CHAPTER 2: CONCEPTUALIZING THE INTERNATIONAL YEAR OF THE SALMON

The IYS Study Group

Formation of the Study Group on the International Year of the Salmon (IYS-SG) was discussed during the meeting of the Committee on Scientific Research and Statistics (CSRS) in Honolulu, Hawaii, USA, in April 2013 (NPAFC 2013). The first objective of the IYS-SG was to develop a short clear prospectus that would describe the initiative in more detail and present a possible timeline. Mark Saunders (Canada) was appointed Chairperson of the IYS-SG, and by 2014, members included Shigehiko Urawa (Japan), Ju Kyoung Kim (Korea) and Moongeun Yoon (Korea), Maxim Koval (Russia), Alex Zavolokin (Russia), Rich Lincoln (USA) and Eric Volk (USA) (International Year of the Salmon Study Group (IYS-SG) 2015b).

Following the 2013 Annual Meeting of the NPAFC, the Secretariat prepared a five-page outline to initiate discussion inside the IYS-SG, which was formed under the CSRS aegis, in January 2014 (Appendix B). This document answered some general questions regarding IYS implementation, e.g. *what are we celebrating in frame of the International Year of the Salmon?* It listed steps of preparatory phase planning including a feasibility meeting (later defined as a scoping meeting) and listed implementation details including a scientific research expedition in the NPAFC Convention Area, a major scientific symposium on status, dynamics, and factors driving production of salmon stocks, and creation of the IYS library. Social and outreach events under the IYS frame were also proposed for consideration by the IYS-SG. At this stage of IYS discussions it was also specified that the initiative would focus only on Pacific salmon and main IYS activities would be concentrated in the North Pacific, with participation generally limited to NPAFC member countries. After consultation and concurrence with the initiator of the idea, Richard Beamish, the Secretariat sent the document to the IYS-SG Chairperson, Mark Saunders, to use suggested ideas in preparation of a short clear prospectus prior to the 2014 Annual Meeting of the NPAFC.

A short prospectus was developed that outlined two phases that would be carried out under the IYS: a scoping phase and an implementation phase (Appendix C). The scoping phase would involve the development of a detailed prospectus by CSRS that would provide a more thorough description of research objectives and activities associated with cost, timeline, participants, and expected results. This phase would also include a scoping meeting, to be convened in 2014, which would involve a discussion to devise a funding strategy, with partners from government, academia, industry, businesses and NGO's. The implementation phase was to be further divided into three major components: a data collation and field collection component, an analytical component, and an outreach component. This was the first official mention of an outreach component to the IYS, with most discussion up until this point focused on research objectives. The outreach component was briefly described as engaging the scientific community as well as the public in a broad sense with respect to IYS research and findings as well as underlining Pacific salmon and steelhead conservation and cultural significance in the North Pacific Rim.

The short prospectus also included some rough details with respect to cost, duration, participants, deliverables, funding, staffing, governance, and a timeline. Total duration was expected to last three to four years with a total cost of $2–4M CAD. Participants were expected to include scientists from

governmental organizations such as NPAFC and PICES, non-governmental organizations (NGOs), and academia, as well as representatives from First Nations groups, unions, communities, and commercial and recreational fisheries. Examples of deliverables included both primary publications and outreach material such as an IYS website and library, videos/documentaries, and popular articles. A possible governance structure of the IYS put forward in the draft prospectus included an IYS Honorary Council (senior officials, sponsors, and fundraisers) and an IYS Steering Committee and Sub-Committees (Data and Information, Research-Field, Research-Analytical, Logistics/Events, and Communications and Outreach). It was anticipated that the IYS initiative would require one to two staff, which could potentially be housed by the NPAFC Secretariat. A possible timeline was also suggested:

2014	Scoping meeting and a detailed prospectus completed
2015	Project initiation (confirmation of funding, establish governance bodies, develop detailed work plans and data management protocols, hiring of staff)
2016/17	Year 1 & 2 – Gulf of Alaska surveys
2018/19	Years 3 & 4 – Analyses, workshops/symposia, publications, a major scientific symposium

At 2014 Annual Meeting of the NPAFC, the Commission agreed that the IYS-SG continue to scope the initiative and to develop an IYS proposal. The following terms of reference were provided (NPAFC 2014 p. 84).

> *The International Year of the Salmon (IYS) Study Group should continue to scope the initiative through a series of virtual and/or face to face meetings of interested parties and outside interests to develop an IYS proposal that will be discussed by the NPAFC at the 2015 Annual Meeting. The proposal developed by this group would address the following considerations:*
>
> 1. *Scope of the Programme (Pacific-Atlantic, Farmed Salmon and other ecosystem considerations, etc.) Benefits of the Programme*
> 2. *Potential for Funding and Identification of Partners (NGO's Industry, State and Federal Agencies, other RFMO's, etc.)*
> 3. *Communications and Outreach Strategy*
> 4. *Identification of Field and Analytical Research (Strategic Research Plan)*
> 5. *Starting Year and Duration*

The proposal was to be virtually reviewed by CSRS and undergo further review by the NPAFC at the 2015 Annual Meeting. Next steps outlined in the short prospectus were to have CSRS confirm support for the principle of the IYS as well as to convene a scoping meeting to develop a science plan for the initiative and discuss potential funding strategies. Further, the suggested start date for IYS initiative was pushed to 2016.

Initial Discussions with NASCO

In discussion of the IYS prospects at the 2014 NPAFC Annual Meeting, involvement of NASCO in future progress of the initiative was mentioned by the Secretariat. The NASCO Executive Secretary, Peter Hutchinson, had expressed a great interest in the IYS since he first became aware of the initiative in July 2013. Hutchinson shared an approach to include all salmon species in the IYS scope, most notably the 'King of Fish'—Atlantic salmon (*Salmo salar*). The NPAFC Secretariat kept NASCO and NASCO-related NGOs updated on further IYS developments and sporadically discussed a better approach to promote the initiative with the NASCO Secretariat. Hutchinson agreed that despite the initial idea having a heavy science focus, the sponsoring of social and outreach events to raise awareness of the resource would be very important.

After receiving preliminary information on the IYS project in June 2014, the NASCO Council tasked the NASCO Secretariat to liaise with the NPAFC and report on its progress the next year. The NASCO Secretariat accepted this task as an opportunity to raise the profile of the work being done in both the North Pacific and North Atlantic to conserve and restore salmon stocks and to understand factors influencing their abundance. The NPAFC and NASCO revived regular communication and planned a face-to-face meeting to discuss details.

The First IYS Scoping Meeting

The IYS-SG and NPAFC Secretariat assembled the First IYS Scoping Meeting on February 17–18, 2015 in Vancouver, Canada, in the boardroom of the secretariat of the Pacific Salmon Commission (PSC). Participants included most members of the IYS-SG as well as scientific experts from member countries who were invited to help produce recommendations on the nature of the IYS, with particular emphasis on developing the scientific objectives. The list of participants and workshop agenda can be seen in the Report of the International Year of the Salmon Scoping Workshop (Appendix D; IYS-SG 2015b). Information was captured during a series of facilitated discussion panels, short presentations, and group discussions. Immediately following the two day meeting, the IYS-SG met to discuss all material that was presented and draft an IYS proposal with the goal of developing "*a compelling case for new coordinated research directed at key scientific issues affecting the future of salmon*" (IYS-SG 2015b p. 1). The main objectives of the workshop were as follows (IYS-SG 2015b p. 1):

1. *Develop a list of major scientific issues that will, or are likely to, affect salmon production in the foreseeable future, and around which an IYS could be developed and funded.*
2. *Identify the unknowns and scientific questions related to each issue.*
3. *Discuss the scope (spatial, temporal, species) of an IYS that will be needed to answer the questions (test the hypotheses).*

National Research Priorities

Prior to the First Scoping Meeting, the NPAFC Secretariat compiled and distributed among participants a questionnaire on national salmon research activities and priorities to facilitate identification of a prospective IYS scientific programme that would be relevant to the national priorities of each country, as well as to find common research themes and emerging issues. During the scoping meeting,

national research priorities that have emerged from research activities were also presented by a representative of each country, followed by plenary discussion. Prior to these presentations, objectives of the 2011–2015 NPAFC Science Plan (Anonymous 2010) were presented by Shigehiko Urawa. The overarching research theme of the 2011–2015 NPAFC Science Plan was "*Forecast of Pacific Salmon Production in the Ocean Ecosystems under Changing Climate*", and included five research components (IYS-SG 2015b p. 3):

1. *Migration and Survival Mechanisms of Juvenile Salmon in the Ocean Ecosystems;*
2. *Climate Impacts on Pacific Salmon Production in the Bering Sea and Adjacent Waters;*
3. *Winter Survival of Pacific Salmon in the North Pacific Ocean Ecosystems;*
4. *Biological Monitoring of Key Salmon Populations;*
5. *Development and Applications of Stock Identification Methods and Models for Management of Pacific Salmon.*

Japanese research efforts presented at the First Scoping Meeting focused on the trend of the declining abundance of chum salmon with a temporal pattern of change that differs among three regions (Pacific, Okhotsk Sea, and Japan Sea Coasts), as well as fluctuations in age and body size of adult chum returning to spawn. National ocean salmon research priorities were presented as follows (IYS-SG 2015b p. 3):

1) *Juvenile salmon surveys in the coastal waters and the Okhotsk Sea to determine the survival mechanism of each regional populations,*
2) *Long-term monitoring of salmon and their habitats in the Bering Sea to forecast salmon production, and*
3) *Winter salmon surveys in the western Subarctic Pacific and the Gulf of Alaska to evaluate possible source of mortality.*

Ju Kyoung Kim, who presented results of salmon research in Korea, emphasized the importance of research and filling knowledge gaps on salmon stock abundance trends, distribution and migration of juvenile and adult salmon, climate impacts, and wild/hatchery stocks interactions. All Korean chum salmon are released from hatcheries and that adult abundance is so low that all are utilized for hatchery production.

With regards to Russian research activities discussed at the First Scoping Meeting, a significant portion focused on the early marine period of Pacific salmon; the freshwater period is well studied and currently used as the basis of forecasts. Although the early marine period is a critical period in salmon life history, these studies are difficult to conduct in eastern Russia due to the long coastlines and large number of rivers. Estuarine and inshore studies are conducted in effort to improve abundance forecasts and better understand biotic and abiotic factors affecting salmon productivity. Additionally, high seas surveys are conducted every year in the Okhotsk Sea, western Bering Sea, and Pacific Ocean in effort "*to improve forecasts of salmon abundance, to determine their biochemical composition and energetic levels, to understand role of Pacific salmon in marine ecosystems, to understand the carrying capacity of the North Pacific, and the determination of growth variability and its consequences for their survival*" (IYS-

SG 2015b p. 4). Carrying capacity was discussed as being a difficult area of research that is only beginning to be addressed in Russia. High seas information helps to improve forecasts but information on stock composition is essential as it provides regional information on abundance. Additional research activities included factors affecting mortality of salmon, including oceanography, plankton communities (food supply), predators, disease, and parasites, as well as the role of Pacific salmon in marine ecosystems under such topics as: "*(1) structure and dynamics of plankton and nekton communities, (2) diets and feeding rates of salmon and other nekton species, (3) trophic status and interactions between salmon and other nekton species, and (4) dynamic of physical environment of salmon*" (IYS-SG 2015b p. 4). Russian research priorities presented at the workshop were " *improvements of forecasts (freshwater and marine studies), stock identification to find out stock-specific migrations and abundance, factors affecting salmon mortality, analyzing carrying capacity of the North Pacific*" (IYS-SG 2015b p. 4).

In the questionnaire, Alex Zavolokin, who presented the review on Russian research activities, pointed out the importance of further studies on bacterial and viral diseases in fish as a factor of salmon mortality, seasonal and interannual dynamics of salmon energetic status estimated by stable isotope analysis of salmon diet and biochemical composition of salmon tissues, as well as development of genetic and phenotypic methods of stock identification. Considering analysis of the impact of environmental conditions, a combination of local (water temperature, stratification, distribution of eddies and fronts) and global (large-scale climate changes) approaches promises better results in the development of advanced understanding. Russian fisheries research institutions have plans to conduct these studies on a regular basis.

Research priorities of the USA presented at the scoping workshop relate back to the five research components of the 2011–2015 NPAFC Science Plan. Investigations under theme 1 (juvenile migration and survival) are conducted in the Gulf of Alaska and the eastern Bering Sea. Multiple activities under research theme 2 (climate impacts) were described, including research cruises similar to those conducted under the Bering-Aleutian Salmon International Survey program, focusing on climate and climate cycle effects on salmon populations. No research programs were being conducted under theme 3 (winter survival) at the time of the workshop. With regards to theme 4 (long-term biological monitoring), "*investigations of salmon abundance is a long-standing objective with extensive catch accounting and monitoring of escapements to several hundred systems in Alaska and the Pacific Northwest*" (IYS-SG 2015b p. 4). Research theme 5 (stock identification) was also stated as being an on-going priority "particularly with respect to method development and monitoring of fishery catch composition" (IYS-SG 2015b p. 4).

Eric Volk, from the Alaska Department of Fish and Game, emphasized in the questionnaire that planning and performance of salmon research are structured in accordance with the concept of critical life history periods. Further development of stock identification methods is critically important since enhanced stock resolution is needed to answer broad scale questions. There are crucial knowledge gaps in the current understanding of species/stock age-specific growth and maturation schedules changing in marine habitats, effects of changing primary and secondary productivity cycles under influence of changing thermal regimes and ice dynamics, and salmon forage base dynamics. Relative to a problem of anthropogenic pollution, new research questions have been raised on the impact of micro plastic particles in the ocean on salmon and their prey.

Similarly to research objectives addressed by other Pacific salmon producing nations, there is a need in Canada to improve forecasts of hatchery and wild salmon abundances. There is also a need to describe, organize, and serve data that has been collected over the past decades. Canadian research priorities discussed at the First Scoping Meeting were highlighted by 12 research questions (IYS-SG 2015b p. 5):

- *How to develop shared data systems to enable comparisons of production and productivity of salmon populations across the North Pacific?*
- *What is the relative importance of density-dependent vs. episodic density-independent processes in regulating salmon survival?*
- *Where and when do juvenile salmon move off the continental shelf?*
- *Where do different populations of salmon migrate to in the North Pacific Ocean?*
- *What are the factors affecting the distribution of salmon in the North Pacific Ocean?*
- *What factors control the productivity of salmon prey in the North Pacific Ocean?*
- *What periods are "critical" and do they vary among species/year?*
- *How can we improve our ability to forecast salmon returns?*
- *How will salmon survivals/distributions be affected by climate change?*
- *What risks are posed to wild salmon by interactions with cultured salmon (including competitive interactions between hatchery and wild fish)? Does carrying capacity vary?*
- *Can genomics help us understand the role of pathogens and physiological condition on salmon survival?*
- *How to develop a cumulative effects approach to understand the key anthropogenic and natural factors affecting survival at each life history stage (freshwater, early marine, coastal, high seas)?*

Terry Beacham and James Irvine presented the Canadian research priorities at the meeting and especially pointed out the importance of studying climate change effects on the oceans as well as Pacific salmon adaptation capacity to new environmental conditions. In the questionnaires, they hypothesized that different migration routes and offshore rearing may account for salmon survival variation. Therefore, identification of region and time, where mortality directly correlates with subsequent returning abundance, might help to fill knowledge gaps related to salmon stock productivity, fishery forecasting and planning. The effect of increasing acidification on salmon prey and salmon growth and growth of anthropogenic noise pollution in coastal areas should be considered as notable sources of salmon habitat alteration. In a brief note regarding IYS ideas, Skip McKinnell also addressed the possible effects of ocean acidification on salmon prey organisms and how and when this may affect salmon food webs, in addition to the possible effects of glacial erosion on productivity in salmon habitat. Beacham emphasized in a note that genomic technologies offer high resolution of stock identification. It should also provide an answer to the question of whether differential gene expression among salmon stocks may account for

survival variability. Significance of interspecific and intraspecific competition for salmon body size and survival was also highlighted with a note that poor salmon nutrition might promote physiological stress.

Following the presentations by each country, integrative ways in which nation-specific research priorities could be included into the IYS initiative were suggested. These included: "*cumulative effects as a way to bring all of these questions together, life-cycle modelling as in important area of research that may address some of the issues, and data downloading to the next generation that was expanded to a need for more rapid knowledge transfer among scientific cohorts*" (IYS-SG 2015b p. 5).

A summary of the responses of the nine salmon experts who responded to the Secretariat's questionnaire can be seen in Table 2.1.

Table 2.1. Prioritization of emerging issues relevant to ocean salmon in 10–20 years (A) and knowledge gaps relevant to ocean salmon research and research ideas that needs to be conducted in the next three to five years (B) based on the NPAFC Secretariat questionnaire filled by nine participants of the First IYS Scoping Meeting.

No.	Topics A	Score*	No.	Topics B	Score*
1.	Ocean acidification	**34**	1.	Survival	**38**
2.	Changes in salmon habitat	**31**	2.	Distribution	**34**
3.	Ocean productivity	**31**	3.	Abundance	**33**
4.	Competition	**28**	4.	Migration	**30**
5.	Disease	**23**	5.	Climate impacts	**30**
6.	Freshwater productivity	**22**	6.	Critical life history periods	**29**
7.	Reduction of salmon distribution	**20**	7.	Salmon prey	**28**
8.	Domestication	**19**	8.	Stock identification	**24**
9.	Expansion of salmon distribution	**16**	9.	Forecasting run size	**24**
10.	Over-fishing	**15**	10.	Growth	**23**
11.	Salmon in polar regions	**14**	11.	Body condition	**21**
12.	Suitable salmon habitat connectivity	**11**	12.	Hatchery/wild interactions	**20**
13.	Pollution	**7**	13.	Salmon predators	**19**
			14.	Disease	**16**
			15.	Behavior	**16**
			16.	Genetics	**15**
			17.	Competition	**15**
			18.	Forecasting run timing	**13**
			19.	Abiotic habitat conditions	**13**
			20.	Genomics	**12**
			21.	Physiology	**11**
			22.	Pollution	**9**
			23.	Water quality	**7**

Remarks: Score is based on results of expert ranking, where 5 points were added to a set of scores for each first place, 4 points for each second place, 3 points for each third place, two points for each fourth place, and one point for each fifth place. Experts were free to list several first, second, third and other places to listed topics. Two experts additionally proposed several topics that could not score more than 2–5 points: In section A, ocean ecosystem models, salmon hatcheries, and regulation of hatchery release numbers; in section B, stable isotope analysis and salmon in marine trophic nets.

The experts mentioned anticipated changes in salmon habitat as the first priority emerging issue relevant to salmon stock conservation in 10–20 years, in addition to ocean and freshwater productivity, ocean acidification, and fish diseases. We should recognize that these matters concerned academia, civil society, the private sector, First Nations, and the community as a whole and they should be addressed in a framework of the IYS outreach programme.

Purpose of the IYS: A Social Benefit

The workshop progressed to a session on the purpose of the IYS, with an introduction on the origins and envisioned motivations by Richard Beamish, followed by a plenary discussion where other perspectives could be explored. The initial concept for the IYS began as an economic research programme supported by science as it was believed that political support for the initiative would have been limited otherwise (Beamish 2012). It was envisioned as a way to achieve a long-term goal of improving forecasting of changes in Pacific salmon abundance resulting from changes to climate and ocean conditions. It was also thought that it would serve to help optimize hatchery production by increased experimentation on release timings.

In addition to an economic benefit, however, a social benefit to the research initiative was brought forward during plenary discussions. An improved understanding and ability to forecast salmon abundances would initiate communication with communities that may be severely affected by declining salmon populations. Furthermore, "*linking salmon to people and culture would draw attention to an idea that the research conducted under an IYS was not simply self-serving, but for the greater goal of helping people with a strong interest in the resource*" (IYS-SG 2015b p. 5). The cultural value of salmon was also addressed, which is linked to conservation and restoration objectives of wild salmon, particularly to Indigenous Peoples and those who rely on the resource for subsistence. In some cases, the persistence of local salmon populations is very closely linked to the survival of human communities; as such, it was stated that there is a "*need for IYS science that was not based solely on economic arguments*" (IYS-SG 2015b p. 5). During final discussions on the purpose of IYS, understanding other aspects of salmon ecology unrelated to sampling to improve forecasting ability was also addressed, including studies looking into habitat, prey, and foraging behaviour.

Identification of Knowledge Gaps and Development of Research Ideas

The objective for the remainder of the first day was to develop a list of research ideas that would be required to understand factors affecting salmon production now and in the future. This detailed list would then be used on the following day to create a list of general research imperatives. This session began with an introduction by Kate Myers followed by a survey of individual opinions and group discussions. With regards to general knowledge gaps surrounding Pacific salmon research, a lack of detailed understanding of where salmon go in the ocean despite considerable attention paid to forecasting and measuring salmon productivity was discussed. The need to develop better models of where salmon go in the North Pacific was highlighted, especially considering the fact that the tools to provide this information are now available. Participants developed a list of criteria that should be considered when developing research objectives for the IYS (IYS-SG 2015b p. 6):

- *be accompanied by measurable indicators of the degree to which the objectives are met;*

- *be determined by assessing the sensitivity of simulation models to various kinds of perturbations and new research would be directed at those characteristics that have the greatest uncertainty;*
- *avoid framing outcomes as scaremongering and focus on why salmon and their ecosystems are changing;*
- *avoid biting off more than can be chewed;*
- *consider legacy and emerging issues such as human population growth, pollution, ocean acidification, offshore development;*
- *provide better information on migration, timing and distributions*
- *might focus on how humans are affecting salmon in the North Pacific;*
- *provide a better understanding of what is meant by ecosystem change;*
- *be a long-term project with short-term rewards;*
- *include a means of finding the human resources to conduct the research, given the current demographic of salmon biologists;*
- *consider whether commercial shipping might contribute to achieving IYS objectives;*
- *consider that industry will want a realistic vision of the future. It is good for business to understand future opportunities so they can adapt and benefit from this knowledge.*

It was stated that the existing framework of the NPAFC would help to undertake questions related to salmon distribution in the North Pacific as well as initiatives related to forecasting and carrying capacity. Issues that may be encountered were also discussed, however, including "*funding, optimizing the use of historical data, stock-specific distributions, and year to year variability*" (IYS-SG 2015b p.6). It was also suggested that data collection be directed at specific hypotheses and that the quantity of observations taken should be enough to improve forecasts, which themselves need to be better conceived. Another suggestion was that research questions be directed towards groups that will be utilizing the end result, specifically subsistence users and the commercial and processing sectors.

The identification of key research questions was initiated with a survey of individuals. Individuals were asked to write down three of their top research priorities which were later sorted into three categories: (1) critical questions related to specific juvenile freshwater salmon life-history phases (2) critical questions related to specific salmon marine life-history phases and (3) critical questions associated with all freshwater and marine salmon life-history phases, as well as a few cross-cutting issues. Detailed tables listing research topics under each of these three categories can be seen in the Report of the International Year of the Salmon Study Group Scoping Workshop (Appendix D; IYS-SG 2015b).

A list of potential research ideas, generated by round table and plenary discussion of knowledge gaps, can be seen below (IYS-SG 2015b pp. 6–7):

- *using societal benefits, such as examples of the NCBI/Human Genome projects that involved data intensive-data coordination activities that are well funded in some circles.*
- *selecting an international scope that will focus on distribution of*

salmon at sea and distributions within national waters;

- *testing hypotheses about winter marine survival*
- *determining the extent to which variations in ocean productivity affect salmon production;*
- *educating people about large ecological issues (examples of good models included NCEAS in California, Gulf Watch Alaska)*
- *determining spring and winter survival;*
- *understanding stock composition;*
- *understanding the carrying capacity of the ocean;*
- *understanding the effects of oceanic diseases and parasites on survival.*
- *determining the survival in coastal waters, especially where international cooperation is required to execute the research programs to achieve a better understanding.*
- *determining the consequences of future increases in Sea Surface Temperature (SST) and how it might affect inter- and intra-species competition;*
- *evaluating sibling ratio forecast models;*
- *understanding the influence of pink salmon on forecasts of abundance of other species;*
- *determining the role of hatcheries in the future of salmon survival;*
- *hatcheries can be used to understand freshwater contributions to survival by making hatchery and wild comparisons (if smolt quality is good);*
- *determining whether international regulations or guidelines are required for hatchery releases to achieve clearly articulated benefits from them. Coastal jurisdictions have different approaches to hatchery developments. The topic was seen as an important one, but with political consequences for raising it;*
- *to determine the drivers of enhancement activities. To understand their relationship with climate change, it would be appropriate to have an appropriately structured group to provide knowledge about trade-offs;*
- *determining if hatchery production affects the quality of salmon;*
- *determining the future effects of carbon pollution (ocean acidification) and its effect on salmon prey and food web structure. There are natural links to other international organizations that are studying this topic. There is variable capacity to monitor oceanic pH and most of it is occurring along coastlines.*
- *examining life-history stage transitions between freshwater and marine and other transitions;*
- *determining whether the first winter is important. Perhaps that winter survival is important, but factors affecting growth probably take longer.*

- *differences in life-history between coasts or between oceans may provide natural experiments and large contrasts to provide some insight.*

The final task of the first day of workshop was the development of criteria for prioritization of research topics. It was thought that topics under the categories of food security benefits (communicating social implications), cultural importance, international scope, relevance to end users, feasibility (doable in 3–5 years), and high impact should be used to prioritize the research topics discussed.

Clarification of Research Objectives

Due to some uncertainty with regards to overall objectives of the IYS from the previous day, day two of the First Scoping Meeting began with the presentation of a preliminary set of research objectives that was then refined to inform group discussions later in the day. Discussion points included the following criteria and suggestions:

- The IYS needs to be a formal international cooperative that will provide a science framework for policy makers and help address food security issues across the North Pacific against the backdrop of a changing environment.
- The goal is to produce an international network of information that everyone will have access to. There must be collaboration and cooperation on an international level as well as dissemination of information and participatory engagement.
- Use of the term "variation" should be avoided as it is not appropriate framing. There is a need to do something different as research has been focused on variation for a long time. Alternatively, language such as "reducing uncertainty" and "improving confidence" should be used.
- Possible funding could come from private organizations (potential for some public funding after popularity increases), other foundations (Moore Foundation, Packard Foundation, etc.), and big corporations (specifically with respect to international shipping).
- It may be beneficial to add a technology piece to appeal to the public, particularly on salmon movement.
- Indicators of success related to broad goals must be defined.
- A children's education/training theme could be implemented, potentially framed as a young scientist's conference. Capacity building could be carried out at universities and aboriginal communities.

Technological Advances

New developments in technology or new applications of existing technology that could be made possible with an IYS research programme were also considered. These developments would provide significant opportunities to improve understanding of salmon biology and their interactions with the environment. Possible advances in technology that were discussed included genetic stock identification, oceanographic and biological modelling, and undersea cabled observation networks.

In the brief note regarding IYS ideas mentioned above, Skip McKinnell addressed the benefits of using new technologies in the IYS initiative. "*Decades of tagging have provided only a relatively crude*

understanding of where and when certain species visit different parts of the ocean. New technologies have come online that will radically change the information flow from such activities." McKinnell also stated that colour sensing satellites could be used to detect mesoscale structures (fronts, eddies, jets) that are generally associated with increased biological productivity. These satellites could be used to determine sampling locations to see if feeding salmon are associated with these structures.

Development of Overarching Research Priorities

Overarching research priorities were developed from the topics discussed during the previous day. Participants were divided into four break-out groups (see Appendix D) to develop a research "portfolio" that should be addressed by the IYS. In the research portfolios, groups were asked to identify indicators of success, determine a set of research priorities related to the research objectives, state the accompanying research questions, document supporting rationale for what makes each priority so compelling, and if time allowed, articulate the scope of research (e.g., species, timeframe, geographic focus).

Group 1

Research priorities:

- Winter research
    - Focus on pink, chum, and sockeye salmon, or a subset where necessary
    - High-seas coordinated sampling and region-specific programs (case studies)
    - Cross-Pacific comparisons could potentially inform about key processes
    - Stock ID with genomics
- Fraser River sockeye and Russian pink salmon as a data-rich systems (especially for stock composition)
- Build multi-stock data sets for hierarchical statistical analysis to generate key questions about processes
    - For instance, why do Alaskan pink and sockeye salmon show positive changes in recruits-per-spawner with increasing SST, whereas BC and Washington show a decrease?
    - Where are the fish during the first 9 months? What are the associated features of the ocean?
- Develop more programs to estimate abundance of seaward migrating life stages (smolts for sockeye salmon, fry for pink and chum salmon)
- Can we still get useful information from scale archives?
- Growth and survival rate differ in how rapidly we can learn about the causes of observed changes
    - Growth can be estimated much better than survival rate
    - Need both because total biomass of adults is the key end variable
- Can genomics help understand condition?
    - Must sample a large number of variables of each fish
- Current information suggests fish are "homing" to certain areas on the high seas; can they respond to climate change to move to another area?

Research questions:

- Winter research
    - Where are stocks at different times in the winter, and are they non-randomly distributed?
    - Are their locations related to oceanographic variables (e.g., sea surface temperature, currents, etc.) or are the fish in the same places across years, regardless of ocean conditions?
    - Are those locations genetically influenced?
- Which ages/places are most important for interannual variation in survival or growth? The answers would probably be specific to each regional case study.
- By what mechanism could ocean acidification affect salmon?
- How do high abundances of pink salmon affect growth and survival of sockeye salmon?
- To optimize hatcheries, are increases in hatchery releases affecting growth and survival of both wild and hatchery fish?
- Is there size-selective mortality in the winter and what is the relative importance for total recruitment?

Supporting rationale:

- How can fisheries managers make better decisions based on new information generated by IYS research?
    - Best to have causally-based explanations, not correlations
- Succinctly describe a few examples of how IYS research can be used
- Tie the results of IYS research results to projections of future states and providing a baseline for future comparisons

Group 2

Indicators of success

- Seasonal mapping and related products to support public engagement and interaction with end users
- Improved forecasting is not a proposed deliverable of IYS (likely not feasible in time frames of IYS)

Research priorities:

- Stock specific sampling of distribution and abundance in coastal and open ocean areas across seasons, accompanied by collection of environmental data with fish condition and health
- Smolt monitoring (survival and relative abundance)
- International harmonization/standardization of data collection, data management, and data sharing
- Coordinated hatchery manipulation

Group 3

Research questions:

- Spatiotemporal effects of environmental variability on salmon life stages across the North Pacific
- Develop measures of risk of salmon to environmental and humans pressures
- Develop tools for evaluating management actions to mitigate risks

Measures of success and evaluation of risk and actions:

- Engagement with stakeholders and researchers
- Determine drivers (e.g., human population growth, climate change, climate variability)
- Identify pressures related to each driver
    - Human population growth (energy demand, food needs, coastal development)
    - Climate change (SST increase, changes in habitat)
    - Climate variability (forage diversity, advection)
- Identify indicators of the state of each pressure
    - For human population growth:
        - Energy demand (number of dams, barrels of oil)
        - Food needs (area of agriculture, amount of water removal for irrigation)
        - Coastal development (number of houses, beach development)
- Evaluate Risk: build out models such as that shown by Randal to evaluate sensitivity and create measures of risk on salmon from the suite of indicators determined before
- Evaluate our capacity to mitigate risk: tune the different "boxes" of the web of indicators

Additional comments from Group 3 included the issue of food security versus salmon resource stability.

Group 4

Stock-specific distribution and abundances of salmon throughout their life-cycle:

- Collection of new distribution and abundances from research surveys
    - Apply new data for retrospective analyses of historical catches
- Marine productivity (bottom-up)
    - Do salmon cue on hydrological features and associated prey concentrations?
- Predation (top-down)
    - Is this a source significant?

Hatcheries:

- Are odd/even pink salmon different species?
    - Differential mortality
- What is optimal hatchery production in the North Pacific and where should hatcheries be located?
- What is the optimum release strategy?

Indicators of Success:

- Identify research goals and objectives on salmon that require collaboration around the North Pacific (i.e., those that can't be achieved by one country alone)
- Role in advising public/decision makers about future of salmon in a changing climate
- IYS helps introduce fisheries into the "food security" dialog
- Engagement of a broad spectrum of participants (academic, NGOs, RFMOs, industry, etc.) in an IYS framework
- Measurable/quantifiable output
- Enhanced cooperation among western Pacific producing countries.

Commonalities between research priorities expressed by participants were associated with the following topics: (IYS-SG 2015b p. 8):

- *Winter ecology*
- *Baseline information including data management and standardization*
- *Spring/summer (early ocean) mortality*
- *Ocean productivity/carrying capacity*
- *Stock interactions*
- *Run forecasting*
- *Life-history, multi-population species comparison*
- *Human impacts (hatcheries, fishing, pollution)*

Indicators of success were also identified by some participants and commonalities between groups included engagement in the IYS by a broad range of participants, as well the initiative helping to introduce fisheries managers into the "food security" dialog.

The First Proposal for the IYS

On February 19, 2015, most members of the IYS-SG met to consider material that was presented and discussed at the First IYS Scoping Meeting, make recommendations to the CSRS on the IYS initiative, and begin the process of drafting what would become the Proposal of the CSRS Study Group on International Year of the Salmon (IYS)—hereafter referred to as the 'First Proposal' (Appendix E; IYS-SG 2015a). IYS-SG members that were absent from the meeting included Maxim Koval and Richard Lincoln. Additional attendees, invited by the IYS-SG Chairperson, included Robie Macdonald (Emeritus, Fisheries & Oceans Canada), and consultants Skip McKinnell and Marc Nelitz.

Concept

The First Proposal defines the IYS as an intensive burst of interdisciplinary, internationally coordinated research focused on salmon and their relation to people. New technologies, new observations, and new analytical methods will be used to address "*knowledge gaps that prevent a clear understanding of the future of salmon in a rapidly changing world*" (IYS-SG 2015a p. 2). Five broad research themes were listed as follows (IYS-SG 2015a p. 2):

1. *Status of Salmon: to understand the present status of salmon and their environment.*
2. *Salmon in a changing salmosphere: to understand and quantify the effects of natural environmental variability and anthropogenic factors affecting salmon distribution and abundance and to make projections of their future changes.*
3. *New Frontiers: to develop new technologies and analytical methods to advance salmon science and to explore the uncharted regions of the salmosphere.*
4. *Human Dimension: to investigate the cultural, social, and economic elements that depend upon sustainable salmon populations.*
5. *Information Systems: to develop an integrated archive of accessible electronic data collected during the IYS and tools to support future research.*

In pursuing these research themes, the First Proposal states that the IYS aims "*to leave a legacy of new or enhanced observational systems, research networks, as well as an unprecedented degree of access to the data and information it will generate*" (IYS-SG 2015a p. 3). Outreach objectives included the goal of attracting and developing a new generation of researchers, as well as generating worldwide interest and involvement of students, the general public and decision-makers.

Rationale

A rationale for the IYS emphasized the link between the well-being of people and salmon. Salmon are of great importance ecologically, economically, socially, and culturally. They are also important source of food security and will become an even greater contributor to this emerging issue in the future. A better understanding of the future of salmon populations is needed, particularly in the face of environmental changes occurring in the salmosphere that will have an effect on salmon distribution and abundance. An understanding of how these changes will play out requires an understanding of the cumulative effects of a wide-ranging number of human and natural factors affecting salmon in order to determine what can be managed and mitigate what cannot. "*An intense burst of international research can provide the field observations to address knowledge gaps as well as the analytical tools, technologies and a new generation of scientists to facilitate the unprecedented international collaboration required to sustain salmon and people in a rapidly changing world*" (IYS-SG 2015a p. 3).

Timeframe

Due to rapid environmental change occurring in the 21st century, it is essential that the IYS is initiated as soon as possible. Current understanding of salmon in the ocean is not adequate to be able to forecast the consequences of these changes, but recent technological developments have made it possible for researchers to make significant progress in this regard. Additionally, as salmon distributions span international boundaries and large-scale processes are responsible for affecting salmon distribution and abundance, an international approach to research must be taken. Scientific expertise is also distributed among nations, and common management and research objectives foster cooperation, which also allows for costs and benefits to be shared among nations.

The timeframe for the IYS put forward in the First Proposal was to have activities develop through a planning and preliminary phase to a peak in 2018–2019, and decline over a period of 7 years. The presence of a focal year(s) provides for better planning and coordination and a focal period of two years is suggested due to anticipated changes in national budget cycles, and also allows for a comparison of even and odd years for pink salmon, the most abundant species of Pacific salmon.

Scope

The proposed geographic scope of the IYS is the salmosphere—defined as the current and future geographic range of salmon in the Subarctic and Arctic Ocean. Species to be considered under the IYS are anadromous members of the sub family Salmonidae, which include the salmons, trouts, and charrs, but exclude graylings and whitefishes. It is suggested that studies regarding farmed salmon should not be considered unless they address an interaction between wild and farmed fish. Further establishing the scope of the initiative, the First Proposal states that it was necessary to establish international partners in the Atlantic in order to create a hemispheric IYS. Many concerns facing salmon conservation and management (e.g., declining abundances and farmed and wild interactions) are common to both the Pacific and Atlantic regions and comparisons between regions would provide valuable ways of understanding ecosystem variability.

Benefits

An IYS would provide a variety of social, economic, and academic benefits through cooperative effort between nations, organizations, and individuals. Typical outputs of a large research programme would be produced, including new and improved distribution maps, better models, and linked and shared data systems. Unlike other research programmes, however, the cooperative approach of the IYS would "*produce a demand for new international standards in methods and data exchange, where none currently exist*" (IYS-SG 2015a p. 7), leading to improved collaboration, understanding, capacity, and awareness. The IYS would also provide aboriginal communities with information necessary to support their cultural practices and the food requirements of their communities. It would also result in better informed regulation and management policies for all salmon-producing countries.

Recommendations

In addition to research activities, the First Proposal states the need for a communication and engagement strategy to facilitate communication between salmon researchers and target audiences, which will include students, young scientists, indigenous peoples, salmon-dependent communities, managers, salmon fishers, seafood industry, and the general public. The initial funding objective for the IYS was to generate enough interest by developing a compelling argument presented in an attractive format with simple descriptions of the need for an IYS in order to gain support from government, as well as business and industry. Additional support and partnerships could come from associations of fish harvesters, conservation foundations, and NGOs. A complete list of potential partners can be seen in Table D.1 of the First Proposal (Appendix E), in addition to detailed descriptions of field and analytical research priorities under each of the research themes.

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