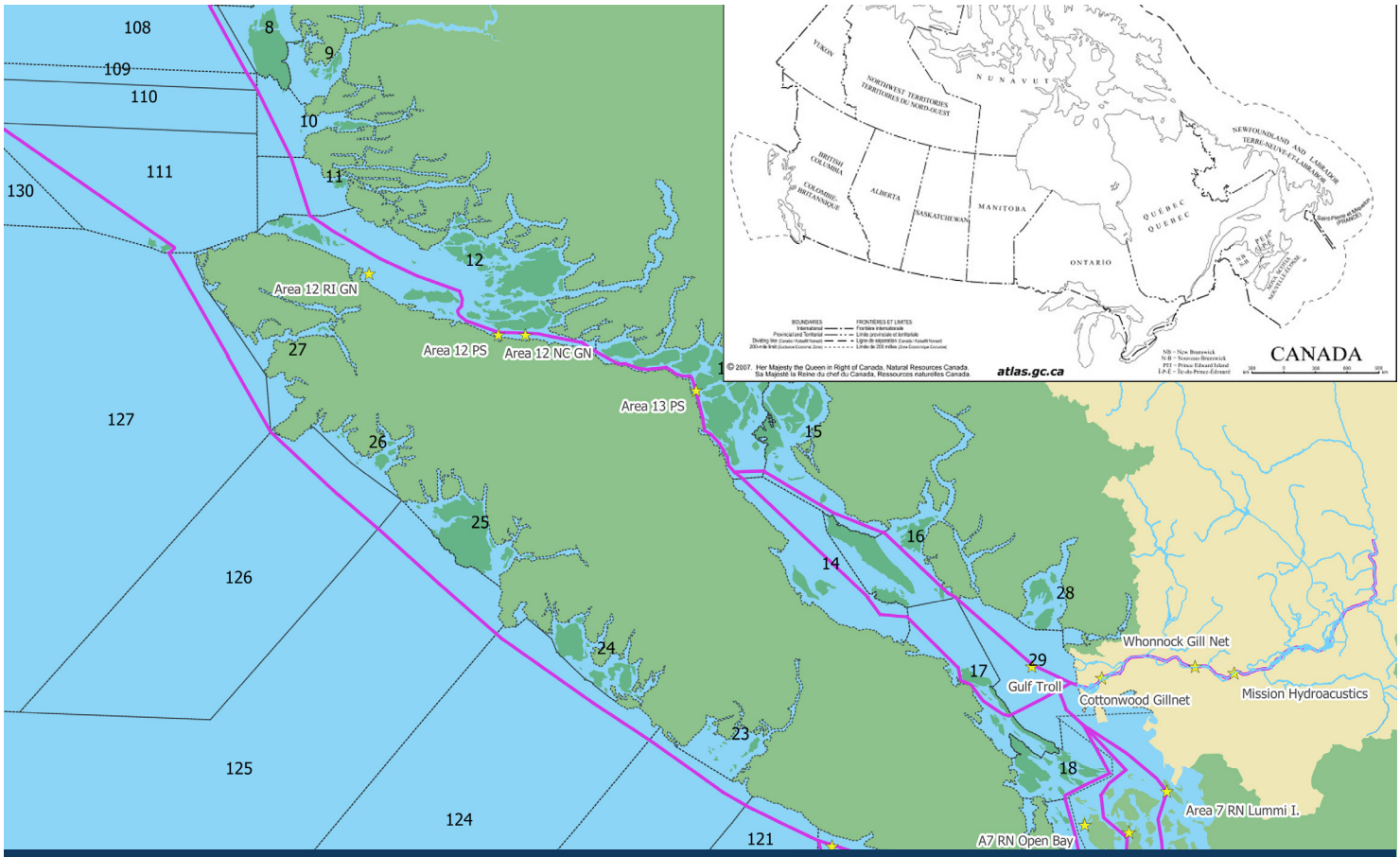

Figure 4. *A map of key fishing and assessment locations for Fraser River sockeye and pink salmon managed under the terms of the Pacific Salmon Treaty in British Columbia, Canada and Washington, U.S.A.*

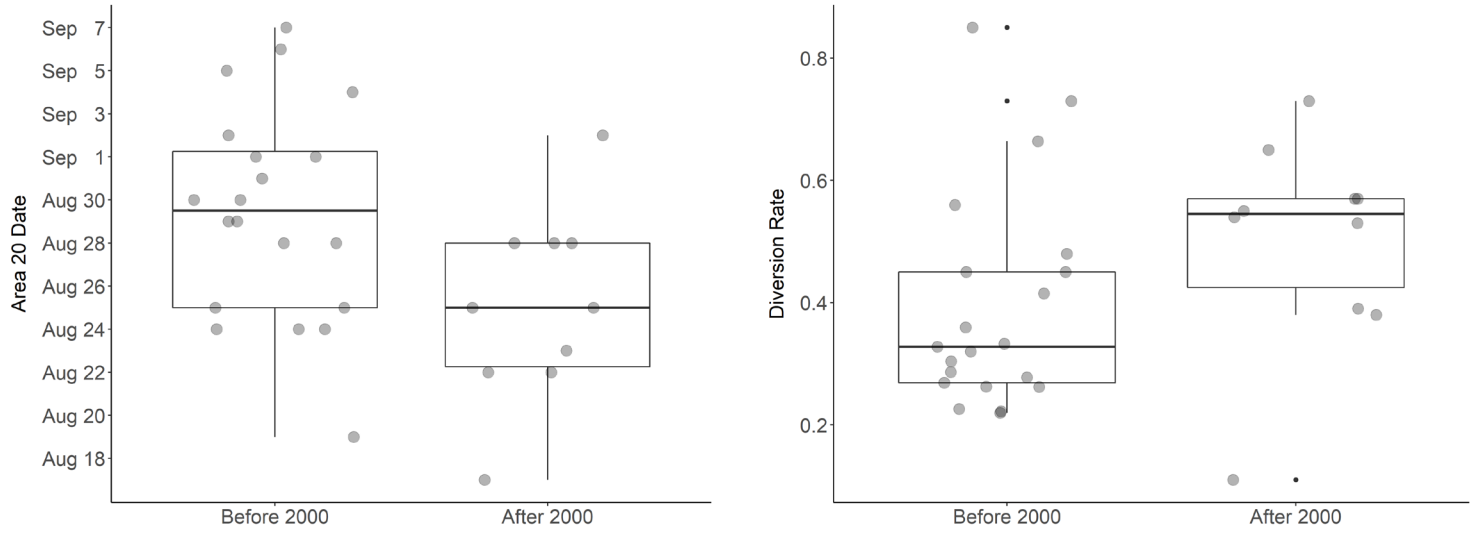

Figure 5. *Box-plots comparing the marine timing of pink salmon in years before and after 2000 (on the left figure) and percent diversion around the northern versus southern end of Vancouver Island (on the right figure). Marine timing is indexed to arrival at a purse seine test fishery located on the southwest coast of Vancouver Island (Figure 4). Data are from 1959–2019.*

catchability coefficients associated with pink salmon catches in marine test fisheries, bias in assumed marine timing, migration behaviour, and run size priors have also contributed more frequently to assessment errors in recent years.

Similar to many other Pacific salmon populations (Dorner et al. 2008; Kovach et al. 2012), Fraser River pink salmon have demonstrated both non-stationarity and/or increased variability in both productivity (DFO 2021) and migration behaviour (Figure 5) over the last 20 years. These changes are not surprising considering the observed trends in several oceanographic variables (e.g., sea surface temperature (SST), Pacific decadal oscillation (PDO), North Pacific gyre oscillation (NPGO)) over the same

time frame (e.g., Agha et al. 2021; Crozier et al. 2021; Litzow et al. 2018), and a recognition that characteristics of Pacific salmon returns will often co-vary with environmental data (Beamish et al. 1999; Peterman and Dorner 2012; Connors et al. 2020). As a result, there is greater uncertainty in pre-season assumptions and priors that are used to parameterize in-season stock assessment tools. In response, both DFO and PSC biologists have recently revised their data sources and models used for both pre-season forecasts and in-season assessments of Fraser River pink salmon.

Methods and Results

Two approaches have been explored to improve the information in pink salmon pre-season priors. The first approach constrains the historical dataset to a reduced number of years, both for model fitting and for generating prior distributions. Given the non-stationarity in the time series of timing and northern diversion (the percentage of the return anticipated to migrate around the northern tip of Vancouver Island en route to the Strait of Georgia; Folkes et al. 2018), initial pre-season estimates provided to fisheries managers in 2021 were based on a reduced subset of historical data from 2001–2019 (Figure 5). Other salmon scientists have noted correlations between environmental regime shifts and aspects of salmon biology (e.g., Beamish et al. 1999) and acknowledge that older historical data may not be representative of current conditions.

The second method used to improve pre-season forecasts identifies environmental covariates which could explain the underlying non-stationarities in salmon abundance or behaviour. For example, DFO forecasts timing and northern diversion rates of Fraser River sockeye and pink salmon using oceanographic covariates associated with conditions experienced by returning adults during marine approach (Folkes et al. 2018). While the actual models are more complex, a simple linear regression illustrates the significant relationship between summer water temperature and the arrival timing of pink salmon to marine test fisheries (Figure 6). DFO also incorporated environmental covariates into their pink salmon stock recruit model to forecast the 2021 return (DFO 2021). A simple log-linear regression between regional spring SST during the ocean entry year illustrates the potential influence of a single environmental covariate, particularly when temperatures are higher than average (Figure 7). Restricting the historical time series greatly improved model fit and significance due to the increased frequency and magnitude of extreme sea surface temperatures, and SST anomalies, in recent years. At lower temperatures, the relationships illustrated in Figure 6 and Figure

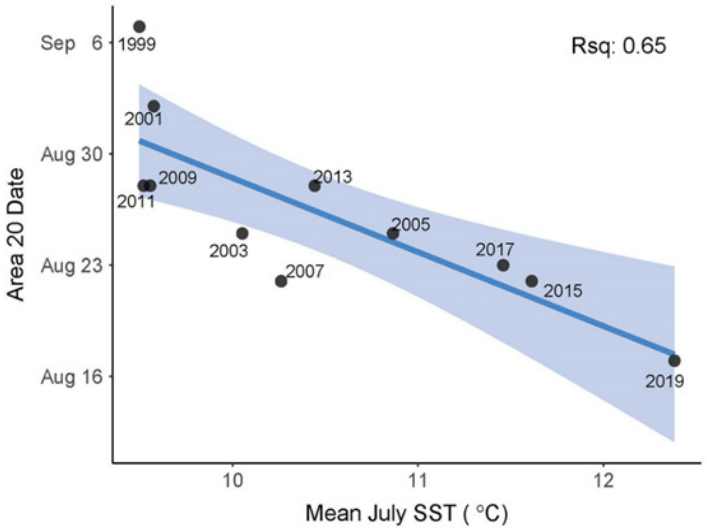

Figure 6. *The relationship between mean SST (ºC) in July of the return year at Pine Island and marine run timing. The shaded region is the 95% confidence interval.*

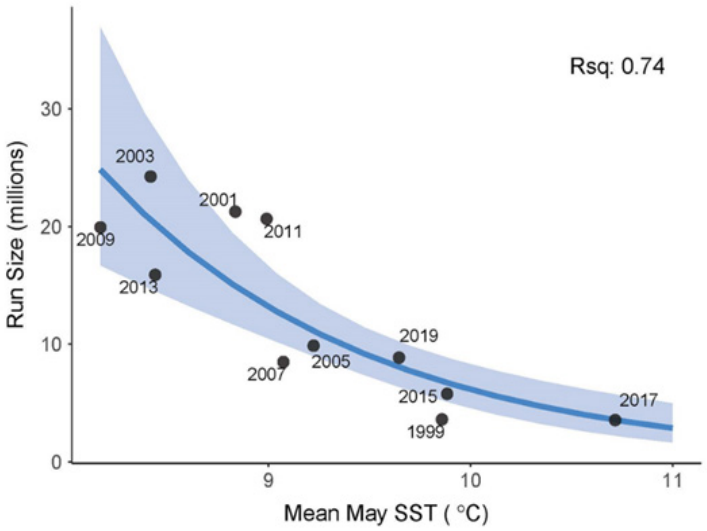

Figure 7. *The relationship between mean sea surface temperature (SST, ºC) in May of the out-migrating year at Pine Island and run size. The shaded region is the 95% confidence interval.*

7 are no longer significant. Non-linear relationships between environmental variables and salmon survival or behaviour are not unusual (Munsch et al. 2020; Eliason et al. 2010), and some variables will only become informative predictors once a certain threshold has been exceeded (Munsch et al. 2020; Satterthwaite et al. 2020). In addition, it is important to select oceanographic covariates for which a biological mechanism can be identified. Such considerations will improve the predictive capacity of the approach and reduce the probability of reliance on models for which the relationship breaks down over time (Gosselin et al. 2021).

More accurate pre-season forecasts also improve the performance of in-season stock assessment tools. For example, pre-season estimates of run size, timing, and northern diversion are used as priors

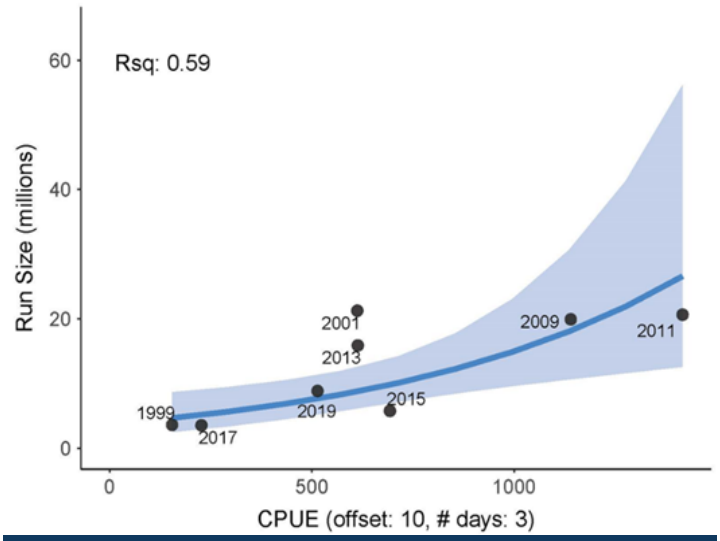

Figure 8. *The relationship between three-day average test-fishery catch per unit effort data collected ten-days prior to the peak migration date and run size. The shaded region is the 95% confidence interval.*

in Bayesian time-density models which generate estimates of total salmon abundance and arrival timing (Michielsens and Cave 2018). The priors are updated using in-season CPUE data from marine area purse seine test fisheries to produce daily estimates of fish abundance. However, even with improved prior assumptions, low and highly variable historical catchability estimates also contribute to uncertain and/or biased in-season run sizes. For example, in 2013, an in-season run size estimate of 26 million pink salmon derived from test fishery CPUE and historical catchability estimates was later revised to an estimate of 16 million post-season—a bias of 78% (PSC 2019). Hydroacoustic estimates produced at a facility in the lower Fraser River (near Mission, BC, Figure 4) provide a much more accurate assessment of daily run size, but unlike the 6–8 day migration time between marine test fisheries and the river exhibited by sockeye salmon (Michielsens and Cave 2018), pink salmon swim more slowly resulting in a two–three week offset between marine approach areas and river entry (White 1998). As a result, hydroacoustic estimates of pink salmon abundance cannot be incorporated into run reconstruction models to update test fishery catchability, or into time-density models to update estimates of total run size (Michielsens and Cave 2018) in time to inform management decisions.

Given the uncertainty in pink salmon catchability, one alternative is to adopt a simplified approach using a direct relationship between CPUE and run size. There is a significant log-linear relationship (R^2 = 59%) between three-day average test fishery CPUE early in the run and total pink salmon run size (Figure 8). This simple tool can be used to provide an early indication of whether the strength of the run is likely to deviate from the pre-season forecast. Alternatively, when available, commercial fishing CPUE data have also been used to estimate pink salmon abundance through the U.S. approach (PSC 2016). While data are limited, historical run reconstructions suggest that U.S. purse seine fisheries operating in the San Juan Islands (Figure 4) have a much lower, and less variable, catchability than the seaward purse seine test fisheries (PSC 2016). When available, the commercial data can be incorporated into existing run reconstruction models and used to update the estimate of test fishery catchability. However, modelers must still use caution when the commercial fishing effort is low and/or there are few days of commercial openings as incorrect migration rate assumptions can still introduce errors into the run reconstructions.

Conclusion

Changing environmental conditions and concurrent changes to productivity and migration behaviour of Fraser River pink salmon necessitates a re-evaluation of traditional stock assessment approaches. Updated model parameterization and use of environmental data to better predict annual timing and abundance of returns may help improve in-season assessments and increase the probability of achieving fisheries management objectives. In addition to improving prior estimates of run size and timing using environmental data, application of a suite of alternative in-season stock assessment tools and data sources are also required for developing robust estimates of pink salmon return. Modelling approaches should be iteratively re-evaluated in a retrospective framework, particularly until causal relationships between environmental covariates and salmon biology are better understood.

Note—This article with updated content is based on the pre-recorded oral presentation given at the Third NPAFC-IYS Virtual Workshop on Linkages between Pacific Salmon Production and Environmental Changes, which took place in May 2021. The presentation is available here.

References

Agha, M., J.P. Losee, M.N.C. Litz, C. Smith, J.J. Schaffler, W.S. Patton, A.M. Dufault, and G.M. Madel. 2021. Temporal patterns and ecosystem correlates of chum salmon (*Oncorhynchus keta*) migration phenology in the Pacific Northwest. Can. J. Fish. Aquat. Sci. doi:10.1139/cjfas-2020-0392.

Beamish, R.J., D.J. Noakes, G.A. McFarlane, L. Klyashtorin, V.V. Ivanov, and V. Kurashov. 1999. The regime concept and natural trends in the production of Pacific salmon. Can. J. Fish. Aquat. Sci. 56: 516–526. doi: 10.1139/f98-200.

Connors, B., M.J. Malick, G.T. Ruggerone, P. Rand, M. Adkison, J.R. Irvine, R. Campbell, and K. Gorman. 2020. Climate and competition influence sockeye salmon population dynamics across the Northeast Pacific Ocean. Can. J. Fish. Aquat. Sci. 77: 943–949. doi: 10.1139/cjfas-2019-0422.

Crozier, L.G., B.J. Burke, B.E. Chasco, D.L. Widener, and R.W. Zabel. 2021. Climate change threatens Chinook salmon throughout their life cycle. Comm. Bio. doi:10.1038/s42003-021-01734-w.

Dorner, B., R.M. Peterman, and S.L. Haesker. 2008. Historical trends in productivity of 120 Pacific pink, chum, and sockeye salmon stocks reconstructed by using a Kalman filter. Can. J. Fish. Aquat. Sci. 65: 1842–1866.

Eliason, E.J., T.D. Clark, M.J. Hague, L.M. Hanson, Z.S. Gallagher, K.M. Jeffries, M.K. Gale, D.A. Patterson, S.G. Hinch, and A.P. Farrell. 2010. Differences in thermal tolerance among sockeye salmon populations. Science 332: 109–112.

Fisheries and Oceans Canada (DFO). 2021. Pre-season run size forecasts for Fraser River sockeye (*Oncorhynchus nerka*) and pink (*Oncorhynchus gorbuscha*) salmon in 2021. Can. Sci. Advis. Sec. Sci. Resp. In press.

Folkes, M.J.P., R.E. Thomson, and R.A.S. Hourston. 2018. Evaluating models to forecast return timing and diversion rate of Fraser sockeye salmon. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/021. 220 pp.

Gosselin, J.L., L.G. Crozier, and B.J. Burke. 2021. Shifting signals: correlations among freshwater, marine and climatic indices often investigated in Pacific salmon studies. Ecol. Indic. 121: 107–167. doi: 10.1016/j.ecolind.2020.107167.

Heard, W.R. 1991. Life history of pink salmon (*Oncorhynchus gorbuscha*). *In* Pacific salmon life histories. *Edited by* C. Groot and L. Margolis. Univ. British Columbia Press, Vancouver. pp. 119–230.

Kovach, R.P., A.J. Gharrett, and D.A. Tallmon. 2012. Genetic change for earlier migration timing in a pink salmon population. Proc. R. Soc., B 279: 3870–3878.

Litzow, M.A., L. Ciannelli, P. Puerta, J.J. Wettstein, R.R. Rykaczewski, and M. Opiekun. 2018. Non-stationary climate-salmon relationships in the Gulf of Alaska. Proc. R. Soc. B. 285: 20181855. doi:10.1098/rspb.2018.1855.

Michielsens, C., and J. Cave. 2018. In-season assessment and management of salmon stocks using a Bayesian time-density model. Can. J. Fish. Aquat. Sci. 76: 1073–1085. doi: 10.1139/cjfas-2018-0213.

Munsch, S.H., K.S. Andrews, L.G. Crozier, R. Fonner, J.L. Gosselin, C.M. Greene, C.J. Harvey, J.I. Lundin, G.R. Pess, J.F. Samhouri, and W.H. Satterthwaite. 2020. Potential for ecological nonlinearities and thresholds to inform Pacific salmon management. Ecosphere 11: 1–21.

Pac. Salmon Comm. 2016. Report of the Fraser River Panel to the Pacific Salmon Commission on the 2011 Fraser River sockeye and pink salmon fishing season. 76 pp.

Pac. Salmon Comm. 2019. Report of the Fraser River Panel to the Pacific Salmon Commission on the 2013 Fraser River sockeye and pink salmon fishing season. 76 pp.

Pac. Salmon Comm. 2021. Report of the Fraser River Panel to the Pacific Salmon Commission on the 2019 Fraser River sockeye and pink salmon fishing season. 93 pp.

Peterman, R.M., and B. Dorner. 2012. A widespread decrease in productivity of sockeye salmon populations in western North America. Can. J. Fish. Aquat. Sci. 69: 1255–1260. doi:10.1139/f2012-063.

Roos, J.F. 1991. Restoring Fraser River Salmon: The History of the International Pacific Salmon Fisheries Commission, 1937–1985.

Satterthwaite, W.H., K.S. Andrews, B.J. Burke, J.L. Gosselin, C.M. Greene, C.J. Harvey, S.H. Munsch, M.R. O'Farrell, J.F. Samhouri, and K.L. Sobocinski. 2020. Ecological thresholds in forecast performance for key United States West Coast Chinook salmon stocks. ICES J. Mar. Sci. 77: 1503–1515.

Thompson, W.F. 1945. Effect of the obstruction at Hell's Gate on the sockeye salmon of the Fraser River. IPSFC Bulletin I. 174 pp.

White, B. 1998. Fraser River pink salmon catch and exploitation patterns: 1989–1995. Pac. Salmon Comm. Tech. Rep. 10. 52 pp.

The Fraser River near Hell's Gate. Photo credit: © misszin / Adobe Stock

Performance Review of an International Organization—The NPAFC Experience

By Vladimir Radchenko
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Since the 1990s, there are growing concerns over the state of World fisheries based on the deterioration of many fish stocks worldwide. The decline of Pacific sardine and walleye pollock in the North Pacific, Atlantic northwest cod, Atlantic salmon, Atlantic bigeye and yellowfin tuna stocks, among many, have raised concerns and awareness. All these stocks' decline took place against a background of an overall decreasing status of global fish stocks, increasing fishing effort and fishing fleet numbers, still widespread illegal, unregulated and unreported (IUU) fishing, and concerns over the environmental impacts of fishing activities on fishery ecosystems and biodiversity.

Even twenty-five years ago, regional fisheries management organizations (RFMOs, in this article the abbreviation includes all regional fisheries bodies) continued working mostly behind the scenes with insufficient public communication and lack of transparency that resulted in broad-based criticism toward efficiency of their performance from researchers, NGOs, and some stakeholders. Organizations did not agree that they were not doing enough to conserve fishery stocks under their responsibility and fight IUU fishing. Despite criticism sometimes looking similar to a battle for grant dollars, there was a grain of truth to these concerns. For example, transparency in decision-making within RFMOs is pointedly required under article 12 of the UN Fish Stocks Agreement, adopted in 1995. Most importantly, there was not an independent third-party's opinion on matters of dispute. In these circumstances, the United Nations General Assembly has wisely called on RFMOs to carry out performance reviews (PRs) to assess the strengths and weaknesses of past actions by specific RFMOs (Haas et al. 2019).

A PR approach and methodology was recommended in several international fora: first during the 26th Session of the FAO Committee on Fisheries (COFI) in 2005, in the United Nations General Assembly (UNGA) in the same year, and subsequently during the first Kobe meeting of tuna regional fisheries management organizations. Then, the call was repeated in the 27th Session of COFI in 2007. This call has been heard, and our partners

Figure 1. *Seventh RSN meeting at FAO Headquarters (Rome) discusses preparation of a FAO publication reviewing the performance reviews of RFMOs and RFBs. Photo credit: FAO/ Giulio Napolitano*

from the North Atlantic Salmon Conservation Organization (NASCO) started going through the PR process first. While only two RFMOs completed performance reviews before 2007, four more did so in 2008–2009, five more including NPAFC in 2010–2011, another seven in 2012, and four in 2013–2014 (Szigeti and Lugten 2015). After 2014, there has been a steady increase of RFMOs completing their PRs at least once, while at least nine had second PRs completed including the Convention for the Conservation of Antarctic Marine Living Resources (CCALMR), Commission for the Conservation of Southern Bluefin Tuna (CCSBT), International Commission for the Conservation of Atlantic Tunas (ICCAT), Indian Ocean Tuna Commission (IOTC), International Pacific Halibut Commission (IPHC), Northwest Atlantic Fisheries Organization (NAFO), North East Atlantic Fisheries Commission (NEAFC), and South East Atlantic Fisheries Organization (SEAFO). NASCO started its third PR in 2021.

It was generally agreed upon and reflected in the Secretariat Business Plan for 2017–2020 (extended until 2022) that the second NPAFC PR, to ensure continued progress by the Commission, would be performed after the International Year of the Salmon (IYS) project completion. To start preparation

for the second PR, it is important to analyze past experience to figure out what can be incorporated to increase effectiveness of review and clarity of recommendations.

For the first time, NPAFC agreed to undertake a performance review at the 15th Annual Meeting in Vladivostok, Russia in October 2007. The main goal was to assess NPAFC performance since the year of establishment against objectives set out in the *Convention for the Conservation of Anadromous Stocks in the North Pacific Ocean*, the UN Convention on the Law of the Sea relating to anadromous stocks, and other relevant international instruments. The PR panel should also identify achievements as well as areas for improvement. At the 16th NPAFC Annual Meeting in Seattle in November 2008, the membership of the Performance Review Panel was agreed upon, and detailed review criteria were adopted by the Commission.

The PR Panel consisted of two external panelists (both as a co-chairperson), Dr. Rosemary Rayfuse, with a focus on the Committee on Enforcement (ENFO), and the Committee on Finance and Administration (F&A) activities, and Dr. Ian Perry, with a focus on the Committee on Scientific Research and Statistics (CSRS), and the chairpersons of three NPAFC committees. Dr. Rosemary Rayfuse is Scientia Professor of Law at the University of New South Wales, Sydney, and a Fellow of the Academy of the Social Sciences in Australia. She researches and teaches in the area of Public International Law in general and more specifically in the Law of the Sea and International Environmental Law. She publishes widely on issues of oceans governance, protection of the marine environment in areas beyond national jurisdiction, the normative effects of climate change on international law, and has special expertise in high seas fisheries, climate change and the oceans, and in polar oceans governance. Dr. Ian Perry is a senior research scientist with the Canadian Department of Fisheries and Oceans at the Pacific Biological Station in Nanaimo. He was the Chair of the international Global Ocean Ecosystem Dynamics (GLOBEC) program, whose goal was to understand how global change will affect the abundance, diversity and productivity of marine populations, and is a past Chair of the Science Board for the North Pacific Marine Science Organization (PICES).

Figure 2. *External members of the NPAFC PR Review Panel, Prof. Rosemary Rayfuse and Dr. Ian Perry, at the Plenary Session of the 2009 NPAFC Annual Meeting in Niigata, Japan. Photo credit: NPAFC Secretariat*

I remember the interview with Dr. Perry during the 17th NPAFC Annual Meeting in Niigata, Japan in November 2009. We had worked closely with Ian before in several PICES' bodies and our communication was open and meaningful. We met with another Russian colleague and answered questions related to the existing CSRS structure, procedures, and functioning; cooperation within and by the Commission with relevant international organizations to obtain the best available information, including scientific advice; and collection and exchange of scientific data and specimens of anadromous species between the NPAFC Parties. I know that Ian interviewed scientists from all delegations and read all CSRS meetings' reports, and suggested 22 recommendations, ten of which were included into the Prioritized List of Actions (LoA) of the PR Report. It is good to have a partner such as PICES that promotes an ecosystem approach in marine research in the North Pacific and helps the understanding of future trends in living resources and the environment. At the same time, for the second PR, it could be useful to invite, in addition, representatives of dedicated salmon management bodies, e.g., Pacific Salmon Commission (PSC). In the last five years, NPAFC and PSC strengthened cooperation by implementing the IYS program and leading an informal Pacific salmon roundtable with participation of scientists, managers, and industry experts.

There were 54 review panel recommendations, which were thoroughly studied by the committees and responded to as related actions were implemented. In general, the LoA has provided the basis for committees' activities planning for future years. Let us read through the list of recommendations accepted by CSRS to the LoA. It included six major items:

- Updating CSRS Terms of Reference (ToR) and creating/updating ToR for the working groups.

- Re-formatting of the Statistical Yearbook to electronic format downloadable from the web.

- Periodic comprehensive overviews and reports of North Pacific salmonid stock status.

• The Secretariat to provide direct support and housing of all scientific databases.

• Creation of a gear standardization working group or network.

• Thorough consideration of issue of incidental takes (bycatch) of anadromous fish including in areas adjacent to the Convention Area.

The CSRS was proud to complete them in one year—eight of ten items in the LoA on Prioritized Recommendations from the NPAFC Performance Review Report included in the 2012 NPAFC Annual Meeting agenda booklet were marked as completed. The amended ToR for CSRS and its subsidiary bodies ToRs were adopted by the Commission in October 2012, well before ENFO completed a similar task in 2015. Also in 2012, CSRS recommended the creation of a single data file for the period beginning 1926 in a format that allows free downloading and wide use for analysis. This development was carried out by the Working Group on Stock Assessment, which first submitted a consolidated statistical document containing the necessary data in 2012 (in the final form—in May 2013) (Irvine et al. 2012). Preparation of files in spreadsheet format and data verification was carried out at the Secretariat in 2013–2014. Before the 2015 NPAFC Annual Meeting, data files on Pacific salmon catches by the member countries and the release of juvenile Pacific salmon from hatcheries were posted on the website for testing, and after the agreement, they became freely accessible. Pacific Salmon and Steelhead high-seas tag recovery databases were moved to the NPAFC server, although the Working Group on Salmon Marking decided on keeping the otolith mark database shared with the Alaska Department of Fish and Game (ADF&G).

As for the gear standardization matter, CSRS concluded that, "report on comparisons of at-sea sampling methods that summarizes previous CSRS-related work on this topic is currently available on the website." Most likely the committee meant NPAFC Doc. 677, Rev. 1 (*Trawl Comparisons and Fishing Power Corrections for the F/V Northwest Explorer, R/V TINRO, and R/V Kaiyo Maru During the 2002 BASIS Survey*) or one of the national documents devoted to some survey methods and gear comparisons. The summary review on this matter was presented only by the comprehensive book chapter "Micronekton and Fish Sampling" by Nancy Davis in the *Ocean ecology of Pacific salmon and trout* book in 2018. Even less evident was the decision made by the committee on the salmon incidental takes (bycatch) issue: "It would be useful for each Party to provide full information of all salmon catches from their fisheries and identify incidental catches where possible." Unfortunately, no substantial progress has been made on the implementation of this recommendation. Bycatch at massive pelagic fisheries in the northwestern North Pacific looks to be one of the most tangible threats to salmon stocks, especially dwelling near southern limits of their areas, where they are also adversely affected by a warming climate. It became even more evident, when the boarding/inspection team from the US Coast Guard cutter *Bertholf* found unreported salmon bycatch on three Taiwanese fishing vessels, 25 fish in total in October 2021. The Master of one vessel confessed that fishermen do not report salmon bycatch and use it for personal consumption. This is one of the recommendations that could be surely repeated during the second NPAFC PR.

Twelve recommendations were not included into the LoA for different reasons. For example, CSRS decided that a five-year Science Plan and one-year work plans cover mid-term planning requirements well. Likely, it is not completely correct considering the unexpectedly long story of the interactive mapping system development since 2017. This delay prevents making the tag-recovery database open to

Figure 3. *Editorial committee works with the CSRS meeting report at the 20th Annual Meeting in St. Petersburg, Russia, in October 2012. Photo credit: NPAFC Secretariat*

Figure 4. *Pacific salmon bycaught with Pacific saury and sea bream in the northwestern North Pacific during the TINRO summer trawl survey. Photo credit: NPAFC Secretariat*

the public from the NPAFC website that could be an important tool to increase CSRS publicity. In some part, mid-term planning of the Commission activities is done by the Secretariat business plan updated at the same time as the NPAFC Science Plan. It might be useful if science-related business plan sections will be considered and endorsed by CSRS in the future. CSRS did not consider a recommendation to establish an observer program for fisheries that take salmon incidentally, and this is understandable since there was no legal framework in place to build such a program. Now, with the signing of the Memorandum of Cooperation and strengthening relationships with the North Pacific Fisheries Commission (NPFC), who develops the observer program for its managed fisheries, this issue could be reconsidered together with partners. Work of observers familiar with Pacific salmon species identification and ecology could not only help with data collection for bycatch-related consideration but obtain professional advice on how to minimize such incidental salmon taking.

Two groups of recommendations first declined by CSRS were later implemented by the Commission. Suggestions to define the "ecologically related species" term; request specific information and syntheses on them from relevant organizations; and provide advice on issues of the conservation of anadromous stocks in the Convention Area, including advice relating to prey and predator species, found their way to be finalized in the NPAFC-PICES Framework for Enhanced Scientific Cooperation in the North Pacific Ocean mutually agreed to in 2014. Advice to the Commission to give careful consideration on how to better utilise the CSRS to ensure fulfillment of the objectives of the Convention have been progressively implemented in practice at joint ENFO/CSRS sessions at annual meetings since 2014 and the creation of the Working Group on Inter-committee Coordination (WGIC) in 2018. This experience tells us: do not rush to decline review panel recommendations until you are certain of all of their options.

ENFO occurred to be more critical to the PR recommendations than CSRS: just five of sixteen ones were accepted into the LoA, but all were successfully implemented. Following received advice, ENFO transformed Enforcement Evaluation and Coordination Meetings (EECMs) into Joint Patrol Schedule Meetings with a simple agenda since 2012 and amended the committee's ToR with inclusion of new provisions to promote implementation of the International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (IPOA–IUU) in 2015. Both inter-sessional ENFO and CSRS meetings were eliminated and that provided significant savings to the Commission's budget. Together with other revealed reserves, this led to NPAFC financial stability and there was no necessity to increase the Parties' contribution for eleven years from 2009/2010 to 2020/2021. The Memorandum of Cooperation between the NPAFC and NPFC was signed in 2019. Finally, all NPAFC member countries became Parties of the FAO Port State Measures Agreement in 2021.

As for declined recommendations, most of them have been done for obvious reasons. Two of them related to designing Cooperating Non-Member status were forwarded for Commission-level consideration where they were rejected due to lack of consensus in 2012. A Recommended Certificate of Origin Program for wild salmon catches and derived products was one of the first to be considered in depth by the Commission. After a review of the situation with Pacific salmon trade and detailed information on the import and export of salmon products, no evidence showed that illegally caught salmon from the Convention Area were sold on the World fish market. In 1995, the Parties agreed that it is not necessary to spend the required financial and human resources to further develop the Certificate of Origin Program. There was a mutual understanding that the issue could be raised again in future meeting agendas, and a corresponding clause was included into the ENFO ToR in 2015. ENFO considered proposed measures to prevent reflagging for the purpose of avoiding compliance with the Convention as a part of Port State Measures and decided on status and function of the Enforcement Procedures Working Group.

Rejection of one recommendation from inclusion into the LoA could be considered as an unfortunate ENFO decision. It was the review panel's advice that the ENFO Integrated Information System (IIS) be centralized and housed within the Secretariat which should be appropriately resourced to operate, maintain and develop the IIS. To the contrary, after issue consideration at the EECM in 2011, the Parties decided it was better that the database maintenance responsibility remained with the Russian Party. Seven years after that decision, the IIS website had crashed, and Russian servicers could not restore its working capacities. There was an attempt to restore the committee's communication tool based on the U.S.-based All Partners Access Network (APAN), but no consensus was reached between the Parties at the 2021 Annual Meeting. ENFO should consider whether a centralized Secretariat-based secure communication tool should be developed under the current circumstances.

F&A accepted review panel recommendations in exactly the opposite way to ENFO: 11 of them were accepted to the LoA while five were declined.

Figure 5. *NPAFC Vessel of Interest, reefer Gral in port (2014). Photo credit: Marine Traffic / V. Tonic*

Figure 6. *Early days of the INPFC history. From left to right: Canadian INPFC Commissioners James C. Cameron and John M. Buchanan, INPFC Executive Director Milton C. James (U.S.), Takashi Miyahara (U.S. researcher), and John L. Hart (Canadian researcher). Photo credit: NPAFC Secretariat*

Despite all eleven LoA items being marked as "completed" at the 2011 Annual Meeting, the hard work had just begun. A decision on a policy on the provision of interpretation at the Commission meetings for new member states was made, while there are no changes in the NPAFC membership and occasions to apply a decision since the PR time. The notice period required for the seating of observers was shortened from 120 to 90 days. Issues related to NPAFC publicity, creation of the Publication Policy Working Group, and translating documents and media materials into all the Commission's languages have been reflected in the NPAFC Communication Plan adopted in 2013 and mostly implemented to the time of the 2020 Annual Meeting. There was an important decision to hire one additional Secretariat staff to increase administrative support and IT capabilities. Since July 2013, the Secretariat staff was increased to five employees.

Among five declined recommendations, four were related to the responsibility of the Commission Officers and Representatives, scheduling of Heads of Delegation meetings, and succession planning for the Executive Director position. F&A considered that the first recommendation should be directed to the Parties while three others have been already implemented with finalizing a template of the annual meeting schedule and adoption of a hiring procedure for a new Executive Director. Advice to digitize the INPFC bulletins, reports, statistical yearbooks, and documents was considered as "completed" since the scanning of old papers started in 2011. However, the sheer volume of the work required continued enormous efforts that were undertaken by at least seven NPAFC Secretariat staff, interns, and volunteers to scan, register, verify, format, and upload the scientific documents accumulated for the forty-one-year INPFC history, from #3 to #3782. In January 2021, voluminous information was added to the open databases on North Pacific ecosystems, salmon, and other commercial fishery species and can be widely used for research and fishery management.

In general, the planning process at the NPAFC Secretariat was significantly enhanced after completing the performance review. Several progressive approaches, even some that were not recommended by the Performance Review panel, were later adopted and practiced. The NPAFC Secretariat Business Plan, addressing human resources issues including succession planning and financial planning, was prepared for the first term of the new Executive Director (July 1, 2013–June 30, 2017) with a commitment to promote employee productivity and the overall organizational health and excellence of the Secretariat. The Business Plan lists the main objective and expected results of the Secretariat's activities, the main tasks to be fulfilled through enforcement and scientific activities, outlines key management measures to accomplish listed tasks, provides analysis of the Commission's financial situation, and summarizes the Budget appropriation, estimate, and forecast for four fiscal years. In 2017, the Commission decided that the Business Plan term should coincide with the five-year Science Plan term, and the second Business Plan was adopted for 2017–2020 with both plans' extension till the end of 2022.

The Secretariat staff's performance appraisal became to be based on individual work plans, in addition to regularly updated job descriptions. This approach together with annual open reporting sessions increases transparency and tightens working relationships within the Secretariat that increased its capacity. It occurred to be helpful in

a situation that required a weighted re-structuring of the staff classification in the Secretariat that was successfully made in accordance with the Canadian Party's proposal in 2015. In 2015, the Secretariat developed the NPAFC Staffing Guidelines that include a section on the supervisory practices including probation period management in the Secretariat. In 2015–2017, no employee required a probation period extension after their performance appraisal in established interim periods of their employment; in 2018, one employee's probation time was extended by six months.

Significant progress was reached in the NPAFC communication activities after the Commission accepted the Communications Plan at the 21st Annual Meeting in November 2013. The goal of the Communications Plan is to enhance the effectiveness of NPAFC communications and advance the NPAFC mission of conserving Pacific salmon and steelhead stocks in the North Pacific Ocean. Up to May 2016, the Secretariat completed 11 of 30 Plan's recommendations since Plan adoption by the Commission. The second Communication Plan Progress report was presented in 2018, and the third—in 2020. In total, the Secretariat completed 27 of 30 Plan recommendations. Most of the deliverables were achieved in 2018–2020 with the creation of the new NPAFC website, expansion of the NPAFC Internship program, and successful IYS implementation. During Communications Plan implementation, NPAFC activities became more transparent and understandable for the public and attracted potential partners among media and academia. As a result, it helped to gather the necessary potential to plan and implement major IYS projects such as the IYS Gulf of Alaska cruises and 2022 Winter Expedition, Likely Suspects Framework preparation, Data Mobilization, etc.

Everyone seems to agree that the PR of international organizations should be performed regularly. The PR looks to be necessary, especially after completion of large multi-year projects or programs. Another potential milestone for the next performance review can be an expected changing of organization membership or establishment of new partnerships. In general, a ten-year period should be considered as the time scale interval for an organizational performance review. Preparation for the PR should include the exploration of recent best practices of partner organizations. An exchange of approaches, criteria, results, and opinions is extremely helpful in organizing a proper review. As a rule, experts from partner organizations could be the best candidates for external panelists' positions. It would also be useful if the UN DOALOS and/or RSN recommend external panelists who are well experienced in reviewing on the international level. Despite the fact that some flexibility is important in adopting criteria for different RFMOs, in the current decade, they definitely should align with the Sustainable Development Goal 14 (SDG 14) "*Life below water*."

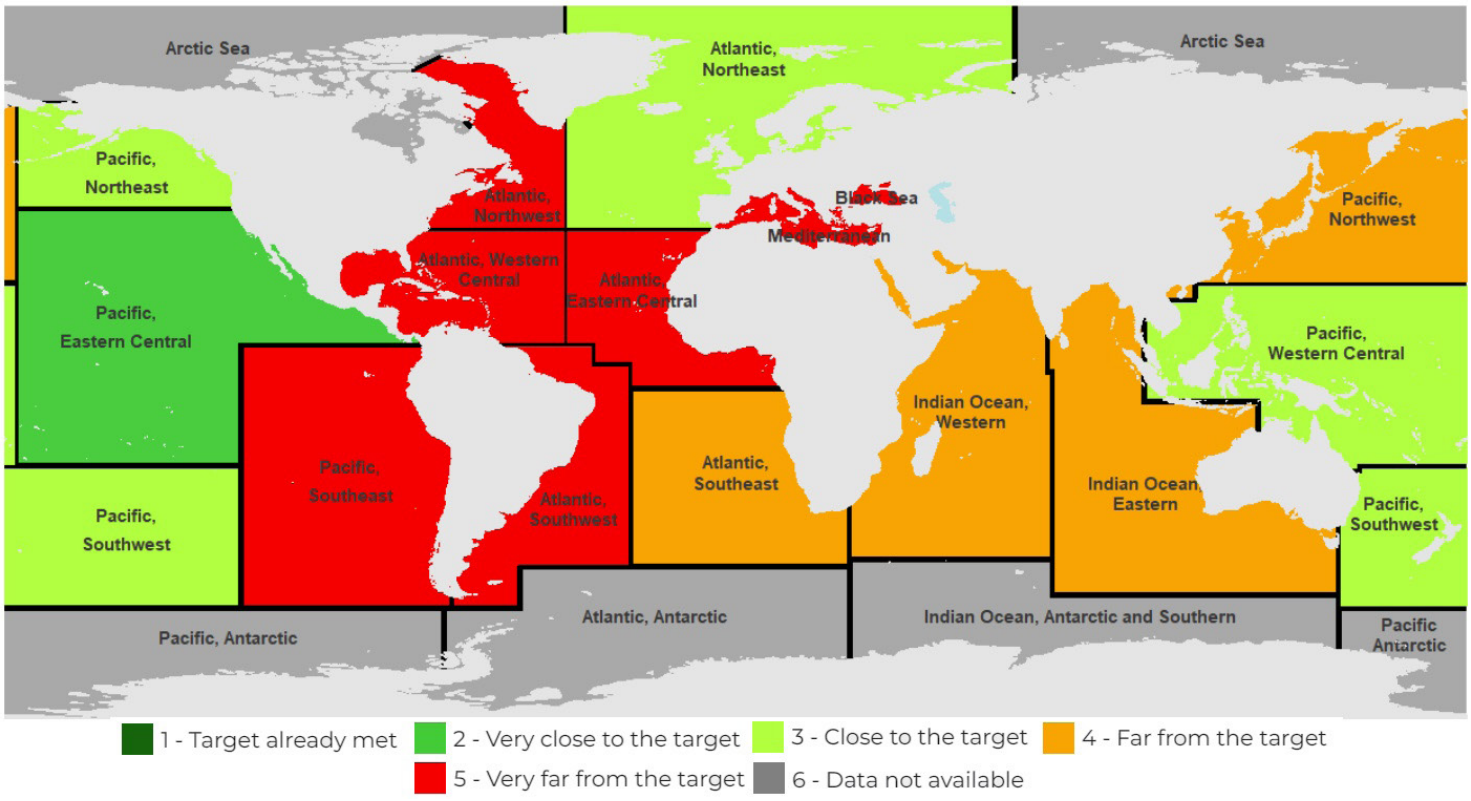


Figure 7. *Current distance to the target of SDG indicator 14.4.1—Proportion of fish stocks within biologically sustainable levels by Fishing Area, 2017 data. Source: FAO 2021*

Inside the organization, chairpersons or representatives of major subsidiary bodies should be involved in the PR process in a better way—as panelists. Nevertheless, wider members' participation is important and that can be reached through individual interviews and questionnaires. The Secretariat shall not be a part of the review panel but should work closely to provide support to the panel activities, access to information, and facilities. Since expenditures related to PR are usually significant, all necessary expenses should be properly budgeted.

Outcomes of the performance review should be as open-ended and inclusive as feasible. It looks to be useful that the review should point to achievements as well as to areas for improvement. Transparency is crucial to the effectiveness of further development of the organization through the implementation of performance review recommendations. No recommendation should be left without a response, even if it will require several years to explore and/or test the feasibility of its implementation.

There are different ways of addressing the PR recommendations shown by different RFMOs. Thus, CCSBT established a tracking system to follow the progress, ICCAT and SPRFMO created internal working groups to address the recommendations, and IOTC adopted a resolution on the PR follow-up. The NPAFC approach, when review panel's comments and ideas have informed the reflections and recommendations contained in the final report, looks to be effective as well. The NPAFC PR report is organized into five chapters, including specific chapters assessing the performance of the Commission based on the functioning of its three standing committees as required by the review criteria. It provides the geographic, historical and legal background, and context of the NPAFC; reviews conservation of anadromous stocks, enforcement activities, financial and administrative matters; and contains general comments and a consolidated list of the PR panel's recommendations for easy reference. The PR report itself can also be a subject of review since it provides recommendations on the background of all basic information about the Commission's activities. Including recommendations into the Secretariat's and/or subsidiary bodies' work plans also showed good efficiency of their implementation. Sharing results of implementation with external panelists involved in the PR, if they will remain available, at least for the first years after review, could also improve progress towards achieving the outlined objectives.

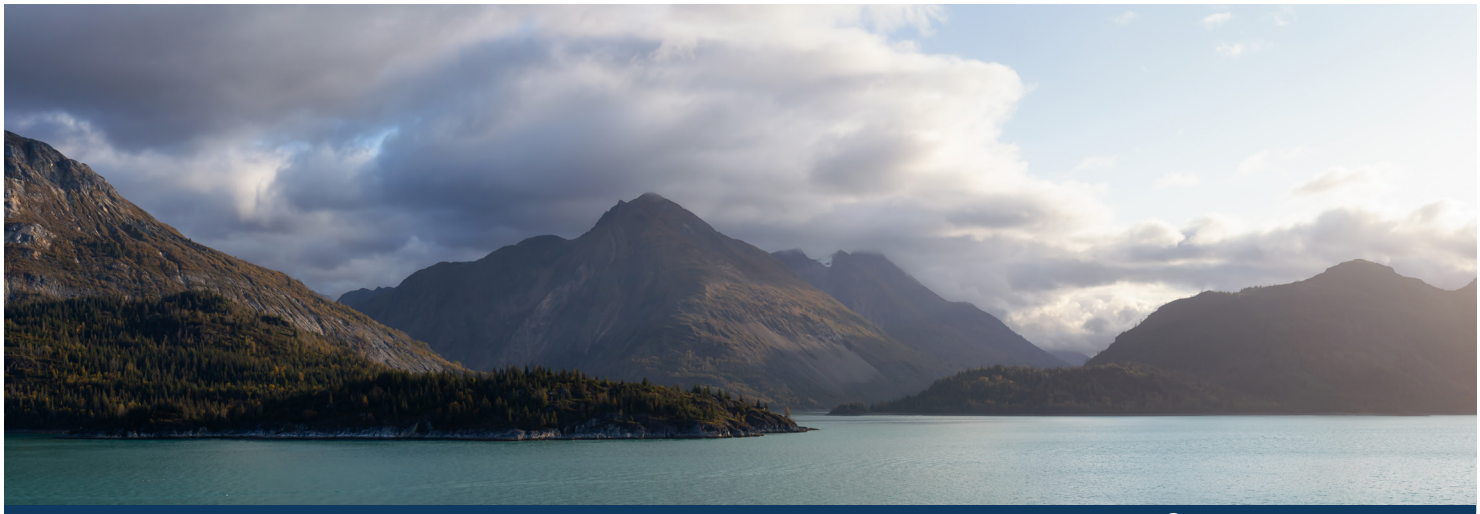
References

FAO. 2021. Tracking progress on food and agriculture-related SDG indicators 2021: A report on the indicators under FAO custodianship. Rome. doi: 10.4060/cb6872en. (Available at https://www.fao.org/sdg-progress-report/2021/en/)

Haas, B., M. Haward, J. McGee, and A. Fleming. 2019. The influence of performance reviews on regional fisheries management organizations. ICES Journal of Marine Science 76: 2082–2089.

Irvine, J.R, A. Tompkins, T. Saito, K.B. Seong, J.K. Kim, N. Klovach, H. Bartlett, and E. Volk. Pacific salmon status and abundance trends—2012 update. 2012. N. Pac. Anadr. Fish Comm. Doc. 1422 (Rev. 2). 90 p. (Available at https://npafc.org)

Szigeti, P.D., and G.L. Lugten. 2015. The implementation of performance review reports by regional fishery bodies, 2004–2014. FAO Fisheries and Aquaculture Circular No. 1108. Rome, Italy. ix + 88 p.



A cloudy and colorful morning during fall at Glacier Bay National Park and Preserve, Alaska. Photo credit: © Edb3_16 / Adobe Stock

IYS Activities and Updates

By Camille Jasinski (IYS Public Relations & Communications Coordinator),
Caroline Graham (IYS High Seas Expedition Coordinator),
Aidan Schubert (IYS Coordinator),
and MacKenzie Kermoade (2021 NPAFC Intern)

The International Year of the Salmon Enters its Final Year in 2022

The International Year of the Salmon (IYS) is a five-year initiative governed by the North Pacific Anadromous Fish Commission (NPAFC) in the Pacific and the North Atlantic Salmon Conservation Organization (NASCO) in the Atlantic. At the outset of the initiative in 2018, the IYS committed to a vision of setting the conditions for the resilience of salmon and people in a rapidly changing world. As the IYS enters its final year in 2022, it continues to fulfill this vision by making significant progress on its Signature Projects, research, and outreach.

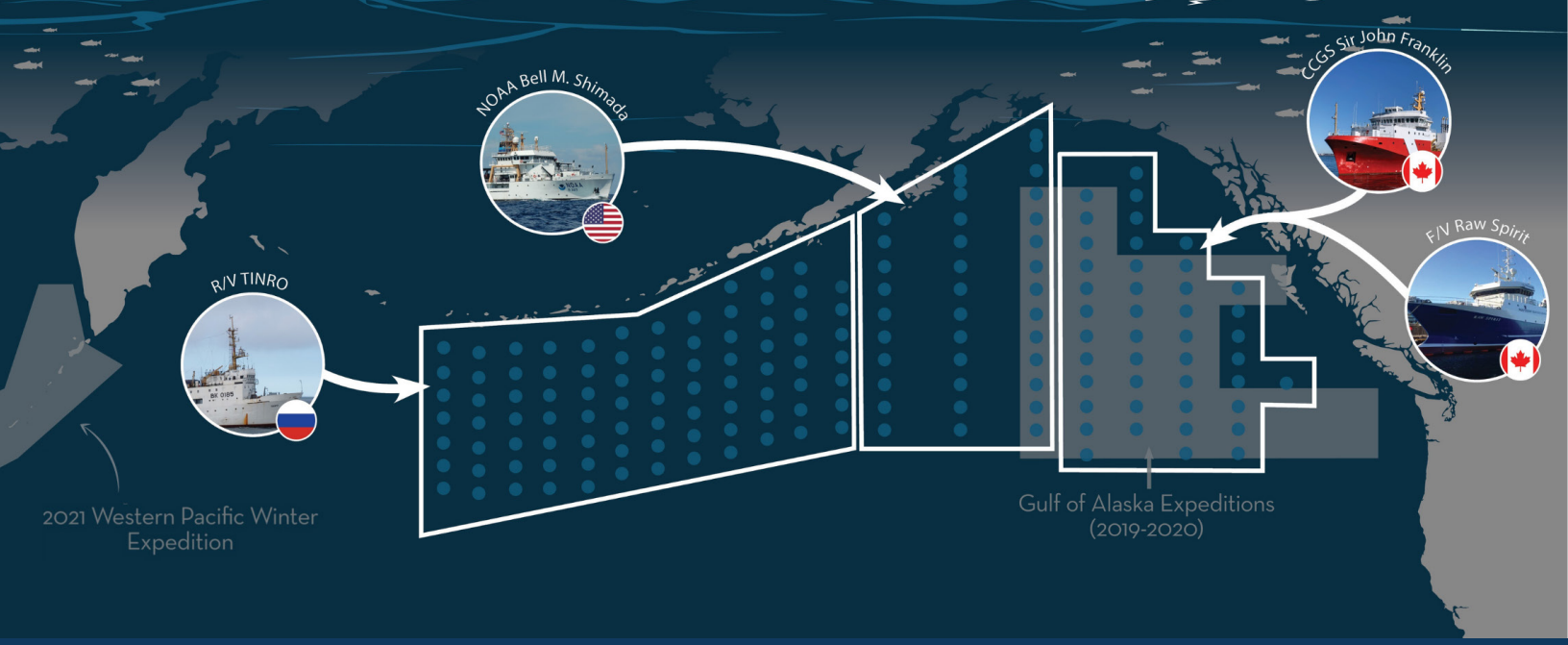
The year 2021 was an extremely busy one for the IYS as it ramped up its preparation for the 2022 Pan-Pacific Winter High Seas Expedition and successfully made progress towards its other key Signature Projects such as the Likely Suspects Framework and Data Mobilization. The year was also defined by even more extreme climate events, such as the unprecedented summer heat dome that gripped the Pacific Northwest, causing devastating loss of marine life and further imperiling already threatened salmon stocks. A better understanding of how an increasingly volatile climate is impacting salmon and their ecosystems remains critical. The IYS continues to build connections and leverage its opportunities to work in a virtual format due to the uncertainties around the COVID-19 pandemic.

2022 IYS Pan-Pacific Winter High Seas Expedition

Despite some uncertainties, the IYS is preparing for the official launch of the 2022 Pan-Pacific Winter High Seas Expedition. Four research vessels and over sixty scientists and crew will depart their respective ports between late January and mid-February 2022 to conduct the largest ever pan-Pacific research expedition to study salmon and their ecosystems in the North Pacific Ocean. The 2022 Expedition is a major international effort engaging governments, academia, NGOs, and industry in NPAFC member countries (Canada, Japan, the Republic of Korea, the Russian Federation, and the United States) to begin a new collaborative approach to filling the gaps in our understanding of what is happening to salmon in a rapidly changing North Pacific Ocean. The fleet for the 2022 Expedition will include one research vessel from Canada (the *CCGS Sir John Franklin*), one from the United States (the *NOAA Ship Bell M. Shimada*), one from Russia (the *R/V TINRO*), and a commercial fishing vessel from Canada (the *F/V Raw Spirit*).

Building off successful international expeditions into the Gulf of Alaska in 2019 and 2020, and the 2021 Western Pacific Expedition, the major objective of the 2022 Expedition is to better understand how increasingly extreme climate variability in the North Pacific Ocean and the associated changes in the physical environment influence the abundance, distribution, migration, and growth of Pacific salmon. The 2022 Expedition will be a full ecosystem survey with pelagic trawling and detailed sampling of marine life in the upper ocean layers, with cruise plans including research on physical, biological and chemical oceanography. While the research vessels from Canada, the Russian Federation and the United States will be deploying trawl nets, the Canadian commercial fishing vessel will deploy gillnets simultaneously to assess the effectiveness of trawl nets to sample the community of fishes and composition of salmon, including steelhead, in these surface waters.

Camille Jasinski is the Public Relations and Communications Coordinator for the International Year of the Salmon (IYS)—North Pacific Region. She is currently completing her master's degree in communications at SFU (Simon Fraser University), after which she hopes to pursue her PhD. Camille's graduate research interests include classical communication theory, ideology, philosophy, surveillance culture, environmental communication, decolonization theory, and Indigenous rights. Camille currently sits as the Co-chair to the IYS Theme Council Group 4—Outreach and Communication. She is also a registered 200-hour yoga and fuse teacher.



The 2022 IYS Pan-Pacific Winter High Seas Expedition Zone Map.

The Research Vessels

Canada: CCGS Sir John Franklin

USA: NOAA Bell M. Shimada

Russia: R/V TINRO

Canada: Raw Spirit

The fleet for the 2022 IYS Pan-Pacific Winter High Seas Expedition.

Novel technologies such as genomics, environmental DNA (eDNA), and ocean gliders will be utilized to test their potential to enhance our monitoring of salmon and their ecosystem. Recent advancements in DNA analyses will allow researchers to determine the river of origin for salmon caught during the expedition, which enables us to understand for the first time the distribution of different salmon stocks across the North Pacific. eDNA analyses will allow researchers to assess the full range of biodiversity represented at sample sites, especially for species not captured in traditional sampling gears. All of the data collected as part of the 2022 Expedition will be made publicly accessible on the shortest feasible timescale.

The IYS has been working on its strategy to maximize communications capacity for the 2022 Expedition. The official 2022 Pan-Pacific Winter High Seas Expedition webpage has been launched and will include a live, interactive map showing the locations of all four research vessels. Scientists on board will be sharing updates and activities from the ships to be shared on IYS online networks, and individual vessel pages will house all the ship-to-shore updates and will be made accessible through the 2022 Expedition webpage. Audiences will be able to follow along with the expedition and get an inside look at life on scientific research vessels. Leading up to the 2022 Expedition, the IYS also hosted a virtual 7-part seminar series, *Exploring Frontiers of Salmon Research in Open Ocean Ecosystems*, which convened experts to discuss a wide range of topics related to the High Seas Expedition. Information about the IYS Seminar Series, including live recordings and blogs, can be found on the Seminar Series webpage.

Data Mobilization

The IYS is continuing its work with partners at the Tula Foundation and Hakai Institute to mobilize data from the 2019 and 2020 International Gulf of Alaska Expeditions using Global Ocean Observing System (GOOS) protocols, as well as a federated approach to standardize the data so they can be rapidly discovered and synthesized. Metadata from the 2019 and 2020 Expeditions can now be found in the IYS Metadata Catalogue and some data sets have been made publicly available. A list of published data sets and their Digital Object Identifiers (DOI) can be found here.

The Cruise Planning Team and the NPAFC ad hoc Study Group on High Seas Data Standardization/ Mobilization continue to work on developing an agreement between the NPAFC member countries on approaches to collecting and mobilizing high seas data, using the 2022 Expedition to test

Newly commissioned logo for the 2022 IYS Pan-Pacific Winter High Seas Expedition.

this approach. The Study Group and the IYS Secretariat are working on presenting the final recommendations and the progress made by the Study Group in a report, to be submitted to the CSRS for consideration at the 30th NPAFC Annual Meeting. The IYS is also working with partners across the hemisphere to pursue broader data mobilization goals related to the development of a standardized salmon vocabulary, the application of graph database technology, and the mobilization of historic high seas salmon data.

SALCUL Indigenous Salmon Management Workshop

In 2021, colleagues from the Norwegian Institute for Nature Research (NINA) and the University of Tromsø (UiT) invited the IYS to help coordinate an Indigenous Salmon Management Workshop under the "SALCUL" project. Focused on Atlantic salmon rivers in Sápmi (Northern Norway/ Finland) and Trøndelag (Central Norway), SALCUL is an interdisciplinary, partnership-based research initiative which aims to develop a process for sharing and co-producing Indigenous and local knowledge and scientific knowledge.

The IYS met with contacts in the North Pacific who are either Indigenous salmon managers or are involved in Indigenous salmon management in late 2021 to discuss their potential involvement in the workshop. These meetings culminated in a trans-basin Planning Session during which consultees from Canada, Finland, Norway, and the United States who represented 12 Indigenous-led organizations discussed the workshop further. This session resulted in recognizing the need to decenter the role of Western Science in the Indigenous-led salmon management process. Key priorities for the SALCUL Workshop were identified, including the need to provide a space to share Indigenous knowledge and salmon management practices at different scales and empower participants to determine a future vision for Indigenous-led salmon management.

The IYS and SALCUL will continue to collaborate on workshop design and planning through the first months of the year, with the workshop currently set to occur in April 2022. As the IYS closes, its team will identify ways through which the IYS legacy can further support Indigenous salmon management in the Northern Hemisphere.

IYS Synthesis Symposium

The IYS has convened a Steering Committee for the joint NPAFC and NASCO IYS Synthesis Symposium. The IYS Synthesis Symposium is slated to take place from October 4–6, 2022 at the Westin Bayshore in Vancouver, Canada. This Symposium will invite partners to review the work, outcomes, and legacy of the 5-year IYS initiative with the objective of exploring recent developments in salmon science and management from across the Northern Hemisphere, creating a vision for the resilience of salmon and people, and producing a roadmap to 2030. Presentations for the IYS Synthesis Symposium will be organized according to the five IYS research themes: status of salmon, new frontiers, information systems, human dimensions, and salmon in a changing salmosphere.

The Symposium, *Salmon in a Rapidly Changing World: Synthesis of the International Year of the Salmon and a Roadmap to 2030*, will have a strong focus on forward-looking perspectives and synthesis, with the ultimate goal of developing a roadmap for the resilience of salmon and people through 2030. To accommodate a focus on synthesis throughout the Symposium, presentations will be the result of a pre-Symposium synthesis process of the current state of knowledge and a future outlook for each sub-session under each theme by experts from the Pacific and Atlantic, with a potential panel discussion and a synthesis of each day's presentations. The IYS will be releasing a call to action for abstract

Presentation slide for the first SALCUL Planning Session.

Poster for the IYS Synthesis Symposium.

submissions for the Symposium, and more information regarding the Symposium can be found on the IYS Synthesis Symposium webpage.

NPAFC-ICES Collaboration

To continue to foster and facilitate partnerships between the Atlantic and Pacific basins, the IYS Secretariat was involved in meetings with representatives from the International Council for the Exploration of the Seas (ICES) Working Group

on Science to Support Conservation, Restoration and Management of Diadromous Species (WGDIAD) to identify and develop areas for collaboration between Pacific and Atlantic scientists. WGDIAD provides a forum for the coordination on diadromous species, including Atlantic salmon, in the North Atlantic Ocean.

A major outcome of these meetings was a Pacific-Atlantic Salmon Roundtable, involving scientists associated with WGDIAD and the IYS Working Group as part of the WGDIAD Annual Meeting in September 2021. Roundtable participants discussed shared challenges and areas of joint interest related to salmon and other diadromous species. A total of 68 people representing 13 countries and 38 organizations participated in the Roundtable, with presentations and discussions on a range of topics, from life history modeling to data mobilization. Overwhelmingly positive feedback from this roundtable has resulted in potential future collaboration between Pacific and Atlantic scientists.

One major topic of interest highlighted in the Roundtable by both Pacific and Atlantic scientists was pink salmon, specifically their ecosystem impacts and distribution changes in the context of the introduction of pink salmon into the North Atlantic in the last half century, and rapid range expansions in the North Atlantic over the past decade as well as migration of Pacific populations into the Arctic. In light of the interest around this topic, the IYS Secretariat and WGDIAD have begun discussions to host a small meeting of pink salmon scientists from the Pacific and Atlantic basins in Vancouver, Canada immediately preceding the IYS Synthesis Symposium in October 2022.

Conclusion

The IYS has made incredible progress on its Signature Projects since its launch in 2018. For its final year, the IYS is looking towards creating a legacy for future scientists, managers, and decision makers. The IYS hopes that the 2022 Pan-Pacific Winter High Seas Expedition will help set the stage for future expeditions in the North Pacific Ocean and contribute to the planning of a broader ocean intelligence system. The 2022 Expedition is being considered as the launch of the planning phase of BECI (Basin-Scale Events to Coastal Impacts), a joint NPAFC-PICES project that has been endorsed by the United Nations Decade of Ocean Science for Sustainable Development. Through its ongoing efforts, the IYS will continue its mission to "support the resilience of both salmon and the people who depend on them" in 2022 and beyond.

Promotional poster for the IYS Seminar Series "Exploring Frontiers of Salmon Research in Open Ocean Ecosystems."

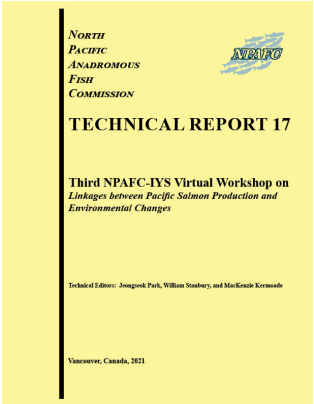
NPAFC Technical Report No. 17

Third NPAFC-IYS Virtual Workshop on *Linkages between Pacific Salmon Production and Environmental Changes*

Technical Editors: Jeongseok Park, William Stanbury, and MacKenzie Kermoade

Workshop Science Committee: Jun Aoyama, Ed Farley, Jr., Jim Irvine, Ju Kyoung Kim, Svetlana Naydenko, Mark Saunders, Shigehiko Urawa, and Jeongseok Park

Proceedings of the Third NPAFC-IYS Workshop on *Linkages between Pacific Salmon Production and Environmental Changes*, May 25–27, 2021 (Pacific Standard Time). Live and pre-recorded oral, and e-poster presentations given at the workshop are available at https://npafc.org/presentations/.



Topic 1: Salmon Production in Changing Environments

Topic 1-1. Status and trends of key salmon populations and their environments

State of Canadian Pacific Salmon in 2019 and 2020: Responses to Changing Climate and Habitat
Sue C.H. Grant, Bronwyn L. MacDonald, Dawn Lewis, Niki Wilson, Jennifer L. Boldt, David A. Patterson, Kendra A. Robinson, Ian Perry, Jackie King, Chrys M. Neville, and Dan T. Selbie
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Patterns of Growth of the Pink Salmon *Oncorhynchus gorbuscha* in Year-Classes with Different Survival Rates during the Marine Life-history Phase
Alexander M. Kaev and Vladimir I. Radchenko
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Recent Trend in Variability of Chum Salmon Stock and its Potential Mechanism in Hokkaido, Japan
Hirokazu Urabe, Hayato Saneyoshi, and Makoto Hatakeyama
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International Variability of Japanese Chum Salmon Abundance in the Summer Bering Sea during a Long Monitoring Survey in 2007–2019
Shunpei Sato and Shigehiko Urawa
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Moving Targets: Assessing Fraser River Pink Salmon Run Size during a Period of Change and Uncertainty
Merran J. Hague, Rachael L. Hornsby, Jessica A. Gill, Catherine G.J. Michielsens, Erica S. Jenkins, and Serena Wong
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Temporal and Spatial Variations in Body Size of Chum Salmon in Hokkaido
Fumi Yamaguchi, Taro Nakamura, and Hirokazu Urabe
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Anastasia M. Khrustaleva, Ekaterina V. Ponomareva, Marya V. Ponomareva, Oksana A. Pilganchuk, and Alexander V. Bugaev
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Molecular Characterization and Expression of Synaptic Plasticity-related Genes in the Olfactory Organ and Brain of Chum and Pink Salmon during Seaward and Homeward Migration
Takashi Abe and Hideaki Kudo
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An Overview of the Recent Salmon Returns in Japan: Poor Returns of Chum and Pink Salmon
Toshihiko Saito
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Topic 1-2. Effects of freshwater habitat change on salmon production

Analysis of Temperature Tolerance in Juvenile Chum Salmon (*Oncorhynchus keta*)
Muhammad Nurul Fajri, Takuto Ouchi, Yoshio Takei, Susumu Hyodo, and Makoto Kusakabe
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The Ecological Context of Aerobic Scope in Cost of Transport for Chum Salmon Migrating Upriver
Takaaki K. Abe and Takashi Kitagawa
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Does Long-distance Downstream Migration Influence the Survival of Chum Salmon? Comparison of Adult Returns between the Upper and Lower Reaches Release Sites
Kiyoshi Kasugai, Mitsuru Torao, and Mitsuhiro Nagata
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The Use of Spatial Stream Network Models to Evaluate the Effects of Varying Stream Temperatures on Wild Coho Life History Expression and Survival
Marisa N.C. Litz, Mickey Agha, John J. Winkowski, Devin West, and Jennifer Kordosky
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Topic 1-3. Survival mechanism of juvenile salmon in changing ocean environments

Ontogeny of Critical Swimming Speeds for Juvenile Chum Salmon
Yuki Iino, Takashi Kitagawa, Takaaki K. Abe, Tsuyoshi Nagasaka, Yuichi Shimizu, and Katsuhiko Ota
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Prey Selectivity and Diet Partitioning of Juvenile Salmon in Coastal Waters in Relation to Prey Biomass and Implications for Salmon Early Marine Survival
Elizabeth A. Daly, Richard D. Brodeur, Cheryl A. Morgan, Brian J. Burke, and David D. Huff
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Return Rates of Chum Salmon are Affected by Different Timings of Juvenile Release
Yuya Kogame and Hayato Saneyoshi
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Low Nutritional Status in the Freshwater Phase and Temperature at Seawater Entry Reduce Swimming Performance of Juvenile Chum Salmon
Mitsuru Torao, Yasuyuki Miyakoshi, and Munetaka Shimizu
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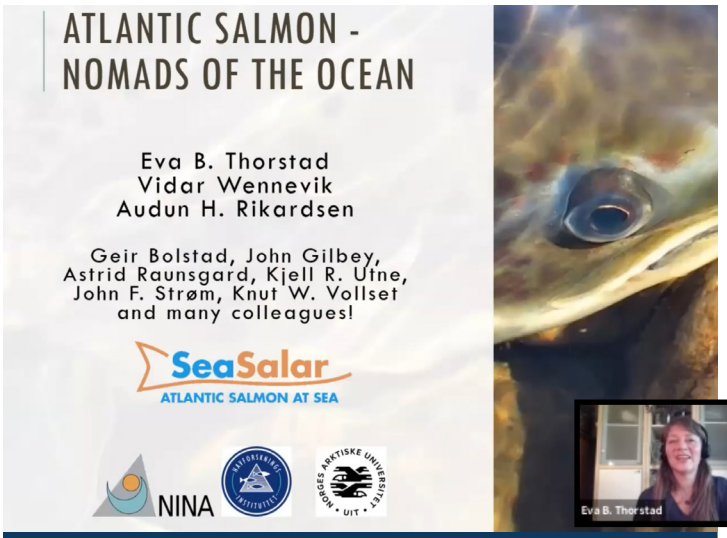
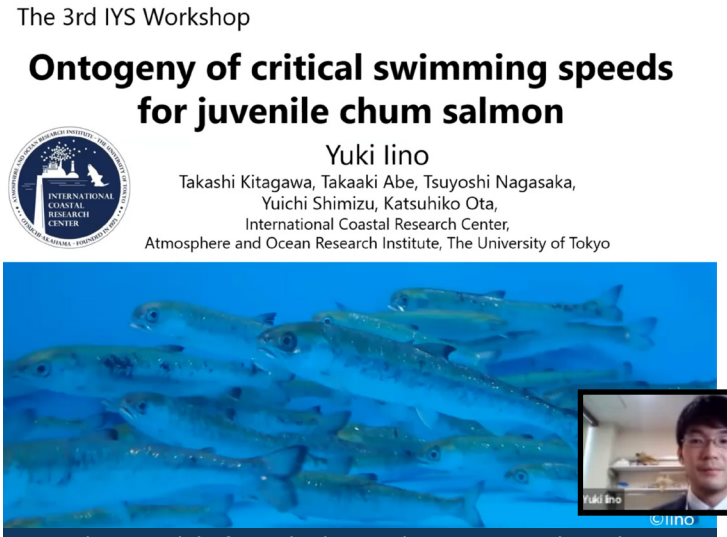


Eva B. Thorstad gives a virtual presentation (Day 1, Keynote 4) at the NPAFC-IYS Vitual Workshop titled: Atlantic Salmon–Nomads of the Ocean.



Introductory slide from the live oral presentation by Yuki Iino on the Ontogeny of critical swimming speeds for juvenile chum salmon.

Survival of Japanese Chum Salmon during Early Ocean Life in 2011–2017
Shigehiko Urawa and Alexander V. Bugaev
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Factors Affecting the Migration of Juvenile Chum Salmon (*Oncorhynchus keta*) from the Coast of Hokkaido to the Okhotsk Sea
Tomonori Azumaya, Hiroshi Kuroda, Tatuya Unuma, Takashi Yokota, and Shigehiko Urawa
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Characteristics of Prey Environment during the Early Ocean Life of Juvenile Chum Salmon in Two Coastal Areas around Hokkaido, Northern Japan
Tomoki Sato, Toshihiko Saito, Kentaro Honda, and Kyuji Watanabe
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Topic 1-4. Winter ocean ecology and survival of Pacific salmon

Stock Identification of Chum Salmon Overwintering in the Gulf of Alaska by Using a New SNP Baseline
Shigehiko Urawa, Terry Beacham, Ben Sutherland, and Shunpei Sato
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Zooplankton Community Structure and Development during Late Winter 2019 and 2020 in the Northeastern Pacific Ocean
Evgeny A. Pakhomov, Brian P.V. Hunt, Alexander Slabinsky, Natalie Mahara, and Alexei Somov
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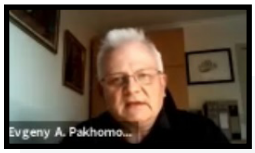
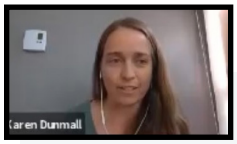
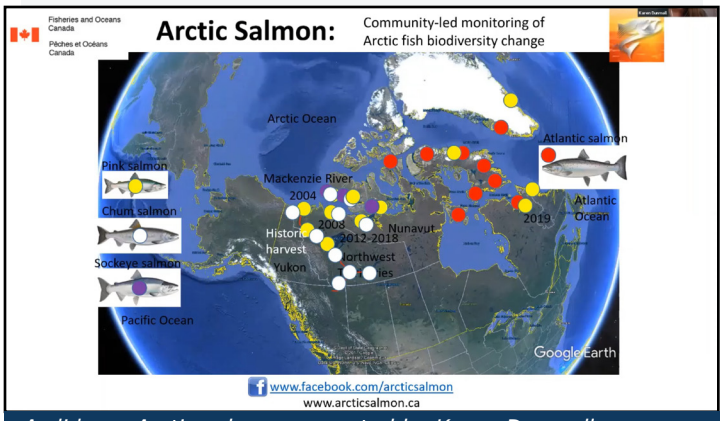


Live Oral 5—Evgeney Pakhomov presents on zooplankton in the northeastern Pacific Ocean.





A slide on Arctic salmon presented by Karen Dunmall.

The International Year of the Salmon Pan-Pacific High Seas Expedition 2022
Caroline Graham, Stephanie Taylor, Vladimir Radchenko, Evgeny Pakhomov, Ed Farley, Laurie Weitkamp, Dick Beamish, Brian Riddell, Jackie King, Chrys Neville, Shunpei Sato, Shigehiko Urawa, Aleksey Somov, Aleksandr Starovoytov, Sang-Seon Yun, Erika Anderson, Tim Van Der Stap, and Mark Saunders
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Trace Elements in Cherry Salmon (*Oncorhynchus masou*) in the Southwestern Part of the Sea of Okhotsk
Nadezhda K. Khristoforova, Anna V. Litvinenko, Vasily Yu. Tsygankov, and Maxim V. Kovalchuk
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Topic 1-5. Linkages between salmon production and climate/ocean changes

Did Recent Marine Heatwaves and Record High Pink Salmon Abundance Lead to a Tipping Point that Caused Record Declines in North Pacific Salmon Abundance and Harvest in 2020?
Gregory T. Ruggerone, James R. Irvine, and Brendan Connors
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The Ups and Downs of Far East Salmon Stocks During Recent Decades: Some Considerations and Possible Causes
Andrey S. Krovnin, Kirill K. Kivva, George P. Moury, and Alexandra A. Sumkina
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Reported Occurrences of Pacific Salmon in the Canadian Arctic Continue to Increase Whereas Reports of Atlantic Salmon Sightings Remain Low
Karen M. Dunmall, Darcy G. McNicholl, Ed Farley, and James D. Reist
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Mechanisms, Impacts, and Mitigation for Thiamine Deficiency and Early Life Stage Mortality in California's Central Valley Chinook Salmon
Nate Mantua, Rachel Johnson, John Field, Steve Lindley, Tommy Williams, Anne Todgham, Nann Fangue, Carson Jeffres, Heather Bell, Dennis Cocherell, Jacques Rinchard, Donald Tillitt, Bruce Finney, Dale Honeyfield, Taylor Lipscomb, Scott Foott, Kevin Kwak, Mark Adkison, Brett Kormos, Steve Litvin, and Iliana Ruiz-Cooley
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William Templin presents on Salmon Genetics at Sea: Three Decades of New Insights at the virtual workshop.

Salmon Conservation Under Changing Conditions and with Freshwater-marine Carryover Effects
Jennifer L. Gosselin, Lisa G. Crozier, Brian J. Burke, and Eric R. Buhle
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Juvenile Yukon River Chinook Salmon in a Warming Arctic
James M. Murphy, Kathrine Howard, Sabrina Garcia, Jamal H. Moss, Wesley W. Strasburger, Fletcher Sewall, and Elizabeth Lee
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Dynamics on Distribution, Production, and Biological Interactions of Pacific Salmon in the Changing Climate of the North Pacific Ocean
Masahide Kaeriyama
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Projected Impacts of Global Warming on Chum Salmon Stocks in Hokkaido, Japan
Hirokazu Urabe and Akiyoshi Shinada
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Recent Changes in the Spatial and Temporal Distribution of Salmon Habitat in the North Pacific
Steven T. Lindley, Nathan J. Mantua, Tanya L. Rogers, and Stephan B. Munch
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Topic 2: New Technologies/Integrated Information Systems for Salmon Research and Management

Topic 2-1. New technologies

Physiological Tools for Evaluating Growth Status of Migrating Salmon
Munetaka Shimizu
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Environmental DNA survey of the Winter Salmonosphere in the Gulf of Alaska
Christoph M. Deeg, Svetlana Esenkulova, Shaorong Li, Brian P.V. Hunt, Ben J.G. Sutherland, Angela Schulze, and Kristina M. Miller
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Hokkaido-wide eDNA Monitoring for Sakhalin Taimen, Endangered Salmonid Species
Hiroki Mizumoto and Hitoshi Araki
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The Identification of Individuals with Hatchery and Natural Origin in a Mixed Sample of Amur River Chum Salmon by Otolith Microchemistry
Pavel B. Mikheev, Denis V. Kotsyuk, Elena V. Podorozhnyuk, Vsevolod N. Koshelev, Tatiana A. Sheina, Mikhail A. Baklanov and Alexey Yu. Puzik
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Migration and Homing Behavior of Chum Salmon Tagged in the Okhotsk Sea, Eastern Hokkaido
Hayato Saneyoshi, Yousuke Koshino, Ryoutarou Ishida, Itsuki Tatsuoka, Hokuto Shirakawa, Yasuyuki Miyakoshi, and Kazushi Miyashita
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Tracking Radio-tagged Masu Salmon (*Oncorhynchus masou*) from the Sky by Use of Drone
Arimune Munakata, Masaya Suzuki, and Tomoichiro Tanaka
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Topic 2-2. Integrated information and management systems

The Salmon of Knowledge
Scott A. Akenhead, George Batten, Tom Bird, Nghia Doan, James R. Irvine, Oksana Korol, Chantal Nessman, and Peter O'Blenis
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Integrated Research on Olfactory and Geomagnetic Imprinting and Homing in Pacific Salmon
Hiroshi Ueda, Nathan F. Putman, and Tatsufumi Okino
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Hokkaido-wide eDNA Monitoring for Sakhalin Taimen, Endangered Salmonid Species
Hiroki Mizumoto and Hitoshi Araki
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Effective Hatchery Releases to Increase Adult Returns of Chum Salmon in the Ishikari River, Hokkaido, Japan
Toshihiko Saito, Kyuji Watanabe, Kentaro Honda, and Tomoki Sato
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Quantitative Estimation of the Ecosystem Services Supporting the Growth of Japanese Chum Salmon
Yuka Karasawa, Hiromichi Ueno, Ryo Tanisugi, Ryo Dobashi, Seokjin Yoon, Akihide Kasai, and Masashi Kiyota
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Predicting the Port-catch Volume of Salmon at Eastern Hokkaido
Yue Zhang, Hiroyuki Shioya, and Masaaki Wada
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Development of a Selection Method of Favorable Juvenile Fish by Egg Weight in Masu Salmon (*Oncorhynchus masou*)
Yoshinari Uematsu, Arimune Munakata, and Hiroyuki Matsuda
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Development of Age Determination Technique Part 1: Neural-Network Based Prediction of Chum Salmon Age by Scale Images
Ryoma Hoson, Hiroyuki Shioya, Yasuyuki Miyakoshi, Fumi Yamaguchi, and Hirokazu Urabe
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Development of Age Determination Technique Part 2: Image Processing for Age Determination Based on the Annuli of a Chum Salmon Scale
Masanobu Yoshida, Hiroyuki Shioya, Yasuyuki Miyakoshi, Fumi Yamaguch, and Hirokazu Urabe
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Challenges to Improving the Chum Salmon Hatchery Program in Kitami Region, Hokkaido
Yasuyuki Miyakoshi
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Research and Development of a Supporting Information System for Optimization of Salmon Release Operations and Monitoring the Coastal Environment on the Okhotsk Coast, Japan
Sei-Ichi Saitoh, Yasuyuki Miyakoshi, Fumihiro Takahashi, Takafumi Hirata, Irene D. Alabia, Takashi Hosokawa, and Tatsuya Miyoshi
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Topic 3 (Special Session): Resilience for Salmon and People: Lessons from the Great East Japan Earthquake in 2011

Topic 3-1. Restoration of ecosystems and human society in the coastal zone systems

Research Project of TEAMS for Restoration of Ecosystems and Human Society
Akihiro Kijima
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Challenges to Make Salmon in Sanriku an Icon of the Region
Jun Aoyama and Susumu Hyodo
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Effects of the Great East Japan Earthquake and Tsunami on Fisheries and Salmon in Iwate Prefecture
Tsuyoshi Nagasaka and Yuichi Shimizu
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First Salmon Ceremony in the Southernmost Area of Salmon Habitat
Kenji Yoshimura and Ryusuke Kodani
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Topic 3-2. Research for retrieval and sustainable management of salmon populations

Recovery from a Critical Disaster and Sustainable Conservation Management for Chum Salmon under a Warming Climate on the Sanriku Coast, Japan
Masahide Kaeriyama, Yuichi Shimizu, Yuki Minegishi, and Jun Aoyama
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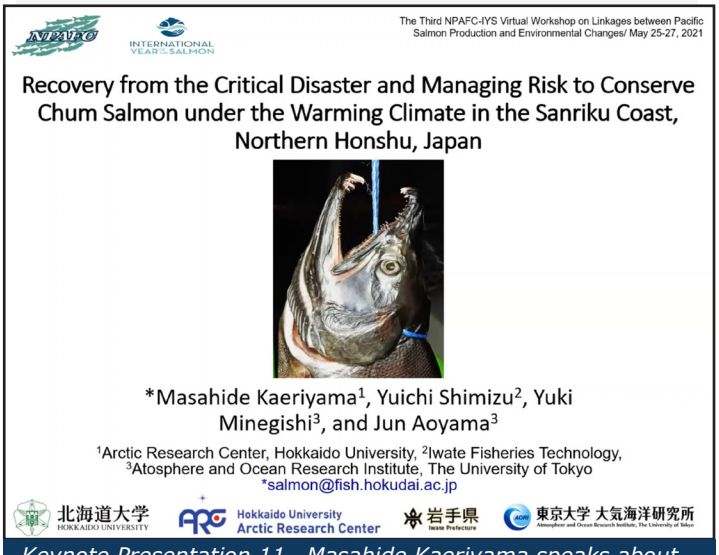

Keynote Presentation 11—Masahide Kaeriyama speaks about disaster recovery in the wake of the 2011 earthquake.

Wild Population and Natural Spawning of Chum Salmon in the Kozuchi River on the Sanriku Coast, Japan
Yuki Minegishi, Tatsuya Kawakami, and Jun Aoyama
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Downstream Migration and Spatial Distribution of Juvenile Chum Salmon in the Otsuchi Bay, the Sanriku Coast of Iwate, Japan
Tatsuya Kawakami, Yuki Minegishi, and Jun Aoyama
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Spawning Environment of Chum Salmon in the Coastal Rivers on the Pacific Side of Northern Japan
Satoki Oba, Tatsuya Kawakami, Yuki Minegishi, and Jun Aoyama
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The Utilization of Cold-water Zooplankton as Prey for Chum Salmon Fry in Yamada Bay, Iwate, Pacific Coast of Northern Japan
Yuichiro Yamada, Kei Sasaki, Kodai Yamane, Miwa Yatsuya, Yuichi Shimizu, Yoshitomo Nagakura, Tadahide Kurokawa, and Hideki Nikaido
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Fine-scale Genetic Population Structure of Chum Salmon on the Iwate Coast, Northern Japan
Shino Kitamura, Tomoaki Goto, Hideharu Tsukagoshi, Yu-ichi Shimizu, Fumihisa Takahashi, and Syuiti Abe
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Topic 3-3. Risk management and sustainability for the coastal zone systems and salmon production

Building Salmon Resilience: Lessons Learned from The Great East Japan Earthquake (GEJE) and Other Ecological Disasters
James R. Irvine, Masahide Kaeriyama, Shigehiko Urawa, and Jun Aoyama
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Legacies of the Tohoku Earthquake and Tsunami Impacting the Northern California Current in the Eastern North Pacific Ocean
Richard D. Brodeur, Jessica A. Miller, John W. Chapman, Gayle I. Hansen, and Delvan R. Neville
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The Challenge of Reconstruction Faced by the Domestic Salmon Industry after the Great East Japan Earthquake and Tsunami in 2011
Ikutaro Shimizu and Katsuhiro Miki
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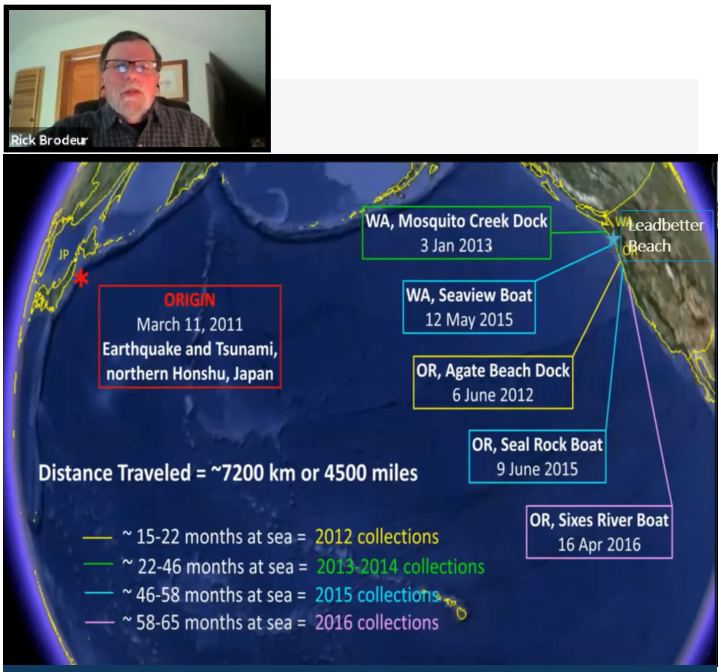

Richard Brodeur speaking on the effects of the Tohoku earthquake on the northern California Current.

Farmed Non-native Coho Salmon in Sanriku Region Affected by Recent Intense Natural Disasters
Kei Sasaki, Tadahide Kurokawa, Koh Hasegawa, and Miwa Yatsuya
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Radioactive Cesium in the North Pacific after the Fukushima Dai-ichi Nuclear Power Plant Accident
Hideki Kaeriyama
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Resilience for Salmon and People—Lessons learned from the Great East Japan Earthquake in 2011: Summary and Discussion
Jun Aoyama, Shigehiko Urawa, and Masahide Kaeriyama
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Announcement

Accepting Applications for the 2022 NPAFC Internship Program

The North Pacific Anadromous Fish Commission (NPAFC) invites citizens from its member countries (Canada, Japan, the Republic of Korea, the Russian Federation, and the USA) to apply for the NPAFC Internship Program. One or two interns will be accepted upon approval of the Commission. The intern will work at the NPAFC Secretariat office in Vancouver, BC, Canada.

The intern will gain experience and knowledge in operations of the NPAFC and will have the opportunity to test his/her interest in international governmental organizations, fisheries management, salmon biology & ecology, and fisheries enforcement. The intern will work under the supervision of the Executive Director and/or his designates. In general, the intern will assist in a variety of tasks, including:

- plan, develop, and complete an individual project in enforcement, science, communication, fisheries management, or administration;
- prepare information for and provide support to special projects, including the International Year of the Salmon (IYS) initiative;
- assist in organizing and editing various NPAFC publications;
- coordinate international cooperative programs and assist Secretariat activities; and
- assist with other work delegated by the Executive Director and/or his designates.

Internship period: Up to a maximum of 6 (six) months, with the start date to be negotiated. Start date must occur between the period of July–December 2022. The intern is expected to perform his/her tasks at the Secretariat office on a daily basis, Monday–Friday, 7.5 hours per day.

Qualifications: Applicants must be a citizen of an NPAFC member country, have a university degree, the ability to read, write, and speak English, the ability to use computers and the Internet, and demonstrated personal initiative. Applicants must currently be a part of the government or academic sector, a recent graduate, or currently enrolled in school for an advanced degree.

Financial support: NPAFC will provide a stipend of CDN $3,000 per month. Travel costs for the intern to and from his/her place of residence and the location of the Secretariat will be at the intern's own expense or by home country support. Travel expenses associated with the intern's work in the Secretariat will be covered by NPAFC. The intern's medical insurance and benefits are not covered by the NPAFC Internship Program.

Applications: Completed applications must include all of the following:

- a cover letter describing the applicant's interests and qualifications;
- resume showing academic and/or work experience;
- three professional letters of reference; and
- personal data page of passport as proof of citizenship.

Email the completed application to secretariat@npafc.org by April 1, 2022. The selected intern will be notified in early June of 2022.

For complete information: Go to https://npafc.org and contact the NPAFC Secretariat for questions at secretariat@npafc.org.

APPLICATION DEADLINE: April 1, 2022

Salmon-topped Rice Bowl

Recipe and photos by Jaehyun Jung
On-The-Job Trainee at the Secretariat

Jaehyun Jung joined the Secretariat as an on-the-job trainee in September 2021. He graduated from the University of Seoul, Korea, with a BSc in Politics and International Relations. He joined the Ministry of Oceans and Fisheries (MOF) of the Republic of Korea in 2007. Since then, he had worked in human resources management and policy for the promotion of the Korean cruise industry and tourism. After moving to the International Cooperation Division at MOF in 2019, he assisted policy for Marine Mammal Protection, and supported fisheries enforcement strategies and international contributions to help eradicate IUU fishing. When offered a chance for a 1.5-year training period abroad, as part of the Korean government's Overseas Study Program, he applied to the NPAFC as a trainee. He chose the NPAFC because he wanted to gain more practical and broad experience related to conservation and management measures. His plan is to research enhanced enforcement activities, including those associated with the Port State Measures Agreement, to ensure sustainable use of fisheries resources in the North Pacific Ocean. Jaehyun has diverse travel experience in Southeast Asia, Europe, and North America. He enjoys playing and watching sports—such as soccer, baseball, and basketball. During his stay in Vancouver with his wife and two kids, Jaehyun hopes to explore various fascinating places, particularly, in eastern Canada.

Ingredients

240 ml	aged soy sauce
120 ml	mirin or white wine
240 ml	water
personal preference	Japanese horseradish
300 g	sliced salmon
1 root	ginger
1/2	avocado
1	onion (sliced)
4 tbsp	sugar
1	scallion
2	sliced peppers
300 g	steamed rice

The ingredients

The completed dish: salmon and avocado sitting on a bed of rice

Method

1. Peel ginger root and cut scallion in half.
2. Add the water, aged soy sauce, mirin (or white wine), scallion, sugar, and ginger to a pot and bring to a boil, stirring occasionally.
3. Allow mixture to boil for one minute.
4. Remove mixture from heat, transfer to bowl and place in fridge to cool.
5. Slice the salmon, onion, and pepper and place in a container. Add the cooled soy sauce to the container and allow to age 8 to 12 hours in the fridge.
6. When ready to eat, steam rice as desired.
7. Place steamed rice in a bowl to serve and add the salmon mixture, avocado, and horseradish.
8. Bon appétit!

Soy sauce mixture beginning to boil (step 2).

The cooled soy sauce mixture is then added to the sliced salmon and vegetable mixture (step 5).

The sliced salmon, onion, and peppers are added to a bowl together (step 5).

The ingredients.

Upcoming Events

Committee on Enforcement Joint Patrol Schedule Meeting

Dates: April 2022

Venue: E-mail Meeting

NPAFC 30th Virtual Annual Meeting

Dates: May 9–11, 16–17, and 19, 2022 (16:00–19:00, Vancouver Time)

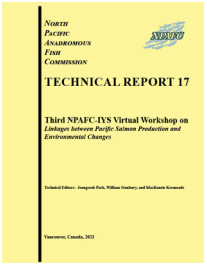
Venue: Online Meeting

IYS Synthesis Symposium—*Salmon in a Rapidly Changing World: Synthesis of the International Year of Salmon and a Roadmap to 2030*

Dates: October 4–6, 2022

Venue: The Westin Bayshore, Vancouver, Canada

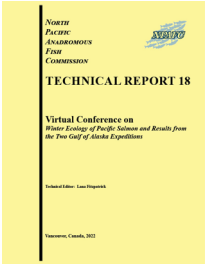
Recently Published



NPAFC Technical Report 17

Includes extended abstracts of oral and E-poster presentations at the Third NPAFC–IYS Virtual Workshop on Linkages between Pacific Salmon Production and Environmental Changes in May 2021. Available at https://npafc.org.

Upcoming Publications



NPAFC Technical Report 18

Includes extended abstracts of oral presentations at the Winter Ecology of Pacific Salmon and Results from the Two Gulf of Alaska Expeditions Virtual Conference in April 2021 and will be announced when available online.

Downtown Vancouver, Canada. Location of the NPAFC Secretariat. Photo credit: © edb3_16 / Adobe Stock

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Visit the NPAFC website: https://npafc.org for more information on events, publications, scientific documents, and salmon catch statistics.

The Commission encourages submission of ideas, articles, and images on NPAFC-related activities for publication in the newsletter.

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