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Report of the International Year of the Salmon Study Group Scoping Workshop

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Abstract
An international workshop was organized and convened in Vancouver, Canada by the Study Group on International Year of the Salmon (SG-IYS, February 17 – 18, 2015). It was attended by most members of the SG-IYS plus invited scientific experts from the member countries. The workshop was structured as a series of facilitated discussion panels, short presentations, and group discussions designed to inform the SG-IYS. This document is a report of the Scoping Workshop. The SG-IYS met immediately after the two-day workshop to develop a compelling case for new coordinated research directed at key scientific issues affecting the future of salmon in the form of a proposal for an International Year of the Salmon.

Background
In 2012, a proposal was made to NPAFC by Canada to establish a major research initiative around the idea of an International Year of the Salmon (Beamish 2012). Discussions ensued within the NPAFC leading to the creation of the Study Group on International Year of the Salmon (SG-IYS) in 2013. Mark Saunders (Canada) was appointed Chairperson. In 2014-2015, Study Group membership also included Shigehiko Urawa (Japan), Ju Kyoung Kim (Korea), Max Koval and Alex Zavolokin (Russia), and Rich Lincoln and Eric Volk (USA).

At the May 2014 Annual Meeting, the Commission directed the SG-IYS to further scope the initiative and provided the following Terms of Reference (Records of the 22nd Annual Meeting, p. 112):

> *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:*
>
> - *Scope of the Program (Pacific-Atlantic, Farmed Salmon and other ecosystem considerations, etc.)*
> - *Benefits of the Program*
> - *Potential for Funding and Identification of Partners (NGO's Industry, State and Federal Agencies, other RFMO's, etc.)*
> - *Communications and Outreach Strategy*
> - *Identification of Field and Analytical Research (Strategic Research Plan)*
> - *Starting Year and Duration*

The SG-IYS convened a Scoping Workshop (February 17 – 18, 2015) in Vancouver, Canada with members of the SG-IYS and invited scientific experts from the member countries to inform development of recommendations on the nature of IYS, in particular the scientific objectives. This document is a report of the Scoping Workshop. In addition to the Study Group members, others contributed to the drafting of this report including, Skip McKinnell (Salmoforsk International), Marc Nelitz (ESSA), and Nancy Davis and Vladimir Radchenko (NPAFC Secretariat).

The SG-IYS met on February 19, 2015 to consider the information presented at the Scoping Workshop and draft the IYS proposal. The IYS proposal is in a separate report.

Motivation

Among all of the animals that serve as a source of food for humans, salmon are iconic. Their wide-ranging habit of migrating from freshwater to the ocean and back are indicators of ecological health. Salmon are highly valued culturally simply for their presence, socially as a source of food and economically as a source of wealth through fisheries and tourism. The well-being of humans and salmon are linked in coastal communities. Indigenous peoples, resource managers, fishers, processors, businesses, governments have demonstrated a need to understand what drives the variation we see in salmon abundance now and into a future with climate change.

Salmon abundance fluctuates on intra-annual to decadal scales and the causes of these variations have not yet found convincing explanations in any ocean. Climate change is expected to introduce additional variability so it is time to increase the efforts of researchers to discover the fundamental mechanisms regulating production. Facing such uncertainty, the Study Group (SG) sought advice from invited experts as it prepared to develop a new proposal for a multinational, multidisciplinary, multi-year research effort directed at critical unknowns associated with salmon production. Collectively the activities conducted within this major research program will be known as International Year of the Salmon (IYS).

Anticipated Results

The workshop was structured as a series of facilitated discussion panels, short presentations, and group discussions designed to capture the information required to inform the SG-IYS. The SG-IYS met immediately after the two-day workshop to draft the proposal. The goal of the SG was to develop a compelling case for new coordinated research directed at key scientific issues.

Welcome & Introductions

Study Group Chairperson Mark Saunders (Canada) called the International Year of the Salmon Scoping Workshop to order at 0900, February 17, 2015. The venue for the workshop was the boardroom of the secretariat of the Pacific Salmon Commission (PSC). Its Executive Director, John Field, spoke first to welcome the participants (Table 1) and to comment on the potential importance of this initiative. He described the history and role of the Pacific Salmon Commission (PSC) and noted the shared goals of the PSC and the NPAFC. Dr. Vladimir Radchenko, Executive Director of NPAFC, spoke next to welcome the participants and review the charge of its Commission to the Study Group. Mr. Saunders introduced himself and described the objectives of the workshop and the workshop agenda (Table 2). Self-introductions of the participants continued until Mr. Saunders closed the introductory session with a review of the motivation for the initiative, focusing on what research needs to be done and why. Mr. Saunders introduced the workshop facilitator, Mark Nelitz (ESSA Ltd.), who reviewed the workshop objectives and described his role as facilitator.

Objectives

The main objectives of the workshop were to:

- 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.
- identify the unknowns and scientific questions related to each issue.
- discuss the scope (spatial, temporal, species) of an IYS that will be needed to answer the questions (test the hypotheses).

National Salmon Research Priorities

<u>NPAFC Science Plan (S. Urawa, Chairperson of the CSRS Science Sub-Committee (SSC))</u>

The Chairperson of the SSC reviewed the current 5- year NPAFC Science Plan. The NPAFC Science Plan is a long-term comprehensive guideline for cooperative research. Member countries conduct national research under the Science Plan. The plan has been revised almost every 5 years after reviews of research progress. The goal of the current 2011-2015 Science Plan is to explain the annual variation in Pacific salmon production. The overarching theme is "*Forecast of Pacific Salmon Production in the Ocean Ecosystems Under Changing Climate*", and five research components are identified:

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.

Progress under the current Science Plan will be reviewed at NPAFC Symposium in Japan on May 17-19, 2015. He described how the IYS might contribute to or be part of the next NPAFC Science Plan.

Japan (S. Urawa)

Japanese salmon research priorities were reviewed. There is a trend of declining chum salmon abundance in Japan since 2004, but the temporal pattern of changes differs among three regions (Pacific, Okhotsk Sea and Japan Sea coasts) of northern Japan. Annual fluctuations are also observed in the age and body size of adult chum salmon returning for spawning. It is a mission for researchers to examine the mechanisms of variations in salmon abundance and body size. Respecting the seasonal migration model of Japanese chum salmon, the national proprieties of ocean salmon research are:

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.

One hypothesis is that the survival of juvenile chum salmon migrating from the coastal water to the Okhotsk Sea is the highest key to determine regional chum salmon returns. Juvenile salmon study in the Okhotsk Sea is very important to understand the early marine survival of chum salmon. There is another hypothesis that the body size and age of chum salmon at maturity are determined by habitat condition in the Bering Sea. Thus a long-term monitoring of salmon has been conducted in the central Bering Sea during summer since 2007. The Gulf of Alaska is an important overwintering habitat for chum salmon stocks from around the Pacific Rim. In addition, the western Subarctic Pacific is the first winter habitat for Asian chum salmon. However, it is still unknown whether the winter is a critical period for salmon in these waters.

Republic of Korea (J-K. Kim)

Korean salmon research priorities were summarized and the history of releases and catches of chum salmon in Korea was reviewed. Studies are focusing on the relationship between currents and migration routes near Korea. Charter fishing vessels have been used to catch juvenile salmon out to 5 km. Long-term research is required clarify information about Korean salmon biology. Japanese research indicates that Korean chum salmon have been found in the Bering Sea. Research associated with otolith marking will continue as well as investigations on juvenile salmon and their prey around the coast of Korea. All Korean chum salmon are released from hatcheries. Adult abundance is very low so all are utilized for hatchery production. There is no information about North Korean salmon populations. Cooperative research was initiated at the beginning of the century, but was not sustained. Efforts are being made to educate the Korean public about the importance of salmon in Korean rivers.

Russian Federation (A. Zavolokin)

Russian research activities and emerging priorities in eastern Russia. The freshwater period is well studied on the main rivers and this information is used as a basis of forecasts. The early marine period is a critical period of marine life, but the long coastlines and large numbers of rivers make the studies very difficult. The main goals of estuarine and inshore surveys are intend to improve forecasts of abundance, and comprehensive studies of biotic and abiotic parameters that affect salmon production. High seas surveys are conducted in the Okhotsk Sea, western Bering Sea, and Pacific Ocean. The main goals of these surveys are: 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. To improve forecasts, high seas surveys are conducted each year. Stock identification is an important component of the forecasts as it provides regional information about abundance using scale patterns, otolith marks, and genetics. Russian studies also focus on factors of salmon mortality such as predators, diseases and parasites. Another important issue is assessment of the role of Pacific salmon in marine ecosystems and its dynamic including: (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. This ecosystem approach has been conducted in Russia for more than 30 years. Current priorities of Russian research include: 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.

Carrying capacity is an extremely difficult research area and Russia is only in the beginning of this kind of assessment. High seas information improves forecasts, but there is a great need for stock composition. Stock identification includes all salmon species with an emphasis on the most abundant species: pink salmon, chum salmon, and sockeye salmon. Surveys are conducted in the fall prior to maturity, giving a 1 year lead time, with follow-up surveys in the North Pacific and Bering Sea about 2-3 months before the fishery. Forecasts are not very accurate presently and that is a problem for planning fisheries. The Aniva Bay pink salmon fishery, for example, in 2006 was 6 times larger than the large run that was forecast.

United States of America (E. Volk)

Research priorities of the USA were summarized in the 2014 CSRS Report (NPAFC Doc. 1545). Research theme 1 (juvenile migration and survival) investigations take place in coastal waters of Gulf of Alaska and the eastern Bering Sea and includes repeated habitat measurements, fine scale field studies, genetic stock identification, growth, and archival tagging of mature and immature salmon. Research theme 2 (climate impacts) is investigated on BASIS-type cruises, which occur every other year in the eastern Bering Sea, focused on climate and climate cycles and their effects on various aspects of salmon production. The ADF&G is collaborating with NOAA to calibrate paired trawl surveys between the large NOAA vessel and the smaller ADFG vessel so that meaningful surveys may be conducted in the absence of the larger platform. . Survival and growth of juvenile Yukon River Chinook salmon during their early marine life is being investigated in the river prodelta, and there are hopes to keep a program alive with the idea of developing a forecasting index. There is long-term oceanographic monitoring in Gulf of Alaska, including physical oceanography, primary/secondary productivity, forage fish species and marine mammals under the Gulfwatch Alaska program , with a planned duration of 20 years. .. Research theme 3 (winter survival) is not an active area of research in Alaska. Research 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. . Datasets are spread geographically, but may be a good resource for a variety of studies. There are many data sets that could be mined with records dating back many decades (e.g. Auke Creek has a 40-year record). An extensive CWT data resource and catch sampling program is still providing stock-specific information for hatchery and wild salmon. Research theme 5 (stock identification) is an on-going priority, particularly with respect to method development and monitoring of fishery catch composition. In 2012, ADF&G completed one of the largest mixed-stock genetic stock identification projects ever undertaken in fisheries of western Alaska. There is a large amount of information available online for catch composition of chum and sockeye salmon in all major fisheries of Western Alaska. . Active research programs investigating effects of hatchery production on fitness of wild stocks is occurring in Alaska and the Pacific Northwest.

Canada (J. Irvine)

The salmon research priorities of Canada were summarized. There is a need to describe, organize, and serve data that were collected during the past decades. A group of international collaborators led by Shoshiro Minobe

(Hokkaido University) are collecting data from all over the North Pacific to examine salinities and temperatures where salmon were/weren't caught. There is a need to improve estimates of hatchery and wild salmon abundances. A new database of recruits and spawners is being released, with new quality control filters based on a rating system that has been developed. A technical report is being published that contains the details of the procedures and the results with the data made available online. This data could be expanded to include other populations from throughout the North Pacific. There is a need to do a better job of assembling, evaluating, and distributing the data.

Twelve research questions were highlighted based on the presentations on national priorities.

- 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)?

Discussion

Suggestions were made to include topics related to these questions including: 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.

Purpose of the IYS (Introduction by R. Beamish)

The IYS idea was spawned as an economic program supported by science (NPAFC Spec. Publ. No. 1). Without an economic approach, it was felt that political buy-in to the program may be limited. Generally, the goals of an IYS were to improve long-term forecasting, motivated by changes in abundances that have been observed, and to determine their relationship to climatic and oceanic conditions in a changing world. The IYS was imagined as a way to reach this objective. It might also serve to optimize hatchery production programs by experimenting with release timing to achieve maximum survival and to use this knowledge for the benefit of wild salmon forecasts. Improved understanding and improved ability to forecast abundances were also thought to be important for social as well as economic reasons. This knowledge would allow greater confidence to communicate the problems that are likely to arise in areas where salmon may not persist. 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. An IYS may also draw attention to conservation objectives and restorations of wild populations, which in turn are linked to cultural values, especially for Indigenous Peoples. Hatcheries are more important to the economic role of salmon in recreational and commercial fisheries. Attention was drawn to the need for IYS science that was not based solely on economic arguments, and in that regard, participants were advised not to underestimate the importance of salmon to Indigenous Peoples and to those who use the resource for subsistence. The survival of human communities, in some cases, may be intimately connected to the survival of the local salmon. The discussion ended with a comment that understanding and forecasting future abundances might require that IYS research be directed more to the environment of salmon (habitat, prey, behaviour) than to the salmon themselves.

R. Peterman discussed approaches to improve understanding and measurable indicators for each of the research objectives that might be considered. Suggestions included use simulation models at the beginning and standardizing variables measured across populations.

Indentifying knowledge gaps (Introduction by K. Myers)
It was noted that the freshwater life-history phase is the most critical period for salmon productivity because such large numbers of individuals are affected by small variations in survival rates. The early ocean/juvenile life-history phase is critical for ocean survival, while the high seas phase has a greater influence on migration timing and fecundity. The history of efforts to plan for salmon research was reviewed as were aspirations for new initiatives in the NPAFC Convention Area. In general, there is a lack of detailed knowledge of where salmon go in the ocean, but considerable attention is paid to measuring productivity and to forecasting. Better models are needed for where salmon are located in the North Pacific. The tools have emerged during the last 30 years to provide this information.

Discussion
Participants commented that research objectives should:

- 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.

NPAFC is well positioned to take on questions related to distribution in the North Pacific, to contribute to research initiatives in forecasting and determining carrying capacity. Issues include funding, optimizing the use of historical data, stock-specific distributions, and year to year variability. Data collection could be directed to testing specific hypothesis. The quantity of observations should be adequate to improve forecasts. The development of forecasts needs to be better conceived, and research questions need to consider what matters to the end users of the information: subsistence users and the commercial and processing sectors.

Critical Unknowns
The identification of key research questions began with a survey of participants. Topics suggested included:

- 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 NCIES in California, GulfWatch in 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 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 foodweb 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.

Criteria for Setting Priority Among Proposals
Proposals should describe the benefit of the new knowledge, noting that the timeframes will differ among clients. Some criteria included:

- food security (communicating the social implications)
- cultural importance
- international scope
- relevance to end users
- feasibility (do-able in 3-5 years)
- impact

Research Topics
Participants were subdivided in 4 breakout groups to take the information developed on the first day and condense and refine the list of issues created on the first day. These issues were used to develop a research "portfolio" that IYS should address. Each portfolio should include information on: (1) a set of research priorities related to the research objectives, (2) the accompanying research questions, (3) supporting rationale for what makes each priority so compelling, and as time allows (4) the scope of research (e.g., species, time horizon,

geographic focus).

The views expressed by individuals were consolidated around the following research topics:

- 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)

Panel on Technological Advances

New tools and developing technologies are providing remarkable opportunities to improve understanding of the biology of salmon and their environments. Examples are genetic stock identification, satellite remote sensing (ocean colour, altimetry, temperature), drifting ocean profilers, undersea cabled networks, earth system models, etc. Some are yet to be developed. An IYS could provide an opportunity for significant new developments in technology or new applications of existing technologies directed at understanding salmon biology.

<u>Advances in Genetic Stock Identification (T. Beacham)</u>

Analysis of protein variation (allozyme) was the first technique used to examine genetic differences among populations. It was used from the 1960s to the early 1990s, but was replaced by genotyping which examined DNA variation directly. Two main classes of DNA variants developed: microsatellites and single nucleotide polymorphisms (SNPs). The key reaction that allowed the technique to develop was polymerase chain reaction (PCR). SNP variation is determined by direct DNA sequencing of specific amplicons. Amplicons are specific sections of DNA that are known to contain SNPs and which are amplified by PCR primers. This technology has allowed for highly multiplexed PCR reactions, where up to 500 individual reactions on 1,000-2,000 individuals are genotyped per chip. It has lowered the “per fish” cost of genotyping compared to existing alternatives.

<u>Oceanographic and biological models (H. Batchelder and B. Wells)</u>

Ocean circulation models such as ROMS (Regional Ocean Modelling System) can be coupled with biological productivity models (eg. NEMURO and COSINE) to capture the magnitude of ecosystem variability in open ocean and coastal environments. When verified against observations, these bio-physical models can be powerful tools for studying the relationship between salmon distribution, migration, and survival. They can be used to fill in the gaps between observations and can be used to explore match-mismatches between biology and oceanic productivity. Models can be used to quantify functional relationships between salmon in their environment. Studying salmon in bio-physical models can lead to better hypotheses that direct new observations toward critical unknowns.

Individual-Based Models (IBMs) are used within bio-physical models to simulate how salmon interact with their oceanic environment. Using reasonable assumptions about prey and temperature, a bioenergetics model reproduced the observed growth patterns of coho salmon in 2000 and 2002 in the California Current (GLOBEC Program, Figure 1). Coho salmon growth was positive in all simulations, even at low prey densities, implying that fish mortality may be determined by predation rather than ocean productivity. Random foraging by juvenile coho salmon was sufficient to sustain basic fish metabolism and allow moderate growth, however the final size range is below observed values based on random foraging. Optimal foraging enabled final coho salmon size distributions to be closer to what was observed.

<u>Undersea cabled observation networks (A. Sastri)</u>

During the past decade, Canada made significant investments into new technology that provides continuous streams of data from the ocean through undersea cabled observatories. Electrical power is delivered to nodes of co-located instruments. Communications to/from the instruments are possible with high resolution data being provided in real-time. A sophisticated data infrastructure has been developed to suit multiple types of very high resolution data, along with sophisticated data archiving capability.

Why Improve Understanding of Variation in Salmon Abundance

Improved understanding of the causes of variations in abundance of salmon to a level that will allow for better forecasts of future variations in abundance is related to issues of:

- food security where salmon is a dietary staple,
- economic security where participants in industries related to salmon are forewarned with sufficient time to mitigate the consequences of changes in abundance,
- provide improved short term forecasts of abundance and, potentially. behaviour of salmon.

Table 1. Participants at the International Year of the Salmon Scoping Workshop. The “member” role indicates Study Group members who attended the scoping meeting, February 17-18, 2015, Vancouver.

Name	Country	Role	Agency	Breakout Group
Mark Saunders	Canada	Member	DFO	1
Alex Zavolokin	Russia	Member	TINRO-Center	1
Terry Beacham	Canada	Participant	DFO	1
Randall Peterman	Canada	Participant	SFU (emeritus)	1
Mike Lapointe	PSC	Participant	PSC	1
Kate Myers	United States	Participant	UW (retired)	1
Vladimir Radchenko	NPAFC	Organizer	NPAFC	1
Eric Volk	United States	Member	Alaska Dept. of Fish & Game	2
Marc Nelitz	Canada	Organizer	Essa Ltd.	2
Dan Selbie	Canada	Participant	DFO	2
Hal Batchelder	PICES	Participant	PICES	2
Steve Latham	PSC	Participant	Pacific Salmon Commission	2
Greg Ruggerone	United States	Participant	Natural Resources Consultants	2
Nancy Davis	NPAFC	Organizer	NPAFC	2
Shigehiko Urawa	Japan	Member	Fisheries Research Agency	3
Jim Irvine	Canada	Participant	DFO	3
Stewart Johnson	Canada	Participant	DFO	3
Brian Riddell	Canada	Participant	Pacific Salmon Foundation	3
Francis Juanes	Canada	Participant	University of Victoria	3
Brian Wells	United States	Participant	NOAA/NMFS	3
Ju Kyung Kim	Korea	Member	FIRA	4
Dick Beamish	Canada	Participant	DFO (emeritus)	4
Ian Perry	Canada	Participant	DFO	4
John Field	PSC	Participant	Pacific Salmon Commission	4
Akash Sastri	Canada	Participant	University of Victoria	4
Skip McKinnell	Canada	Organizer	Salmoforsk International	4

Table 2. Agenda of the International Year of the Salmon Scoping Workshop (February 17-18, 2015, Vancouver).

February 17—DAY ONE: The main goal for today is to create a detailed list of research ideas/issues/questions based on a panel discussion reviewing current and emerging national priorities and the participants identifying knowledge gaps in round table discussions.

0900 Welcomes (Radchenko, Field, Saunders)

0915 Introduction of participants (Saunders)

0930 Workshop objectives and organization (Saunders/Nelitz)

0945 **NPAFC Science Plan – current and emerging national priorities:** Panel Discussion (IYS Study Group members: Saunders, Urawa, Kim, Zavolokin, Volk)
NPAFC has a long history of developing and implementing science plans. One member of the panel (Urawa) will briefly summarize the current NPAFC science plan. A representative from each member country will then briefly highlight the national priorities that have emerged from research activities that have already occurred. This summary is intended to help clarify the context for IYS to ensure it is consistent with the emerging national priorities of member countries, rather than provide a detailed summary of research activities of member nations.

1115 **Purpose of IYS – What are the problems IYS should address?** Introduction (Beamish) and Plenary Discussion
The session will begin with a brief introduction on the origins of IYS and its envisioned motivations. There will then be time to explore perspectives of others through plenary discussion.

1300 **Identifying knowledge gaps – What new knowledge is required** Presentation (Myers), Silent Generation, Round Table, and Plenary Discussions
The remainder of the day is dedicated to developing ideas for new research required to understand the factors affecting salmon production now and in the future. The objective for the day is to create a list of research ideas, developed from individual opinions and discussion that will serve as the basis of developing general research imperatives on Day 2.

- What are the big unknowns that demand attention?
- What has changed and what is changing?
- What can be done to provide fishery managers and regulators with better advice?

Each participant will be asked to write down their top 3 research priorities or specific research questions that address these motivating questions and then briefly elaborate on one of them.

1530 **Identifying knowledge gaps – continued** Round Table and Plenary Discussion
1630 Daily wrap-up, assignments (Saunders/Nelitz)
1700 Adjourn

February 18—DAY TWO: The main goal for day two is to distill a compelling list of overarching research priorities from the detailed list of ideas developed on Day 1. The day will begin with a review and discussion of preliminary research objectives. Breakout groups will then be convened to condense and refine the list of issues from the previous day with each group reporting out in plenary. A short panel discussion on new and emerging technologies will be provided in the afternoon. Concluding discussion at the end of the day will touch on related issues such as when, how, and what scope, in addition to opportunities for capacity building, and previous experience with large research programs. At the end of the day, the Study Group hopes to have enough information to create a proposal for an IYS.

0900 Introduction to Day 2 (Saunders/Nelitz)

0915 **Research objectives** Plenary Discussion
Based on a request for clarity from the previous day, a preliminary set of research objectives will be presented and refined to inform breakout group and plenary discussions throughout the day.

1030 **Technological Advances (Ocean Observing, Genomics, Modelling, etc.)** Panel Discussion (Sastri, Beacham, Batchelder, Wells)
New tools and developing technologies are providing remarkable opportunities to improve understanding of the biology of salmon and their environments. Examples are genetic stock identification, satellite remote sensing (ocean colour, altimetry, temperature), drifting ocean profilers, undersea cabled networks, earth system models, etc. Some are yet to be developed. An IYS could provide an opportunity for significant new developments in technology directed at understanding salmon biology. Does this inform development of scientific objective/research themes/activities?

1300 **Major scientific issues and key questions** Breakout Group Discussion
Participants will be subdivided in 4 breakout groups. The goal of each group is to use the research objectives to condense and refine the list of issues created on Day 1. These issues will be used to develop a research "portfolio" that IYS should address. Each portfolio should include information on: (1) a set of research priorities related to the research objectives, (2) the accompanying research questions, (3) supporting rationale for what makes each priority so compelling, and as time allows (4) the scope of research (e.g., species, time horizon, geographic focus).

1445 **Major scientific issues and key questions** Plenary Discussion (Saunders/Nelitz)
In plenary, a representative from each group will describe the results of their group discussion and present their list of priorities. Results will be compared and discussed to identify commonalities and areas of divergence with the goal of developing general agreement on the most compelling issues and key questions.

1645 Wrap- up, next steps, and closing (Saunders)

Table 3. Critical questions related to specific juvenile freshwater salmon life-history phases identified at the IYS Scoping Meeting.

Eggs/alevin (incubation/emergence)	**Fry/parr (juvenile rearing)**	**Smolt (emigration/estuary)**
Role of synoptic processes (e.g. climate change & phenology) on egg incubation & emergence and therefore total productivity (poor data representation) Flow (climate change, inter-annual variability) Temperature (bioenergetics) Prey base Predation	Preferred prey is not sufficient. Can abundance be experimentally adjusted to determine effects on survival and growth? (SL)	Overwinter and outmigration survival of parr/smolts Species comparisons to understand factors regulating species that are doing poorly (e.g., pink and chum vs. Chinook) (SJ) Effects on survival of smolt size and condition Prey availability. How to assess? How will it change? Outmigration predation Channelization Timing match/mis-match Bottom-up (environmental) processes drive annual deviations in production. (BR) Climate change, change in ocean current How stable are relative stock abundances after sampled life history stages, and can these be used to update forecasts of abundance based on the earliest- returning stocks? (e.g. is just post- smolt) (SL) Habitat use, growth, survival, behavior in the context of climate change and other cumulative impacts (FJ) Effects of climate change on the distribution and production of juvenile salmon, especially in the Okhotsk Sea (SU). Future SST increase in Okhotsk Sea may cause: - Reduction of salmon distribution space - Increase of inter or intra- specific competition - Reduction of individual growth - Increasing mortality the following winter - Possibility of negative process should be evaluated by an international cooperative program.

Table 4. Critical questions related to specific salmon marine life-history phases identified at the IYS Scoping Meeting.

Immature (coastal migration)	**Adult (ocean rearing/migration)**	**Spawners**
□ Do stocks with different survival rates migrate at different times, have different migration routes and rear in different ocean areas? (TB) □ Where and when does mortality occur that is significantly related to returning adult abundance? (TB) □ Carrying capacity-density dependent effects on growth (and survival? □ Variability in adult returns is controlled by survival during the period when first enter marine environment, so consider the type, abundance, seasonality, aggregation of prey of ocean entry salmon (HB) □ Rapid growth reduces probability of predation and starvation, therefore; simulation results of juvenile salmon feeding and growth in coastal systems are extremely sensitive to assumptions about level of optimal foraging (vs. random foraging); need better information about salmon foraging behavior (HB) □ Prey availability □ HTL predation □ Rearing area/distribution □ Overall impact of period on cohort strength □ Climate change effects on distribution and amount of salmon “habitat” □ Validate (experiments) early marine (6- 10 week) mortality rates determine production (species specific) (BR) □ Overwinter (first winter) distribution and fitness (BR) □ Migration routes, drivers of mortality, distribution in first winter, role of individual variation □ Where are the fish and when are they there? i.e., to identify physical and biological conditions that support the survival of salmon stocks (assumes coastal and shelf regions govern survival and therefore stock abundance) (Perry)	□ How much ocean acidification will affect survival rates of juvenile salmon (RMP) □ Marine survival (from juveniles to adult recruits) specifically first 9-12 months at sea (RMP) □ What is the relative importance to population dynamics of the reduced body size that is associated with greater abundance of salmon in the ocean? (RMP) □ Salmon ocean distribution. How consistent is it between years? What does the distribution tell us about the environment? □ How are Columbia R sockeye distributed in the North Pacific? (SM) □ Climate effects on distribution, maturation, and growth □ Mixed stock analysis □ Where are the fish and when are they there (i.e., to identify physical and biological conditions that support the growth and body size of returning salmon stocks, assumes high seas regions govern return body size of stocks) (Perry)	How significant is the effect of □ stress during spawning migration on egg/fry/smolt quality? □ Spawner-recruit variability and covariates

Table 5. Critical questions associated with all freshwater and marine salmon life-history phases identified at the IYS Scoping Meeting.

All Freshwater	All Marine
• Hatchery smolt quality when compared to wild and variability over time (e.g., Is there a relationship between hatchery production levels and quality?) • Cumulative effects (Perry) • What is the distribution of salmon food abundance and nutritional value relative to the distribution of salmon in spacetime and relative to the more easily remotely measured biophysical parameters? (SL) • Can we measure this in a way that provides a baseline for future comparison (as well as something that allows us to extend the present baseline backward in time)? (SL) • Stock identification is important. GSI is a good tool. Otolith marking is now also a good tool to identify hatchery origins of salmon in the ocean. (SU) • Landscape processes (nutrient) driving freshwater aquatic productivity. Calcium-phosphorus limitation linked to climate change. Match/mismatch.(MS) • Freshwater productivity because it affects abundance of seaward migrating juveniles. (RMP)	• Natural mortality sources and drivers: is there anything other than predation, parasites, and diseases? What is a scope of such hidden sources of natural mortality? • Marine survival exhibits long- term change while salmon year class live for 2- 5 years. We observed the large- scale changes of salmon species productivity and related them to some physical factors dynamics. Re- analysis of such dependencies could be useful. • Stock identification of Fraser River sockeye in the Gulf of Alaska (TB) • Causes of mortality in the ocean • What is the relationship between ocean productivity and salmon production? (SM) • Influence of food quality on survival and growth, especially for juveniles in coastal and shelf regions, i.e., it is likely that prey abundance and biomass are not the only determining (prey) factors (Perry) • Salmon abundance, distribution, and migration routes in winter, prey abundance and distribution in winter, salmon predator abundance and distribution in winter, and salmon habitat (ocean conditions) in winter (KM) • What kills salmon? Predators? Who are they? Growth/predator interaction? Starvation? Disease/growth/predation interactions? (GR) • Winter mortality at critical period. Does this simply growth related mortality? If predators are key, why increase predators during /after winter? (GR) • How much mortality during early marine vs. middle /late marine? Variability? Why no delay in maturation if late marine mortality is low? (GR) • Salmon species interactions. Implications for hatchery management. (GR) • Factors affecting salmon production in winter and spring: prey, predators, diseases, parasites? • Stock- specific composition, distribution and migrations and interactions between different stocks during marine life • Assessment of the carrying capacity of the North Pacific for Pacific salmon, and its dynamics • Quantifying disease, prey, identifying predators. Behavioural responses to environmental change. (FJ) • Factors limiting primary production > suitable salmon prey. Is it all about iron? • Winter ocean distribution • Behavioural changes under changing climate, e.g., will salmon go deeper to retain their preferred temperatures? (Perry) • What will be the impact of climate change on suitability of North Pacific habitat for productivity of

All Freshwater	All Marine
	Pacific salmon?

Cross- cutting issues in Tables 3-5

- Life cycle approaches (BW)
- Sensitivity analyses
- What does improved forecasting mean to end users of our information? What do we think we will deliver? What is the question? What is the metric, what is the path?
- Based on current assessment capacity/ability – how much change needs to occur in order to be recognized? (SJ)
- Need environmental (temp, oxygen, food) at locations where and when salmon are and where salmon are not. Applies to all life stages but more critical to younger life stages. (Hal)
- Improve communication
- Monitoring of selected populations for abundance by life history stage (MS)
- Cumulative effects models across all life history stages (MS)
- Stage specific abundance, survival, and growth estimates (KM)