Executive Summary

Pacific salmon (*Onchorhynchus* spp.) are an essential part of Alaska's commercial, recreational, and subsistence fisheries, providing economic opportunities to communities in Alaska as well as supplying important food and traditional and cultural practices for tens of thousands of Indigenous and rural people and communities. Alaska maintains some of the best freshwater and marine habitats for salmon health and resilience. Despite this, some Alaska salmon populations are facing sustained and dramatic declines, with devastating impacts to food security and traditional ways of life for the people that depend on them. In addition, some salmon stocks are experiencing wide fluctuations in returns that lead to high inter-annual variation creating uncertain economic outcomes. Because of these declines, Congress enacted the Alaska Salmon Research Task Force Act (AKSRTF; Appendix 1) to identify the gaps in knowledge that are needed to understand the variability and declining trends. The purposes of the act are to: 1) ensure that Pacific salmon productivity and abundance trends in Alaska are characterized and that research needs are identified; 2) prioritize scientific research needs for Pacific salmon in Alaska; 3) address the increased variability or decline in Pacific salmon returns in Alaska by creating a coordinated salmon research strategy; and 4) support collaboration and coordination for Pacific salmon conservation efforts in Alaska.

In this regard, the AKSRTF recommends the following:

Gravel to Gravel (G2G) life history research strategy

Salmon life begins and ends in the gravel and throughout their life history they depend on freshwater and marine habitats to grow and thrive. Through G2G, Tribes, State and Federal agencies and institutions and others work together to build a strong foundation for co-stewardship, where Traditional and Indigenous Knowledge along with western science play important parts in resilient habitats and communities within Alaska.

Potential Drivers influencing Pacific salmon production in Alaska and recommended applied research needs

Based on a review of existing knowledge, the AKSRTF identified the following potential drivers influencing production within the Pacific salmon life cycle in Alaska (in order of the number of life history stages impacted from all to less) and associated priority research needs:

Warming climate and extreme events

- Research to understand and quantify the effects of natural environmental variability and human factors on Alaska salmon distribution and abundance.

Salmon health and condition

- Research to understand the connections between freshwater and the marine environment that lead to pathogens or declines in thiamine levels for salmon as these changes could affect the ability of returning adults to successfully reach the spawning grounds, successfully spawn, the numbers of eggs produced and fertilized, and their ability to produce viable offspring.
- Research to understand prey quality and quantity on health and condition of salmon in marine and freshwater habitats.
- Research to understand the mechanism(s) behind declining size at age as these declines impact the amount of food available per fish, the number of eggs per female for future generations, and can contribute to declining run sizes.

Predators

- Research to understand potential conflicts between predator or endangered predators and prey (salmon).
- Research to address the role of hatchery salmon release sites has on drawing in assemblages of predator species that otherwise would not be present in coastal nurseries, thereby potentially increasing predation pressures on wild stocks that may also inhabit these nurseries.

Marine food limitations

- Research to understand the implications of habitat use by Alaska salmon populations at various levels of abundance, the productive capacity of habitats for each life stage, and the potential implications of density-dependent effects.
- Research to better understand the role of salmon in pelagic communities, the food availability for salmon and the nutritional quality of prey organisms, including harmful algal blooms, to better understand inter-and intra-specific competition among salmon at sea.

Marine harvest and bycatch

- Research to reduce bycatch, interception, and Illegal, Unreported, and Unregulated (IUU) fishing through improved understanding of distribution and migration patterns of Alaska salmon stocks to better predict and avoid incidental harvest in the migratory corridors for Alaska salmon including Bering Sea, Aleutian Island, and Gulf of Alaska areas and regions in the North Pacific where there is increased potential for IUU fishing.
- Research to improve our ability to determine the stock origin of chum and Chinook salmon taken in marine harvest, bycatch, and interception.
- Research to understand the frequency of occurrence and mortality rate (direct and discard) attributed to unobserved fishing mortality (e.g., IUU, unreported catch, incidental catch/mixed stocks); and once this information is known, what is the impact to the populations.
- Research to better define how all sources of marine harvest influence salmon abundance and how does this vary by species / region.
- Research to understand genetic diversity and fitness effects from fishing that may reduce a population's resilience and ability to recover from climate induced depression of population abundance or low productivity.

freshwater habitat changes

- Research to develop meaningful measures of ecosystem performance (space and time scales) that supports biological diversity of Alaska salmon to maintain and conserve the processes that confer resilience (habitat and/or genetic diversity) in face of ongoing environmental change.
- Research that improves our understanding of the impact of hatchery strays on wild salmon where intermingling with those stocks in freshwater has the potential to reduce genetic diversity, reproductive success, and resilience to climate variability and change.

freshwater harvest

- Research that addresses mortality rate attributable to unobserved freshwater fishing mortality due to release, incomplete capture, unreported catch, and illegal fishing and how this source of mortality impacts the populations.

- Research that documents production changes and spawning success in the high Arctic as salmon begin to return in larger numbers to the region.

Recommended Applied Strategies to Address Priority Research Needs

Improved stock identification methods

Develop/improve novel stock and fish identification methods at a finer scale than is currently available from genetic mixed stock analysis. In some areas, like western Alaska, current stock groupings based on genetic distinctions cover wide geographical areas that do not allow a full understanding of the impacts of marine harvest at the finer resolution used for management and impact assessment.

Better characterization of ocean distributions and marine migration routes

Develop/improve/expand research to understand the migratory routes and ocean distributions for western Alaska salmon to reduce bycatch potential (*see recommendations by the Alaska Bycatch Review Task Force report dated November 2022; Appendix 5*) and interception and to understand potential for impacts on their health from shifting food webs and competitive pressures.

Expanded ocean ecosystem surveys

Develop/improve/continue ocean surveys to understand how shifts in climate and ocean conditions (climate warming/extreme events) impact the food web and health and condition of juvenile salmon populations, with the primary research goal to identify additional marine management actions, with the secondary goal of improving forecasts of short- and long-term prospects for decision makers.

Strategies to minimize human impacts on freshwater and coastal habitats

Develop/improve/expand strategies to prioritize actions that reduce human impacts on freshwater and coastal ecosystems with the goal of maximizing the number, diversity, and health of wild smolts and spawners.

Making use of new technologies

Develop/improve/expand use of new technologies and advanced analytical methods for Alaska salmon research, including molecular identification, genomics, environmental DNA, mass marking, intelligent tags, salmon observation systems, and remote sensing/ autonomous vehicles.

More effective monitoring of salmon Indicator Stocks

Develop/improve/continue to identify indicator stocks for Chinook and chum salmon that can be monitored and tracked throughout their life cycle to better understand mechanisms impacting survival in marine and freshwater habitats and provide an early warning system.

Improved stock assessments for in-season management

Develop/improve/continue stock assessment programs that allow for timely in season management decisions to mitigate uncertainties in adult salmon return strength.

Life-cycle modeling and management strategy evaluations for climate resilience

Develop/improve/expand approaches to modeling biological impacts of climate change on full life cycle of Pacific salmon that include management strategy evaluations to test how different management actions may impact production in relation to climate scenarios, ensemble models to characterize uncertainty in climate impact projections, and ocean intelligence systems for targeted information on impacts of climate warming and extreme events on ocean ecosystems and salmon growth and health.

Better data management and sharing – work in progress

Recommended Framework

Work with Tribes/Federal/State to initiate Two-Eyed Seeing framework that embraces “learning to see from one eye with the strengths of Indigenous knowledges and ways of knowing, and from the other eye with the strengths of mainstream knowledge and ways of knowing”

Critical Need to Understand Shifts in Alaska Salmon Productivity

Alaska is warming at a rate two times faster than the Lower 48 contiguous states which is having a profound effect on Alaska salmon populations. Improved understanding of the mechanisms that regulate the distribution, migration and abundance of Alaska salmon will promote their conservation, allow for better projections, characterize uncertainty for production trends under climate warming, and enhance the sustainable fisheries management, food security and economic security for Alaskans.

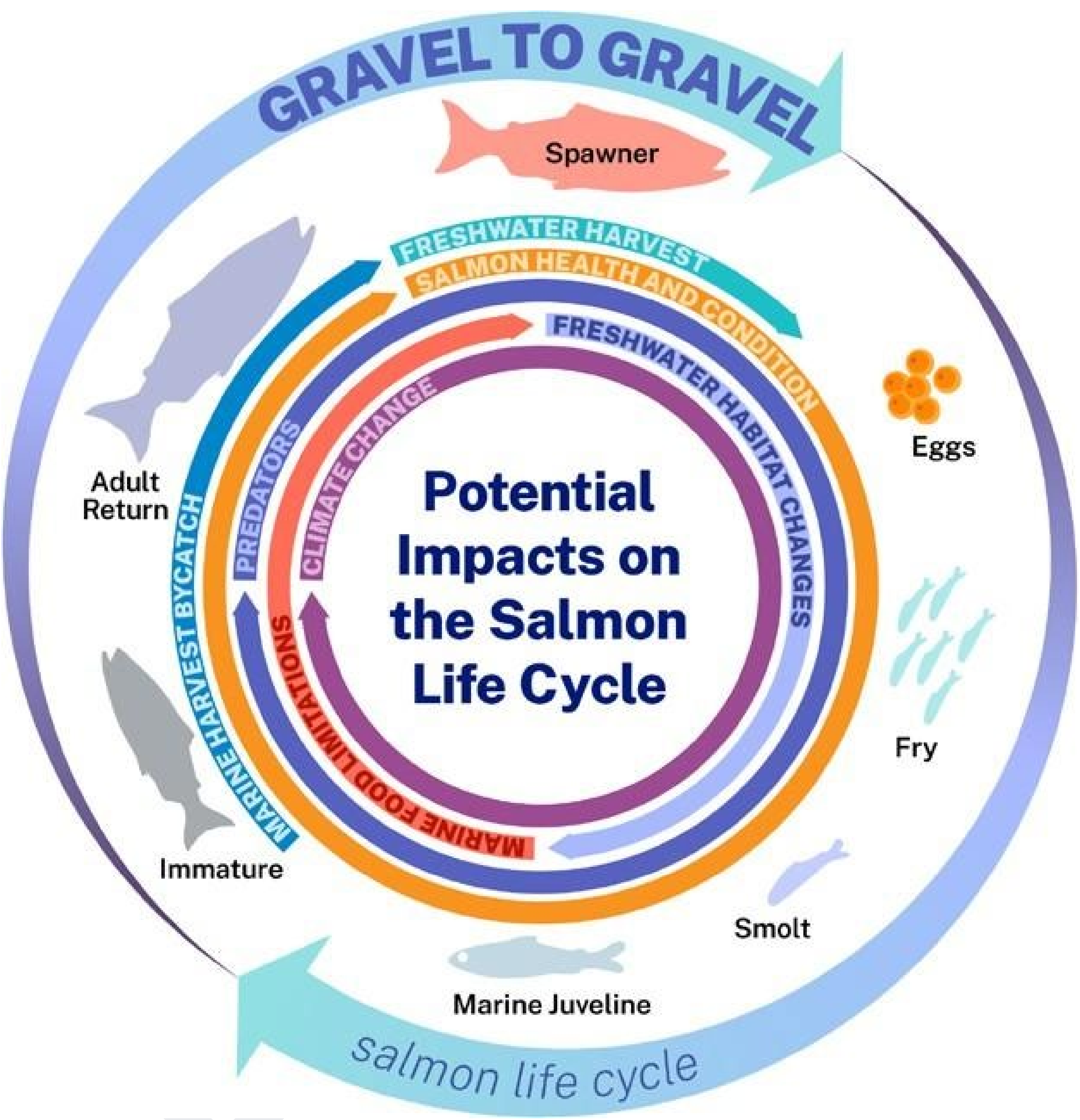
These dramatic shifts in Alaska salmon productivity are occurring despite the fact that freshwater habitats where Alaska salmon reside during their life history are relatively pristine, especially when compared to habitats that salmon stocks encounter at lower latitudes. Existing knowledge regarding Alaska salmon ecology indicates that warming in both freshwater and marine habitats is creating divergent impacts on salmon species and stocks where some are responding positively to warming (i.e., abundance is increasing) and others are declining in response. For example, residents of the Yukon River drainage have experienced declines in returning Chinook salmon since 2001 with minimal improvement and periodic crashes in chum salmon, most recently in 2021-2023. These declines have led to the cessation of in-river commercial fisheries for Chinook salmon and severe restrictions to subsistence fishing for all salmon species, including a complete closure of subsistence fishing in 2022.

It is critical that we take action now to understand mechanisms driving Alaska salmon production and to provide a path for mitigating negative impacts. Acting now allows for a response before there is further decline, making immediate action more successful and cost effective than waiting until stocks become critically low or reach depleted status.

As such, the AKSRTF members were acutely aware of the impact the declining Chinook and chum salmon returns in western Alaska are having on culture and food security in that region. Through the AKSRTF Act, the AKSRTF formed the Arctic Yukon Kuskokwim Working Group (AYK WG) to identify priority research needs for salmon in that region. A report from the AYK WG is located on page 27. Public testimony often included recommendations for action that can be done now, such as management actions to close fisheries where western Alaska salmon are harvested as bycatch or interception. Although the AKSRTF understood it would be impossible to meet all expectations, our commitment was to develop priority research needs that would enable decision makers at local and regional levels to act quickly in response to research results.

It is through this lens that the AKSRTF set out to recommend a coordinated research strategy based on the review of existing Pacific salmon research and the identification of knowledge gaps, and applied research needed to better understand why Alaska salmon are experiencing increased variability and declines.

Coordinated Research Strategy (Gravel to Gravel/ Life History Figure)



Salmon life begins and ends in the gravel (Gravel to Gravel – G2G) and throughout their life history they depend on freshwater and marine habitats to grow and thrive. It is through the utilization of diverse, pristine habitats found in Alaska that salmon can gain resiliency to the effects of climate warming. However, Alaska salmon are facing greater challenges than those at lower latitudes due to the pace of warming (two times faster than lower latitudes) and extreme events (marine heat waves, loss of seasonal sea ice, drought, spikes in freshwater temperatures, etc.) that can have dramatic impacts on their survival. Through, G2G federal agencies, Tribes, state agencies and institutions and others can work together to build a strong foundation for co-stewardship, where traditional and Indigenous Knowledge along with western science play important parts in support of resilient habitats and communities within Alaska.

We propose a G2G assessment approach of coordinated research where individual projects, regardless of whether they are led by state, federal, university, tribal, or non-profit entities, will share information with all other projects, and this strategy includes an intentional integration of data and information across research projects. Prior salmon research efforts have undoubtedly enabled important advancements in our knowledge and understanding of poor salmon abundance patterns across Alaska. However, when each research project is advanced and understood in isolation, which is the norm, we often fail to develop a synthesized and holistic perspective across the entire salmon life cycle. Consequently, it becomes difficult to develop an integrated and unified picture of the nature of where salmon bottlenecks are, and to clearly identify the most important drivers of these bottlenecks. Perceived progress takes a long time to develop, and it becomes challenging for experts with different perspectives to coalesce under a common understanding.

To do this, for each stock selected for study, an intensive suite of studies will be implemented concurrently over a 5 to 6-year period. Together, the suite of projects should address all relevant potential drivers for salmon abundance identified in the AKSRTF report and all life stages, ideally with overlap across multiple projects. In addition to data collection studies, retrospective analyses and modeling efforts will be useful to “bring it all together” by consolidating data across suites of projects and integrating data from separate studies. This synthesis will highlight critical factors or life stages limiting salmon adult run abundance and inform potential policy and management actions. Research approaches that are intensive and holistic, employing coordinated and focused examinations of all potential drivers at once, have been particularly successful for identifying factors most important to survival and productivity of salmon in other areas (e.g., Salish Sea Marine Survival Project), and it is expected that the G2G assessment approach would be similarly successful.

Potential Drivers for Alaska Salmon Production

Based on a review of existing knowledge, the AKSRTF identified the following potential drivers influencing production within in the Pacific salmon life cycle in Alaska (listed in order of the number of salmon life history stages impacted (all to less); no priority assigned): warming climate/extreme events, salmon health and condition, predators, marine food limitations, marine harvest and bycatch, freshwater habitat changes, and freshwater harvest. Research gaps were then identified within these potential drivers of Alaska salmon productivity which set the stage for the AKSRTF to develop priority research needs and applied strategies (listed in the Executive Summary) to address each potential driver.

Warming Climate/Extreme Events (impacts all life stages)

Alaska is warming at a rate two times faster than the lower latitudes, and this warming is affecting all aspects of the salmon life cycle. Indirect impacts of climate-related phenomena include changes to timing of salmon smolt outmigration and upriver migration, reduced fitness in response to shifts to lower quality prey as well as shifts in their ocean migration and distribution patterns. Warming is also increasing the frequency of extreme events that have profound negative impacts on some species and stocks of salmon depending on what freshwater systems are utilized for spawning and the migration routes taken during their marine life history. Extreme events can lead to short term (days to weeks) changes in water flow, oxygen levels in freshwater, and spikes in freshwater temperatures, as well as seasonal changes (months) such as loss of seasonal sea and lake/river ice, and longer-term phenomena (months to years) such as marine heat waves. These extreme events have direct physiological impacts on salmon stocks, such as heat stress that can compromise the success of returning adult spawners or juveniles in the ocean and reduce health and condition of salmon in the marine environment in response to shifts to lower quality prey as well as shifts in their ocean migration and distribution patterns.

Salmon Health and Condition (impacts all life stages)

Changes to the health and condition of Pacific salmon in Alaska have been noted by fishers and biologists. Across Alaska, Chinook salmon and other species of salmon have been experiencing declining size at age as well as shifts in age at maturity (to younger age). Other changes include increased presence of ichthyophonus (a fungal-like infection) and a reduction in thiamine levels in Chinook salmon, both of which are believed to come from their marine prey. Other changes that are found for Alaska salmon include deficiencies in fat stores, particularly during early marine life history stages and potentially during adult spawning migration. All of these changes could increase mortality rates during marine life history stages and affect the ability of returning adults to reach spawning grounds and spawn successfully, and decrease their ability to produce viable offspring.

Predators (impacts all life stages)

Predation occurs throughout the Pacific salmon life cycle, but can be difficult to assess, especially in estuarine and marine environments. Salmon sharks are estimated to consume 73 to 146 million Pacific salmon each year. Many marine mammal predators of salmon, particularly seals and sea lions, have increased in abundance in recent decades. Changes in subsistence practices along some Alaska rivers, for example, the decreased need to harvest fish such as northern pike to feed dog teams, has resulted in increasing abundance of freshwater predators in some places, as has the expansion of pike beyond its native range.

Socio-economic changes over since the 1970s have also affected the ecological system. As snow machines replaced dog teams for transportation, community residents kept fewer dogs and needed fewer salmon and non-salmon fish species, such as sheefish and Northern pike, to feed them. Some researchers have theorized that the decreased harvests of these piscivorous fish have led to increased predation on juvenile salmon in the fresh water environment.

Marine Food Limitations (impacts marine life history stages)

Many Alaskan salmon stocks are experiencing particularly poor marine survival, which could be due to marine food limitations. Pacific salmon move from rivers to sea to take advantage of better feeding and growing opportunities in the ocean. However, there are several indications that critical changes have occurred for Alaskan salmon marine feeding and growth opportunities that adversely impact their marine survival and/or their health and condition when they return to their natal spawning rivers. For instance, local and Indigenous knowledge holders are raising concerns about deteriorating fat content and health of returning salmon. Additionally, a growing body of scientific literature associates many of these abundance or size declines with competition among salmon species, including those of hatchery origin. Therefore, it is critical to understand the mechanisms and degree to which marine food limitations may be causing poor returns of Alaskan salmon, and to understand what actions could possibly mediate these conditions.

Marine Harvest and Bycatch (immature and maturing life stages)

Marine harvest of Pacific salmon occurs at multiple scales (i.e., international, national, state, regional, etc.) and there are many complexities to reporting and attributing catch (limits to genetic stock identification) at these various levels. In addition, most ocean fisheries have some amount of bycatch or interception of Pacific salmon as part of the harvest process. There are challenges in tracing bycaught salmon to their stock of origin given that the various stocks intermingle in the marine environment.

Freshwater Habitat Changes (spawning adult to smolt life stages)

Much of Alaska's freshwater habitat is considered relatively pristine compared to those in lower latitudes. While intact landscapes are most likely to support biological diversity and the reliable delivery of salmon to ecosystems and people, they remain subject to large-scale drivers such as warming climate. For example, intact freshwater landscapes help to buffer environmental variability and contribute to long-term stability of salmon populations through differing responses to varying conditions (much like the stabilizing effect of asset diversity on financial portfolios), yet the buffering can be overwhelmed in times of drought or changing water tables.

In some regions of Alaska, dramatic changes to freshwater habitat have been brought on by glacial recession, isostatic rebound, and tectonic forces. These changes to the landscape impact freshwater habitats in countless ways, both positive and negative, across the state. Intact habitat allows for salmon populations to respond positively in some cases, such as in Glacier Bay in Southeast Alaska, where receding glaciers have resulted in new freshwater habitats and colonization by salmon. In other cases, invasive species such as *Elodea* present a significant risk to salmon streams in some regions of Alaska as the plant affects the quality of habitat for juvenile salmon. Hatchery adults also stray into streams where wild stocks are spawning and have been known to intermingle with those stocks potentially reducing genetic diversity, reproductive success, and resilience to climate variability and change. The presence of hatchery strays can also make it difficult to monitor escapements of wild salmon by inflating aerial and foot survey counts, and has resulted in reductions in geographic coverage of wild stock escapement indices in some areas where high hatchery stray proportions have been documented.

Traditional Knowledge holders often communicate that sport fishing can interfere with salmon survival, both through the physical disturbances caused by sport fishers walking in streams and on riverbanks, as well as through overall disrespectful behavior towards salmon often described as "playing with one's food." Beavers have also increased in number in interior regions of Alaska: "...the beavers, they dam the river where the spawners can't even go through the dam…seeing...lots of beaver dams. There used to be no beavers in our area (Kuskokwim River)…migrating into the lower streams…down to the coast now." In addition, more roads along freshwater river systems can create new challenges: "A chemical sprayed on tires actually kills salmon…driving on roads...can affect the salmon."

Freshwater Harvest (adult life stage)

The effect and magnitude of historical freshwater harvest (commercial, sport, and subsistence) on salmon populations is not well understood. Even though freshwater harvest has been reduced or eliminated in some areas because of recent declines, the productivity of stocks continues to decline, which suggests that freshwater harvest is not the primary driver on the abundance relative to other influences. The biggest information gap for subsistence harvest is in the Arctic, but, overall, this is not seen as a major influence on abundance relative to other influences.

For subsistence harvest, traditional and Indigenous Knowledge illustrates that salmon provides not only an essential food source for families, but also supports important cultural, linguistic, and family traditions that encourage health and wellbeing within communities. Changing patterns in the harvest and use of salmon continue to drive disconcerting social changes in the region, such as reducing the time that families spend together at fish camps and the resulting challenges to passing on cultural knowledge between older and younger generations. "We have to respect them and keep what you do catch very clean and handle them carefully...The animal, fish, or something we take into our home the women they take care of it right away...with no complaining...because the person who hunts will get more not less...if we leave it... will not catch anymore while others are catching more. We have to respect them and keep what you do catch very clean and handle them carefully." "…our people are into sharing. Elders first. Families first. We never kept the first king. We shared it." "Our cultural and our self-identity was giving to the Elders and sharing our catch."

Existing Knowledge

Because of salmon's importance to food security as well as its cultural and economic value, there is a lot known about what salmon need to thrive, particularly in the freshwater phase of their life cycle. Adult salmon require the ability to move from the ocean to freshwater habitats, which must provide the conditions that support the healthy development of eggs, fry, and juveniles. Collectively, freshwater habitat quality can be characterized by the 4Cs: "clean, cool, complex, and connected". Spawning beds must consist of clean gravel that is free of silt, or there must be sufficient movement of water between the stream and its gravel bed ("hyporheic flow", or upwelling/downwelling) to prevent eggs and embryos from suffocating. Streams and lakes must be free of toxic levels of heavy metals, pesticides, and other pollutants. Complex habitats, such as rivers with healthy floodplains, are important for fueling food webs and giving juvenile salmon the ability to move into side channels that might have better feeding conditions or fewer predators. Habitat features such as undercut banks and logjams provide small salmon protection from high flows and from predators, and lakes and beaver ponds can provide good overwintering habitat for species such as coho salmon that spend at least a full year in freshwater before going to sea. Rivers with good forest cover, intact floodplains, or active hyporheic zones can also provide salmon the opportunity to seek out waters that are neither too cold in the winter nor too warm in the summer. Finally, young salmon must be able to migrate downstream to the ocean without being blocked by dams or culverts or entrained in diversions, and returning adult salmon must also be able to travel unimpeded to their spawning grounds.

Each female salmon can produce several thousands of eggs during her one chance at spawning. Because of this, salmon can support high levels of non-industrial harvest (i.e., nearshore and in-river; commercial, sport, and subsistence) when freshwater and ocean conditions are good. They can also rebound from population declines when the climate is favorable and freshwater habitats have not been impacted by damming, logging, or floodplain development. Healthy salmon populations seem to do best when they are subject to an intermediate level of harvest. Too little harvest can allow too many adults on the spawning grounds, which can reduce egg survival, and when too many juvenile salmon are produced they can compete with each other for food. When harvest is too high, freshwater habitats suffer from the lack of gravel cleaning by spawning salmon and a dearth of nutrients that are brought in from the ocean to spawning grounds by adult salmon. Very small populations can also lose genetic diversity, which can jeopardize their ability to evolve in response to external stressors such as climate change. These ecological concepts align well with an ethic that is shared among many Indigenous peoples in Alaska, which is to harvest salmon when they make themselves available, take only what is needed, and to leave salmon alone when they are not doing well.

The ocean is where salmon spend most of their lives, and where they put on 99% of their body weight. However, this is a challenging place to study, and we only have a broad understanding of this phase of their life cycle. Upon entering the ocean, salmon generally move in a counterclockwise direction around the North Pacific, cycling between productive summer habitat in the Bering Sea and ice-free waters of the Gulf of Alaska during the winter. Salmon feed on a variety of prey, including zooplankton (e.g., copepods, krill, crab larvae) when small and moving up to squid and forage fishes, such as herring, as they grow. Salmon growth and survival is the result of complex and poorly understood interactions among climate, food, predators, and competitors. Large-scale climate variation, such as shifts in the Aleutian Low Pressure system, control the oceanic currents, ocean temperatures, and weather patterns that set up food production in the ocean - phytoplankton and zooplankton - and oscillations between conditions favorable and unfavorable for salmon can be seen throughout Alaska's history (e.g., the 1976/77 "regime shift" that was a boon for Alaska salmon fisheries). The number of hatchery salmon released into the ocean is also at an all-time high, likely leading to reduced food for wild salmon in certain places and times.

In recent years, we have seen the emergence of extreme events such as drought, short term spikes in river temperatures, and marine heatwaves, which manifest as dramatic and persistent increases in temperatures across broad regions of the North Pacific. Marine heat waves profoundly alter marine ecosystems, including affecting what and how much food is available for salmon and the kinds of predators they face, and they are accompanied by hot weather over land as well, leading to river temperatures high enough to weaken or kill migrating salmon even as far north as the Yukon River. Extreme events such as heat waves complicate our ability to maintain optimal levels of salmon harvest, because the methods for setting harvest are usually developed against some average background level of natural mortality and are not well-equipped to deal with big shifts in natural mortality.

Following these scientific observations, we acknowledge that Western science is not the only knowledge source useful for understanding the complex relationships between salmon, their environments, their life-cycle needs, climate, and other factors. Indigenous and traditional knowledge often goes beyond that which is directly related to ecological aspects of the natural world and includes values associated with the entire world view, such as relationship, responsibility, reciprocity, and redistribution (4 Rs). Empirical observation is critical but in ways that focus on and teach appropriate human action as an integral part of the natural world. For example, beliefs about reciprocal relationships of care between humans and fish teach culturally appropriate behavior around concepts of salmon return and conservation.

With regards to existing knowledge about salmon, Indigenous and traditional knowledge have existed, been passed down, and been built upon for thousands of years.

"Growing up in the village, we lived from the land, river and sea. While engaging in subsistence activities, passed and taught from generation to generation, we continue to do so with great respect to the environment we live in, which can be unforgiving if not taught to survive in it. They taught us how to travel on different land, river, weather and sea ice conditions which can change in a heartbeat.

All that they taught us is woven into the fabric of our culture, to be able to survive and perpetuate the life of our culture. We were taught how to relate to the environment we were born to, as well as relating to other persons within our culture. For example, the great respect we have for our parents, aunts and uncles. To share our hunting catches with widows and those that need help. Translating the nuances of our culture and life is a challenge at times, from one language to another. I think that Indigenous knowledge better conveys all those things passed on that are deep at the core of the subsistence lifestyle we live. The permanency and perpetuity of our culture. Closely too is traditional knowledge, that conveys the timelessness of cultural traditions and subsistence practices. To continue, unbroken, with our subsistence way of life."
(*Oscar citation, per his preference*)

This knowledge can appear in many forms and from multiple cultural traditions and is commonly derived from keen, long- term observation of and interaction with local landscapes. Ultimately, we need an intertwined and holistic approach to understanding Alaska salmon, including relationships between Alaska salmon and all living and nonliving things, that includes observations from multiple knowledge types and from a variety of experiences from scientific research to generational observation and harvest.

"...'Traditional Knowledge,' it includes both Western and Indigenous knowledge…[there] are non-natives and have a lot of Traditional Knowledge regarding fish and game. So, I personally feel that using the term "Traditional Knowledge" is an inclusive term which is what this Task Force was required to use. Incorporating Indigenous Traditional Knowledge would benefit knowledge from the locals throughout the state also using Traditional Knowledge from local fisherman regardless of ethnicity." (*Jacob, cited per preference*)

As such, Indigenous and Traditional Knowledge is included in this report to the best of our ability. Information sources include ethnographic interviews, public testimony, and literature sources focused on the social science of traditional knowledge. (Table #) In addition, information and recommendations provided by the Arctic-Yukon-Kuskokwim Working Group, which has local members from each of the Arctic, Yukon, and Kuskokwim regions of Alaska, provided another opportunity to document traditional knowledge which will be presented later in this report.

Productivity Trends

North Pacific

The North Pacific Anadromous Fish Commission (NPAFC) collates Pacific salmon commercial catch data and the number of hatchery salmon released into the North Pacific Ocean each year. These data come from Canada, Japan, Korea, Russia and the United States, where Alaska salmon harvest is separated from Washington, Oregon and California. (Note that catch numbers are an imperfect metric of salmon abundance, because they also depend on fishing effort.) What is noticeable within this near 100-year time series is the number of Pacific salmon harvested each year by all five nations is at historically high levels since the 1990s (Figure 1). Peak commercial catches of 600 million Pacific salmon by all five nations occurred several times during the mid-2000s to present. Hatchery salmon releases began during the 1950s, but the numbers of salmon released into the North Pacific Ocean increased during the 1970s and has peaked at around 5 billion salmon each year from 1987 to present (Figure 2). Overall, Japan, the United States, and Russia release the highest number of hatchery salmon into the ocean each year when compared with Canada and Korea.

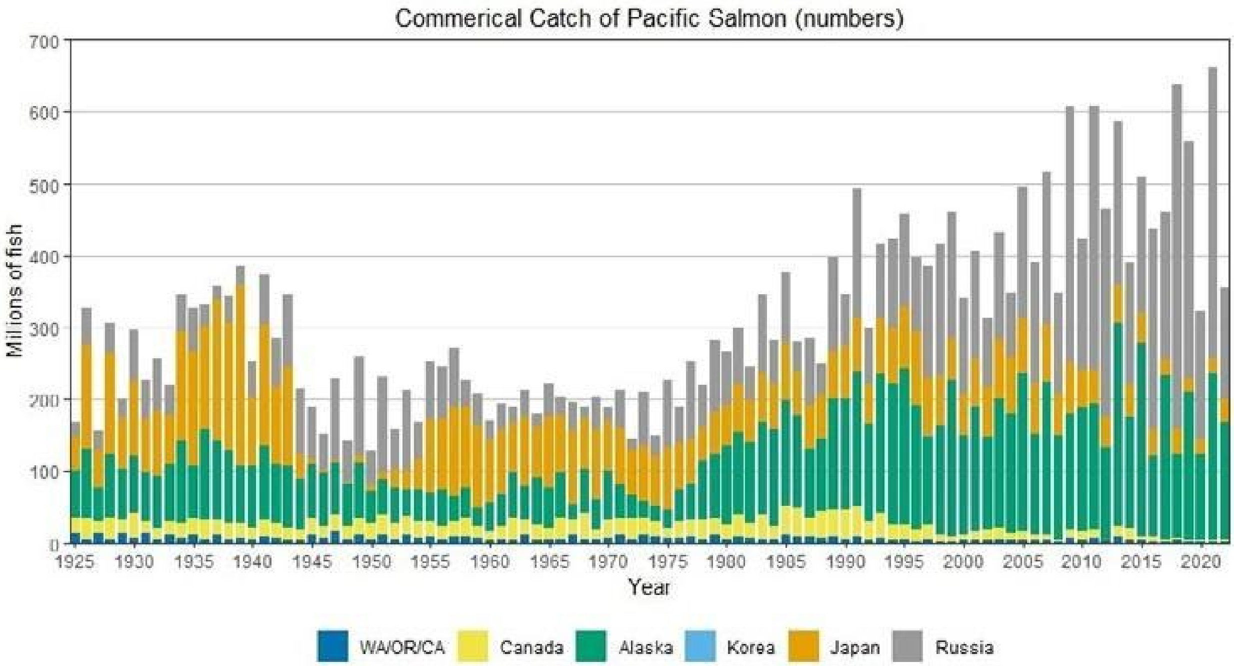


Figure 1. Commercial catch (millions of fish; 1925 to 2022) of Pacific salmon within nearshore and rivers for Canada (light blue), Japan (dark blue), Korea (green), Russia (purple), and the United States (blue/green).

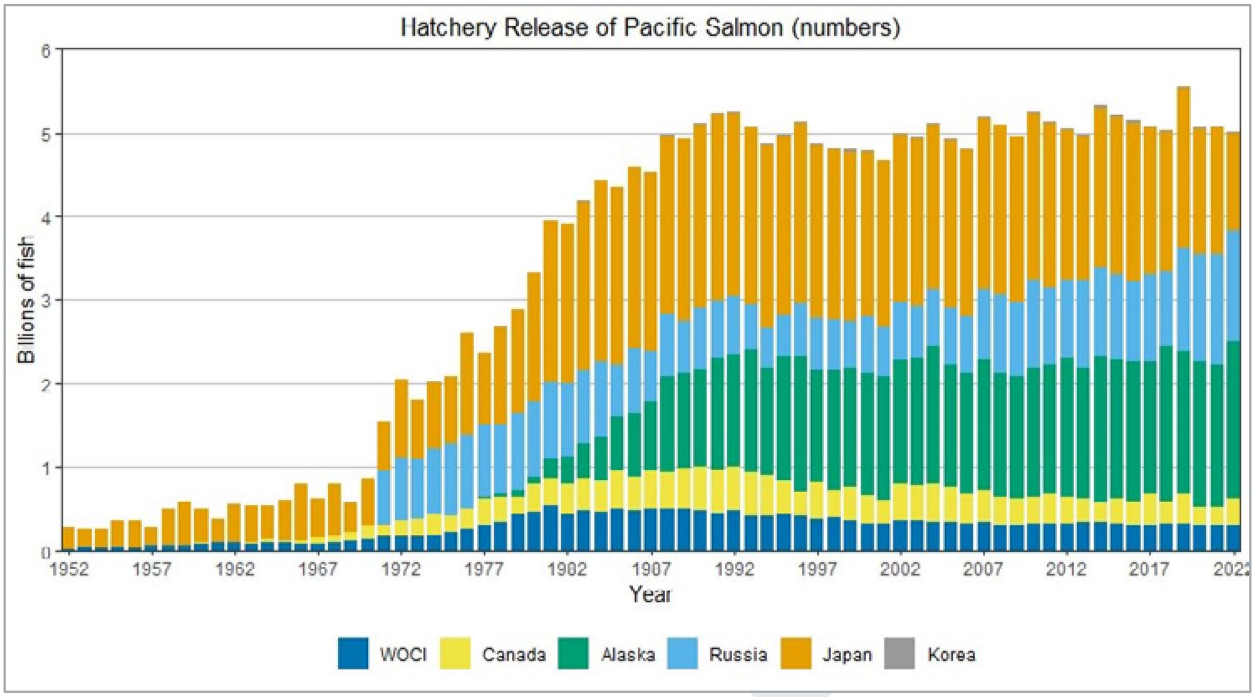


Figure 2. Hatchery releases of Pacific salmon (billions of fish) by Washington, Oregon, California (WOCI; dark blue), Canada (yellow), Alaska (green), Russia (light blue), Japan (orange), and Korea (grey). within nearshore and rivers for Canada (light blue), Japan (dark blue), Korea (green), Russia (purple), and the United States (blue/green).

State of Alaska

The time series of salmon harvest by species and region are shown in Figures (3–7). The time period shown (1959–2022) illustrates the variability in harvest during since statehood and includes the higher production period starting 1976/77, the onset of increased releases of salmon from hatcheries, and recent declines in productivity for some species and stocks. Chinook salmon commercial harvest averaged around 600 thousand from the late 1950s to mid-1970s, then increased to roughly 800 thousand during the early 1980s and has since gradually declined to around 250 thousand. In general, the downward trend in Chinook salmon commercial harvest since the mid-1980s includes dramatic declines within the AYK, Central and Southeast regions and high variability in harvest within the Westward region starting around 2007. Chum salmon commercial harvest was around 5 million from the late 1950s to 1980 but then increased to around 18 million through 2018. The commercial harvest of chum salmon has recently declined to levels seen during the mid-1980s, and subsistence harvest to lowest levels on record, with the AYK region having the largest decline. Sockeye salmon commercial harvest in Alaska has varied between 10 to 60 million. Commercial harvest of sockeye salmon has been strong during recent years with proportionally higher harvest coming from Bristol Bay in the Central Region. There is also large regional variability in sockeye salmon harvest with recent declines in some regions and record harvests in others.

Pink salmon are characterized by considerable variability and commercial harvest has varied between 50 to 210 million annually since the mid-1980s. The lowest catches occurred during 1959 and 1978 and the highest catches occurred during 2013 and 2015. Much of the pink salmon harvest occurs within the Gulf of Alaska regions including Southeast Alaska, Prince William Sound and Kodiak. Harvest within the Bering Sea is considerably lower in comparison. Pink salmon are caught in sport and subsistence fisheries, but those numbers are small compared to commercial harvest. Coho salmon commercial harvest has ranged between 2.5 to nearly 10 million, following the 1976/77 shift with the peak commercial harvest occurring during the early 1990s and the lowest commercial harvest occurring during 2020. Much of the recent decline in coho salmon harvest is within the Southeast and AYK regions.

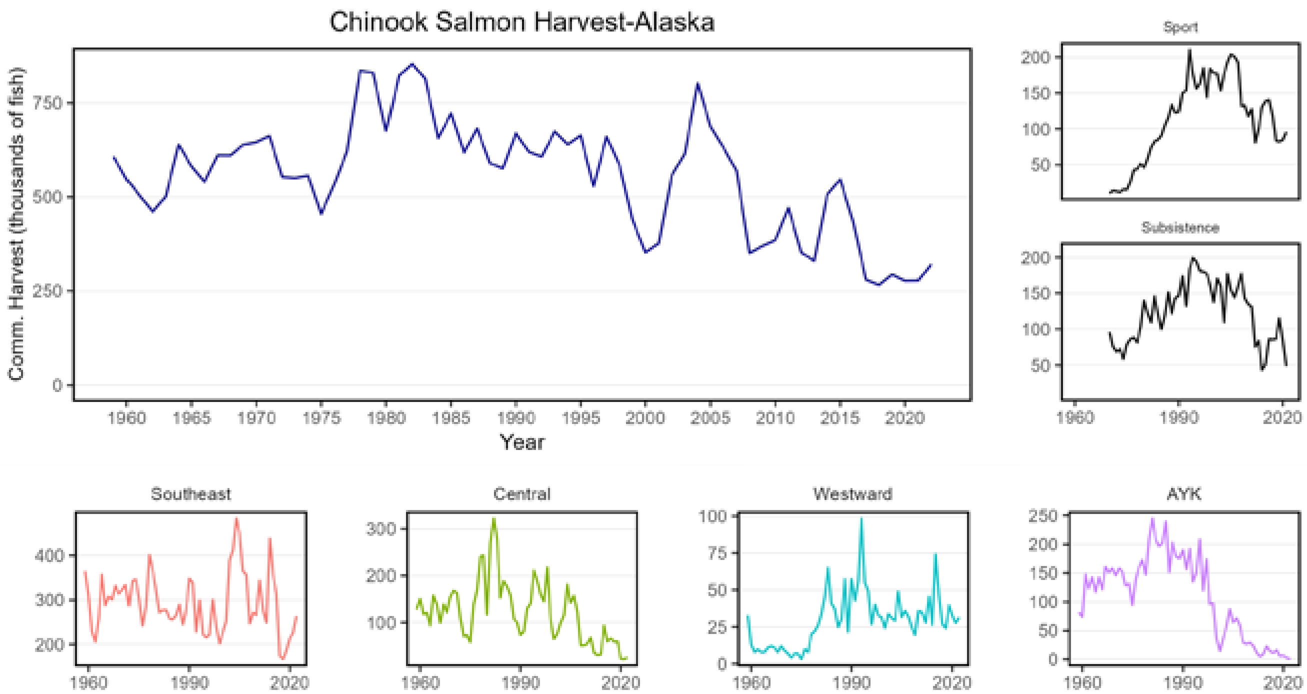


Figure 3. Number (thousands) of Chinook salmon harvested in Alaska (1959–2022). Series include total commercial harvest (main panel), commercial harvest for ADF&G Commercial Fisheries Regions (lower panels), and sport and subsistence harvest through 2021 (side panels). Note change in scale of y-axis. Data source: ADF&G, adapted from NPAFC (2023).

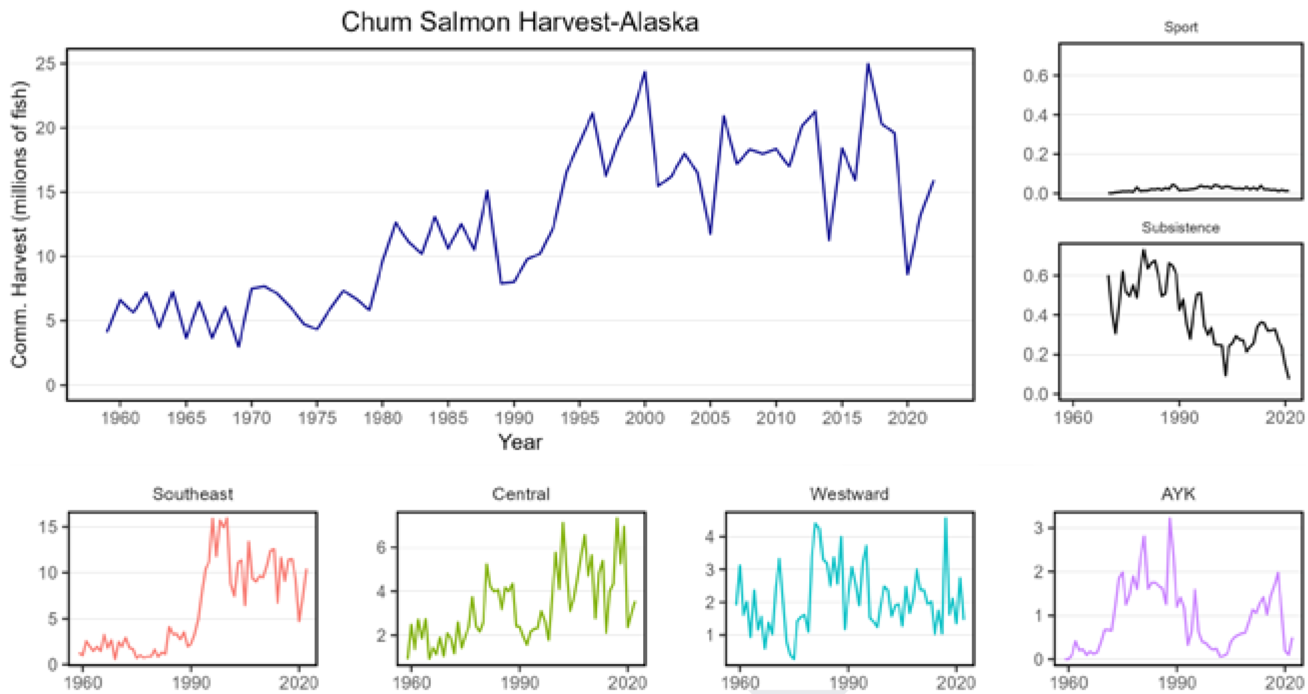


Figure 4. Number (millions) of chum salmon harvested in Alaska (1959–2022). Series include total commercial harvest (main panel), commercial harvest for ADF&G Commercial Fisheries Regions (lower panels), and sport and subsistence harvest through 2021 (side panels). Note change in scale of y-axis. Data source: ADF&G, adapted from NPAFC (2023).

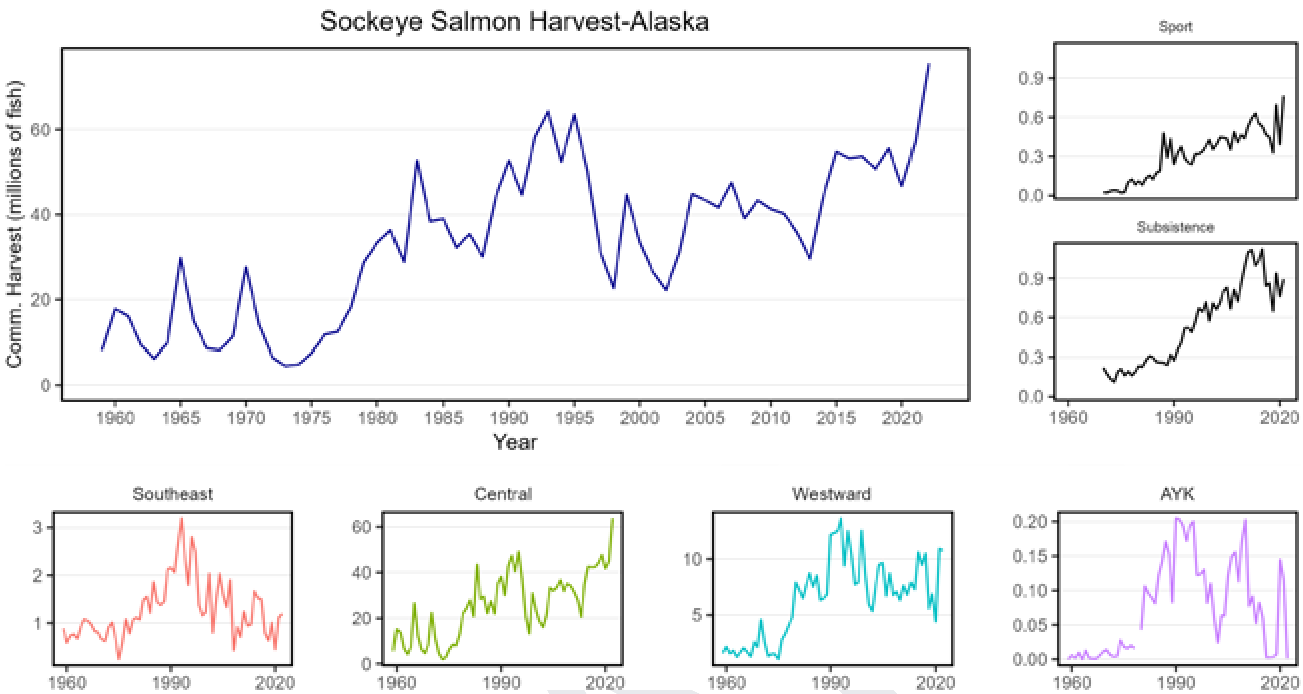


Figure 5. Number (millions) of sockeye salmon harvested in Alaska (1959–2022). Series include total commercial harvest (main panel), commercial harvest for ADF&G Commercial Fisheries Regions (lower panels), and sport and subsistence harvest through 2021 (side panels). Note change in scale of y-axis. Data source: ADF&G, adapted from NPAFC (2023).

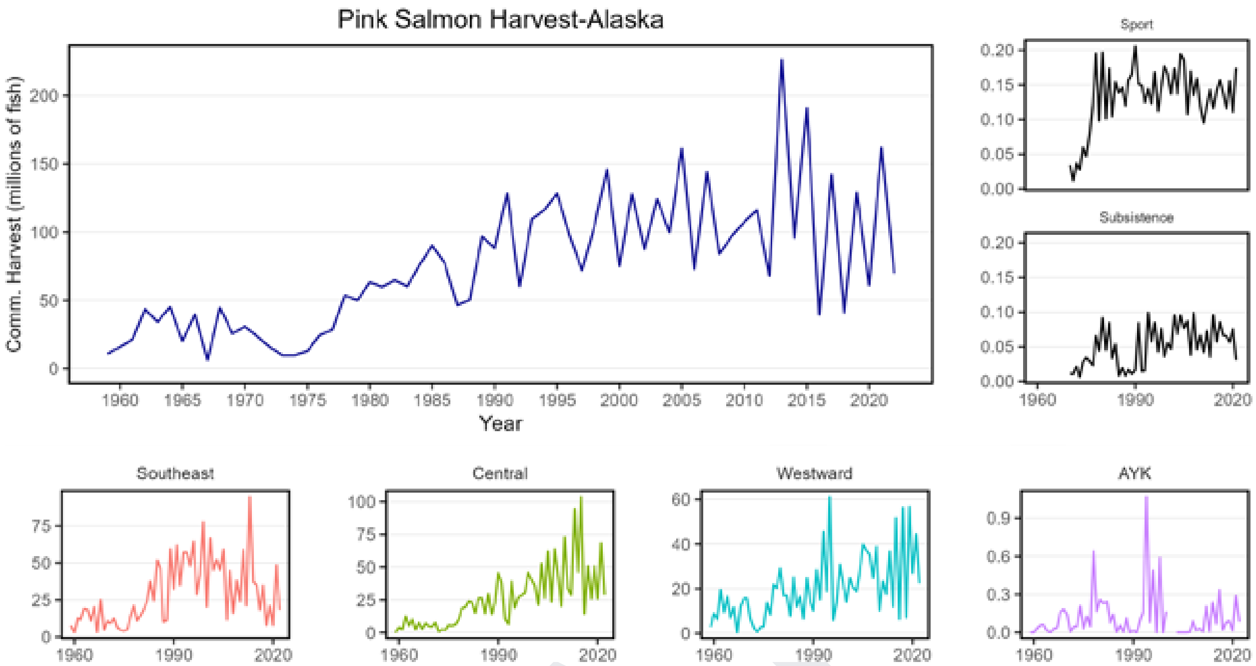


Figure 6. Number (millions) of pink salmon harvested in Alaska (1959-2022) as reported annually to NPAFC. Series include total commercial harvest (main panel), commercial harvest for ADF&G Commercial Fisheries Regions (lower panels), and sport and subsistence harvest through 2021 (side panels). Note change in scale of y-axis. Data source: ADF&G, adapted from NPAFC (2023).

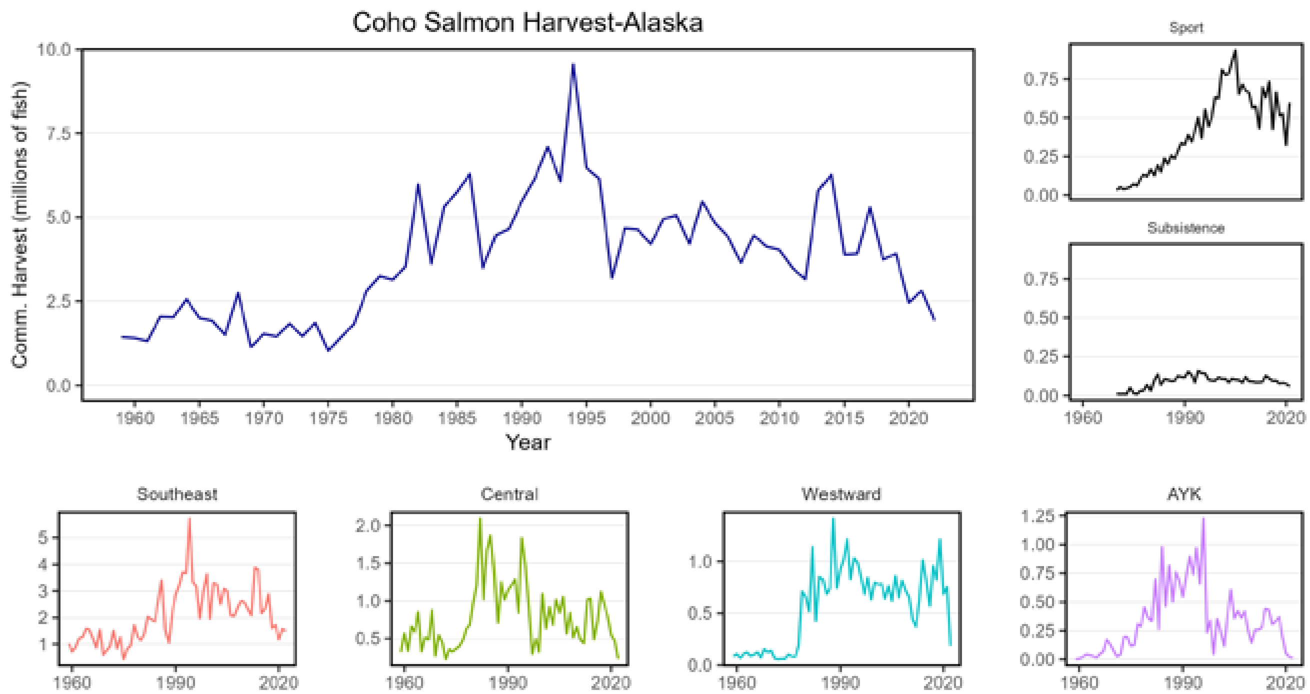


Figure 7. Number (millions) of coho salmon harvested in Alaska (1959-2022). Series include total commercial harvest (main panel), commercial harvest for ADF&G Commercial Fisheries Regions (lower panels), and sport and subsistence harvest through 2021 (side panels). Note change in scale of y-axis. Data source: ADF&G, adapted from NPAFC (2023).

See Appendices 1 – 7

Arctic Yukon Kuskokwim Working Group Report

EXECUTIVE SUMMARY

1. The most pronounced declines of chum salmon and Chinook salmon in Alaska have occurred in the Arctic-Yukon-Kuskokwim (AYK) region, a vast and remote area dominated by the Yukon and Kuskokwim rivers, and including habitat throughout Norton Sound and into the western Arctic. Communities throughout this region have been intimately dependent on salmon for subsistence and culture for millennia and are currently suffering immense hardship due to restrictions on fishing intended to protect dwindling AYK salmon populations. The AYK Working Group (WG) of the Alaska Salmon Research Task Force (AKSRTF) included 42 volunteer members (no volunteers were excluded) representing a wide variety of knowledge holders, from salmon harvesters and processors to agency and academic scientists, with extensive experience with salmon in this region. The goal of the WG activities was to develop a prioritized list of research needs for understanding the causes of recent declines in AYK chum salmon and Chinook salmon populations.

2. The AYK-WG held virtual meetings twice-monthly in the autumn of 2023 to develop a process for assembling a list of potential concerns contributing to recent declines in AYK salmon and for translating these into a set of prioritized research themes. The WG adopted the framework developed by the AKSRTF that organized potential research themes around the life cycles of salmon. A variety of criteria were used by WG members to establish the prioritization, including whether the research could provide new insights in the short-term and whether the knowledge derived from this research had the potential to be actionable in fisheries management. There was not a consensus across diverse WG members regarding the most likely causes of salmon declines, and priorities described here represent research that a majority of WG members felt would help support resilient salmon populations.

3. The two top priority research themes identified by the WG were to **better understand impacts of marine harvest on AYK salmon** and **changes in the quantity and quality of marine food for AYK salmon**. For marine harvest, emphasis was placed on improving: 1) the sampling of marine fisheries (state, federal, and foreign) for incidental harvest of salmon, 2) methods for identifying the stock of

origin of chum and Chinook salmon caught in these fisheries, and 3) the escapement monitoring needed to quantify the consequences for salmon populations throughout the AYK region. Research to improve understanding of changes in the quantity and quality of food for AYK salmon in marine environments included understanding climate-related changes to salmon food resources, as well as the impacts of hatchery-origin pink salmon and chum salmon, and high abundance sockeye salmon from Bristol Bay, on feeding, growth, and survival of wild AYK chum salmon and Chinook salmon.

4. Additional top priority research themes included understanding **changes in the health of migrating and spawning adult salmon** and **how climate change is affecting freshwater and marine ecosystems**. The health of migrating and spawning adults theme included particular emphasis on understanding the interacting effects of reduced body size and physiological condition, changes in disease prevalence and parasite loads, and changes in the hydrology and water temperatures experienced by adult fish in freshwater habitats. These interacting factors are expected to affect both the survival of fish during their spawning migrations and their fitness once they have reached spawning grounds, yet these effects on population dynamics of AYK salmon are currently not clear. The climate change theme emphasized interactions between changing physical features of freshwater and marine ecosystems (e.g., hydrology, water temperature) and nearly all other themes described in this report. Additional research topics that were also highlighted included understanding how climate change affects the incidence of harmful algae blooms, changes in sea ice, and melting permafrost – all of which could have important impacts on AYK salmon ecosystems.

6. The three lowest priority research themes were: 1) changing freshwater conditions (beyond effects on spawner health), 2) historical freshwater harvest, and 3) marine and freshwater predators. While considered important by many WG participants, these were not considered as high a priority as the themes mentioned above. Within these research themes were topics such as estimating the effects of increases in freshwater predators because of reduced harvest on these species, changes in flow regimes affecting egg incubation and juvenile rearing, and increased predation by expanding marine mammal populations.

8. The WG also identified critical activities to improve coordination of research across AYK and to develop more equitable opportunities for people of this region to have more meaningful engagement in the fishery science, management, and regulatory processes. In particular, the WG was united in its support to develop formal approaches to integrate Indigenous and western ways-of-knowing in the management process. There was also widespread emphasis on research that explored the efficacy of alternative management approaches for achieving sustainability, given the inevitable uncertainties in data and understanding. Other emphases for improving research coordination across the AYK included developing robust and publicly accessible databases that could incorporate data collected by communities, agencies, and academic institutions. Last, the WG believes that more emphasis should be placed on synthetic research approaches, such as life-cycle modeling, that would provide the platform for better synthesis of research that is widely spread across geography, time, and life stages of AYK salmon.

1. Overview of the charge to the Working Group as Part of Act

Congress passed the Alaska Salmon Research Task Force Act during December 2022 to form an Alaska Salmon Research Task Force (AKSRTF) to characterize trends in the productivity and abundance of Pacific salmon in Alaska, identify and prioritize research needs with respect to understanding increased variability or decline in Pacific salmon returns to Alaska, and to establish a coordinated research strategy to address salmon returns that are in decline or experiencing increased variability. One requirement within the Act was for the AKSRTF to establish a work group (by July 2023) focused specifically on the research needs associated with salmon returns in the Arctic-Yukon-Kuskokwim (AYK) regions of western Alaska.

2. Overview of the AYK region and its salmon

The Arctic-Yukon-Kuskokwim (AYK) region of western Alaska is located north of Bristol Bay and is dominated by the watersheds of the Kuskokwim and Yukon rivers which drain into the Eastern Bering Sea. The region also includes smaller rivers draining to Norton Sound and Kotzebue Sound, and extends into the Alaska Arctic where rivers drain to the Chukchi and Beaufort seas. The headwaters of the Yukon River extend into Canada where approximately 40% of the watershed is located (Figure 1).

Five species of anadromous Pacific salmon spawn in AYK rivers, though the most important species for fisheries and the cultures of the people living in the region are chum salmon and Chinook salmon. In the Alaska Arctic, north of Kotzebue Sound, salmon are not historically the preferred subsistence fish (although attitudes may be in transition with expanding salmon distributions); hence, research on salmon in this vast area remains low.

The AYK region includes the traditional homelands of several Alaska Native groups, with Inupiat and Yup'ik people typically living in coastal regions, and Athabascan people living in upriver regions for millennia (Langdon 2002, Wolfe and Spaeder 2009). The cultures, economies and nutritional foundation of tribes throughout the AYK region are intimately woven with salmon, particularly chum salmon and Chinook salmon. Sockeye salmon, pink salmon, and coho salmon are also harvested, along with a variety of freshwater resident species such as northern pike, burbot, and whitefish.

Fisheries in the AYK region are primarily subsistence fisheries. The region has supported in-river commercial fisheries for Chinook salmon and chum salmon over the last century, and some sport fisheries exist as well. Due to severe salmon population declines over the last two decades, there have been increasing restrictions on commercial, sport, and subsistence fisheries to protect spawning populations of these species in all rivers. Chum salmon populations in the AYK region showed severely depressed populations in 1999-2001, and again in 2020 - 2023. Chinook salmon populations in the region have shown steady declines since the early 2000s. Closed and restricted salmon fishing infringes on the opportunity for rural residents to maintain a subsistence way of life (Alaska National Interest Lands Conservation Act [ANILCA] of 1980, 16 U.S.C. § 3101–3233) and opportunity to pass down subsistence culture to younger generations.

The vast watersheds of rivers that drain the AYK region remain largely undeveloped and remote, which presents serious impediments to western science approaches to understanding the ecology of the watersheds and their salmon. Management of fishery resources is also hampered by these geographical challenges because of the inevitably high levels of uncertainty in stock assessments of fish populations, and the widely dispersed nature of fishing which makes it difficult to monitor.

The cultures, economies, and food security of people who live throughout the AYK region are being seriously impacted by declining salmon returns and the associated restrictions on fisheries. Climate change is also producing new challenges for people living in the AYK region. These changes are affecting the cultures and sustainability of AYK communities that primarily lead salmon-centered subsistence lifestyles. The AYK Working Group emphasizes the urgency of the need to take action to maintain vibrant and sustainable communities that are robust to the inevitable changes in the salmon resources that form the foundation of these communities.

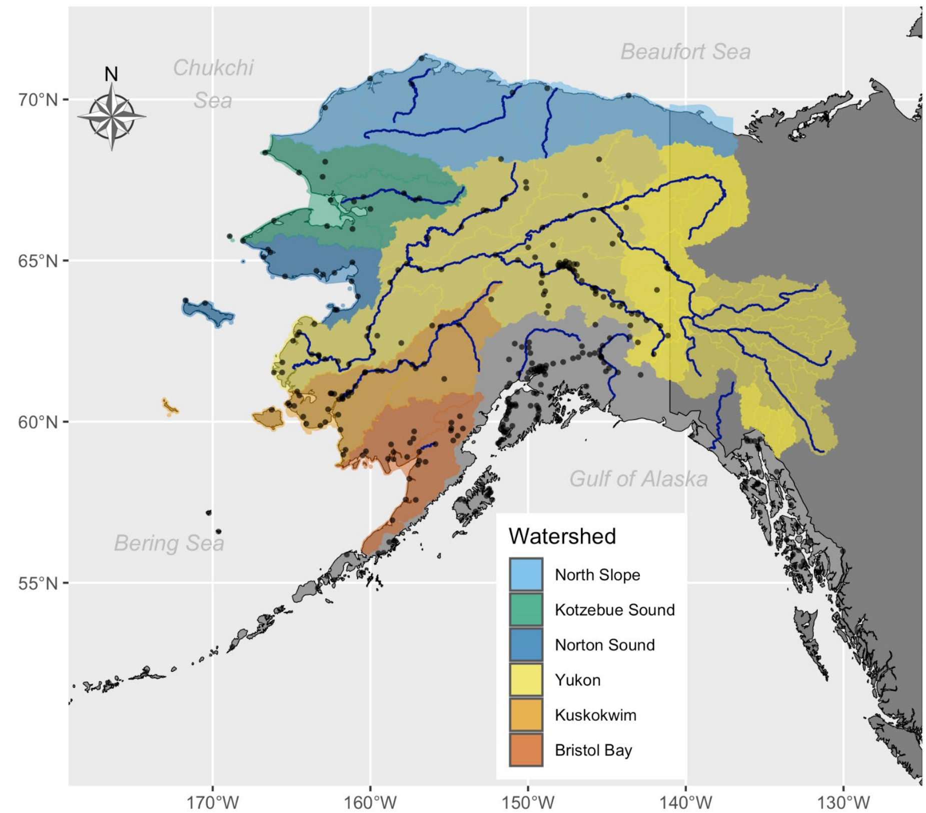


Figure 1. Map of Alaska with the major watersheds and communities (black dots). The Arctic-Yukon-Kuskokwim region is located north of Bristol Bay north through Norton and Kotzebue Sounds into the Alaska Arctic. Watershed data available from the United States Geological Survey (https://www.sciencebase.gov/catalog/item/5a1632bae4b09fc93dd1721f). Community locations provided by the U.S. Census Bureau.

Background

The Alaska Salmon Research Task Force Act identified the need to convene an AYK Working Group (hereafter AYK WG), to address the research needs related to salmon declines in the Arctic-Yukon-Kuskokwim region. Fifteen members of the Task Force who had knowledge and expertise for this region volunteered to serve on this AYK WG. However, it was acknowledged that the information needs and expertise for the AYK WG should be far broader than those represented by Task Force members alone. Nominations for public members of the working group (non-task force members) were solicited in July 2023. All nominated public members who agreed to serve on the AYK WG were accepted as working group members. In total, 42 individuals agreed to serve on the AYK WG, including 15 Task Force members and 27 public members (Appendix 1). The AKSRTF appointed Katie Howard (Alaska Department of Fish & Game) to lead the AYK WG on behalf of the task force, and Daniel Schindler (University of Washington) was elected by public members of the AYK WG to co-chair the working group.

A strength of the convened AYK WG was the diversity of perspectives represented by the 42 members (Appendix #). These members are knowledge holders from Kuskokwim Bay, Kuskokwim River, lower, middle and upper parts of the Yukon River, Norton Sound, North Slope, academia, federal and state management agencies, environmental and fisheries non-profits, tribal organizations, inter-tribal fish commissions, and the commercial fishing industry.

Many AYK WG members repeatedly expressed the value and need for voices at the table to equitably include western science and local and Indigenous knowledge holder insights and expertise. Due to the short timelines stipulated for this endeavor, the large geographic scope of the AYK region, and limited resources to support in-person communications, the work and collaboration among working group members was heavily reliant on technology and digital forms of communications (e.g., video conferences, Excel and Word documents through cloud sharing, and email). It should be acknowledged that technology-heavy communications create their own inequities, particularly for a region where internet access can be limited and computer-based information sharing may be somewhat foreign to some members, particularly elders. This was a significant challenge for the AYK WG and it is recommended that, if another group is similarly convened in the future, resources and planning be used to allow for in-person engagement as a more equitable means of communication and collaboration among knowledge holders.

Working Group Process

The AYK WG met by virtual teleconference about every 2 weeks from September through December 2023 to discuss potential explanations for AYK salmon declines, other research needs in the region, and AYK-specific research priorities. Initial meetings were an open discussion for WG members to express ideas and concerns, which guided the co-chairs in developing structures and agendas for subsequent meetings.

The AYK WG adopted the conceptual framework developed by the AKSRTF for the possible explanations of AYK salmon decline for the following themes: 1) spawner health; 2) freshwater harvest; 3) freshwater predators; 4) marine predators; 5) freshwater conditions for eggs and juvenile rearing and migration; 6) marine food limitation; 7) climate change; and 8) marine harvest (focused primarily on bycatch in federal fisheries, harvest and interceptions in state-managed salmon fisheries, and illegal, unreported and unregulated foreign fisheries). It was clear from initial scoping meetings that AYK WG members wished to express concerns and suggest research priorities that were not strictly evaluating reasons for AYK salmon declines, so additional categories and discussion topics were created, and research priorities were not confined to evidence for salmon declines.

Shared spreadsheets allowed AYK WG members to formalize questions and hypotheses they had within each of these different research themes. AYK WG members who found access to the shared spreadsheets challenging were encouraged to reach out to the co-chairs to ensure their input was captured on the spreadsheets by working with other AYK WG members. AYK WG members with better technology access and comfort were encouraged to work with those who found these forms of communication challenging, so that as many perspectives as possible were represented.

After discussing research questions and hypotheses that fell under each of the research themes specified by the AKSRTF, the AYK WG discussed how best to prioritize these research themes The AYK WG agreed that each member should have the independence to assess each research priority based on their own knowledge base and criteria. Examples of criteria that AYK WG members cited in their assessments were: a) whether reducing a specific scientific uncertainty would lead to actionable management changes, b) whether reducing a scientific uncertainty was a short-term or long-term goal, c) whether research on a specific topic would improve synthesis of AYK salmon ecology, d) whether research on a specific topic would improve community engagement and knowledge sharing, e) would research lead to more holistic science such as what Tribes currently use rather than the typically narrow focus of western science, f) would research on a topic produce knowledge that was immediately applicable, g) whether research would provide immediate information with high potential benefit, h) whether the research would benefit management of salmon ecosystems in the Arctic region of the

AYK, and i) whether the research would produce knowledge that would be applicable beyond the AYK region.

The primary goal of the AYK WG was to prioritize research needs where research could fill knowledge gaps in understanding recent AYK salmon declines. To establish these priorities, members of the AYK WG were presented with the list of research questions and hypotheses developed by the group (Appendix 2). As a way for individuals to express their own perspectives about how to prioritize potential research, each AYK WG member was asked to assign a total of 20 points across all potential hypotheses or questions, with the constraint that the maximum score they could assign to an individual question or hypothesis was 10. We received scores from the majority of AYK WG members (29 of 42) and these scores were summed across individual AYK WG members and across hypotheses and questions to provide weights to each of the eight AKSRTF research themes. We also summarized scores by tallying the number of AYK WG members who assigned a score of at least 1 to any of the questions or hypotheses within each of the eight AKSRTF research themes. The intention of this exercise was not to treat individual hypotheses or questions as competing alternative explanations for the recent AYK salmon declines. Rather, it was a process for summarizing the variety of perspectives on what were the highest priority research themes across the entire spectrum of beliefs held by members of the AYK WG. Last, we ranked individual questions and hypotheses based on the total number of points assigned to them by all the AYK WG members who participated in the survey. All hypotheses and questions and their associated scores are provided in Appendix 2. Here we highlight the top nine as these attracted the majority of attention from across the AYK WG.

Subsequent to AYK WG discussions, co-chairs drafted a report on behalf of the WG, with a first draft provided to the AYK WG for review by March 11, 2024. Co-chairs revised the report based on AYK WG member feedback and delivered a final report to the Task Force on March 21, 2024.

3. Overview of AYK WG general priorities for future research needs on AYK salmon

Results from the survey of AYK WG members about priorities for future research provided one mechanism for summarizing across the range of perspectives within the AYK WG. AYK WG members developed a set of questions that could be explored by future research to support resilient AYK chum salmon and Chinook salmon populations. The two specific questions that received the highest scores across AYK WG members both deal with the availability and quality of marine food for AYK salmon (Figure 2, purple bars). The top specific hypothesis focused on competition between AYK salmon and hatchery pink and chum salmon, and with high abundances of sockeye salmon from Bristol Bay. The second most popular question was concerned with whether changes in climate and marine food webs may be limiting growth and survival of AYK salmon.

Four of the top nine questions dealt with bycatch and interceptions of AYK fish in federal, state, and foreign fisheries (Figure 2, blue bars). Three of these hypotheses focused on understanding the biological impacts of these marine harvests on AYK salmon populations. One of these questions was concerned with increasing the analytical resolution to distinguish the stock of origin of AYK fish captured in marine fisheries.

Climate change, particularly as an interacting stressor on all other drivers of change in AYK salmon populations, was one of the nine top questions discussed by the AYK WG (Figure 2, yellow bar). Two of the top nine specific hypotheses and questions focused on the implications of changes in spawner health and quality for AYK salmon populations (Figure 2, red bars). All other specific questions received less than 20 points from the scoring exercise performed by the AYK WG (Appendix 2).

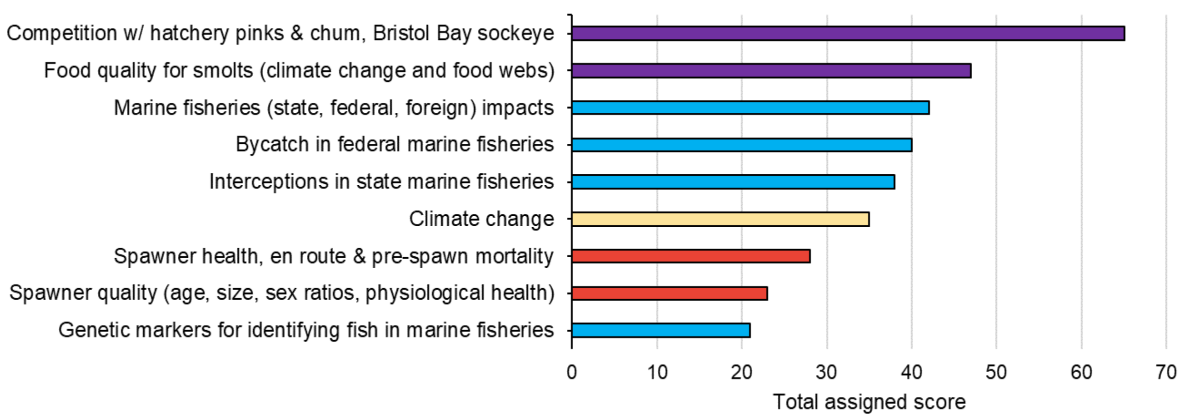


Figure 2. Total assigned scores to the top nine individual research questions considered by the AYK WG, colored by the associated research theme. All other questions or hypotheses received less than 20 total points. Hypotheses and questions are colored according to: 1) Marine Food Limitation theme (purple), 2) Marine Harvest theme (blue), 3) Climate Change theme (yellow), and 4) Spawner Health theme (red).

When summing AYK WG scores across all questions within each research theme, marine harvest, marine food limitation, climate change and spawner health were the top research priorities (Figure 3, black bars). The highest priority research theme was to better quantify the impacts of marine harvest on AYK chum salmon and Chinook salmon stocks (Figure 3, black bars). The second highest research priority identified by this approach was to understand the consequences of changes in marine food limitation for AYK salmon growth and survival. The third highest priority research theme was to understand the effects of a variety of stressors affecting the health and quality of migrating and spawning adult salmon and how these translate into population dynamics. Understanding climate change, particularly through interactions with other stressors of AYK salmon, was the fourth highest priority research theme identified by the AYK WG scoring exercise. We note, however, that there were elements of climate change in research priorities that were included under other themes. The remaining four research themes all received some level of support for prioritization in the following descending order: freshwater conditions that affect egg incubation and juvenile growth and survival, freshwater harvest, marine predators, and freshwater predators. These last four categories received only about 22% of the total weight assigned by the AYK WG to the eight research themes. The top four research themes collectively received 78% of the total weight of scores from the AYK WG (Figure 3).

As a complementary way to summarize research priorities across the diverse members of the AYK WG, we also tallied the number of AYK WG members who assigned any degree of weight to each of the AKSRTF research themes (Figure 3, gray bars). This method of summarizing perspectives from across the AYK WG generally reinforced the priority list established by the weighted scoring method, except for two notable differences. First, marine harvest and marine food limitation were ranked equally as the two top research priorities. Spawner health and climate change were the next two priorities and their order in the rankings did not change. Of the remaining four research themes, marine predators received more than twice as much weight via this second method of ranking themes compared to the first method. However, the combined weight of the lowest priority four research themes was still only about 32% compared to 68% for the four top research themes (Figure 3). In the sections below we discuss each of these general research themes and the distribution of support for individual questions or hypotheses that were aggregated under each theme.

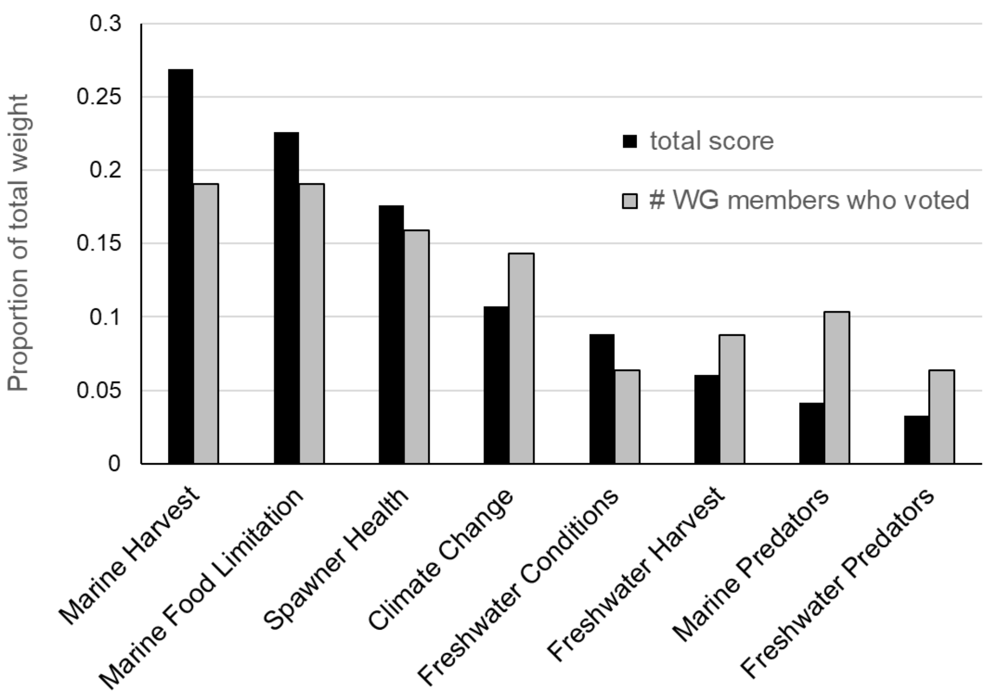


Figure 3. Summary of the AYK Working Group research priorities organized by themes established by the AKSRTF. Black bars show the distribution of relative weights assigned by WG members to hypotheses or questions that were aligned within each theme. Values are relative weights that are proportional to the sums across scores assigned to individual hypotheses and questions under each research theme. Gray bars are weights that are proportional to the number of WG members who expressed any level of weight to each of the research themes.

In the section below, in decreasing order of priority by research theme, we describe the details of individual questions or hypotheses that could guide research within each of the general themes.

A) Marine Harvest

Support for research quantifying and mitigating marine harvest impacts on AYK salmon was a dominant topic throughout AYK WG discussions. Within the theme of marine harvest, there were relatively high scores prioritizing research that further quantified the number of AYK salmon harvested in state, federal, and foreign marine fisheries, and improved data and methods to compare these numbers to the abundances of AYK salmon stocks as a way to estimate the biological and social consequences of marine fishery catches. Emphasis was also placed on improving the resolution of current techniques (i.e., genetic stock identification, GSI) for estimating stock-specific impact rates of marine harvest on individual AYK salmon stocks. Overall, there was roughly equal emphasis placed on understanding interceptions in state, federal and foreign fisheries. There was recognition of the amount of effort currently being applied towards rigorously quantifying Chinook and chum salmon bycatch in federal marine fisheries, though weak stock resolution in current GSI and limited coverage of Chinook and chum salmon escapements throughout the AYK region place limits on the desired resolution of these efforts to understand their biological impacts. The scoring was similarly high for more research to understand the biological implications of both chum salmon and Chinook salmon catches in state and foreign fisheries.

B) Marine Food Limitation

Research on marine food limitation for AYK chum salmon and Chinook salmon was identified as another top priority research theme by the WG. The highest score for all individual research questions and hypotheses was in this theme. The AYK WG expressed particular support for research understanding competition between AYK salmon and increasing pink salmon, chum salmon, and sockeye salmon abundance from other regions, and especially in consideration of hatchery-produced competitors. This research theme also received relatively high scores for research to determine whether there were climate-induced changes in the quantity and quality of marine food for AYK salmon in the Bering Sea, and whether changes in nearshore habitat conditions were reducing the survival of AYK smolts upon their migration to the nearshore ocean.

C) Spawner Health

Research to understand causes and consequences of adult salmon health status while migrating and spawning was a relatively complex theme as WG members identified many dimensions of this problem that affect the survival of fish as they migrate from the ocean to spawning grounds, and their subsequent success on the spawning grounds. In particular, emphasis was placed on understanding the effects of changing climate and ocean conditions on en route and pre-spawn mortality of adult fish. Whether changes in the incidence of parasites and diseases (such as with *Ichthyophonous*), and nutritional health exacerbated these effects on reproductive health and stock productivity. Warming river temperatures with climate change was also identified as a poorly understood interactor with other factors that affect the health of adult fish in freshwater habitats. Other concerns within this broad theme emphasized quantification of thresholds or conditions where genetic population sizes were so low that there was increased risk of extirpation of individual sub-populations in AYK watersheds, and quantifying how widespread these thresholds were surpassed at present. Also identified as an important research activity was to systematically review existing in-river stock assessments to determine whether there was adequate precision and accuracy to quantify *en route* mortality in the large AYK rivers, particularly in the Yukon River where there is an international commitment to meet an escapement goal for Chinook and chum salmon that spawn in Canadian components of the watershed. Last, there was concern that little was known or acknowledged about the effects of handling fish for research purposes on their stress levels and eventual success on the spawning grounds.

D) Climate Change

The AYK WG widely emphasized that the consequence of climate change in freshwater and marine habitats was an overriding priority because climate change is likely modifying or amplifying nearly all other stressors identified in other research themes. Beyond climate change as an amplifier of other stressors, the AYK WG identified other research questions to be pursued. These include understanding linkages between climate stressors in the ocean and in freshwater habitats, whether climate-driven changes in sea ice have affected plankton phenology and potential mismatches with AYK salmon, and whether climate change has increased the incidence and intensity of harmful algal blooms that affect juvenile salmon growth and survival in the ocean. There was also interest in understanding whether the expansion of anadromous salmon into the Arctic was affecting the ecology of resident fishes in rivers that historically did not have salmon in them, though this question did not receive any support in the scoring exercise.

E) Freshwater Conditions

Changing freshwater habitat conditions that affect egg incubation success, and juvenile salmon rearing and migration conditions, rated to be of intermediate priority, focused on issues related to whether changes in watershed habitat productivity and capacity were reducing the fitness and abundance of salmon smolts leaving AYK rivers. Related to this question was whether changes in hydrology may be affecting the complexity, connectivity and geomorphology of freshwater habitats in ways that affect freshwater food webs that support juvenile salmon growth, and hydrologic effects on egg incubation conditions. Additional questions were focused on whether climate driven effects on floods, spring ice breakup, thermal regimes, and permafrost loss were contributing to a degradation of freshwater habitat for juvenile salmon. Other considerations included asking whether the expansion of beavers was altering salmon habitat in substantial ways, and whether the declines of marine-derived nutrients from declines in abundant species (e.g., pink salmon and chum salmon) were reducing the productivity of freshwater habitats.

F) Freshwater Harvest

One of the lower priority research themes was associated with current and legacy effects of harvest in freshwater fisheries. The research question that received the highest score within this theme was focused on understanding whether the current escapement goals were still valid given the observed changes in the environment and the different constraints on population productivity that are expressed in freshwater versus marine ecosystems. Other important concerns were focused on understanding whether there were legacy effects of historical freshwater fisheries, particularly commercial fisheries, on the current demographic structure of AYK salmon populations, which have shown a pronounced decline in average body size and age-at-maturity for Chinook salmon in particular. Other questions were focused on whether large fish that become entangled in but drop out from small mesh gill nets actually survive to reproduce, as is typically assumed. While it is often assumed that the consequences of managing to the higher end of an escapement goal range has the same biological consequences as managing to achieve the bottom end of an escapement goal range, several AYK WG members believed this assumption needed to be more thoroughly explored. Further, there was interest to explore the consequences for harvest on weak stocks when they mingle with dominant or highly abundant stocks within the same river, and whether there were ways to develop more stock specificity in freshwater fisheries. Last, because of the recent proliferation of early-maturing males ("jacks") in Chinook salmon, some AYK WG members believed that research should explore whether there were potential negative consequences of harvesting these small individuals from a population, though this question also received no support in the scoring exercise.

G) Marine and Freshwater Predators

The two research themes determined to be the lowest research priority by the AYK WG were associated with changes in the predation rates on salmon in marine and freshwater habitats. In marine habitats there was concern that increasing apex predators such as resident killer whales, seals, and salmon sharks may be reducing marine survival of AYK salmon and generating new evolutionary pressures on large fish that may be related to declining body size in AYK salmon, particularly Chinook salmon. In freshwater habitats, there was concern that piscivores may be increasing because of declining harvest of resident species (such as northern pike) that could be translating into increased predation rates on juvenile salmon. Other questions were focused on whether the proliferation of beavers was enhancing predation on juvenile salmon through changes in habitat that facilitate predators such as pike and juvenile coho salmon, and whether climate-induced changes in freshwater habitats were increasing vulnerability of juvenile salmon to freshwater predators.

Other research needs and priorities for improving science and management of AYK salmon

The AYK WG also identified critical activities to improve coordination of research across the AYK and to develop more equitable opportunities for people of this region to have more meaningful engagement in the fishery science, management, and regulatory processes. These concerns complement similar existing efforts to prioritize research on Chinook salmon and chum salmon in the AYK region by the Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative (Schindler et al. 2013). In addition to discussing the eight research themes of the AKSRTF as they relate to understanding the recent declines in AYK chum salmon and Chinook salmon, the AYK WG discussed several other research needs for improving the science and management of AYK salmon. These additional themes are listed and described briefly below.

A) Knowledge integration and alternative approaches towards fishery management

The AYK WG was united in its support to develop and explore the efficacy of formal approaches to integrate traditional, Indigenous, and western ways-of-knowing in the science and management process. At present, there is little integration of alternative sources of knowledge and perspectives about how the AYK salmon ecosystems function despite a considerable amount of knowledge held by the individuals who live throughout the region. The challenge is to find ways to weave different types of knowledge and different perspectives into a coherent framework for informing management and conservation efforts. The AYK WG believes that exploring alternative ways of accomplishing this integration is itself a research priority that has the distinct potential to both improve understanding of AYK salmon and their ecosystems, and to improve integration of a variety of knowledge types to better inform the management process.

B) Need for synthetic life-cycle approaches to improve integration

As AYK salmon complete their life cycles, their biology integrates across a wide variety of habitats, from freshwater streams, lakes and wetlands, to estuaries and the coastal ocean, to the Bering Sea and Gulf of Alaska. Understanding how changes in management and the environment affect salmon populations is seriously challenged by this complexity. Most research on AYK salmon has focused on individual life stages in specific habitats which, as the AYK WG expressed, has hampered scientific progress towards developing a holistic understanding of the drivers of population dynamics. The AYK WG believes that more emphasis should be placed on synthetic research approaches, such as life-cycle modeling, that would better integrate across geography, time, and life stages of AYK salmon. Additional emphasis would be placed on integrating life cycle modeling, field research, traditional knowledge, and management activities into a coherent framework to enhance knowledge generation and improve management outcomes.

C) Management under uncertainty

Fisheries management is an imperfect process that makes decisions despite incomplete understanding of ecosystems and fish populations, including their responses to management actions. These challenges are especially acute in the AYK region of Alaska because ecosystems are so vast, remote, and heterogeneous which hinders comprehensive monitoring needed to reduce key uncertainties in data and models used in management. People who rely on salmon fisheries also hold a wide range of values and goals for assessing the success or failure of management decisions. Thus, there was widespread support for research that evaluates trade-offs associated with various management strategies for achieving a variety of goals for stakeholders, given the inevitable uncertainties in data and understanding. Such research would use combinations of simulation modeling and community engagement to co-develop projects that explicitly quantify trade-offs associated with the potential risks and rewards of alternative management strategies given uncertainties in how ecosystems function and how they may change in the future.

D) Database coordination

A final emphasis for improving research coordination across the AYK included developing robust and publicly accessible databases that could incorporate data collected by communities, agencies, and academic institutions. This is a non-trivial task given the heterogeneity in types of data relevant to salmon populations and aquatic ecosystems throughout AYK. Research is needed to develop ways to both capture the vast amounts of historical data on AYK salmon and ecosystems, and to seamlessly add new data streams as further research is pursued. Both serious design considerations and substantial funding will be needed to accomplish this ambitious goal, but the invaluable payoff would be increased transparency in research and management, and greater leveraging of data to improve ecological understanding. Such an effort would need to proactively plan for the sustainability of such a database, and to make specific policies to acknowledge and respect data sovereignty.

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See Appendices 8 – 9

Appendix 1

Engrossed in Senate (12/14/2022)

117th CONGRESS 2d Session

S. 3429

AN ACT

To establish an Alaska Salmon Research Task Force. *Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,*

SECTION 1. SHORT TITLE.

This Act may be cited as the “Alaska Salmon Research Task Force Act”.

SEC. 2. PURPOSES.

The purposes of this Act are—

(1) to ensure that Pacific salmon trends in Alaska regarding productivity and abundance are characterized and that research needs are identified;

(2) to prioritize scientific research needs for Pacific salmon in Alaska;

(3) to address the increased variability or decline in Pacific salmon returns in Alaska by creating a coordinated salmon research strategy; and

(4) to support collaboration and coordination for Pacific salmon conservation efforts in Alaska.

SEC. 3. SENSE OF CONGRESS.

It is the sense of Congress that—

(1) salmon are an essential part of Alaska’s fisheries, including subsistence, commercial, and recreational uses, and there is an urgent need to better understand the freshwater and marine biology and ecology of salmon, a migratory species that crosses many borders, and for a coordinated salmon research strategy to address salmon returns that are in decline or experiencing increased variability;

(2) salmon are an essential element for the well-being and health of Alaskans; and

(3) there is a unique relationship between people of Indigenous heritage and the salmon they rely on for subsistence and traditional and cultural practices.

SEC. 4. ALASKA SALMON RESEARCH TASK FORCE.

(a) In General.—Not later than 90 days after the date of enactment of this Act, the Secretary of Commerce, in consultation with the Governor of Alaska, shall convene an Alaska Salmon Research Task Force (referred to in this section as the "Research Task Force") to—

(1) review existing Pacific salmon research in Alaska;

(2) identify applied research needed to better understand the increased variability and declining salmon returns in some regions of Alaska; and

(3) support sustainable salmon runs in Alaska.

(b) Composition And Appointment.—

(1) IN GENERAL.—The Research Task Force shall be composed of not fewer than 13 and not more than 19 members, who shall be appointed under paragraphs (2) and (3).

(2) APPOINTMENT BY SECRETARY.—The Secretary of Commerce shall appoint members to the Research Task Force as follows:

(A) One representative from each of the following:

(i) The National Oceanic and Atmospheric Administration who is knowledgeable about salmon and salmon research efforts in Alaska.

(ii) The North Pacific Fishery Management Council.

(iii) The United States section of the Pacific Salmon Commission.

(B) Not less than 2 and not more than 5 representatives from each of the following categories, at least 2 of whom shall represent Alaska Natives who possess personal knowledge of, and direct experience with, subsistence uses in rural Alaska, to be appointed with due regard to differences in regional perspectives and experience:

(i) Residents of Alaska who possess personal knowledge of, and direct experience with, subsistence uses in rural Alaska.

(ii) Alaska fishing industry representatives throughout the salmon supply chain, including from—

(I) directed commercial fishing;

(II) recreational fishing;

(III) charter fishing;

(IV) seafood processors;

(V) salmon prohibited species catch (bycatch) users; or

(VI) hatcheries.

(C) 5 representatives who are academic experts in salmon biology, salmon ecology (marine and freshwater), salmon habitat restoration and conservation, or comprehensive marine research planning in the North Pacific.

(3) APPOINTMENT BY THE GOVERNOR OF ALASKA.—The Governor of Alaska shall appoint to the Research Task Force one representative from the State of Alaska who is knowledgeable about the State of Alaska's salmon research efforts.

(c) Duties.—

(1) REVIEW.—The Research Task Force shall—

(A) conduct a review of Pacific salmon science relevant to understanding salmon returns in Alaska, including an examination of—

(i) traditional ecological knowledge of salmon populations and their ecosystems;

(ii) marine carrying capacity and density dependent constraints, including an examination of interactions with other salmon species, and with forage base in marine ecosystems;

(iii) life-cycle and stage-specific mortality;

(iv) genetic sampling and categorization of population structure within salmon species in Alaska;

(v) methods for predicting run-timing and stock sizes;

(vi) oceanographic models that provide insight into stock distribution, growth, and survival;

(vii) freshwater, estuarine, and marine processes that affect survival of smolts;

(viii) climate effects on freshwater and marine habitats;

(ix) predator/prey interactions between salmon and marine mammals or other predators; and

(x) salmon productivity trends in other regions, both domestic and international, that put Alaska salmon populations in a broader geographic context; and

(B) identify scientific research gaps in understanding the Pacific salmon life cycle in Alaska.

(2) REPORT.—Not later than 1 year after the date the Research Task Force is convened, the Research Task Force shall submit to the Secretary of Commerce, the Committee on Commerce, Science, and Transportation of the Senate, the Committee on Environment and Public Works of the Senate, the

Subcommittee on Commerce, Justice, Science, and Related Agencies of the Committee on Appropriations of the Senate, the Committee on Natural Resources of the House of Representatives, the Subcommittee on Commerce, Justice, Science, and Related Agencies of the Committee on Appropriations of the House of Representatives, and the Alaska State Legislature, and make publicly available, a report—

(A) describing the review conducted under paragraph (1); and

(B) that includes—

(i) recommendations on filling knowledge gaps that warrant further scientific inquiry; and

(ii) findings from the reports of work groups submitted under subsection (d)(2)(C).

(d) Administrative Matters.—

(1) CHAIRPERSON AND VICE CHAIRPERSON.—The Research Task Force shall select a Chair and Vice Chair by vote from among the members of the Research Task Force.

(2) WORK GROUPS.—

(A) IN GENERAL.—The Research Task Force—

(i) not later than 30 days after the date of the establishment of the Research Task Force, shall establish a work group focused specifically on the research needs associated with salmon returns in the AYK (Arctic-Yukon-Kuskokwim) regions of Western Alaska; and

(ii) may establish additional regionally or stock focused work groups within the Research Task Force, as members determine appropriate.

(B) COMPOSITION.—Each work group established under this subsection shall—

(i) consist of not less than 5 individuals who—

(I) are knowledgeable about the stock or region under consideration; and

(II) need not be members of the Research Task Force; and

(ii) be balanced in terms of stakeholder representation, including commercial, recreational, and subsistence fisheries, as well as experts in statistical, biological, economic, social, or other scientific information as relevant to the work group's focus.

(C) REPORTS.—Not later than 9 months after the date the Research Task Force is convened, each work group established under this subsection shall submit a report with the work group's findings to the Research Task Force.

(3) COMPENSATION.—Each member of the Research Task Force shall serve without compensation.

(4) ADMINISTRATIVE SUPPORT.—The Secretary of Commerce shall provide such administrative support as is necessary for the Research Task Force and its work groups to carry out their duties, which may include support for virtual or in-person participation and travel expenses.

(e) Federal Advisory Committee Act.—The Federal Advisory Committee Act (5 U.S.C. App.) shall not apply to the Research Task Force.

SEC. 5. DEFINITION OF PACIFIC SALMON.

In this Act, the term "Pacific salmon" means salmon that originates in Alaskan waters.

Passed the Senate December 14, 2022.

Appendix 2

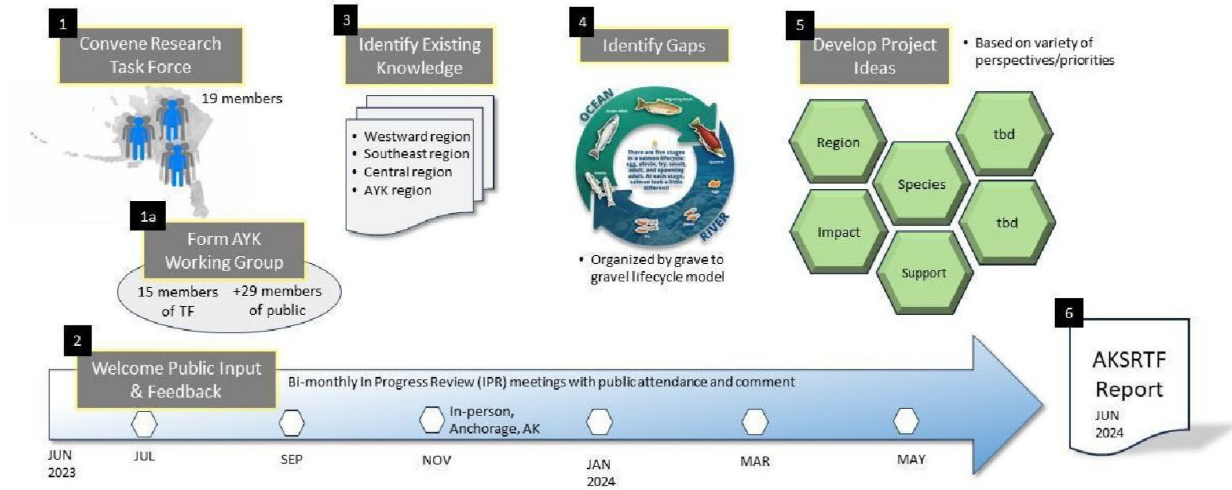
Alaska Salmon Research Task Force

During the first meeting in June 2023, the AKSRTF members agreed on an approach/milestone timeline for the objectives provided in the ACT (Table 1).

Table 1

Date	Approach/Milestones
June 28, 2023	Task Force Establishes Regional Teams (TF members; address ALL of ALASKA) to build EXISTING KNOWLEDGE and begin to discuss RESEARCH GAPS/NEEDS
July 27, 2023	Task Force Meeting; Establish the ARCTIC YUKON KUSKOKWIM WORKING GROUP
August 18, 2023	Begin to close our REVIEW OF EXISTING KNOWLEDGE; Final comments on DRAFT REPORT OUTLINE
October 2023	DRAFT document on EXISTING KNOWLEDGE – and initial list of RESEARCH GAPS/NEEDS (place on website for Public review)
November 2023	FINAL DRAFT EXISTING KNOWLEDGE; Continue to list RESEARCH GAPS and NEEDS (Public input)
April 2024	DRAFT FINAL REPORT; Begin one month Public Review
May 2024	FINAL DRAFT of REPORT
June 2024	FINAL REPORT

Figure 8 illustrates the process the AKSTRF utilized to complete the objectives and prepare a Final Report for the June 2024 deadline. First, the AKSRTF formed Regional Teams (Southeast, Central, Westward, and Arctic-Yukon-Kuskokwim) with the task of: 1) providing reference materials to understand salmon returns in Alaska; 2) identifying gaps in understanding the Pacific salmon life cycle in Alaska; and 3) recommendations on filling knowledge gaps that warrant further scientific inquiry. In addition, the AKSRTF formed an Arctic-Yukon-Kuskokwim (AYK) Working Group (WG) to focus on the research needs associated with salmon returns in the AYK regions of Western Alaska. The AYK WG merged the AYK Regional Team members (15) from the AKSRTF with 30 other members from the Arctic, Yukon, and Kuskokwim region (see AYK WG Report section for more details).



In consideration of the ACT objectives, the AKSRTF scheduled bimonthly (every other month) public meetings to discuss current progress and solicit feedback from the public. Public comment on these tasks was solicited throughout the process during bimonthly meetings, online through our AKSRTF web page and during the in person/hybrid meeting held in Anchorage, AK on November 14 and 15, 2023. The DRAFT report was also provided on the web page for Public comment and input during mid-October to mid-November (prior to our November 14 and 15, 2023 in person hybrid meeting in Anchorage, AK) and during the month of April 2024.

AKSRTF Meetings

Table 2 shows the dates and focus of the AKSRTF Meetings open to the public.

Date	Format and Primary Focus
7/27/2023	Virtual. Establish the ARCTIC YUKON KUSKOKWIM WORKING GROUP
9/19/23	Virtual. Discuss report outline and progress toward existing knowledge and research gaps
11/14-15/23	Hybrid in Anchorage, AK. Existing knowledge and gaps, Research needs and Public comment/testimony
1/25/24	Virtual. Report on progress toward DRAFT Report
3/27/24	Virtual. Report on DRAFT FINAL REPORT
5/22/24	Virtual. Comment on DRAFT FINAL REPORT and incorporation of public comments

Appendix 3

Existing Knowledge Review

Indigenous Knowledge/Traditional Knowledge

Source	Quotes
SCIA	18:38 Murkowski – "We don't fish. we don't eat." & "Multiple other factors, including management structures we have to look at"
SCIA	31:20 Ridley – "130,000 salmon, 1-3% prohibited species catch, but we know every salmon counts"
SCIA	37:20 Samuelson – "serve on all councils to represent leverage holistic approach, etc."
SCIA	44:10 Ulvi – "claim that Aleutian fisheries taking fish from western Alaska nothing new" since 1905 officially
SCIA	49:50 Winkelman – "Not just negatively affecting our culture and wellbeing, but our good health."
SCIA	1:05:00 Menadelook – "In my opinion, if we don't do anything we'll run out of salmon and/or marine mammals in 5-6 years."
SCIA	1:07:00 Menadelook – "I think that the main thing we need to do is change the way the salmon is managed…managed towards maximum commercial yield instead of other yield…That's what's killing salmon."
SCIA	:17:30 Ridley – "I had an Elder tell me that they lived through the Great Depression but didn't even know it because they had everything they needed."
SCIA	1:20:00 Samuelson – "My brother is the provider in my family. He had Covid and went out anyways to get a moose. He had no choice. The provider role in our communities is so important."
SCIA	1:24:30 Winkelman – "This are (Y-K Delta) has one of the highest rates of traditional food consumption in the entire state..."
Interview	4:44 Adolph Lupie – "I'm turning 70…My parents are gone. They told me that I'll be reaching this era when we will get no more fish on the rive swimming, but we have to deal with it with…science."
Interview	10:51 Adolph Lupie – "…today we are hurting and suffering, sacrificing fish."
Interview	2:36 Evon Waska – "We came, our mom and dad, (to look) forward to the return of the salmon, and that's the way I grew up."
Interview	3:27 Evon Waska – "Most of the year it's winter in Alaska. To sustain us through the long winter months…our parents taught us how to live the way of life of how important our salmon was."
Interview	12:22 Evon Waska – "Sometimes that king salmon would be the only dinner we had."
Interview	14:59 Evon Waska – "I'm into commercial fishing… that was a great help…we entered the cash economy and didn't get rich…Unemployment, lack of jobs… getting heating oil, bills…commercial fishing ended in 2014...that was their income…Got to stop hardship."

Interview	21:20 Evon Waska – "…no more commercial fishing… milk is now 10, maybe 10-12 bucks, maybe 15 bucks a gallon…you have to barge 'em and freight air freight…my people are going to turn to subsistence."
Public Testimony Nov. 15	2:18:36 Brooke Woods – "…the crisis we're in. This is a cultural crisis."
Public Testimony Nov. 14	2:31:25 Stanislaus Sheppard – "North Pacific Fishery(ies) (Management) Council member said..., "Sounds like we're in a humanitar[ian] crisis."
Public Testimony Nov. 14	2:56:25 James Nicori – "We work together. We have to work together."
Public Testimony Nov. 14	3:27:40 Virgil Umphenour – "Whenever there's no salmon (I think - hard to hear - might say famine) it affects the entire ecosystem."
Section	**Traditional Knowledge**
Existing Knowledge	15:12 Adolph Lupie – "There will be a lot of mosquitoes before the salmon come in."
Existing Knowledge	
Existing Knowledge	15:26 Adolph Lupie – "Mountains…there'll be lots of snow and they'll be flooding…more water means more fish coming."
Existing Knowledge	17:55 Adolph Lupie – "…salmon will come in really fast when we have a good stormy weather from the south…it's bringing them in from the ocean."
Existing Knowledge	25:44 Adolph Lupie – Explaining Traditional Knowledge to westerners with an example – "My dad used to...when he's carpentering...he used a stick to measure and eyeball. I told him...we could use a measuring tape...but he said that the stick measure is more accurate...when you're doing carpentry. Experiencing with it for long time you get used to it and you can eyeball how good to cut it."
Existing Knowledge	34:17 Adolph Lupie – "The moon…the phases… controls the tide…."
Existing Knowledge	Public Testimony Day 1 – 2:45:40 James Nicori – "Predicting the salmon…starting winter...They check the thickness of the ice and how much snow we have on the hills…In the springtime they really pay attention to birds that are coming and when the birds are plentiful they are happy to have salmon this summer."
Existing Knowledge	Public Testimony Day 1 – 2:47:00 James Nicori – "Observe the storm coming in…when we have strong west wind it pushes some of the Yukon fish into the Kuskokwim and if we have really south winds it pushes some …that are supposed to be going into the Kuskokwim into the Yukon."
Section	**Research Priorities based on Traditional Knowledge**
Interview	5:28 Adolph Lupie – "I wish to learn more …salmon in the ocean and our Kuskokwim River."
Interview	30:22 Adolph Lupie – In regards to salmon ecology – "How come we don't include things like photosynthesis, plants, food, light..." referring to the fact that we don't look at everything, just the fish.
Interview	40:33 Adolph Lupie – "Drop the scientific protocols and integrate Traditional Knowledge."
Interview	40:53 Adolph Lupie – "Talk to more that are not fluent in English. Talk to ones that have more knowledge with their language. They have better words to describe the fish and the situation going on."

Interview	41:17 Adolph Lupie – "What I mean by (scientific) protocols…someone once had to do research on… not catching more fish while the other one was catching a lot…can we share that too?" – Look into how we can share fish that are collected for research purposes."
Interview	35:38 Evon Waska – "My suggestion is, why don't you tag 'em and see where they go…some electronic device."
Interview	36:40 Evon Waska – * "The interceptions are reaching Western Alaska." – research into interceptions of Western Alaska salmon
Public Testimony Nov. 15	2:11:46 Dan Gillikin – "Personally would love to see nothing more than... a large scale program for collecting stream temperature data."
Public Testimony Nov. 15	2:17:45 Brooke Woods – "I just don't think we're looking at the physical and mental impacts of no salmon to our diet…It's essential."
Public Testimony Nov. 15	2:19:45 Brooke Woods – "My big concerns are... bycatch in the pollock industry…and Area M fishery."
Public Testimony Nov. 15	2:20:40 Brooke Woods – "We need to look at the marine environment and see what we can do as far as management decisions."
Public Testimony Nov. 15	2:20:55 Brooke Woods – "'…looking at the health and wellbeing of our people and what salmon means."
Public Testimony Nov. 15	2:22:50 Brooke Woods – "Pink salmon hatchery production...needs to be addressed."
Public Testimony Nov. 15	2:32:00 Gabe Canfield – "The impacts that are happening to Alaska Pacific salmon and Alaska Pacific salmon habitat. Beyond the more well known ones… some more localized human impacts…superfund sites and areas of impacted water quality…increased road creations...human impact(s) to critical salmon habitat...should be a priority...heard from community visits across community (Yukon River) this summer."
Public Testimony Nov. 14	2:37:00 Stanislaus Sheppard – "We're all fighting for the same thing. That's salmon...We're talking about protecting the migratory routes just like birds."
Public Testimony Nov. 14	2:42:00 James Nicori – "If it is possible in any way, create a buffer...west coast of Alaska where the salmon travels…12 mile buffer zone…so trawlers and bycatch cannot be operating...Create a buffer zone."
Public Testimony Nov. 14	2:50:25 James Nicori – "The ladies cutting the fish… say, "Come look at this fish."The intestines were welded to their meat and to their bones. They can't figure out why that is happening. And sometimes... growth on the body...and they smell differently. "
Public Testimony Nov. 14	2:53:55 James Nicori – "…six inches (net)... can catch the bigger salmons but they hang…before you pull in your net they come loose and they fall down into the bottom of the river…That's salmon reproduce being wasted...We have to look at too."
Public Testimony Nov. 14	3:01:30 Charles Lean – "I think that should be a research priority. At what point do we throw in the towel and say that stocks done? It's never coming back." - referring to addressing sustainable escapement threshold
Public Testimony Nov. 14	3:04:30 Charles Lean – "I'd like to see these research efforts focus on existing science. I'd like to see synthesis papers...reach some conclusions…something you can act on."

Public Testimony Nov. 14	3:05:40 Charles Lean – "Most importantly taking action and evaluating that action towards efficacy."
Public Testimony Nov. 14	3:06:15 Charles Lean – "I think there's a lot of things that we should be looking at…drivers of the system… bigger ecosystem kind of approach."
Public Testimony Nov. 14	3:07:58 Tiffany Agayar – "...I was wondering if anybody has ever compiled all the data together with how they run, returning back to their streams."
Public Testimony Nov. 14	3:11:15 Tiffany Agayar – "I was just wondering... if they were thinking of making a reconciliation of tagged fish..with different areas where fish are." - asking about synthesis and compilation of tagged fish data (e.g., migration)
Public Testimony Nov. 14	3:12:20 Tiffany Agayar – "I believe that tracking would help with being able to point how to and when to regulate just like they do on the Yukon."
Public Testimony Nov. 14	3:15:20 Kathleen Demientieff – "I would rather have the Native (community - not sure - indiscernible) approve...we have Traditional Knowledge."
Public Testimony Nov. 14	3:59:45 Daniel Schindler (Dan Gillikin) – "...freshwater stream temperature regime...."
Public Testimony Nov. 14	4:02:35 Vanessa von Biela – "We do have a lot of water temperature data from across the state… one of the major problems…we're thinking about them in terms of averages…but is that an accurate reflection of what animals are experiencing?...often missing events because we're doing things like taking averages." - saying we need more detailed water temperature data
Public Testimony Nov. 14	4:04:45 Dan Gillikin – "Second, is the loss of MDN subsidies to our streams…What has been the total loss of biomass contributed by returning salmon in these systems over the last 10, 20, 30, 40 (years). This loss has had to of reduced the carrying capacity of these systems...Can this be correlated to juvenile growth inferred from scale analysis?"
Public Testimony Nov. 14	4:08:40 Vanessa von Biela – "What does that mean for the way we manage salmon if the productivity of the ecosystem is gonna be reduced?"
Public Testimony Nov. 14	4:09:55 Vanessa von Biela – "The one research gap that I can identify is we really don't have the funding to do all the things that we need to do."

Section	**Traditional Knowledge**
Climate Change	29:30 Adolph Lupie – "Climate change…we are experiencing it and handling it…integrating the science and Taditional Knowledge."
Climate Change	Godduhn et al. 2020 – Another fisher shared similar sentiments regarding the effects of climate change on the fishery: "You have climate change, the biology of the water, the salmon ecosystem is changing, the acidity is increasing, the temperature is increasing which changes their food that they eat and have available."
Climate Change	Godduhn et al. 2020 – One of the more common themes among responses pertained to the effects of climate change. Many respondents cited late freeze-ups, early breakups, and an overall lack of snow and ice for the past several years.
Climate Change	Public Testimony Day 2 – 2:28:30 James Nicori – "One summer we had…temperatures in the low 90s, upper 80s a couple weeks. They were

	starting to have fish floating down the river…haven't reached spawning grounds."
Climate Change	Public Testimony Day 1 – 2:52:25 James Nicori – "Temperature was in the 90s three or four days…Our river was too warm for those salmon to survive... salmons were being overheated and they floated down the river."
Climate Change	Public Testimony Day 1 – 4:08:20 Vanessa von Biela – "...we're learning very quickly...that several of these salmon stocks are just becoming far less productive…with changes to climate."
Predation	Mikow et al. 2019 – Some respondents described how the sloughs and tributaries of the Kuskokwim River are constantly changing. A beaver dam or sandbar could block a free-flowing slough, creating a dead end slough: "And those are full of [salmon] carcasses. And then the predators are there: the rainbows, dollies, pike, sheefish are there, going crazy in those areas"
Predation	Public Testimony Day 1 – 3:32:18 Virgil Umphenour – "On my hunting operation where I guide out of Huslia...grayling...would be digging up the salmon eggs…and grayling ate (them)."
Freshwater Habitat Change	35:04 Adolph Lupie – "When there's high water, they (salmon) go to the river banks to eat grass and moss."
Freshwater Habitat Change	Mikow et al. 2019 – Key respondents also described their perceptions that sport fishers interfere with salmon spawning and contribute to the physical disturbance of Chinook salmon spawning habitat by walking in streams and on riverbanks.
Freshwater Habitat Change	Public Testimony Day 2 – 2:26:30 James Nicori – "... the beavers, they dam the river where the spawners can't even go through the dam…seeing...lots of beaver dams. There used to be no beavers in our area (Kuskokwim River)…migrating into the lower streams…down to the coast now."
Freshwater Habitat Change	Public Testimony Day 2 – 2:35:50 Jacob Ivanoff – "A chemical sprayed on tires actually kills…driving on roads...can affect the salmon."
Harvest	13:25 Adolph Lupie – "We have to respect them and keep what you do catch very clean and handle them carefully...The animal, fish, or something we take into our home the women they take of it right away...with no complaining...because the person who hunts will get more not less...if we leave it... will not catch anymore while others are catching more.We have to respect them and keep what you do catch very clean and handle them carefully."
Harvest	18:44 Adolph Lupie – "When's it's too hot we don't try to fish for subsistence."
Harvest	6:59 Evon Waska – "Wood boaters...As soon as ice went out the setnet went in. King setnet…those weapons were 8.5 to 8 inches."
Harvest	7:26 Evon Waska – "…our people are into sharing. Elders first. Families first. We never kept the first king. We shared it."
Harvest	7:46 Evon Waska – "Our cultural and our self-identity was giving to the Elders and sharing our catch."
Harvest	10:36 Evon Waska – "The moms would teach the daughters how to cut fish."
Harvest	12:37 Evon Waska – "Mom and dad were boss. They would say enough of those." – meaning time to stop fishing.

Harvest	McDevitt & Koster 2021 – Many respondents attribute the decline in the use of fish camps to increased restrictions on fishing opportunity and an associated increase in fishing costs
Harvest	McDevitt & Koster 2021 – Although thousands of residents throughout the drainage harvest salmon each season, several factors differentiate one region of the river to the next. These include differences in the physical nature of the river through its course, species distribution and abundance, types of gear used by fishers, and population sizes of communities.
Harvest	McDevitt & Koster 2021 – The most common gear types for harvesting salmon include drift gillnets, set gillnets, fish wheels, and rod and reel. Although both set and drift gillnets are used drainage-wide, disparate physical characteristics between the three regions of the river typically demand different gear types in each region.
Harvest	Godduhn et al. 2020 – These (Kuksokwim River) communities are all highly subsistence-dependent with strong traditions surrounding the use of salmon.
Harvest	Godduhn et al. 2020 – ...harvest of wild foods is still a primary way of life for most residents.
Harvest	Godduhn et al. 2020 – Residents affirm that salmon provides not only an essential food source for families, but also supports important cultural, linguistic, and family traditions that encourage health and wellbeing within communities. Changing patterns in the harvest and use of salmon continue to drive disconcerting social changes in the region, such as reducing the time that families spend together at fish camps and the lack of transmission of cultural knowledge between older and younger generations.
Harvest	in Godduhn et al. 2020 – Limited archeological documentation in the region suggests that Kuskokwim River residents historically exploited consistent salmon runs that provided the most reliable element of the resource base, certainly for the last 3,000 years (Shaw 1998).
Harvest	in Godduhn et al. 2020 – Prior to Alaska statehood in 1959, commercial fishing in the Kuskokwim Area was regulated by quota, and subsistence fishing was unregulated and mostly undocumented; fishers either kept fish they caught for subsistence use or, if a commercial buyer were available, they could sell the fish (Ikuta et al. 2013).
Harvest	Mikow et al. 2019 – Fishers in all study communities explained that they maintain close communication with family and friends downstream to obtain news about the arrival timing of Chinook salmon.
Harvest	Mikow et al. 2019 – Almost all key respondents observed a decline in Chinook salmon abundance in fishing areas near their communities, and some have decided to no longer target the species as a conservation measure.
Harvest	Ikuta et al. 2013 – Salmon have been a vital source of protein and a cultural and economic resource since time immemorial.
Harvest	Ikuta et al. 2013 – Many fishing traditions related to avoiding waste were described by research respondents. People do not catch more fish than can be processed in a timely manner, and avoid cutting in the hottest time of day, when the quality of the meat degrades.

Harvest	Ikuta et al. 2013 – Historical methods of harvesting salmon near Kwethluk include gillnets, fish spears, fish traps, and dipnets.
Harvest	Brown et al. 2012 – The most widely used resource category was fish...which was also the resource most commonly harvested and the one making up the bulk of the total subsistence harvest.
Harvest	Public Testimony Day 2 – 2:30:00 James Nicori – "In the older days…there weren't any biologists going around...the fish cutters, the wives...were fish biologists…told us no more fishing."
Harvest	Public Testimony Day 1 – 2:40:25 James Nicori – "… just tell us (take) what you can and let the rest go so we can have more to come in later years."
Harvest	Public Testimony Day 1 – 2:40:40 James Nicori – "When the salmon comes in fish on the first run that are coming…the first ones are mostly male and they go up to the headwaters for the females. So…when you have enough...the females pass by."
Harvest	Public Testimony Day 1 – 3:58:00 Victor Lord – "If the fishing got real low, people would pull their nets on their own."

Combination of Regional Teams' References (As of 10/2/23)

Reference Title

2020 KRITFC Community-Based Harvest Monitoring Program Summary & Report

2020 Takotna River Salmon Run Timing and Abundance

2021 KRITFC Community-Based Harvest Monitoring Program Summary & Report

2021 Kuskokwim River Salmon Situation Report

2021 Takotna River Salmon Run Timing and Abundance

2022 Kuskokwim River Salmon Situation Report

2022 Takotna River Salmon Run Timing and Abundance

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Public comments from the Web Site here (during April 2024)

Appendix 4

THE 2023–2027 NPAFC SCIENCE PLAN Primary Goal and Research Objectives

The primary goal of the 2023–2027 Science Plan is to: "Establish a research framework to develop a mechanistic understanding of the impact of changing climate on salmon abundance and distribution trends in the North Pacific Ocean." (1) Improve knowledge of the relative biomass, distribution, migration, and fitness of Pacific salmon in the ocean (Present Knowledge); (2) Understand causes and anticipate changes in the production of Pacific salmon and the marine ecosystems producing them (Forward Action).

Improved understanding of the mechanisms that regulate the distribution and abundance of Pacific salmon will promote the conservation of anadromous populations in the North Pacific Ocean, allow for better projections, or at least include realistic uncertainty given climate change, of Pacific salmon production trends in the future, and enhance the sustainable fisheries management, food security, and economic security in member nations.

The timing of the NPAFC 2023–2027 Science Plan overlaps with the proposed implementation of Basin-scale Events to Coastal Impacts (BECI; 2021–2030). It is anticipated that a BECI science plan will be finalized at the PICES Annual Meeting during fall 2023.

NPAFC Research Themes

(1) Status of Pacific salmon and steelhead trout (Present Knowledge);

(2) Pacific salmon and steelhead trout in a changing North Pacific Ocean (Forward Action);

(3) New technologies;

(4) Management systems;

(5) Integrated information systems.

Theme 1. Status of Pacific Salmon and Steelhead Trout (Present Knowledge)

Outcome: The present status of salmon and their environments is documented and reported.

The purpose of this theme is to document and effectively report on the present status of salmon and their habitats. The NPAFC collates annual statistics on catch, escapement, and hatchery releases of Pacific salmon around the Pacific Rim. There is an ongoing need to maintain and improve monitoring of spawning escapement, catch, smolt production and other biological information for potential use in the projecting salmon return strength or ocean survival. Long-term time series are particularly valuable in understanding linkages between climate and Pacific salmon production. Data on hatchery fish should be maintained separately from data on wild fish as much as practicable. Biological information such as age composition of a population, body size, fecundity and egg size are monitored whenever feasible.

(1-1) Status of Key Salmon Populations □

Monitor Key Populations—Continue reporting on ongoing monitoring programs for key salmon populations and identify new sampling opportunities. Identify additional key populations that can be monitored to provide status information for co-existing salmon populations and their ecosystems.

Stock Assessments—Monitor current and emerging stock assessment methods in cooperation with partners potentially including ICES, NASCO and the Pacific Salmon Commission.

Report on Status of Salmon in the NPO—Report annually on the Status of Salmon in the NPO. Consider utilizing the Interactive Mapping System developed within the NPAFC Working Groupon Salmon Marking. Could be northern hemispheric in scope in cooperation with Atlantic and Arctic partners.

Data Quality—Improve the quantification and documentation of uncertainty associated with existing and new data time series and maintain wild and hatchery salmon data separately in the timeseries.

New Baseline Information—Provide a data review and annual Pacific salmon hatchery and wild abundance data updates to Ruggerone and Irvine (2018). These methods could be drawn from those described in Ruggerone et al. (2010) and Ruggerone and Irvine (2018) and adapted as needed. These data would be reviewed and provided by NPAFC member countries as part of the WGSA annual workplans. These data would be managed and warehoused by the NPAFC, similar to the catch and hatchery release statistics: https://npafc.org/statistics/. The long-term goal will be to make it possible for each party to easily estimate the annual wild and hatchery abundance and biomass of salmon in the North Pacific Ocean.

(1-2) Monitor Salmon in the Ocean

Gathering information on the marine ecology of Pacific salmon is critical to our understanding of how climate variability impact ecosystem function, salmon fitness, distribution, migration and survival. Anadromous salmon migrate in the ocean to maximize their growth and survival. Their seasonal migration and distribution patterns are stock specific, and fundamental migration routes may be genetically fixed. Increasing information on seasonal ocean migration and distribution of key salmon populations contributes to: planning effective ocean monitoring surveys, better climate modelling and projecting, better management to avoid incidental salmon bycatch, and efficient enforcement activities to protect salmon in the ocean.

Therefore, the recommendation is to:

- Continue integrated ecosystem marine survey monitoring activities currently conducted by Parties within respective exclusive economic zones and the Convention area to collect observations on the biological and physical oceanographic characteristics and observations on size-at-age, external traits, gonads, health and condition (e.g., energy density/lipid, thiamine deficiency, parasites and diseases), stomach contents, and potential population impacts.

- Monitor northward expansion of salmon into Arctic regions (e.g. northern Bering Sea; Chukchi Sea; Beaufort Sea).

Theme 2. Pacific Salmon and Steelhead Trout in a Changing North Pacific Ocean (Forward Action)

Outcome: The effects of natural environmental variability and human factors affecting salmon distribution and abundance are understood and quantified.

Climate change may result in significant variability and overall declines in the carrying capacity and usable habitat (distribution) of Pacific salmon in the North Pacific Ocean, potentially leading to expanded use of the Arctic Ocean, at least seasonally. An improved understanding of linkages between environmental changes and Pacific salmon production will help to plan for the economic consequences of these changes. The objectives are to understand and quantify the effects of environmental variability and anthropogenic factors affecting salmon distribution and abundance, and to project future changes with improved models.

(2-1) Pacific Salmon Distribution/Migration, Climate and Ocean Changes

In recent years, there have been shifts in the distribution of salmon in northern regions, but some declines at the southern edges of their distribution along the Asian and North American continents. These geographical shifts in salmon abundance may be related to climate-induced changes in habitat/environments operating at regional and local scales. What are the relevant mechanisms influencing shifts spatial distribution and migration? What is driving Pacific salmon movement into the Arctic?

(2-2) Pacific Salmon Density Dependence, Carrying Capacity, Climate and Ocean Changes

With the potential of limited food resources in the ocean, it is important to understand the implications of habitat use by Pacific salmon populations at various levels of abundance, the productive capacity of habitats for each life stage, and the potential implications of density dependent effects.

There is a need to understand odd/even year differences in survival/growth of salmon species thathas been correlated with pink salmon abundance. Is this a top-down effect? Or are there otherexplanations that may help explain this correlation?•

There is a need for more comprehensive studies on the role of salmon in pelagic communities, thefood availability for salmon and the nutritional quality of prey organisms.•

Understand inter-and intra-specific competition among salmon at sea.

(2-3) Pacific Salmon Critical Periods, Climate and Ocean Changes

Variation in the early marine survival of Pacific salmon has been hypothesized to have a major role in determining the numbers of adults that return to spawn. However, there has been limited evidence to support this hypothesis. We need to understand the causes of mortality at each stage of the salmon life cycle and evaluate whether any particular life history period is critical.

Ocean Entry—Juvenile abundance, timing and body size at ocean entry may be important parameters that are critical to understanding and quantifying mortality at sea. Examine how these parameters are associated with salmon survival or brood year strength.

Growth—Increased energy efficiency for growth of juveniles in the early marine period may be a key to their survival and optimization of hatchery production.

Prey Organisms—Identify which prey organisms are important for salmon growth at each stage and region, and examine if the abundance of prey organisms limits salmon production.

Salmon Health—Examine effects of pathogens and stressors on the growth and survival of salmon in the ocean.

(2-4) Modelling the Future for Salmon

Reliable projection models of future salmon distribution, abundance and survival is important for sustainable resource management and for projecting future variations in production due to changing climate. Researchers and analysts should consider developing statistical models as well as ecosystem models coupled with biophysical models to estimate the impact of climate change on salmon populations, and to create future scenarios for salmon distribution and abundance. •

Explain the unequal stock/species specific response of Pacific salmon to climate change. E.g., why are Asian pink salmon and Bristol Bay sockeye thriving under contemporary conditions while other species/stocks are not doing as well?

Model projections of impacts of climate change on salmon production and make progress in understanding unexplained variability in salmon abundance, migration, growth, size-at-age, and survival.

Theme 3. New Technologies

Outcome: New technologies and analytical methods are advanced and applied to salmon research.

Novel stock and fish identification methods including new molecular techniques, hatchery mass marking, and intelligent tags continue to be developed, and these tools are integral to comprehensive and cost-effective monitoring and mechanistic studies to facilitate the formulation of effective models predicting the distribution and abundance of salmon populations. Although considerable progress has been made in both the basic understanding of population differentiation of mixed marine salmonid assemblages and in genetic research technologies, this knowledge is still insufficient to understand the spatial distribution of different populations in the ocean and the differences in their responses to changing environmental conditions. Implementing genetic methods to differentiate mixed marine salmonid assemblages and to expand the database of reference samples are increasingly needed.

- *Molecular Identification*—Develop effective molecular techniques and baselines to identify the geographical origin of individual fish/population.
- *Genomics*—Use genomic technology for the rapid assessment of the physiological health status and cause of the condition of salmon.
- *Environmental DNA (eDNA)* —Develop eDNA methods for the rapid and non-lethal estimation of salmon distribution and potentially abundance.
- *Mass Marking*—Develop mass marking techniques to identify hatchery salmon in mixtures of populations. Thermal otolith marking is a successful tool for mass marking, but available mark patterns are limited.
- *Intelligent Tags*—Develop tagging methods to investigate the habitat conditions, predators and navigation mechanism of salmon migrating in the ocean.
- *Salmon Observation Systems*—Improve tracking technologies to increase knowledge of stock-specific patterns of migration and survival at each life stage.
- *Remote Sensing/Autonomous Vehicles*—Application of remote sensing technologies such satellite imagery and ocean gliders/saildrones outfitted with sensors such as acoustics and new camera technologies to understand changes in the biophysical environment experienced by salmon.

The NPAFC should focus on the following new tools and activities to improve salmon identification:

- Conduct additional pink salmon genetic baseline studies to address questions regarding GSI and range expansion.
- Expand our understanding of eDNA methods, appropriate use and application.
- Develop and standardize Pacific salmon genetic data and analysis methods for a comprehensive coastwide genetic baseline database.

Theme 4. Management Systems

Outcome: Information required for effective management systems is available and applied to enforcement activities, social systems, and salmon movements into the Arctic.

The objective is to provide scientific advice that effectively informs management systems including their cultural and socioeconomic aspects. Enforcement of NPAFC's convention measures that prohibit directed fishing for anadromous fish within the Convention Area is the responsibility of NPAFC's Committee on Enforcement (ENFO). The CSRS is increasingly playing a role in providing information on the probable distribution of Pacific salmon at different times of the year, and therefore likely locations of illegal, unreported, and unregulated (IUU) fishing.

Climate change adaptation is a social process, and this is one of the key challenges facing salmon, ecosystems and humans moving forward. At this time, we allocate very little research effort towards the sociology of adaptation process in societies. The role of NPAFC to form collaborations on salmon, will need to consider how shifting salmon distributions and abundances, among other species, may disrupt the NPAFC role and connections moving forward. This involves shifting away from status quo ways of managing fisheries and salmon, with transformational shifts in our management systems.

With a northward shift in salmon distributions given climate change, the impacts on coastal communities will be large and will require NPAFC to engage with other fields of knowledge, such as the social sciences, to facilitate connections, agreements, collaborations between Nations. The absence of this field of expertise in NPAFC represents a critical gap that will be required to meet the huge challenges of climate change.

Theme 5. Integrated Information Systems

Outcome: Freely available information systems mobilize and synthesize historic and current data about salmon and their environment.

It is essential that salmon and ecosystem data are readily available for researchers and for machine learning AI applications. Therefore, the goal is to build upon data mobilization approaches developed during the IYS. This includes: (1) the development of data mobilization approaches that ensure adherence to the FAIR principles with data Findable, Accessible, Interoperative and Re-usable; (2) the application of a "federated" approach to integrating data sets from the respective parties in common agreed to data formats, e.g. the Global Ocean Observatory System standards (GOOS); (3) improve the ability to share information and collaborate on research efficiently using a modern web-based framework. Data assembled as part of the other themes are to be linked in a central data system.

Cooperative Research Approaches and Implementation of the Science Plan Pertinent approaches to cooperative research under the 2023–2027 Science Plan will include compilation and synthesis of existing data and metadata to generate and test specific hypotheses, integration of ecological monitoring research in the ocean using research vessels and/or remote sensing, conceptual and quantitative modeling, process-oriented field and laboratory studies, and retrospective analyses. Scientific results from cooperative studies using these approaches will progressively reduce major gaps in knowledge with respect to the research themes, as well as make significant contributions to BECI research in collaboration with other relevant partners such as ENFO, PICES, ICES and NASCO. New scientific information will also contribute to effective enforcement activities by member nations to protect Pacific salmon from IUU fishing in the Convention Area. Progress on research themes or issues of the 2023–2027 Science Plan will be reviewed annually during the NPAFC Annual Meeting. Symposia, workshops, and other science meetings will be scheduled during this time as appropriate.

Appendix 5

ALASKA BYCATCH REVIEW TASK FORCE FINAL REPORT — NOVEMBER 2022

Salmon Recommendations

Much of the salmon research identified was similar for both the Bering Sea/Aleutian Island and the Gulf of Alaska. Listed below is the research identified for Western Alaska salmon and research which is unique for the Gulf of Alaska.

Western Alaska Salmon

Research Goals

- Research to improve our ability to determine the stock of origin of chum and Chinook salmon taken as bycatch.
- Research to reduce bycatch through improved understanding of distribution and migration of Western Alaska chum and Chinook salmon stocks migration patterns to better predict and therefore avoid bycatch “hot spots” in the BSAI region.ng.

Research that helps us understand the relative importance of particular mechanisms for driving abundance of Western Alaska Chinook and chum.

a) Improved information on marine migration patterns

i. The projects AFSC mentioned that Sabrina Garcia (Chinook salmon) and Wes Larson (chum salmon) are leading in the Bering Sea: Model ocean distribution and migration of AK Chum and Chinook salmon stocks in the Bering Sea to predict distribution and hotspots.

ii. A tagging project of immature chum salmon in the North Pacific Ocean to help us understand their destination, timing, and maturity.

iii. A synthesis of marine migration information from fishery-dependent data sources, marine surveys, and tagging studies, and how these patterns have changed with a changing climate.

b) Improved information on the characteristics of fishery catches.

i. There are still improvements that can be made in the ability to assess age, and specifically stock-specific age of Chinook and chum salmon caught in any marine fisheries.

c) Improved information to help understand fishery impacts

i. Improved Adult Equivelant (AEQ) modeling through ‘stock specific’ chinook and chum salmon bycatch. Particularly for western Alaska chum salmon, AEQ analyses are limited by:

- age classification data gaps in adult chum abundance across all of the western Alaska stock group. Studies that improve the ability to estimate abundance of all chum salmon in the western Alaska stock reporting group. Continued genetics work is needed.
- the ability to break up that reporting group. This might be remedied by using technologies that go beyond genetic assignment alone (use of pathogens, stable isotopes, etc.)

Research that can provide an additional (non-adult) abundance estimate

This will be really powerful for helping triangulate which life stages are most important for determining good or poor productivity. The committee recommends that research should span the life-cycle of the salmon species.

a) Understand critical survival periods for western Alaska salmon through integrated ecosystem assessment surveys including expansion of the northern Bering Sea pelagic trawl survey into the near shore waters north of the Yukon River including Norton Sound.

i. Similar research is being planned in the southern Bering Sea to have a more comprehensive assessment of Western Alaska Chinook and chum.

NOTE: Neither of these projects are funded beyond 2023.

ii. Ecosystem indicators: summer sea temperature, phytoplankton/zoo plankton community structure; salmon and pelagic fish catch per unit effort, distribution, energy density for fitness, size, stomach contents. These indicators are being utilized to understand climate impact on the northern Bering Sea ecosystem, fish fitness and survival. The recent information from the northern Bering Sea pelagic trawl survey suggests that the marine heat wave within the NBS during 2016 to 2019 negatively affected juvenile Chum salmon fitness (shift to low quality prey, increased metabolic rates due to higher SST), likely leading to high winter mortality. The data suggest that Chinook salmon abundance is impacted by factors affecting them in freshwater and early marine residence.

b) Studies that help understand how ocean/climate conditions impact future runs

i. Marine pelagic trawl surveys in the northern and southern Bering Sea can help us address this (see above).

ii. NOAA and ADF&G are collaborating on using International Year of the Salmon (IYS) catches and samples to examine immature AYK chum salmon in the North Pacific Ocean during winter. (This is not yet funded.)

iii. Immature salmon surveys (like the IYS surveys) in the Bering Sea and North Pacific Ocean. There is currently no funding support for charter vessel to conduct the survey, collecting and processing samples or paying for gear and supplies.

c) Studies that help us understand the role of diet, health, and disease on the survival and spawning success of Western AK Chinook and chum

i. Understanding vectors of Ichthyophonus infection for Yukon Chinook salmon, and whether it is causing significant en route mortality during the spawning migration

ii. Understanding diet, nutrition, and condition of Western AK Chinook and chum stocks at juvenile (marine pelagic trawl surveys in the northern and southern Bering Sea – see above), immature (IYS surveys, industry catches, etc.), and adult life stages (returning samples from lower river test fisheries- pilot work started for Yukon Chinook, but only funded through 2022).

Gulf of Alaska Chinook Salmon

Conduct annual genetic and spatial assessment of Gulf of Alaska (GOA) Chinook salmon. This recommendation is intended to include, in addition to the genetic assessment that is currently taking place, that efforts should be made to produce estimates of both the spatial and temporal bycatch of Alaska stocks of Chinook salmon, as well as characterizations of the age, sex and size of the bycatch of Chinook salmon identified as stocks of Alaska origin. If further progress can be made towards identifications of stock of origin of Alaska Chinook salmon taken as bycatch, that too should be pursued.

a) Studies that help us understand the relative role of marine interceptions and bycatch.

i. Improved information on marine migration patterns and its relation to fishery locations and timing. Extend the distribution and timing projects using bycatch data in the Bering Sea to include the western GOA.

ii. Improved demographic information that will enable assessment of stock specific impacts.

•Collect samples to improve demographic information such as stock, age, sex, size and maturity for Chinookand chum salmon caught in any marine fisheries.

•Improved information to help understand fishery impacts through AEQ or similar analyses.

b) Research that can provide an additional (non-adult) abundance estimate. This is useful for helping triangulate which life stages are most important for determining productivity.

i. Juvenile salmon surveys: a survey occurs annually in the eastern GOA to monitor Southeast Alaska salmonstocks (Southeast Coastal Monitoring project).

•ADF&G will pilot a juvenile salmon survey in the western Gulf of Alaska in 2023. This will align with surveys in the

northern and southern Bering Sea and Southeast Alaska to give a comprehensive assessment of Alaska Chinook and chum salmon early in the marine life stages.

Note: neither the GOA nor the Bering Sea projects are funded beyond 2023

c) Studies that help us understand how ocean/climate conditions impact future runs.

i. Marine pelagic trawl surveys in the Bering Sea and Gulf of Alaska (including western/central Alaska and SEAK surveys).

ii. Immature salmon surveys (like the IYS surveys) in the Bering Sea, Gulf of Alaska, and North Pacific Ocean.

Appendix 6

Agencies and Non-profits that support Alaska salmon research/information

Alaska Bycatch Advisory Council

https://www.adfg.alaska.gov/index.cfm? adfg=bycatchtaskforce.main

On March 10, 2023, the Commissioner of Fish and Game established the Bycatch Advisory Council to advise the department on ways to implement the recommendations contained within the final report of the Alaska Bycatch Review Task Force (see Appendix 4).

U.S. Fish and Wildlife Service – Gravel to Gravel Initiative

https://www.fws.gov/page/gravel-to-gravel-keystone-iniative

With Gravel to Gravel investments, the U.S. Fish and Wildlife Service is actively supporting and funding a variety of projects that will ensure safe, resilient, and equitable futures for our people, salmon, land, and waters. We are working to shape this Initiative with local and regional partners, including the Tanana Chiefs Conference, Association of Village Council Presidents, Kawerak, Inc., the Kuskokwim Intertribal Fish Commission, the Yukon River Intertribal Fish Commission, the Bureau of Land Management, USGS, National Park Service, the Yukon River Drainage Fisheries Association, State of Alaska, and nonprofit partners like Trout Unlimited. Importantly, the initiative is not a one-and-done effort. Gravel to Gravel-funded projects will build upon previous work and partnerships, while catalyzing the future of our service in Alaska – leveraging new funding, and strengthening fresh relationships, as we continue our work in serving Alaska's people, ecosystems, and wildlife.

U.S. DOI Bureau of Land Management (BLM) – Gravel to Gravel Keystone Initiative

https://www.blm.gov/programs/aquatic-resources/alaska/ gravel-gravel-keystone-initiative

The Department of the Interior is investing more than $16 mil-lion over the next four years from President Biden's **Bipartisan Infrastructure Law** to improve the resilience of ecosystems and salmon in Alaska's Yukon, Kuskokwim and Norton Sound region as part of the Gravel to Gravel Keystone Initiative. This initial multi-million-dollar investment serves as a catalyst for additional in-vestments in Gravel to Gravel, which is made up of three elements:

Investments to improve resiliency of Pacific salmon
Renewed commitment to strengthening relationships through co-stewardship
Responding to ecosystem threats to food security.

While the BLM is working across all three elements of Gravel to Gravel, we are heavily focused on improving watershed resiliency through assessment and restoration. And we, in the BLM are doing what we can where we can with the provided funding to make a positive and significant impact for the communities and ecosystems of the Yukon, Kuskokwim, and Norton Sound region.

NOAA Fisheries – Alaska Fisheries Science Center

https://www.fisheries.noaa.gov/alaska/ecosystems/alaska-ecosystem-monitoring-and-assessment

Pacific salmon play an important role in Alaska's marine ecosystems and are a valuable commercial, recreational, and subsistence resource. NOAA Fisheries scientists forecast salmon harvests, assess the impact of commercial fisheries on salmon, and evaluate how salmon populations respond to environmental changes. The information we provide helps managers make science-based decisions to ensure sustainable fish populations, fisheries, and fishing communities.

Pacific Salmon Commission

https://www.psc.org/

The Pacific Salmon Commission is the body formed by the govern-ments of Canada and the United States in 1985 to implement the Pacific Salmon Treaty. It is our shared responsibility to conserve the Pacific Salmon in order to achieve optimum production and to divide the harvests so that each country reaps the benefits of its investment in salmon management. The Pacific Salmon Commission oversees two Endowment Funds established in 1999 to support projects in Canada and the United States that develop improved information for resource manage-ment; rehabilitate and restore marine and freshwater salmon habitats; and, enhance wild stock production through low tech-nology techniques.

Alaska Department of Fish and Game

https://www.adfg.alaska.gov/

The Alaska Department of Fish and Game maintains active and comprehensive management and research programs to ensure fish and wildlife populations are "utilized, developed, and maintained on the sustained yield principle," in accordance with Alaska's Constitution.

- ***Salmon Ocean Ecology Program***

https://www.adfg.alaska. gov/index.cfm? adfg=salmonoceanecology. main#:~:text=Our% 20Mission,salmon%20in% 20the%20marine% 20environment.

The Salmon Ocean Ecology Program supports statewide salmon fisheries management through the assessment and monitoring of salmon in the marine environment. Our goals are to understand the marine life of Alaskan salmon, use this information to assist fishery management decision-making, and help answer pressing questions about marine processes that influence the abundance and characteristics of our salmon populations.

- ***Alaska Sustainable Salmon Fund***

http://www.akssf.org/

The Alaska Sustainable Salmon Fund (AKSSF) program, administered by the **Alaska Department of Fish and Game**, manages the State of Alaska's allocations from the federal Pacific Coastal

Salmon Recovery Fund (PCSRF). PCSRF was established by Congress in 2000 to protect, restore, and conserve Pacific salmon and steelhead populations and their habitats. AKSSF allocates its funds annually through competitive calls for pro-posals (CFPs) that open in the spring (usually mid-April). Eligible projects conserve habitat, restore habitat, monitor subsistence salmon populations, investigate the causes of Chinook declines, and conduct climate impact studies to identify resilient salmon habitat. Please see the AKSSF Objectives document for more information.

North Pacific Anadromous Fish Commission

https://www.npafc.org/

The North Pacific Anadromous Fish Commission (NPAFC) is an international inter-governmental organization established by the Convention for the Conservation of Anadromous Stocks in the North Pacific Ocean. The Convention was signed on February 11, 1992, and took effect on February 16, 1993. The member countries are Canada, Japan, the Republic of Korea, the Russian Federation, and the United States of America. As defined in the Convention, the primary objective of the NPAFC is to promote the conservation of anadromous stocks in the Convention Area. The Convention Area is the international waters of the North Pacific Ocean and its adjacent seas north of 33° North beyond the 200-mile zones (exclusive economic zones) of the coastal States. For the purposes of NPAFC, anadromous fish include Pacific salmon and steelhead trout. Anadromous stocks are the stocks of these species that migrate into the Convention Area.

Scientific Research

The Convention authorizes fishing for anadromous fish in the Convention Area for scientific purposes under national and joint research programs approved by the NPAFC. The taking of anadromous fish for scientific purposes must be consistent with the needs of the research program and provisions of the Convention and be reported to the Commission. Scientific research is conducted under the **Science Plan**, which may include investigations on species ecologically related to anadromous stocks. The member countries cooperate in collecting, reporting, and exchanging biostatistical data, biological samples, fisheries data, and organizing scientific communications, such as seminars, workshops, exchanges of scientific personnel, and publications. The members provide catch, enhancement, and other technical information and material pertaining to areas adjacent to the Convention Area from which anadromous stocks migrate into the Convention Area.

Yukon River Drainage Fisheries Association

https://yukonsalmon.org/

A wide array of issues affect Yukon River fisheries. Therefore YRDFA concentrates its work in a number of program areas to achieve its mission. These include: Policy Advocacy - A wide range of agencies and boards impact Yukon River management, from the State of Alaska Board of Fish to the federal North Pacific Management Council and the international Yukon River Salmon Agreement. YRDFA participates in dialogues with all these agencies, representing the interests of Yukon River communities in state, federal, and international forums. Conservation & Restoration - YRDFA works to protect wild salmon stocks and the habitats upon which they depend. Through biological research and participation in management, YRDFA works on behalf of Yukon River fishers. Cultural Preservation - Traditional ecological knowledge is a vital source of information about salmon populations and a rich part of Yukon River cultures.

YRDFA documents Local and Traditional Knowledge (LTK) about the salmon, the river, and the people. YRDFA works to incorporate LTK into Yukon fisheries management and works to protect the subsistence rights that are the foundation of Alaskan Native culture. Economic Opportunity - Inhabitants of communities in the Yukon River drainage possess valuable knowledge and skills that can be indispensable to the success of local projects. YRDFA strengthens fishing communities by bringing jobs and training to communities, and increasing participation in fisheries management. YRDFA also works to increase market opportunities and values for Yukon River salmon. Information Sharing - YRDFA is the only consistent forum for ongoing dialogue and information-sharing between all parties with interests in the Yukon River fishery. YRDFA plays a key role in keeping fishermen and women informed and relaying their opinions to managers. YRDFA brings together fishers from throughout the watershed to reach consensus on policy positions that are good for the salmon, the people, and the river.

Yukon River Inter-Tribal Fish Commission

https://www.tananachiefs.org/tribal-resources-stewardship-program/fish-commission/

The Yukon River Inter-Tribal Fish Commission (YRITFC) with Tanana Chiefs Conference (TCC) was founded in 2014 when Yukon River Tribes came together in St. Mary's and formed the Fish Commission in response to low king salmon returns. YRITFC works with a variety of partners to oversee 28 federally recognized villages.

Yukon Delta Fisheries Development Association

https://ydfda.org/

Our mission is to create a self-sustaining, independent fishing company that will create income and employment opportunities for Yukon Delta residents.

Kuskokwim River Inter-Tribal Fish Commission

https://www.kuskosalmon.org/

Thirty-three federally-recognized Tribes working together toward unified salmon co-management, research, and monitoring as we protect Kuskokwim salmon and traditional ways of life. Formed in 2015, the Kuskokwim River Inter-Tribal Fish Commission (KRITFC) works to develop a meaningful role for tribes and rural residents engaged in the management of Kuskokwim fisheries from the headwaters to the sea.

Arctic Yukon Kuskokwim Sustainable Salmon Initiative

https://www.aykssi.org/

In response to salmon declines, Bering Sea Fishermen's Association and regional Native organizations (Association of Village Council Presidents, Kawerak, Inc., and Tanana Chiefs Conference) joined with state and federal agencies to create the AYK SSI, a proactive science-based program working cooperatively to identify and ad-dress the critical salmon research needs facing this region. The AYK SSI is the largest example of co-management of research-funding addressing salmon within the Pacific Rim and one of the largest, most successful programs of its kind in North America. OUR MISSION is to collaboratively develop and implement a comprehensive research plan to understand the causes of the declines and recoveries of AYK salmon.

Bristol Bay Regional Seafood Development Association

https://www.bbrsda.com/

Our mission is to maximize the value of the Bristol Bay fishery for the benefit of our members. One of the primary activities of the BBRSDA is funding (actually co-funding, in most cases) projects designed to strengthen our fishery. Across a broad range of disciplines – economic research, quality-improvement, fisheries science and marketing, among others – these programs are where most of our members' annual 1% assessment goes. BBRSDA's participation in approved projects – as well as the responsibilities of funded entities – are defined in contracts with the grantees (ADFG, research institutions, fishermen, service providers, municipalities, etc.).

Prince William Sound Science Center

https://pwssc.org/

In Prince William Sound, wild and hatchery-bred pink and chum salmon are important commercial fisheries. Pink salmon is the largest of any commercial fishery and is serviced primarily by the purse seine fishery. Commercial, recreational and subsistence harvests of salmon profoundly affect the economic and cultural fabric of Prince William Sound communities. Coho, sockeye, Chinook, pink, and chum salmon support valuable fisheries in the region. The economic impact of these fisheries is critical to many small coastal communities here, and around the globe. Yet, the interactions between wild and hatchery fish are little understood. Our research focuses primarily on two species of Pacific salmon found in Alaska, both of which evolved from their ancient rainbow trout ancestors. They start their lives as freshwater fish, then change and develop the ability to live and grow in the ocean where they mature. As native fish evolve and interact with hatchery fish, there are inevitable impacts. We seek to understand those impacts in order to help maintain the unique identity and health of every species.

Alaska Sealife Center

https://www.alaskasealife.org/

Our Science Mission The overall goal of our Science Program is to develop an under-standing of the role of marine mammals, birds and fish in the arctic and subarctic marine ecosystems, and to generate scientific knowledge relevant to resource management and policy. Our projects focus on Alaska marine life and environments, but reach globally with international collaborations. The Center's unique geo-graphic location, marine cold water research facilities, live animal collections, and specialized staff allows us to use a combination of experimental and field research to:

- Investigate physiological and ecological processes affecting marine animal population dynamics.
- Conduct controlled experiments to understand factors affecting reproductive success and fitness in marine species.
- Monitor marine animal responses to environmental variability and stressors.
- Evaluate human impacts on our marine environment and animal populations.
- Develop tools to support recovery and restoration of marine resources.

University of Washington Alaska Salmon Program

https://alaskasalmonprogram.org/

Our program focuses on all aspects of the ecology and evolution of Pacific salmon in the watersheds of western Alaska, the Bering Sea, and the Gulf of Alaska. We actively pursue discovery science in an era of rapid global change to produce data and knowledge for managing and conserving regional ecosystems and their fisheries, and provides insights relevant to fisheries and watershed management across the globe. Our educational mission provides research opportunities for undergraduate and graduate students, and we seek to engage with regional K-12 programs, other citizens, and management agencies to improve our collective understanding of these remarkable ecosystems.

Salmon and People Project

https://global.si.edu/projects/salmon-and-people-project

Project Highlights The Kenai Lowlands region of the Kenai Peninsula in south central Alaska covers roughly 9400 square km. The watersheds of this region support abundant salmon that underpin sport fisheries and millions of dollars in economic activity related to commercial salmon fisheries. The food security and cultural identity of many residents all depend on abundant and reliable salmon populations. Over the past 15+ years, the Smithsonian Environmental Research Center's Dennis Whigham has collaborated with Coowe Walker of the Kachemak Bay National Estuarine Research Reserve (KBNERR), Ryan King of Baylor University (BU) and Mark Rains of the University of South Florida (USF). The collaboration has resulted in research that shows the important ecological relationships between el-ements of the landscape like local plants and how many young salmon there are in the streams. The continued existence of resilient salmon populations, partic-ularly on lands like the Kenai Lowlands that lack state or federal conservation status, will require Alaskans to decide what invest-ments they need to make to ensure they can sustainably support the goods and services provided by the landscape.

State of Alaska's Salmon and People

https://alaskasalmonandpeople.org/

The mission of the State of Alaska's Salmon and People project is to create an equitable decision-making platform for all stakeholders through information synthesis, collaboration, and stakeholder engagement.

Center for Salmon and Society

https://www.uaf.edu/cfos/research/center-for-salmon-society/index.php

The Center for Salmon and Society seeks to engage all salmon-connected Alaskans in objective forums to foster dialogue using the best available science to identify trade-offs inherent in complex natural resource decisions.

The Salmon Project

https://salmonproject.org/

The Salmon Project is a celebration of wild salmon's place at the heart of Alaskan life, and the diverse ways it is present in our values, our culture, and our landscape.

About

From 2012 to 2019, The Salmon Project shone a spotlight on the role salmon has in all Alaskans' lives, reinforcing our culture and identities, and showing how our individual choices affect this incredible resource. By telling the story of our shared Salmon Love, we laid a foundation for a statewide movement to ensure that Alaskans' lives will always be salmon lives. Our project moved out of its active stage at the end of 2019. Many of our projects and initiatives are evergreen.

Our Vision

To create a future where Alaskans are united in an:

Awareness of the economic, environmental, social and cultural importance of salmon for ourselves, and for all Alaskans, including those whose connection to salmon is different than our own.
Understanding of the challenges facing Alaska's wild salmon resource.
Commitment to collective decisions and personal actions that will ensure future generations of Alaskans live with an abundance of wild salmon.

Alaska Fish Habitat Partnerships

https://www.alaskafishhabitat.org/

Our Philosophy Working together to protect, maintain, restore and enhance fish habitat throughout Alaska. ***Our History*** Alaska's first partnership to be formally recognized by the National Fish Habitat Partnership board was the Mat-Su Basin Salmon Habitat Partnership in 2006, followed by the Southwest Alaska Partnership in 2008, the Kenai Peninsula Partnership in 2010, and the

Southeast Alaska Partnership in 2014. The Western Native Trout Initiative and Pacific Lamprey Partnership serve larger geographies that include Alaska.

Alaska's Partnerships Rainbow Trout at Fish Creek, Matanuska-Susitna Valley, Alaska. USFWS/K.Mueller Operating under the banner of the **National Fish Habitat Partner-ship**, Alaska's recognized fish habitat partnerships are working on behalf of Alaska's wild, native fish and their habitats. These six recognized partnerships are part of a national network of locally-driven, voluntary, and non-regulatory collaboratives. Active partnerships made up of diverse interests are increasingly necessary to sustain Alaska's locally and globally important fisheries – especially in geographic areas where habitat overlays a mosaic of private, state, tribal and federal lands and threats to fish habitat are at play.

Basin-Scale Events to Coastal Impacts (BECI)

https://beci.info/

BECI (Basin Scale Events to Coastal Impacts) is an ambitious project to develop an international ocean intelligence system for the North Pacific Ocean that uses enhanced observations, numerical modeling, and data analytics infrastructure to provide timely and targeted information on the impacts of current and future climate events on ocean ecosystems. BECI was proposed by the North Pacific Anadromous Fish Commission (NPAFC) and the North Pacific Marine Science Organization (PICES) which was endorsed by the United Nations Decade of Ocean Science and Sustainable Development (UNDOS) in 2021.

North Pacific Research Board

https://nprb.org/

Supporting Research in the North Pacific Alaska supports some of the most diverse and abundant marine ecosystems in the world. Species large and small depend upon the state's unique marine environments for survival from coastal kelp beds to the undercarriage of multi-year Arctic sea ice. For coastal communities and those that utilize Alaska marine resources, this dependence extends beyond food or survival to traditional, cultural, and economic values that are shared by many—even to those outside the state. Alaska generates more than 40% of the commercial fish landings in the United States. It is no wonder that with over 44,000 miles of coastline stretching from the frigid, exposed waters of the Beaufort Sea to the sheltered narrows of the Inside Passage, a shared responsibility and knowledge is required to support the long-term health of these ecosystems. Understanding Alaska's marine ecosystems is a collaborative effort. Using science and local traditional knowledge, scientists from all over the world are studying the oceanography, plants, and animals of the North Pacific, Bering Sea, and the Arctic Ocean through funding support by the North Pacific Research Board (NPRB). NPRB's mission is to build a clear understanding of these ecosystems thereby enabling effective management and sustainable use of marine resources.

Department of Interior, Office of Subsistence Management

https://www.doi.gov/subsistence/osm

The Office of Subsistence Management is housed within the U.S. Fish and Wildlife Service, and provides administrative support to the Federal Subsistence Board and the Federal Subsistence Regional Advisory Councils. The staff of the Office of Subsistence Management includes fish and wildlife biologists, anthropologists, technical and administrative staff, and liaisons to the Alaska Department of Fish and Game and the Alaska Native community. The staff provides support for the regulatory process and the Fisheries Resource Monitoring Program.

Arctic Beaver Observations Network

https://sites.google.com/alaska.edu/a-bon/

The Arctic Beaver Observation Network (A-BON) is a group of scientists, indigenous groups, land managers, and local observers who are concerned about the expansion of beaver populations into Arctic landscapes. This collaboration began in 2020 and assembles a broad range of perspectives from Alaska, Canada, Europe, and Russia to coordinate research and observations related to beaver colonization of the Arctic and the impacts it is having on ecosystems and people.

Appendix 7 – Alaska Salmon Research Task Force Members and Affiliations

Andrew Munro, *North Pacific Fishery Management Council*

Dr. Andrew Munro is a fisheries scientist and statewide stock assessment scientist for the Alaska Department of Fish and Game. He has been a member of the North Pacific Fishery Management Council's Scientific and Statistical Committee (SSC) since 2019. He has expertise in fish biology, stock assessment, and salmon. Munro is also well-versed in the Council's history with Pacific salmon conservation efforts in the federal fisheries, and the management needs for understanding the Pacific salmon life cycle in Alaska. Munro also chairs a Working Group on Stock Assessment for the North Pacific Anadromous Fish Commission. He also participates on technical panels for the Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative. He has a PhD in Fish and Wildlife Biology from Montana State University, an MS in Biology, with an emphasis on Marine and Freshwater Ecology from East Stroudsburg University, and a BS in Biology, with a concentration in ecology and a minor in chemistry, from Ursinus College in Collegeville, Pennsylvania.

Ed Farley (Chair), *NOAA Fisheries, Alaska Fisheries Science Center*

Dr. Farley has extensive experience and expertise in marine ecology of Pacific salmon. He also commercially fished in Bristol Bay from 1982 to 1997. Farley holds a PhD in Fisheries from the University of Alaska Fairbanks. His dissertation focused on early marine ecology of Bristol Bay sockeye salmon to better understand mechanisms in their marine life history that impact pro-duction. Farley has worked for NOAA Fisheries at the Alaska Fisheries Science Center since 1997. He is currently the program manager of the Ecosystem Monitoring and Assessment Program. The program is focused on understanding the impacts of climate change on ecosystems and fish fitness and survival. He developed and implemented the Alaska Fisheries Science Center's salmon early marine ecology surveys in the eastern Bering Sea in 1999. The data from these surveys are used to forecast adult returns of Yukon River Chinook salmon and to understand how the rapidly warming Bering Sea is impacting early marine growth and survival of Bristol Bay sockeye salmon and western Alaska Chum and Chinook salmon. He is the chair of the Science Sub Committee of the North Pacific Anadromous Fish Commission (NPAFC). This sub committee is charged with conservation of Pacific salmon in the North Pacific Ocean. Since 1997, Farley has developed and led NPAFC efforts to understand production dynamics of Bering Sea salmon stocks (Asian and North American) through the Bering Aleutian Salmon International Survey (BASIS) Program and to understand winter ecology of Pacific salmon through the International Year of the Salmon Program. Farley was the lead author on the ocean ecology of sockeye salmon chapter in the Ocean Ecology of Pacific Salmon and Trout. This document was published in 2018. It is where much of the NPAFC marine research has been summarized.

Bill Templin, *Alaska Department of Fish and Game*

Dr. Bill Templin is currently the chief fishery scientist for salmon at the Alaska Department of Fish and Game, Division of Commercial Fisheries. In this capacity, he is responsible for overseeing the division's statewide salmon research and stock assessment programs and helping ensure that research is well integrated with fisheries management. He has 29 years of experience conducting and overseeing fisheries research on commercially important fish and shellfish species in Alaska. For nine of these years, he served as the principal geneticist, in charge of the department's genetics program. During this time, he has represented the State of Alaska in various statewide, national and international settings including the Pacific Salmon Commission, North Pacific Anadromous Fish Commission, and the Intergovernmental Consultative Committee on Fisheries.

Andrew Piston, *Pacific Salmon Commission*

Andrew "Andy" Piston currently supervises the Southeast Alaska pink and chum salmon research programs, Ketchikan area sockeye salmon research programs, and other regional salmon stock assessment projects for the Alaska Department of Fish and Game. He is responsible for monitoring the escapement, production, survival and harvest patterns, and overall health of Southeastern Alaska's pink and chum salmon stocks. He is also responsible for developing recommendations and scientific advice for managers, the Alaska Board of Fisheries, Pacific Salmon Commission, and other organizations. He works cooperatively with NOAA Fisheries to implement the Southeast Coastal Monitoring Project and to produce joint pre-season pink salmon harvest forecasts. He has been involved with salmon research projects in Southeast Alaska since 1994. He has served on the Northern Boundary Panel of the Pacific Salmon Commission since 2016, when he was appointed by the Governor of Alaska. Previously, Piston served as the co-chair of the Northern Boundary Technical Committee. He has been a technical committee member since 2010.

Oscar Evon, *Native Village of Kwigillingok*

Mr. Evon was born and raised in Kwigillingok, Alaska. He is a subsistence fisherman and member of the Native Village of Kwigillingok. He is the Director of Regional Affairs for the Coastal Villages Region Fund. He served as a board member from 2000-2009, eventually becoming Board of Directors president and chair. He also acted as the fund's director of programs. Evon's previous roles include Tribal administrator and COVID-19 coordinator for the Native Village of Kwigillingok, office manager for Alaska Moravian Bible Seminary, and community outreach coordinator for E3 Alaska. He serves on the North Pacific Fishery Management Council's Salmon Bycatch Committee.

Jacob Ivanoff (vice Chair)**,** *Native Village of Unalakleet*

Mr. Ivanoff is a resident of Unalakleet, Alaska. He has personal knowledge of, and direct experience with, subsistence harvest and uses of salmon in rural Alaska. He is highly educated, receiving knowledge from Elders and others about salmon and through various positions he has held professionally over the years. Ivanoff is affiliated with the Native Village of Unalakleet, with the Tribe, and with other salmon-related entities in the Bering Strait region. Ivanoff is chair of the Alaska Department of Fish and Game's South Norton Sound Advisory Committee.

Karla Jensen, *Native Village of Pedro Bay.*

Ms. Jensen is a Services Specialist 1 with the Pedro Bay Village Council. She is a Board member for the United Tribes of Bristol Bay. The Board of Directors consists of representatives from each of United Tribes of Bristol Bay's 15 member Tribal governments. United Tribes of Bristol Bay is a Tribal consortium working to protect the traditional Yup'ik, Dena'ina, and Alutiiq ways of life in Southwest

Alaska that depend on the pristine Bristol Bay watershed and all it sustains, most notably Bristol Bay's wild salmon. As a political division of our member Tribal governments, their work is primarily focused in three areas: Tribal consultation with government agencies on issues affecting the Alaska Native way of life; grassroots organizing in the local, statewide, and national arena; and youth empowerment and organizing in the Bristol Bay region.

Caroline Brown, *Alaska Department of Fish and Game*

Ms. Brown is the statewide Subsistence Research Director. She is responsible for coordinating all ethnographic research and policy recommendations on subsistence practices for the Subsistence Section of Alaska Department of Fish and Game. Prior to this role, Brown was the Northern Regional Program Manager from 2017-2020 and the lead subsistence resource specialist for interior Alaska from 2002-2017. Brown holds an MA degree in anthropology from the University of Chicago where she was also a PhD candidate. Over the last 20 years, Brown has conducted multiple projects involving the documentation and analysis of local, traditional and Indigenous knowledge throughout Alaska. She also serves as the alternate U.S. co-chair on the U.S./Canada Yukon River Panel.

Justin Leon, *Kuskokwim River Inter-Tribal Fish Commission*

Mr. Leon serves as the Fisheries Biologist for the Kuskokwim River Inter-Tribal Fish Commission. Before this, he served as the Senior Tribal Climate Resilience Liaison for the Alaska Region for the Native American Fish and Wildlife Society. Through his roles as the Alaska Tribal Liaison with Native American Fish and Wildlife Society and Fisheries Biologist with the Kuskokwim River Inter-Tribal Fish Commission, Leon has garnered experience working with Alaska Native Tribes and Tribal citizens, and bridging local and Indigenous Knowledge with western science. Leon has a BS from the University of Georgia in wildlife management. He moved to Alaska after graduating in 2008 and has made Alaska home since then. He obtained his MS in fisheries from the University of Alaska Fairbanks, where he focused on Chinook salmon in the Yukon and Kuskokwim rivers. After graduate school, he spent 10 years as a fishery biologist for the Alaska Department of Fish and Game. As a fishery biologist, he worked with crab and salmon research, and wild fisheries stock management in Northwest Alaska, the Alaskan interior, and the Aleutian Islands.

Michelle Stratton, *Alaska Marine Conservation Council/Fisherman*

Ms. Stratton works for the Alaska Marine Conservation Council. She was born and raised in Palmer, Alaska, and grew up set netting for salmon with her family on the west side of Cook Inlet. She began her career as a technician for the Alaska Department of Fish and Game before earning her MS degree in Fisheries Science from the University of Alaska Fairbanks. At the same time, she was working eight years as an ADF&G fisheries biologist. In her position at Alaska Marine Conservation Council, Stratton devotes much of her time toward fisheries research and education, helping build connections between Alaska's fishing communities and the scientific processes that support them. As a lifelong subsistence hunter and fisherman, Stratton has a passion for fisheries biology and its role in sustaining the thriving food systems and wild places that she has lived within most of her life. She also is an owner-operator of a set net site on the south end of Kodiak Island.

Mike Flores, *Charter Boat Fisherman*

Mr. Flores has over 30 years of experience owning and operating a large charter fishing business on the Kenai Peninsula. He has recently completed service on the Alaska Bycatch Task Force. Mr. Flores is serving on the Charter Halibut Management Committee of the North Pacific Fisheries Management Council. He is familiar with the processes and procedures of Alaska State boards and committees.

Austin Estabrooks, *At-sea Processors Association*

Mr. Estabrooks is a natural resource analyst for the At-sea Processors Association (APA). He has worked on various aspects of salmon bycatch mitigation undertaken by the pollock catcher processor (CP) fleet operating in the Bering Sea. He is the primary author of the Incentive Plan Agreement (IPA) under which the CP fleet operates to meet the objectives of Amendment 91 and 110. He is responsible for monitoring in-season bycatch of both Chinook and chum to help identify hot-spots for avoidance as well as working closely with Auke Bay geneticists to identify longer term spatio-temporal trends of chum salmon stock distributions as reflected in the bycatch. He has conducted at-sea experiments with salmon lights and salmon excluder devices using deploy and retrieve cameras to quantify escapement. Through the Pollock Conservation Cooperative Research Center, Mr. Estabrooks also advises APA on funding extensive research on Alaska salmon. This includes recent projects developing species distribution models for Chinook salmon and investigating Yukon chum salmon early life history. Prior to APA, he spent nearly five years in the Bering Sea and Gulf of Alaska working as a North Pacific Groundfish observer, where he collected systematic genetic samples of salmon bycatch in the pollock fishery.

Tom Carpenter, *Commercial Fisherman*

Mr. Tom Carpenter hails from Cordova, Alaska. In 2022, he was appointed by Alaska Governor Mike Dunleavy to serve on the Alaska Board of Fisheries. He is retired from the U.S. Coast Guard and has participated in various fisheries throughout his career. He has served as a crewman on a seiner and a gillnetter before buying his own boat. He also purchased and operated a sporting goods store in Cordova. Carpenter has served for over 22 years on the Copper River/ Prince William Sound Advisory Committee.

Steve Reifenstuhl *retired, Northern Southeast Regional Aquaculture Association*

Mr. Reifenstuhl has over 45 years of experience in Alaska salmon fisheries management, research (salmon biology and ecology, post-secondary education), salmon habitat restoration (cooperative projects with U.S. Fish and Wildlife Service) and salmon hatchery production. Among his various roles and accomplishments, he was a founding board member of Alaska's Salmon Hatchery/ Wild research program, served on the S.E. Regional Advisory Council, North Pacific Research Board Advisory Panel and was a board member of United Fishermen of Alaska. He recently retired as general manager of the Northern Southeast Regional Aquaculture Association.

Megan McPhee, *University of Fairbanks, Alaska*

Dr. Megan McPhee is an associate professor at the College of Fisheries and Oceans, University of Alaska, Fairbanks, located at the Juneau Fisheries Center. She is a fisheries ecologist who focuses on the ecology, evolutionary biology, and population structure of Pacific salmon. Relevant research topics include marine ecology of chum salmon, connections between climate, growth rate, and age/size at maturity in western Alaska Chinook salmon and Southeast Alaska steelhead; effects of competition on growth of western Alaska chum salmon in the North Pacific, genetic stock identification of western Alaska chum salmon, and hatchery-wild interactions in Southeast Alaska. She sits on the steering committees of the Southeast Alaska Fish Habitat Partnership and the International Year of the Salmon. She is also an associated faculty with the Tamamta program at UAF, which seeks to elevate the role of Indigenous knowledge in fisheries education and research.

Megan Williams, *Arctic Program, Ocean Conservancy/ University of Alaska Fairbanks*

Dr. Megan Williams is a fisheries scientist with Ocean Conservancy. Her education and professional experiences have focused on fisheries interactions with apex predators and predator ecology in Alaska. She has worked extensively on bycatch issues and climate readiness in fisheries management at both state and federal levels since 2010. Her current work focuses on integrating western science and Traditional/ Indigenous Knowledge to understand cumulative threats to salmon and rural communities and to identify climate resilient solutions. She also serves as the chair of the Alaska Scientific Review Group that advises NOAA Fisheries and the U.S. Fish and Wildlife Service on the best available science and subsistence information to be included in annual Marine Mammal Stock Assessment Reports in Alaska.

Tommy Sheridan, *University of Alaska Fairbanks*

Mr. Sheridan is the associate director for the University of Alaska Fairbanks (UAF) Alaska Blue Economy Center. He is also currently serving as community site coordinator for the Alaska Regional Collaboration for Innovation and Commercialization (ARCTIC) Program through UAF's Alaska Center for Energy and Power to establish Cordova, Alaska as a Community Innovation Hub. He spent eight years working for Northern Southeast Regional Aquaculture Association in the salmon hatchery industry, six years working for Alaska Department of Fish and Game as a commercial salmon fisheries manager, and three years working for Silver Bay Seafoods in the seafood processing sector. He has graduate level education in fisheries and fisheries management, and has taught undergraduate fisheries courses in both Alaska and Oregon. He has served as a board member for Prince William Sound Aquaculture Corporation, Alaska Fisheries Development Foundation, Prince William Sound Science Center, and Sitka Sound Science Center. He was appointed to the Governor's Alaska Bycatch Review Task Force (ABRT) in 2021, and currently serves on the North Pacific Anadromous Fish Commission as one of two US Commissioners.

Noëlle Yochum, *Alaska Pacific University/ Trident Seafoods*

Dr. Noëlle Yochum is affiliated faculty with Alaska Pacific University and is the Senior Manager of Fishing Innovation and Sustainability for Trident Seafoods. Prior to this, Dr. Yochum led the Conservation Engineering group at the Alaska Fisheries Science Center (NOAA Fisheries). In both capacities, Dr. Yochum's focus is on collaborative research with industry and scientific partners to find innovative ways to evaluate and mitigate incidental impacts of fishing, including bycatch, bycatch mortality, and effects on fish habitat. This work is done through field and laboratory research to understand fish behavior and to improve fishing gear design and practices. In addition to work in Alaska and the U.S. west coast, she has conducted related work on the U.S. east coast and abroad.

Katie Howard, *Alaska Department of Fish and Game*

Dr. Kathrine "Katie" Howard is a statewide fishery scientist with the Alaska Department of Fish and Game and serves as the Salmon Ocean Ecology Lead. She holds a PhD and an MS degree in zoology from the University of Hawaii and a BS in biology and a BA in English from the University of Idaho. Katie began at ADF&G in 2009 as the Yukon Area Research biologist and was quickly promoted to the Arctic-Yukon-Kuskokwim regional research biologist before becoming the AYK fisheries scientist and eventually holding a statewide scientist position overseeing the Salmon Ocean Ecology Program. Katie has been involved with multiple initiatives and projects that include collaborative marine surveys to assess juvenile Chinook and chum salmon stocks, North Pacific Anadromous Fish Commission, and International Year of the Salmon.

Appendix 8. Names and primary affiliations of the Arctic-Yukon-Kuskokwim Working Group of the AKSRTF.

Name	Primary Affiliation
AKSRTF Members	
Andrew Munro	Alaska Department of Fish and Game
Austin Estabrooks	At-Sea Processors Association
Bill Templin	Alaska Department of Fish and Game
Caroline Brown	Alaska Department of Fish and Game
Ed Farley	NOAA Fisheries, Alaska Fisheries Science Center
Jacob Ivanoff	Native Village of Unalakleet
Justin Leon	Kuskokwim River Inter-Tribal Fish Commission
Katie Howard (co-chair of WG)	Alaska Department of Fish and Game
Megan McPhee	University of Alaska Fairbanks
Megan Williams	Ocean Conservancy
Michelle Stratton	Alaska Marine Conservation Council/Fisherman
Noelle Yochum	Trident Seafoods
Oscar Evon	Coastal Villages Region Fund (CVRF)
Steve Reifenstuhl	Salmon Biologist/Consultant (Retired)
Tom Carpenter	Commercial Fisherman
Public Members	
Adolph Lupie	Lower Kuskokwim River

Andy Bassich	**Upper Yukon River**
Bill Alstrom	**Lower Yukon River**
Brooke Woods	**Yukon River**
Charlie Lean	**Norton Sound**
Charlie Wright	
Courtney Weiss	**Yukon Delta Fisheries Development Association (YDFDA)**
Curry Cunningham	**University of Alaska – Fairbanks**
Dan Gillikin	**Native Village of Napaimute, Aniak, AK**
Daniel Schindler (co-chair of WG)	**University of Washington**
Hannah Heimbuch	**Commercial Fisher**
James Nicori	**Kuskokwim region**
Jennifer Hooper	**Association of Village Council Presidents, Yukon-Kuskokwim Delta Region**
Jessica Black	**Associate vice chancellor for rural, community education and Native education. University of Alaska - Fairbanks**
Joe Spaeder	**Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative**
Mark McNeley	**Native Village of Nelson Lagoon**
Martin Andrew	**Kuskokwim region**
Marvin Okitkun	**Kotlik, lower Yukon Delta**
Michelle Quillin	**Tanana Chiefs Conference, Fairbanks**
Patrick Barry	**NOAA Alaska Fisheries Science Center**

Ragnar Alstrom	**Executive Director, Yukon Delta Fisheries Development Association (YDFDA)**
Renae Ivanoff	**NSEDC's Fisheries Research and Development Director**
Scott Gende	**National Park Service**
Serena Fitka	**Yukon Delta Fisheries Development Association (YDFDA)**
Todd Sformo	**North Slope Borough - Department of Wildlife Management**
Vanessa von Biela	**U.S. Geological Survey, Alaska Science Center**
Virgil Umphenour	**Upper Yukon River**

Appendix 9. List of all hypotheses and research questions considered by the AYK WG for understanding the causes of recent declines in AYK chum salmon and Chinook salmon. Individual hypotheses and questions were developed as components of each of the major research themes (possible explanations) specified by the AKSRTF. Individual scores are the total number of points allocated to each hypothesis or question by the AYK WG, which were summed within each theme (total score = TS) to develop weights for prioritizing research across the AKSRTF research themes.

Research Theme: Possible explanation for AYK salmon decline (TS = total score)	Individual score	Specific question or hypothesis
Spawner Health **TS = 102**	28	Quantify causes, magnitude, and consequences of *en route* and pre-spawn mortality. What are interactions with climate and changing ocean conditions? Roles of disease and parasites
	23	Improved understanding of spawner quality (age, sex ratios, size, genetic divesity, nutritional and health condition of spawners) and how changes to spawner quality impact reproductive success and stock productivity
	9	Identifying vectors of salmon disease, and conditions leading to changes in disease prevalence and intensity (e.g., environmental conditions and/or changes to migratory patterns)
	13	Interactive effects of multiple stressors on spawning adults during their freshwater migration (e.g., climate conditions)
	3	Sublethal impacts, such as straying or other behavior changes, during poor migration conditions (i.e. warm temperatures, low water) on migrating fish
	19	Identifying conditions/thresholds where genetic population size is so critically low that stocks are at particular risk for extirpation, and assessing whether any existing stocks meet those criteria

	6	**Programmatic review to determine whether inriver stock assessments have adequate precision and accuracy for estimating abundance**
Freshwater Harvest (Commercial and Sport) **TS = 35**	**9**	**What are legacy effects of historical FW fisheries (e.g., gear effects, harvest rates) on current population status and demographics?**
	6	**What is role of unobserved fishery-mortality (e.g., drop-outs from small mesh nets) on mortality rates, fishery selection, and ultimately population productivity?**
	4	**What is the extent that FW harvest can further depress weak stock components while targeting productive stocks (related to management under uncertainty). Can we improve stock resolution and harvest specificity?**
	12	**Are the current BEG's/SEG's spawner recruit relationships used to estimate surplus fish available for harvest still valid in light of new theories about where mortality may be occurring i.e. fresh vs marine waters and does it matter?**
	4	**Ecological consequences of harvesting to achieve the upper limits of escapement goal range, compared to lower limits of escapement goal range?**
	0	**Is there any down side (related to future recruitment) to focusing harvest on "Jack" Chinook salmon?**
Freshwater Predators **TS = 19**	**9**	**Are changes in freshwater predators reducing FW survival of juvenile salmon?**
	1	**Do changing environmental conditions (temp, flow, turbidity) have an influence on predation success and/or the abundance and size of predators?**
	3	**How do beavers indirectly affect predation on juvenile salmon by altering habitat?**
	0	**Are changes in harvest of FW predators changing predation on juvenile salmon?**
	6	**Do climate-induced changes in coho salmon alter predation regimes on other salmon in FW**
Marine Predators	**12**	**What is the role of changes in marine apex predators (orcas, sharks, sea lions) on demographic structure (eg. body sizes and ages) and abundance of AYK salmon? What are abundance trends, diets and spatial distribution of predator populations?**

TS = 24	**5**	**What are impacts of marine predators on pre-adult and smolt life stages?**
	7	**Are there interactions between changing climate and marine predators that affect ecology of AYK salmon?**
Freshwater conditions for eggs and juvenile rearing and migration **TS = 51**	**14**	**Are changes in watershed habitat productivity and capacity reducing fitness and abundance of smolts leaving watersheds?**
	15	**Is the hydrology (discharge, magnitude, duration, bank full flows) changing and what is the effect? Loss of complexity, disconnected habitats, channel morphology. Effects on FW food webs and growth and survival of juvenile salmon. Effects on egg incubation?**
	6	**Have changes in marine-derived nutrients (MDN) from declining salmon populations, changes in fish and wildlife management, reduced the productivity of freshwater nursery habitats?**
	5	**Is the spread of beavers into areas that had not previously had beavers changing the quality and quantity of habitat for salmon?**
	0	**How do fires, permafrost degradation, and localized logging in riparian zone for firewood influence habitat value?**
	11	**Climate effects on floods, spring breakup, thermal refuges, flows, temperatures, permafrost ?**
Marine food limitation **TS = 131**	**47**	**Are changing marine food webs and climate reducing quantity and quality of food for smolts?**
	65	**Is competition with hatchery pinks and chums, Bristol Bay sockeye, reducing marine survival of AYK salmon?**
	19	**Are changes in nearshore habitat conditions affecting smolt survival of AYK salmon**
Climate change (freshwater and marine) **TS = 62**	**35**	**Interactions between climate change and all other factors**
	0	**What are the impacts of increasing presence of salmon in the high Arctic on resident non-salmon species?**
	8	**Are large scale climate variation linked between freshwater and marine ecosystems in the AYK region? If so how do we separate them, do we need to?**

	16	**Climate-driven changes in sea ice and impacts for plankton phenology (match/mismatch)**
Marine Harvest **TS = 156**	**42**	**What are 1) catch rates and 2) stock composition of fish in state, federal and foreign fisheries? How do these compared to escapement estimates in AYK watersheds. Need more effective monitoring of all 3 components**
	49	**Is bycatch in US federal fisheries causing declines of AYK salmon?**
	38	**Are interceptions in other Alaska state fisheries causing declines of AYK salmon?**
	15	**Is foreign IUU (illegal, unregulated, unreported) fisheries causing declines of AYK salmon?**
	21	**Are genetic markers adequate for understanding impacts of bycatch and interceptions on population dynamics?**