The First NPAFC-IYS Workshop on

Pacific Salmon Production in a Changing Climate

May 26–27, 2018
The Boutique Hotel, Khabarovsk, Russia

The North Pacific Anadromous Fish Commission (NPAFC; www.npafc.org) will host the First International Year of the Salmon (IYS) Workshop on "Pacific Salmon Production in a Changing Climate" to be held on May 26–27, 2018, at the Boutique Hotel, Khabarovsk, Russia. The IYS Workshop will bring together scientists, managers and other stakeholders to consider the current and future status of salmon and their habitats in a changing climate for the conservation of anadromous populations.

Background and International Year of the Salmon (IYS)

Salmon are biologically and economically important for Northern Hemisphere countries; however, they are facing unpredictable future: e.g., continued warming and increased variability in the world's oceans that may impact salmon ocean distribution, migrations pathways, growth, and marine survival. To improve our understanding of salmon marine ecology, the North Pacific Anadromous Fish Commission (NPAFC) and North Atlantic Salmon Conservation Organization (NASCO) are leading an ambitious program "the International Year of the Salmon (IYS)" with focal year in 2019 (http://www.npafc.org/new/science_IYS.html).

The IYS is an international framework for collaborative outreach and research, and seeks to increase understanding and raise awareness of the challenges facing salmon and the measures to support their conservation and restoration against increasing environmental variability. The overarching theme of the IYS is "Salmon and People in a Changing World", and the proposed research themes are (1) status of salmon; (2) salmon in a changing salmosphere (the current and future geographic range of salmon); (3) new frontiers: (4) human dimension; and (5) information systems. These five research themes are integrated into the current NPAFC Science Plan, whose goal is to understand variations in Pacific salmon production in a changing climate (http://www.npafc.org/new/science_plan.html).

Workshop Objectives

Workshop objectives are to:

- review knowledge of the distribution, growth and survival of Pacific salmon in the ocean (current status);
- review the causes of variations in Pacific salmon production (mechanisms);
- anticipate future changes in the production of Pacific salmon and the marine ecosystems producing them (e.g., modelling); and
- identify research priorities and international cooperative research plans for the IYS initiative.

Improved understanding of the mechanisms that regulate the distribution and abundance of Pacific salmon and steelhead trout will promote the conservation of anadromous populations in the North Pacific Ocean, allow for better forecasts of salmon production trends in the future, and enhance the sustainable fisheries management, food security, and economic security in salmon nations.

Topic Sessions

To reflect the IYS research themes, the workshop will be structured with the following five topic sessions:

Topic 1. Status of Pacific salmon and steelhead trout

Time series of regional salmon production and biological and physical characteristics of key salmon populations and their ocean habitat provide broad scale perspectives necessary to examine the underpinnings of ocean salmon production and marine ecosystem conditions. The purpose of this session is to understand and effectively report the present status of Pacific salmon and their habitats, and the factors influencing biological traits such as seasonal migration, distribution, abundance, growth, and survival.

- Biological monitoring of key salmon populations
- Seasonal migration and distribution
- Growth and survival

Topic 2. Pacific salmon and steelhead trout in a changing North Pacific Ocean

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

- Retrospective salmon studies
- Linkage between Pacific salmon production, climate and ocean changes
- Modeling the future for salmon

Topic 3. New technologies

Novel stock and fish identification methods including new molecular identification, genomics, environmental DNA (eDNA), hatchery mass marking, intelligent tags, and remote sensing continue to develop, and these tools are integral to the formulation of effective models predicting the distribution and abundance of salmon populations.

Topic 4. Management systems

The objective is to provide scientific information that effectively informs integrated management systems for the sustainable conservation of Pacific salmon populations, including the ecosystem-based management, the development of models forecasting salmon survival and returns, the management strategy of harvest and escapements, the conservation of genetic units and diversity, the restoration and protection of habitat, the control of diseases and pollutions, and the improvement of enhancement technologies.

Topic 5. Integrated information systems

The objective is to improve the ability to share information and collaborate on research efficiently using a modern web-based framework. Integrating data products with existing data systems and using archives of accessible electronic data collected during the research period will support future research and public understanding of the role of salmon in ocean ecosystems.

TIMETABLE AT-A-GLANCE *(subject to change)*

May 26, 2018 Saturday

Item	Time slot	Duration*	Topic	Presenter	Author	Chairperson(s)
Pre-registration (May 25, Friday)	16:00-18:00	2 hr				
Registration	08:15-08:45	30 min				
Opening Remark (1)	09:00-09:05	5 min		Vladimir Radchenko		
Opening Remark (2)	09:05-09:10	5 min		Alexander V. Bugaev		
Introduction of IYS	09:10-09:30	20 min		Mark Saunders		
Topic 1: Status of Pacific Salmon and Steelhead Trout						
Keynote-1	09:30-10:00	30 min	T1	James R. Irvine	James R. Irvine et al.	J. Irvine, N. Klovach
Oral-1	10:00-10:20	20 min	T1	Toshihiko Saito	Toshihiko Saito et al.	↓
Coffee Break (Posters)	10:20-10:40	20 min				
Oral-2	10:40-11:00	20 min	T1	Chung Il Lee	Chung Il Lee et al.	
Oral-3	11:00-11:20	20 min	T1	Nataliya Klovach	Nataliya Klovach et al	
Oral-4	11:20-11:40	20 min	T1	Alexander M. Kaev	Alexander M. Kaev	
Oral-5	11:40-12:00	20 min	T1	Sergei Zolotukhin	Sergei Zolotukhin et al.	
Lunch (1 hr 20 min)	12:00-13:20	1 hr 20 min				
Oral-6	13:20-13:40	20 min	T1	Shunpei Sato	Shunpei Sato et al.	
Oral-7	13:40-14:00	20 min	T1	Kentaro Honda	Kentaro Honda et al.	
Oral-8	14:00-14:20	20 min	T1	Maksim Koval	Maksim Koval et al.	
Oral-9	14:20-14:40	20 min	T1	Sue C.H. Grant	Sue C.H. Grant et al.	↓
Poster Session & Coffee Break	14:40-15:40	60 min				
Topic 2: Pacific Salmon and Steelhead Trout in a Changing North Pacific Ocean						
Keynote-2	15:40-16:10	30 min	T2	Andrey Krovnin	Andrey Krovnin et al.	A. Buagev, E. Farley
Oral-10	16:10-16:30	20 min	T2	Terry D. Beacham	Terry D. Beacham et al.	↓
Oral-11	16:30-16:50	20 min	T2	Ed Farley	Ed Farley et al.	
Oral-12	16:50-17:10	20 min	T2	Ed Farley	Ed Farley et al.	
Oral-13	17:10-17:30	20 min	T2	Chrys M. Neville	Chrys M. Neville et al.	↓
Reception	18:30 (TBA)					

May 27, 2018 Sunday

Item	Time slot	Duration*	Topic	Presenter	Author	Chairperson(s)
Oral-14	09:00-09:20	20 min	T2	James R. Irvine	James R. Irvine et al.	A. Buagev, E. Farley
Oral-15	09:20-09:40	20 min	T2	Vladimir I. Radchenko	Alexander V. Bugaev et al.	↓
Oral-16	09:40-10:00	20 min	T2	Ekaterina Lepskaya	Ekaterina Lepskaya et al.	
Oral-17	10:00-10:20	20 min	T2	Karen Dunmall	Karen Dunmall et al.	
Oral-18	10:20-10:40	20 min	T2	Masahide Kaeriyama	Masahide Kaeriyama	↓
Coffee Break (Posters)	10:40-11:20	40 min				
Topics 3–5: New Technologies, Management and Integrated Information Systems						
Keynote-3	11:20-11:50	30 min	T4	Dick Beamish	Dick Beamish	S. Kim, S. Naydenko
Oral-19	11:50-12:10	20 min	T4	Andrew Gray	Andrew Gray et al.	↓
Oral-20	12:10-12:30	20 min	T4	Brittany Jenewein	Brittany Jenewein et al.	
Lunch (1 hr 30 min)	12:30-14:00	1 hr 30 min				
Oral-21	14:00-14:20	20 min	T4	Miwa Yatsuya	Miwa Yatsuya et al.	
Oral-22	14:20-14:40	20 min	T4	James R. Irvine	James R. Irvine et al.	
Oral-23	14:40-15:00	20 min	T5	Oleg Ivanov	Oleg Ivanov et al.	↓
Coffee Break (Posters)	15:00-15:20	20 min				
Panel Discussion	15:20-16:50	1 hr 30 min		IYS Working Group		M. Saunders
Closing Remark	16:50-17:00	10 min		Shigehiko Urawa		

*Time slot breakdown:
Contributed speakers: 15 min presentation + 3 min question/discussion + 2 min to change speakers
Keynote speaker: 25 min presentation + 3 min question/discussion + 2 min to change speakers

May 25 (Friday)
16:00-18:00 Pre-Registration (inside Small Room, Boutique Hotel)

May 26 (Saturday)
08:15-08:45 Registration (inside Small Room, Boutique Hotel)
09:00-14:40 Oral Presentations (Big Room)
14:40-15:40 Poster Presentations (Small Room)
15:40-17:50 Oral Presentations (Big Room)
18:30-20:30 Reception (TBA)

May 27 (Sunday)
09:00-10:40 Oral Presentation (Big Room)
10:40-11:20 Poster Presentations (Small Room)
11:20-15:00 Oral Presentations (Big Room)
15:20-16:50 Panel Discussions (Big Room)

Oral Presenters

Please have your presentation saved on a USB memory stick and give it to the Secretariat when you arrive to pre-register or register at the workshop. Please see the following schedule so the Secretariat can have your presentation saved on the computer well in advance of the session.

If you have not submitted your presentation when you pick up your registration materials at the registration desk at the workshop, **the latest time to submit your oral presentation to the Secretariat is the following.**

If your presentation time is	Bring your presentation to the Secretariat by
May 26 (Saturday) a.m. (morning)	May 25 (Friday) **during** pre-registration 16:00–18:00 or May 26 (Saturday) **between** 8:15–8:45 a.m.
May 26 (Saturday) p.m. (afternoon)	May 26 (Saturday) **by** 11:00 a.m.
May 27 (Sunday) a.m. (morning)	May 26 (Saturday) **by** 17:30
May 27 (Sunday) p.m. (afternoon)	May 27 (Sunday) **by** 11:00 a.m.

Poster Presenters

Posters should be set up at pre-registration on Friday, May 25, 16:00–18:00 p.m., or at registration on Saturday, May 26, 08:15–08:45 a.m.

Poster should be removed on Sunday afternoon May 27 by 17:30. Posters not removed by 17:30 may be discarded.

TENTATIVE Program

(*Subject to change without notice*)

May 26 (Saturday) Oral Presentations *(Big Room)*

09:00-09:10 **Welcoming Remarks**
Vladimir I. Radchenko (Executive Director of NPAFC) and Alexander V. Bugaev (Workshop Co-Chair)

09:10-09:30 **Introduction of the IYS**
Mark Saunders (Chair of the IYS WG)

Topic 1: Status of Pacific Salmon and Steelhead Trout

(*Chairs: James Irvine & Nataliya Klovach*)

Poster Presentations *(Small Room)*

Topic 1: Status of Pacific Salmon and Steelhead Trout

Topic 2: Pacific Salmon and Steelhead Trout in a Changing North Pacific Ocean

Topic 4: Management System

Keynote Oral Presentation 1

Topic 1. Status of Pacific Salmon and steelhead trout

Overview of status for Pacific salmon populations in the eastern North Pacific

James R. Irvine[1*], Andrew R. Munro[2], William Templin[2], Mary Thiess[1], Sue Grant[3]

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Salmon abundance in the eastern North Pacific, as indexed by commercial catches, remains at relatively high levels, but stock status varies considerably among species, populations, and areas. Anomalous environmental conditions in marine and freshwater ecosystems have induced highly variable returns and altered biological traits such as age, body size and time of returns for several salmon species and populations. In Alaska, pink and sockeye salmon are the primary species harvested, followed by chum salmon. Most odd-year returning pink salmon have been meeting or exceeding escapement goals while providing large harvests. There has, however, been a decline in the proportion of escapement goals met for genetically separate even-year returning pink salmon, which has also coincided with low harvests. Sockeye salmon harvests and spawner escapements in Alaska have been relatively stable recently, as have those for chum and coho salmon. Chinook salmon stocks throughout Alaska have experienced a downturn in abundance over the past two decades. Despite some improvements in meeting escapement goals in central and western Alaska, recent abundances in southeast Alaska are the lowest on record. Chinook in the Canadian portion of the Yukon River are also below long-term average levels, as are many Chinook populations throughout British Columbia (BC). In northern BC, coho are generally at average to abundant levels and while southern coho populations have seen some improvements in recent years, many are still depressed. Coho and Chinook salmon are important in BC, particularly for recreational fishers while the more numerous pink, chum, and sockeye salmon have tended to be the more in commercial fisheries. Most even-year returning pink salmon populations are stable or declining while more abundant odd-year populations are stable or increasing. Chum salmon tend to be doing less well in northern BC than in the south, although there are exceptions. For sockeye salmon the opposite pattern tends to exist; northern populations, despite some recent low returns, are generally doing better than southern populations (e.g., Fraser). In Washington, Oregon, and California, Chinook, chum and coho salmon are the most abundant species; numbers of sockeye returning through the Columbia River to the Okanagan in southern BC have been well above long term averages most recent years. Improved understanding of linkages between oceanographic and freshwater conditions and salmon productivity is needed to better understand and predict changes in stock status.

Oral Presentation-1

Topic 1. Status of Pacific Salmon and steelhead trout

Current status of chum and pink salmon: what is reducing adult returns in Japan?

Toshihiko Saito[1*] and Yasuyuki Miyakoshi[2]

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Declines of adult chum and pink salmon in abundance become evident since somewhere around 2010 in Japan, and the 2017 returns of both species decreased to the pre-1980s abundance levels. Since the annual numbers of released juvenile salmon have been almost constant for decades, marine mortality after releases may be elevated in recent years. To examine the reasons for the recent declines of Japanese salmon, relationships between the brood strengths of salmon and sea surface temperatures (SSTs) during the early marine phase in coastal waters around Japan were investigated in this study. The brood strengths were positively correlated with SSTs for some regional stock groups, suggesting that warm SSTs were associated with better juvenile survival (and consequently increased brood strengths) at regional scales. The processes regulating juvenile survival through SSTs are unknown, but negative anomalies of SSTs during March through May or June were observed almost every year since 2010 in coastal waters around Japan. In addition, the SST anomalies changed abruptly from negative to positive values in recent years as summer approached. The abrupt changes in SSTs were remarkable in 2013 and 2014. Low SSTs and/or the abrupt SST changes in coastal waters around Japan may be linked to high marine mortality of juvenile salmon.

Oral Presentation-2

Topic 1. Status of Pacific Salmon and steelhead trout

Current return of chum salmon with latitude and marine environment in the eastern coast of Korea

Chung Il Lee[1*], Hyun Je Park[1], Hae Kun Jung[1], Ju Kyoung Kim[2], Do Hyun Lee[2]

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Chum salmon, *Oncorhynchus keta*, is major species which returns to rivers in Korea, and about 98% of chum salmon are returning to the rivers connected with the eastern coast of Korea. Migration route of chum salmon in the East/Japan Sea (EJS) from sea to river or vice versa is unclear, and recently the return of young salmon has increased relatively. The ecological characteristics of the migration route will be explained step by step through this study. Release and returning of chum salmon in Korea is highly correlated with two-year lags, and returning rate is generally proportional to latitude and release amount. The movement from offshore to inshore in the EJS occurs at approximately the same time in the norther part (Sokcho, 39°N) and the southern part (Ulsan, 35°N), most of chum salmon moves northward and southward around Sokcho with time, and chum salmon that moves northward is much higher than southward movement. Time to return around Ulsan is almost the same with the northern part, even though Ulsan is located at the southernmost of the eastern coast of Korea in the EJS. These patterns seem to be related with the distribution of subpolar front in the EJS, further research is needed in the future with international research program.

Oral Presentation-3

Topic 1. Status of Pacific Salmon and steelhead trout

Current stock assessment of Pacific salmon in the Far East of Russia

Nataliya Klovach[*1], Olga Temnych[2], Valeriy Shevlyakov[2], Evgeniy Shevlyakov[3], Alexander Bugaev[3], Vladimir Ostrovskiy[2], Alexander Kaev[5] and Vladimir Volobuev[6]

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In the Russian Far East, Pacific salmon reserves remain at historically high levels, but slightly below the level of recent years. The total catch of all species of Pacific salmon by the coastal fishery in the Far East of Russia in 2017 was 353 thousand tons, which is 13,000 tons less than the catch of the cyclical 2015, and 85,000 tons less than the catch in 2016. At the same time, 353 thousand tons of salmon caught in the Far East, 241 thousand tons were caught in Kamchatka. In all other regions, 112,000 tons of salmon were caught in total. High salmon catches in the Kamchatka were provided by numerous approaches of pink salmon to the northeastern coast, as well as retaining high numbers of chum salmon and sockeye salmon on both coasts of the peninsula. So from 204 thousand tons of pink salmon caught in the Far East, 153 thousand tons were caught in the northeast of Kamchatka with a good escapement to the spawning grounds. In all other regions of the Far East, except for Sakhalin Coast, the state of stocks of all types of salmon also remains at a high level. On Sakhalin, on the contrary, we can state catastrophic fall in pink salmon stocks. The reason for this being both the climatic changes that led to a shift in the feeding area of salmon to the north, as well as the build-up of fishing capacity in recent years, as well as poaching in rivers.

Oral Presentation-4

Topic 1. Status of Pacific Salmon and steelhead trout

Decline of abundance of pink salmon in Sakhalin-Kuril region as a result of the extreme environmental factors

Alexander M. Kaev*

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The abundance of pink salmon adult returns to the Iturup Island area and to four areas of the eastern Sakhalin have declined in recent years. Several reasons have been suggested that would explain this decline, including some environmental ones. In this work, I propose and prove that the occurrence of the low yielding pink salmon broodlines is related mainly to the effect of typhoons. Typhoons cause strong autumn floods in rivers that destroy bottom on spawning grounds, and storms in the coastal seawaters that negatively affect juveniles after their downstream migration. This hypothesis is proven by the observed decline in abundance of pink salmon broods affected by typhoons during their embryonic development in rivers or juvenile feeding in the coastal area. This was the leading factor of the observed catastrophic decline in pink salmon abundance in the southern areas of this region in 2015, and a predicted abrupt reduction of pink salmon abundance in the northern part of the Sakhalin coast in 2017. The increase in typhoons frequency in some adjacent years caused the sequence of several years of low yielding broodlines. The absence of synchronism in abrupt changes of abundance for all pink salmon stocks in the region could be explained by continuous changes in force and impact range of typhoons.

Oral Presentation-5

Topic 1. Status of Pacific Salmon and steelhead trout

What formed the Pacific salmon biomass in Amur River basin in 2000–2010s?

Zolotukhin Sergei*, Kanzeparova Albina

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The Amur River is the biggest salmon basin in Asia, and the tenth longest river in the world. Commercial catch data for all Amur River Pacific salmon species show the same trend: a sharp peak of catches in the 1910s and the subsequent decline to a minimum in the early 2000s, and a sharp peak again, 100 years later, in the 2010s. In the 1990s number of pink salmon, summer chum and fall chum salmon in the Amur River was low, and could not form a very large generation. After 1998 as a result of small parent generations of pink and chum salmon, progeny number were very small. Commercial catches of pink salmon, summer chum and fall chum salmon in the Amur River during 1990–2005 were as small as 2–5 thousand metric tons each. After 2005, the number of Pacific salmon in the Amur River began to grow. Commercial catches of each species reached 5,000 metric tons in 2009, and quickly exceeded 10 thousand. In 2016, the catches of pink salmon reached a new historical maximum of 23,100 metric tons. What factor prevailed for the formation of the of Amur River salmon biomass? Escapement graphs declined for all species of Amur River Pacific salmon, and in 1998 reached a minimum, which lasted until 2005. Probably, Pacific salmon populations were not affected by change in the average surface air temperature during spawning or egg incubation and in its ocean range as well, as the first peak of their abundance occurred near 1910 during a maximum of negative anomalies, and the second peak occurred near 2010 during the maximum of positive anomalies. It is unlikely that hatchery to production could affect the Amur River Pacific salmon population with its small contribution compared to natural processes. It is most likely that the abundance of Amur River Pacific salmon generations is regulated after its seaward migration within estuaries and in early marine periods, when the juvenile mortality is increased by ice presence and ice movement within the coastal zone. Many factors impatc the level of survival of Amur River Pacific salmon during ocean migration, which has the highest weight among other factors. We are not aware of any data that would show that the number of Pacific salmon of the Amur River is determined mainly in the river basin. It is determined even from small generations by the survival level during the ocean migration period, which varies according to climate changes in its ranges.

Oral Presentation-6

Topic 1. Status of Pacific Salmon and steelhead trout

Geographical stock origins of juvenile chum salmon migrating along the Pacific Ocean coast of Hokkaido, Japan, during early summer

Shunpei Sato[1*], Ayumi Nakashima[2], Kazuyuki Yamaya[3], and Shigehiko Urawa[1]

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The origin and migration routes of juvenile chum salmon migrating from Hokkaido and Honshu regions were estimated by otolith thermal marking and genetic stock identification. Fish samples were collected from the Muroran, Kojohama, Atsuga and Harutachi coasts on the western Pacific coast of Hokkaido (HKD-WP) and the Konbumori coast on the eastern Pacific coast of Hokkaido (HKD-EP) during May to July of 2013–2016. Otolith and genetic samples were collected from each juvenile chum salmon after a measurement of fork length (FL) was taken. Otolith samples were examined for the presence of thermal marks and the hatchery origins of these samples were determined using thermal mark patterns. As for genetic samples, after DNA extraction, each sample was assayed for 45 single nucleotide polymorphism (SNP) loci and five regional stock contributions (three regional stocks in Hokkaido and two regional stocks in Honshu) were estimated by a conditional maximum likelihood using a SNP baseline dataset from 81 Japanese populations. A total of 14,535 fish were collected along the five survey coasts. Mean FL of juvenile chum salmon collected from the Muroran and Kojohama coasts were smaller than that of the Atsuga, Harutachi, and Konbumori coasts. In the Muroran, Kojohana, Atsuga, and Harutachi coasts, otolith marks were detected in 2,366 (19.6%) out of 12,098 juvenile chum salmon, and 92.4% of otolith-marked juveniles originated from hatcheries along the HKD-WP. On the other hand, on the Konbumori coast, 593 (24.3%) out of 2,437 samples were otolith-marked fish, of which 558 samples were released from hatcheries of HKD-EP. During 2013-2015 seasons, otolith-marked chum salmon originated from hatcheries along the Pacific and Japan Sea coasts of Honshu were mainly collected from the Atsuga, Harutachi and Konbumori coasts, and almost all fish were large fish (>10 cm in FL). However, no otolith-marked fish released from Honshu hatcheries were caught in 2016. Stock composition analysis of small juvenile fish (<10 cm in FL) indicated that the Pacific coast of Hokkaido stocks were most dominant on the five survey coasts during all survey years. Percentages of the Pacific coast of Honshu (HON-PO) stocks of large juvenile chum salmon were higher than that of small juvenile fish during 2013–2016. However, the proportion of the HON-PO stocks of large juvenile fish in 2016 was lower than that of 2013–2015. These results suggest that juvenile chum salmon stocks originating from the Pacific coast of Honshu migrate to HKD-EP via HKD-WP, e.g., around the Atsuga and Harutachi coasts.

Oral Presentation-7

Topic 1. Status of Pacific Salmon and steelhead trout

Growth rate characteristics during early marine life and sea-entry conditions of juvenile chum salmon originating from two rivers along the Pacific coast of Hokkaido, Japan

Kentaro Honda[1*], Tatsuya Kawakami[2], Kotaro Shirai[3], Takashi Kitagawa[3], and Toshihiko Saito[1]

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Juvenile chum salmon originating from rivers along the Pacific coast of Hokkaido, Japan, migrate northwards to the Sea of Okhotsk, typically passing by the easternmost part of Hokkaido. In this study, juvenile chum salmon originating from the Tokachi (42°41'N, 143°40'E) and Yurappu (42°16'N, 140°17'E) rivers consisting of three sampling-year groups each [2005 (n = 23, 72.0–90.0 mm FL), 2007 (n = 34, 72.0–107.1 mm FL), and 2009 (n = 34, 64.0–94.0 mm FL) for Tokachi and 2013 (n = 27, 93.5–113.9 mm FL), 2014 (n = 31, 92.2–115.9 mm FL), and 2016 (n = 25, 91.9–104.6 mm FL) for Yurappu] sampled in June–July at Konbumori (42°50–56'N, 144°34'E; ~80 km northeast of the Tokachi river mouth) and at Atsuga or Harutachi (42°15–24'N, 142°12–29'E; ~150–180 km east of the Yurappu river mouth), respectively, were used. We examined the relationship for each group between back-calculated growth rate (mean daily growth in FL) during early marine life of juvenile chum salmon and their estimated dates and FLs at sea entry, using daily-increment analysis of otoliths. Average (± SD) growth rates of Tokachi specimens were 0.57 ± 0.11 mm/day, 0.61 ± 0.11 mm/day, and 0.55 ± 0.08 mm/day for groups sampled in 2005, 2007, and 2009, respectively, whereas those of Yurappu specimens were 1.06 ± 0.11 mm/day, 0.99 ± 0.11 mm/day, and 0.88 ± 0.08 mm/day for groups sampled in 2013, 2014, and 2016. Any remarkable trends were not found in relationships between growth rates and dates and FLs at sea entry for each sampling-year group except for the 2005-Tokachi group of which fish migrated to the sea later showed a relatively higher growth rate. Growth rates of Yurappu specimens were even higher than those originating from same river sampled at Konbumori (~400 km east of the Yurappu river mouth) during 2005–2014 (0.71 ± 0.12 mm/day, n = 27) estimated in a previous study. Few remarkable relationships between growth rate and date and FL at sea entry were possibly resulted from our small sample size and/or from the fact that we only sampled fish selected through growth-dependent survival mechanisms during early marine life. Moreover, higher growth rates observed by Yurappu specimens particularly those sampled in 2013 and 2014, which are being assumed as poor-return stocks, may suggest that only fish with such high growth rates could survive even in years when massive mortality took place.

Oral Presentation-8

Topic 1. Status of Pacific Salmon and steelhead trout

Biology of juvenile ozernovskaya sockeye salmon *Oncorhynchus nerka* (the Ozernaya River, basin of the Kurilskoye Lake) during downstream migration and early marine period of life

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Biology of Ozernaya River sockeye salmon (the biggest population in Asia) have been studied since 1932. The spawning, and ecology of juveniles in the Kurilskoye Lake (before downstream migration to the Ozernaya River), as well as the marine life and spawning migration of adult fish has been studied during this period. However, the biology of juvenile sockeye during their downstream migration and early marine period has been poorly studied even though these life cycle stages are the most critical for Pacific salmon, as known. This significantly complicates the forecasting of future returns of adult fish that is necessary for effective stock management and rational fishing. The first integrated study of juvenile ozernovskaya sockeye salmon in Kurilskoye Lake, Ozernaya River (riverbed and estuary) and coastal waters of the Okhotsk Sea was conducted in June–August 2017. The data obtained confirmed that downstream migration of juvenile sockeye from Kurilskoye Lake starts in late May or early June and ends in the second half of July. Downstream migration of juveniles in the Ozernaya River run less than one day (through a high speed of water flow). The average size of migrants age 1+, 2+ and 3+ in the riverhead (according to interannual data) are 8.1, 9.7 and 10.8 cm, respectively. We have determined that such large juvenile sockeye do not stay in the estuary and migrate to the Okhotsk Sea immediately. Hydrological conditions in river mouth area and adjacent coastal waters allow juvenile sockeye to quickly smoltificate and to adapt for life in marine environment. As a result, juvenile sockeye are already widespread in coastal sea waters (to the north of the Ozernaya River mouth) to the end of July and early August. According to the results of trawl surveys, abundance of juvenile sockeye in the coastal waters of the Okhotsk Sea is comparable to the total abundance of migrants from the Kurilskoye Lake (correlation coefficient $R = 0.86$). Thus, in the life cycle of ozernovskaya sockeye salmon, downstream migration and the early marine period of life are not critical. This feature of biology is a one of the factors that makes it possible with almost 100% accuracy to prognosticate the number of returns of adult fishes in the Ozernaya River (the average accuracy of prognosis of ozernovskaya sockeye salmon returns was 103.6% for the last 10 years). The field studies were supported by the Russian Foundation for Basic Research (project nos. 17-05-01224).

Oral Presentation-9

Topic 1. Status of Pacific Salmon and steelhead trout

An introduction to Fisheries & Oceans Canada's new State of the Salmon Program

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A new State of the Salmon (SOS) Program has been recently established by Fisheries and Oceans Canada's Pacific Region. The goal of the SOS Program is to improve our understanding of the state of Pacific Salmon populations in Canada, and the factors that contribute to their state. To achieve this goal, the SOS Program will monitor and compare trends in abundance, productivity, and other biological characteristics (such as fecundity, size-at-age, and run timing) of Canadian salmon populations in the Northeast Pacific, and the freshwater and marine ecosystems they occupy. Information on salmon will be linked to more detailed stock assessment monitoring, and broader scientific research conducted on these populations and their ecosystems. A case study on Fraser Sockeye conservation units (CUs) provides a foundational framework for this emerging SOS Program. A CU has been identified as the fundamental unit of Canadian Pacific salmon biodiversity based on their life-history, genetics and ecological traits. There are 19 Fraser Sockeye CUs that are relatively data rich, with stock-recruitment data extending back to the 1950's, depending on the CU. Comparisons of Fraser Sockeye CU productivity (recruits-per-spawner) have been conducted to identify periods of common and divergent patterns across CUs and periods. These comparisons can be used to identify drivers of these patterns at, respectively, broad regional or local scales. In the past decade Fraser Sockeye CU productivity has generally declined, with a period of considerable variability in productivity occurring between 2009 and 2014 among CUs. In the last three years (2015–2017), productivity has returned to low levels for most CUs, with 2016 representing the lowest abundances observed for the Fraser Sockeye aggregate since the late-1880's. Both freshwater and marine factors likely have contributed to the observed patterns in productivity. More work is required to collate, filter, and compare other salmon characteristics of Fraser Sockeye, and other salmon species throughout the Pacific Region. As this SOS Program evolves, these comparisons can be used in dialogue with local and regional experts on salmon and their ecosystems. The key to this Program will be to develop integrative processes to synergize our collective knowledge, which will be used to foster such relationships with internal and external experts on salmon and their ecosystems.

Keynote Oral Presentation-2

Topic 2. Pacific salmon and steelhead trout in a changing North Pacific Ocean

Present state and future of Far East salmon stocks under changing climate

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The present state of Far East salmon stocks has been determined by climatic conditions of reproduction and feeding in 2010–2017. Warming of 2014–2017 slowed down a decrease in Kamchatka pink salmon stocks started in 2013–2014. However, decline of the East Sakhalin stocks continued in 2012–2017 under the influence of both adverse environmental conditions during spawning, downstream migrations and early marine feeding, and poaching in the rivers. The sockeye salmon stocks in 2018–2021 will remain at the high level, owing to warming of 2014–2017. The anticipated cooling in the Northwest Pacific will cause a decrease in the Asian salmon catches during the 2020s. The survival rates of hatchery chum salmon will decrease significantly, as it occurred in Hokkaido. In general, in the second half of the 2020s the total catches of Far East salmons will decline down to 150–200 thousand tons.

Oral Presentation-10

Topic 2. Pacific salmon and steelhead trout in a changing North Pacific Ocean

Validity of inferring size-selective mortality and a critical size limit in Pacific salmon from scale circulus spacing

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Size-selective mortality, either through predation during early marine rearing or lack of energy reserves during the first marine winter, has been suggested to be of paramount importance during the first year of marine rearing for many species of Pacific salmon. Scale circulus spacing has been interpreted as an index for body size, and we reviewed the effect of size-selective mortality on descriptive statistics for a scale circulus spacing index (SCSI). In order to invoke size selection as an important driver of mortality during the first year of ocean rearing, it is necessary to demonstrate not only that size-selective mortality is directed towards the smaller members of the population, but that the selective nature of the mortality can account for a substantial portion of the observed mortality. If the assumption is made that a random sample of a single juvenile population has been obtained, then studies that employ a SCSI to infer size-selective mortality coupled with a critical size must demonstrate a shift toward larger values of the SCSI, but also a concomitant reduction in the variance and range of the SCSI and an increase in the skewness and kurtosis of the SCSI values. Through simulation we found that the percentage of adults that displayed a SCSI value greater than the maximum observed in the juvenile sample was highly dependent on the initial juvenile sample size and size-selective mortality rate. Geographical distributions of juvenile Pacific salmon can be stratified by size, with larger individuals migrating earlier from local ocean entry locations than smaller individuals, and thus differential timing migration of juveniles based upon body size prior to the collection of the marine juvenile sample may be a more plausible explanation of published trends in the SCSI, rather than invoking substantial size-selective mortality and a critical size limit.

Oral Presentation-11

Topic 2. Pacific salmon and steelhead trout in a changing North Pacific Ocean

Is there a critical size and period for Pacific salmon?

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For Pacific salmon (*Onchorhynchus spp*), their early marine residence and first winter at sea are hypothesized as "critical periods" for their survival where salmon that do not reach a "critical size" during these periods have lower marine survival. However, recent manuscripts by Canadian and Russian colleagues question this view. We present results from integrated ecosystem research within Alaska's large marine ecosystem that suggest mortality of Pacific salmon and other marine fishes during winter is dependent on ecosystem function and fat reserves they attain during the summer growing season as juveniles. We also present results from published manuscripts that utilize salmon scales as a means to identify size-selective mortality and critical size metrics for pink salmon (*O. gorbuscha*) and sockeye salmon (*O. nerka*) populations in Alaska. The goal is to provide this information for further discussion on IYS research activities and identify the important metrics for Pacific salmon health and survival that could improve our conceptual models for ocean mortality and our understanding of the potential mechanisms that influence Pacific salmon survival.

Oral Presentation-12

Topic 2. Pacific salmon and steelhead trout in a changing North Pacific Ocean

Pink salmon as "sentinels" for Arctic change

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Pink salmon (*Onchorhynchus gorbuscha*) are not a new occurrence in the Arctic, yet over the past decade their relative abundance appears to be increasing. Are pink salmon a "sentinel" for rapid climate warming in the Arctic? We summarize what is known about juvenile Pink Salmon marine ecology in the northeastern Bering Sea and Chukchi Sea with information from integrated ecosystem surveys conducted during 2002 to 2017. This period is marked by rapid change in marine conditions in the Arctic and an increase in the number of adult pink salmon captured in the High Arctic. Our objectives are to: 1) summarize the distribution, relative abundance, size, condition, and diet of juvenile pink salmon in the northeastern Bering Sea and Chukchi Sea, 2) examine annual variability in summer sea surface temperatures, primary production (Chl-a), and zooplankton species composition and biomass; 3) discuss these metrics in relation to observed trends in abundance of adult pink salmon within the northeastern Bering Sea and Arctic.

Oral Presentation-13

Topic 2. Pacific salmon and steelhead trout in a changing North Pacific Ocean

What can be learned with the return of coho fishing to the Strait of Georgia?

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The decline in marine survival of coho salmon from the Strait of Georgia beginning in the 1980s was synchronous with the decline in survival in Puget Sound and on the west coast of Washington and Oregon, indicating that the decline was related to large scale climate events. In 1994 there was also a change in the behaviour of coho salmon that resulted in virtually all juveniles leaving the Strait of Georgia in the late fall and not returning until just prior to entering freshwater. This caused the collapse of a lucrative recreational fishery in the strait. The collapse of the fishery continued through to 2013 when maturing coho salmon again returned to the Strait of Georgia in the spring of their second marine year. This earlier return coincided with an increase in the abundance and size of juvenile the previous September. We propose that the change in distribution in 1994 and the return of coho salmon to the Strait of Georgia in 2013 is a consequence of a change in the ocean ecosystem resulting in improved prey availability during their first marine summer beginning about 2012. We propose that juvenile coho that do not achieve an energy threshold in the summer of their first ocean year leave and remain outside the Strait of Georgia. This history of changes in the coho salmon production and behaviour in the Strait of Georgia is an example of the importance of understanding climate changes to ocean ecosystems at a regional scale.

Oral Presentation-14

Topic 2. Pacific salmon and steelhead trout in a changing North Pacific Ocean

Unravelling how climate and competition shape sockeye salmon dynamics across the Northeast Pacific Ocean

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It is well known that both ocean conditions and inter- and intra-specific interactions can influence salmon growth and survival. However, to date there has been little analysis of the potential mediating effects of ocean conditions on density dependent interactions among salmon at sea. Such mediating effects may occur, for example, as a result of climate induced reductions in growth during early marine life leading to increased sensitivity to density dependent effects later in marine life. Alternatively, favorable ocean conditions during early and/or late marine life may mask the detection of density dependent interactions or mediate their potential effects. In this study, we quantify the extent to which there is evidence for a mediating effect of ocean conditions on density dependent interactions among salmon at sea. Using data from over 40 Sockeye salmon populations across the eastern north Pacific Ocean, along with information on ocean climate conditions and indices of potential salmon competitors, we find evidence to suggest that ocean conditions mediate the consequences of density dependent interactions among salmon at sea. The individual and combined influences of these stressors vary across large spatial scales that are characterized by groups of populations with differences in life history diversity (e.g., variability in age at ocean entry). Our findings provide a macroecological foundation upon which to consider how interactions among a changing ocean, inter-specific competition, and the erosion of life history diversity may shape the dynamics of sockeye salmon populations across the eastern north Pacific.

Oral Presentation-15

Topic 2. Pacific salmon and steelhead trout in a changing North Pacific Ocean

Climate change and Pacific salmon productivity on the Russian Far East

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Climate change impacts on Pacific salmon (pink, chum and sockeye) productivity was assessed based on long-term (1971–2015) fisheries statistics and dynamics of 17 climate indices using stepwise multivariate regression analysis. Three regional stock groups were analysed: Eastern Kamchatka and Chukotka (BPG), Western Kamchatka and continental coast (NOG), and Sakhalin, Kuriles, Amur River, and Primorye (SOG). A set of eight climate indices ("indicators") with dynamics in a good agreement with fluctuations of Pacific salmon catches were selected by correlation analysis: the Aleutian Low Pressure Index (ALPI), the Pacific-North American Oscillation (PNA), the West Pacific Teleconnection Index (WP), the Pacific Decadal Oscillation (PDO), the Northern Hemisphere Land and Sea Surface Temperature Anomalies (N.HEMI+dSST), the Geomagnetic disturbance Index (Ap), the Sun Spot Index (SSI), and the Length of Day Index (LOD). We calculated yearly index values using a moving average technique. Averaging period (two years for pink salmon and four years for chum and sockeye) depended on marine life duration. The lowest values of regression coefficients that imply a weak correlation between productivity and climate change indices are received for pink salmon: R = 0.38 for BPG, 0.36 for NOG, and 0.75 for SOG. Minimum number of indicators (four) are selected in comparison with other salmon species: N.HEMI+dSST, PDO, Ap, and SSI. For all regional groups, N.HEMI+dSST reflects the strongest effect of positive near-surface air and sea surface temperature (SST) anomalies on pink salmon productivity: beta coefficient varies from 0.24 to 0.60. In SOG, PDO reflects negative effect of negative winter SST anomalies in central and western North Pacific: beta coefficient = 0.35. Moderate to high values of regression coefficients are received for chum salmon: R = 0.63 for BPG, 0.92 for NOG, and 0.80 for SOG and sockeye: 0.91–0.92 for BPG and NOG, respectively. The N.HEMI+dSST indicator reflects the strongest effect of positive temperature anomalies: beta coefficients ranged from 0.65–0.91 for chum and 0.61–0.85 for sockeye. Ap indicator reflects a negative effect of positive geomagnetic disturbance anomalies: beta coefficients ranged from -0.37 – -0.25 for chum and -0.14 – -0.42 for sockeye. We built distribution maps of Pearson correlation coefficient (r) for the statistical relationship between commercial salmon catches by regional groups and SST anomalies during the autumnal outmigration (September to November) and wintering (December to February) of salmon juveniles in their first year at sea. Satellite monitoring data of 1982–2015 were used. Catches in numbers were calculated in view of age of maturity and spawning return (0.1 for pink, 0.3-0.4 for chum, and n.2-n.3 for sockeye). Pacific salmon catch trends in NOG and SOG positively correlate with SST anomalies in the Sea of Okhotsk in autumn. Maximum correlation coefficients are 0.5–0.7 for pink and 0.4–0.6 for chum and sockeye. In winter, temperature effects salmon productivity in less degree. The strongest negative correlation (r = -0.4 – -0.5) is observed for the BPG sockeye salmon. Direct interrelation between salmon productivity and temperature is observed for autumnal outmigration while it has divergent trends in winter.

Oral Presentation-16

Topic 2. Pacific salmon and steelhead trout in a changing North Pacific Ocean

Pacific salmon (catch, spawning migrations, production) and the toxic «tide» events in the seas of Russian Far East: new risks?

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In June of 2017 the toxic «tide» of Alexandrium tamarense-complex was observed on the coast of Olutorsky Bay in the area of pink salmon commercial fishery plots. The density of PSP in the water sample with Alexandrium tamarense-complex representatives was 330 mcg/l. The consequence of the toxic «tide» was comparatively low catch of pink salmon in Olutorsky Bay and extremely low density of pink salmon spawners on the spawning grounds in the Pakhacha and the Apuka – the major spawning rivers there. Pink salmon is the species with the minimal homing among Pacific salmon species (*Oncorhynchus*), this is why only a small part of the spawners gone when running into the «blooming» zone, but the main part of them redirects their way from home rivers blocked by the toxic event for the other ones. The circumstance causes negative effects on pink salmon production in this area in several odd years in future. According to our data, there is an increase of precipitations in June-September (especially in July), and in monthly fluctuation range in Kamchatka. Moreover, 2017 was specific due to higher number of cyclones in the Northwest Pacific Ocean and hence a record volume of summer precipitations for the period from 1980. In case if the trend with the cyclones will continue, the chance for the toxic «tide» events in the coastal waters, where Pacific salmon migrate and commercial fisheries operate, increases. The situation can lead to redistribution of migration flows of the species with a short-cycle where the species with a long-cycle and a strong homing will die, trying to enter home river for spawning anyway. In future that in its turn will cause abrupt and at first glance inexplicable reduction of Pacific salmon production in particular river basins where Pacific salmon spawn in Kamchatka.

Oral Presentation-17

Topic 2. Pacific salmon and steelhead trout in a changing North Pacific Ocean

An evidence for historic and modern post-glacial colonizations of chum salmon at the northern range edge

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Biodiversity change in the Arctic coincides with warming cycles and species' responses can manifest as distributional shifts. Accurate predictions of these biodiversity shifts require understanding of both the capacity of marine species to respond to environmental change and the viability of the Arctic marine environment as habitat to support distributional shifts. Here we use chum salmon, *Oncorhynchus keta*, in the Canadian Arctic to assess viability of the Arctic as habitat since deglaciation, and demonstrate the capacity of this species to adapt to environmental change. Chum salmon are ideal indicators of Arctic marine habitat viability due to their historic persistence in the Arctic, their present increasing abundance and distribution, and expectations of shifts in species compositions and habitats with continued warming. Using population genetic analyses and by testing colonization scenarios using Approximate Bayesian Computational analyses, we found that chum salmon colonized the Upper Mackenzie River from the Upper Yukon River during early deglaciation, presumably developing anadromous migrations to the Beaufort Sea subsequent to this. Current vagrant occurrences appear to originate from northern Siberian populations. This confirms that the current distribution of chum salmon in Arctic Canada extends northward to the Mackenzie River, and identifies a genetically distinct, geographically isolated spawning population of chum salmon that has experienced and perhaps adapted to changing Arctic conditions for thousands of years. This has implications for predicting risks and opportunities associated with biodiversity shifts in a future Arctic, and highlights the need for baseline knowledge of Arctic species and habitats in order to accurately predict future changes.

Oral Presentation-18

Topic 2. Pacific salmon and steelhead trout in a changing North Pacific Ocean

The global warming effect for migration route of Japanese chum salmon

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To evaluate the effect of global warming on distribution and migration routes of Japanese juvenile chum salmon (*Oncorhynchus keta*), I analyzed ocean condition, particularly sea surface temperature (SST) in the North Pacific Ocean, including the Okhotsk Sea, using the objective analysis "COBE-SST" (Ishii et al. 2005) operated by the Japan Meteorological Agency. In the 2010s, the area of optimal temperature (AOT: 8-12 ºC) of juvenile has quietly departed from Hokkaido Island, even though the AOT was in touch with Hokkaido until the 2000s. The AOT in August gradually decreased, and became less than half in the 2010s. The survival rate of the Hokkaido chum salmon population in 2001–2014 significantly had a negative correlation (R2=0.4502, P<0.001) with the SST in July off the Shiretoko Peninsula, despite no correlation with the PDO. These results suggest that Hokkaido juvenile chum salmon have missed a migration route to the Okhotsk Sea, decreased the distribution area and the carrying capacity in summer, and declined the survival rate since the 2010s under the global warming effect in the Okhotsk Sea.

Keynote Oral Presentation-3

Topic 4. Management systems

Decision windows, critical thresholds and managing hatchery production for resilience in changing ocean ecosystems

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It is expected that resilience among populations of Pacific salmon species will allow some degree of adaptation as ocean ecosystems respond to greenhouse gas accumulations. It could also be expected that hatchery produced populations will have progressively poorer survival because of their reduced resilience. Currently, hatcheries directly or indirectly produce about one quarter of the total catch of all species of Pacific salmon and it is possible that hatchery releases could increase as wild populations become more challenged. Improving survival and optimizing hatchery production probably will become more complex as our scientific understanding of decision windows, critical thresholds and resilience improves and identifies the need to incorporate resilience into hatchery practices.

Oral Presentation-19

Topic 4. Management systems

The use of marine ecosystem metrics for preseason forecasts of salmon harvest

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Annual forecasts of pink salmon (*Oncorhynchus gorbuscha)* harvest and Chinook salmon (*Oncorhynchus tshawytscha*) returns to the Yukon River were developed to advise fishery managers, members of fishing industries, and the public. Although the forecasts were developed independently for different species and widely separated geographic localities, the projects illustrate the utility of using marine ecosystem metrics for forecasting future harvest of salmon. In the case of pink salmon harvest forecasts, metrics and models are derived from ongoing time series of oceanographic and juvenile salmon data collected by the Southeast Coastal Monitoring (SECM) project. Each year a preseason forecast of total pink salmon harvests in Southeast Alaska is provided to industry and fishery managers by oral presentations and web pages. In northern Alaska, recent declines of Yukon Chinook salmon, in particular the US/Canada treaty managed Canadian-origin stocks, have been problematic. Declines have triggered closures of commercial, sport, and personal use fisheries, and severe restrictions on subsistence fisheries and Chinook salmon bycatch in the eastern Bering Sea groundfish fisheries. A time series (2003–2017) of juvenile Chinook salmon abundance was constructed for the Canadian-origin (Upper Yukon) stock group using data from late-summer pelagic rope trawl surveys in the northern Bering Sea during the Bering Aleutian Salmon International Survey (BASIS). Juvenile abundance is significantly correlated ($r = 0.87$, $p < 0.001$) with adult returns, indicating that much of the year-to-year variability in survival of the Canadian-origin Chinook salmon occurs during their early life stages (freshwater and initial marine). This analysis facilitates a forecast of future adult returns of Canadian-origin Chinook. It also contributes to pre-season management guidance for Yukon River Chinook fisheries and Chinook bycatch management in the eastern Bering Sea groundfish fisheries.

Oral Presentation-20

Topic 4. Management systems

A model to estimate the exposure of Interior Fraser River steelhead to marine and in-river fisheries

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The Fisheries and Oceans Canada Integrated Fisheries Management Plan states the objective for Interior Fraser River (IFR) steelhead is to minimize the impact of commercial south coast fisheries and to increase spawner abundance. For Fraser River commercial gill net fisheries, the strategy is to protect 80% of the IFR steelhead run with a high degree of certainty. The Department is currently reviewing this strategy with the Province, including expanding it to other fisheries; Therefore, a tool is needed to estimate impacts of fisheries on IFR steelhead to evaluate if the department is meeting the current objective. The information required for a complete box-car model estimating harvest impacts is not available, so a model was designed that incorporates readily available data: fishery opening times, run timing, and migration speed. A hierarchical Bayesian normal model was developed first to estimate run timing of migrating steelhead past the Albion test fishery in the lower Fraser River in British Columbia, Canada. Run timing estimates (peak and spread) for each year from 1995–2017 were then incorporated into the exposure model. The current version of the model examines IFR steelhead exposure to Canadian commercial fisheries (including First Nations economic opportunity fisheries) in Johnstone Strait and the Fraser River up to Sawmill Creek (24 fisheries with different area/gear/target species combinations, e.g. “Area B seine chum”). Using the run timing and migration speed information, fish were simulated moving forward and backward from the Albion test fishery in space and time. The time each fish was present in an area was compared to fishery opening times, and if a fish was present in the area at the time of a fishery opening in the same area, that fish was considered “exposed” to the fishery. For each year of the analysis, the metrics examined included: (1) The proportion of IFR steelhead population exposed to each fishery annually (% exposure); and (2) The cumulative exposure of each fish to all fisheries (what % are exposed to 1, 2, 3… etc. fisheries). Preliminary results suggest some fisheries are much more likely to expose a large proportion of the population to fishing activity than others. This information can be used by managers to estimate relative impact (exposure) of proposed fishing plans for a suite of fisheries (e.g. Area B chum, Area D sockeye, Area H pink) and within an individual fishery (e.g. alternative plans for Area B chum), as well as to monitor patterns of exposure over time. However, the model does not give a sense of actual impacts to population (i.e. harvest rate), indicating a strong need for fisher-independent information about steelhead encounters. The model is still being developed with input from the Province of British Columbia, and ideas for further improvements are welcomed.

Oral Presentation-21

Topic 4. Management systems

Effects of duration of net-pen acclimation and timing of river stocking on early growth and adult return of chum salmon along the Pacific coast of Honshu, Japan

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The number of chum salmon *Oncorhynchus keta* returning to the Pacific coast of Honshu, Japan, in the southernmost part of this species' distribution, has decreased notably in recent years. One reason is the decline in stocked fry following the tsunami disaster of March 2011; another possible reason is the changing coastal environment. A recent study pointed out that warm water during the coastal residence period of juvenile chum salmon could be negatively affecting their early survival off Iwate Prefecture, northeast Honshu. To facilitate cost-effective fry production and improve adult return of chum salmon, we modified the present stocking program and developed new strategies, especially focusing on the duration of net-pen acclimation and the timing of river stocking. We tested two stocking programs in Iwate Prefecture, one in Yamada Bay and the other in the Orikasa River, for 2012–2016 year classes: 1) short-term net-pen acclimation, where fry were acclimated to seawater in a net pen for one week before release in the bay (shorter than the usual four weeks), and 2) early release, where fry were released into the river in February (earlier than the usual middle March–early May). We collected juveniles in the bay for about 40 days after release and measured growth rates by otolith daily ring analysis. Fry capture and growth rates and adult return rates of the test groups were compared to those of control groups (the usual river release, and 4-week net-pen acclimation, released in April or May). Capture rates of both short-term and 4-week acclimation were slightly higher than those of usual river release, suggesting that net-pen acclimation decreases early mortality. In age-4 adults of the 2012 year class, the river return rate from short-term net-pen acclimation was 1.94 times that from the usual acclimation, and 1.06 times that from usual river release. Growth rates of the early release group were generally lower than those of the April–May release groups, probably because of the lower temperatures. These results indicate that the duration of net-pen acclimation and the timing of stocking are important in determining early growth and survival of chum salmon. This study was supported by the Great East Japan Earthquake Reconstruction Project sponsored by the Agriculture, Forestry, and Fisheries Research Council, Japan.

Oral Presentation-22

Topic 4. Management systems

Preliminary findings from IYS survey of Fisheries and Oceans Canada salmon staff to identify collaborative opportunities

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Preliminary analysis of results from a 2017 International Year of the Salmon (IYS) survey confirmed collaborative opportunities exist that should allow Fisheries and Oceans Canada (DFO) to better understand and manage salmon populations. In total, 351 staff from across the country who work on Pacific or Atlantic salmon were surveyed and asked about the potential for collaboration on 37 topics within six IYS themes (Status of Salmon, Salmon in a Changing Salmosphere, New Frontiers, Human Dimensions (connecting salmon with people), Information Systems, and Salmon Outreach and Communication). From 164 surveys received, 124 were useful for cluster analyses presented as “heat maps” factored by job type and region. There were sharp differences in response rates among seven job types: resource (fishery) managers (43 responses from 91 recipients), non-hatchery technical staff (30/83), biologists (35/70) and scientists (13/21) within Science Branch, enhancement staff (19/36), staff managers (17/35), and policy analysts/economists (6/15). Less clear but interesting differences emerged among DFO regions: Pacific (122/262), Maritimes (18/43), Gulf (9/21), Newfoundland and Labrador (6/11), Quebec (5/7), National Capital Region (2/5), and Central and Arctic (1/2). Each participant selected one of five choices in response to the question of whether they saw potential to expand collaboration each topic; responses were scored from 0-4 (scores in brackets): no or not applicable (0); yes but unlikely at present (1); yes and have activity with need (2); yes and I can help others (3); and yes collaboration is vital to my work and should be high priority to DFO (4). Field data collection, First Nations (aboriginal) cultural and economic opportunities including co-management, and effective science communication were the three highest ranked topics overall while toxicology, the changing role of salmon in society, and advances in genetics and genomics were the three lowest. Human Dimensions and Information Systems were the two highest ranked themes while Salmon in a Changing Salmosphere was the lowest. Further information about who is doing what, where, and with whom will be analyzed as a network. Depending on final results, the survey may be extended to others outside DFO who work on salmon, potentially expanding the emerging “DFO Salmon Network” to one with national or international membership.

Oral Presentation-23

Topic 5. Integrated Information Systems

Increasing outreach: non-salmon species in the Subarctic North Pacific

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A multinational salmon survey in the North Pacific planned as a part of the International Year of the Salmon (IYS) provides an opportunity to collect valuable data on non-salmon species in the Subarctic North Pacific. The North Pacific Fisheries Commission (NPFC) considers taking part in the survey to get new data and improve knowledge on NPFC's species of interest. The goal of this work is to review the past pelagic surveys conducted in the North Pacific with the emphasis on the period from January to April and find out what can be expected from participation of NPFC in the NPAFC IYS survey. All eight priority species of NPFC (North Pacific armorhead, Splendid alfonsino, Pacific saury, Neon flying squid, Japanese flying squid, Chub mackerel, Spotted mackerel, Japanese sardine) were caught during the pelagic surveys in the western and central Subarctic North Pacific in January–April from 1980–2017. Mackerels and Japanese sardine had the highest occurrence and were registered in trawlings about 800 times. Their catch per hour reached 407 and 682 th ind (41 and 27 t), respectively. Splendid alfonsino had a lower occurrence rate (132 records) in comparison with the above species but its catch was also high (up to 99 th ind., 24 t). Pacific saury occurred in 38 trawlings (557 ind., 38 kg). Potential outputs for NPFC from joining the project could include improved knowledge about distribution and migration of priority species, validation and adjustment of models (ecosystem, suitable habitats etc.), new biological information for priority and other species of fish and squids, and other data related to oceanography, fish diets and zooplankton. The IYS could benefit from cooperation with NPFC through increased outreach and higher involvement of regional stakeholders, collaborative studies on marine ecosystems and modelling, development of integrated information systems and strengthened ties between NPAFC and NPFC. It could be of direct benefit to Canada, Korea, Japan, Russia and USA as they are members of both NPAFC and NPFC.

Poster Presentation-1

Topic 1. Status of Pacific Salmon and steelhead trout

Environmental factors affecting the survival of juveniles and recent returns of chum salmon in the Okhotsk coast of Hokkaido

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The Okhotsk coast of Hokkaido is the principal area of chum salmon, *Oncorhynchus keta*, production in Japan. In recent years, returns of chum salmon to the Okhotsk coast have been at a historic high, although decreases of chum salmon in the other coasts of Hokkaido have been remarkable since 2008. The recent high abundance of chum salmon on the Okhotsk coast should be due to the favorable ocean conditions and a successful enhancement program. However, the returns of chum salmon to the Okhotsk coast of Hokkaido have decreased since 2014. Extreme low returns of 2010, 2012 and 2013 brood year classes were observed. A program monitoring the distribution, abundance, and growth of juvenile chum salmon in the estuarine and coastal areas (within 7 km from the shore) has been conducted since 2002. At present, it is difficult to determine the specific factor explaining the recent low returns. However, some environmental conditions would affect the survival of juvenile chum salmon; warm sea water temperature and abundant zooplankton in May have positive effects and weak warm current (the Soya Warm Current) in June has negative effect on survival of juvenile chum salmon. These factors may relate to the distribution in the coastal area and the timing of offshore migration of juvenile chum salmon.

Poster Presentation-2

Topic 1. Status of Pacific Salmon and steelhead trout

Interannual dynamics of Pink and Chum Salmon juvenile's abundance and their average body sizes in the Sea of Okhotsk and western Bering Sea during 1998–2017

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The dynamic of abundance and average sizes of pink salmon and chum salmon juveniles have been analyzed according to the annual complex trawl surveys data, conducted in the autumn of 1998–2017 in the Sea of Okhotsk and in the western Bering Sea. Abundance of pink salmon juveniles in the Sea of Okhotsk in 1998–2017 varied within the range of 442–1,833 million individuals in the line of odd generations, and 569–2,752 million individuals in the line of even generations. Pink salmon has absolutely dominated the abundance among juveniles, ranging from 53 to 89% of its total abundance. The abundance of chum salmon juvenile during the study period varied from 164 to 926 million individuals, an average of 32% from the total of these two salmon species. The results of the correlation analysis performed using the data on pink salmon and chum salmon juveniles within each trawl catch conducted during their 1998–2016 in the early marine period indicate a statistically significant correlation between the pink salmon and chum salmon juveniles abundance in the autumn period (Spearman correlation coefficient +0.77, $p < 0.05$). Dynamics of average body size for pink and chum salmon juveniles during study period is also synchronous (Spearman correlation coefficient +0.54, $p < 0.05$). The changes in abundance and average body size of pink and chum salmon juveniles in the western Bering Sea are similar. Statistically significant Spearman correlation coefficients between pink and chum juvenile salmon abundance are very high - + 0.85, between average body weight sizes of these species - + 0.79. These results confirm the conclusion about the complementarity of these species in both Sea of Okhotsk and Bering Sea. The influence of fodder supply for pink salmon from Sea of Okhotsk and Bering Sea stocks on the growth of juveniles, their abundance and possible mortality in the period of marine and ocean migrations is discussed.

Poster Presentation-3

Topic 2. Pacific salmon and steelhead trout in a changing North Pacific Ocean

Migration and homing behavior of chum salmon tagged in the Okhotsk Sea, eastern Hokkaido

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Chum salmon is an important species for commercial fisheries in Hokkaido. Recently the coastal sea water temperatures in the fall have been higher than the historic mean. In the years with high coastal sea water temperatures, it has been observed that the timing of chum salmon return is delayed. To elucidate the influence of sea water temperature on migrating behavior of chum salmon in the coastal area, we visually counted the number of swimming chum salmon from the research vessel, and captured chum salmon by angling and released fish that were tagged with archival tags into the Okhotsk Sea, in early September 2016 and late August 2017. After release, the tagged fish were recaptured in the coastal areas or rivers. The sites where many chum salmon were counted, the sea water temperatures were 15–18°C at the surface layer, 5–15°C at a depth of 15m, and below 2°C at depths > 50 m. In both 2016 and 2017, 14 chum salmon were tagged and released. Of the tagged fish that were released, six and 2 fish were recaptured in 2016 and 2017, respectively. All of the tagged fish were recaptured only at the Okhotsk coast. Some of the tagged fish migrated diurnally between the surface layer and a depth of 200m layer. During daytime the tagged fish preferred sea water temperature of 1°C at a depth of 200m. Our study suggests that sea water temperatures are affecting salmon behavior in the coastal areas.

Poster Presentation-4

Topic 2. Pacific salmon and steelhead trout in a changing North Pacific Ocean

Environmental variability and chum salmon production at the northwestern Pacific Ocean

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Chum salmon, *Oncorhynchus keta*, distribute widely in the North Pacific Ocean, and about 76 % of chum salmon were caught from Russian, Japanese, and Korean waters in the northwestern Pacific Ocean during the last 20 years. Although it has been speculated that the recent increase in salmon production was caused not only by the enhancement program of chum salmon but also favorable ocean conditions since the early 1990s, the ecological processes for determining the yield of salmon were not clearly delineated. To investigate the relationship between yield and controlling factors for ocean survival of chum salmon, time-series of climate indices, seawater temperature and biological information in the northwestern Pacific including Korean waters were analyzed using some statistical tools. The results of cross-correlation function (CCF) analysis and cumulative sum (CuSum) of anomalies indicated that there were significant environmental changes in the North Pacific during the last century, and each regional stock of chum salmon responded upon Pacific Decadal Oscillation (PDO) differently: for the Russian stock, the correlation between PDO index and catch was a significantly negative with a time-lag of 0–1 years; for the Japanese stock, significantly positive with a time-lag of 0–7 years; and for the Korean stock, positive but no significant correlation. The results of statistical analyses with Korean chum salmon also revealed that the coastal seawater temperature over 14 °C and the return rate of spawning adult to natal river had a negatively significant correlation.

Poster Presentation-5

Topic 2. Pacific salmon and steelhead trout in a changing North Pacific Ocean

An evaluation of the influence of stock abundance and global temperature anomaly on Pacific salmon body weight in the North Pacific Ocean

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Relationships between Pacific salmon catch values (1961–2015) as a stock abundance index, the Northern Hemisphere Land and Sea Surface Temperature Anomaly Index (N.HEMI+dSST) and Pacific salmon body weight in commercial catches of the North Pacific countries was assessed using stepwise multivariate regression analysis. The correlation coefficient R is <0.3 in 15%, $> 0.3 \leq 0.6$ in 45%, and > 0.6 in 40% of the cases examined. In most cases (~ 85% for all Pacific salmon species), a complex interrelation is observed between average body weight and "stock abundance + global temperature anomaly" indices. The highest correlation coefficient ($R> 0.6$) was computed for chum and Chinook salmon in Russia, pink and chinook salmon in Alaska, pink and chum salmon in Washington, Oregon, California (USA), and chum and sockeye salmon in Canada. The N.HEMI+dSST index is the most significant factor in about 70% of the multiple regressions under consideration. The stock abundance index is the most significant factor in multiple regression models for pink and sockeye salmon in Russia and Alaska. For the most of Pacific salmon stocks, there are different changing long-term trends in Pacific salmon body weight dynamics and no universal relationships are evident.

Poster Presentation-6

Topic 2. Pacific salmon and steelhead trout in a changing North Pacific Ocean

Return of chum salmon and water quality and ecology in the rivers connected with the eastern coast of Korea

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Chum salmon, *Oncorhynchus keta*, is major species which returns to rivers in Korea, and about 98% of chum salmon are returning to the rivers connected with the eastern coast of Korea. The returning rate of chum salmon in Korea is generally proportional to latitude, and release amount, water quality and ecological status in rivers are important factors allowing the species to return to those rivers. In the present study, water qualities and biological characteristics were monitored in five rivers from Taehwa river, the southernmost of the eastern coast in Korea to Myeongpa river, the northernmost of the coast. The five rivers, namely, Taehwa, Yeongok, Namdaecheon, Bukchon and Myeongpa from the south to the north of the eastern coast, are situated in distinctly different environmental conditions, with the latter four rivers being surrounded by natural forests, but Taehwa river running through large industrial and urban area before it reaches the sea. Thus, Taehwa river is expected to have poor water quality by human induced influences, while those in the other rivers are improved according to the latitude and geographical features. Among those rivers, Namdaecheon, the major releasing and returning area of chum salmon has relatively good status, especially biological condition (i.e. prey, predator, competition species) compared with the other rivers, whereas in Taehwa river, prey competition for chum salmon with animals that belong to the same trophic level seems to be relatively strong, and consequently, prey selection of chum salmon may be restricted. The results from this study will contribute in future researchs that seek the best habitate for returning chum salmons, and better predict the release/survival mechanisms of juvenile salmons in Korean river systems.

Poster Presentation-7

Topic 2. Pacific salmon and steelhead trout in a changing North Pacific Ocean

Using thermally-marked otoliths and coded wired tags for the management of Korean chum salmon

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A stock is a basic unit in the assessment and management of fish populations. A basic requirement of effective fishery management is the ability to separate stocks within a single fish species population. Fishery scientists and managers have tried to find effective techniques for stock separation to estimate the production or to regulate harvest rates of individual fish stocks exploited together in mixed-stock fisheries. Extensive tagging studies have confirmed that most Pacific salmon return to their natal river to spawn. Among them, otolith thermal marking is a widely used technique for identifying origins of hatchery-produced salmonids, and coded wired tags (CWT) is an animal migration tracking device for tracking fish migration. We have applied otolith thermal mark technique and CWT to identify Korean chum salmon stock and investigate the biological characteristics of chum salmon since mid-2000s. The results from two techniques such as stock separation, growth, proper timing of fingerling releases and the proportions of returning age will be presented.

Poster Presentation-8

Topic 2. Pacific salmon and steelhead trout in a changing North Pacific Ocean

Artificial migration and protection of chum salmon (*Oncorhynchus keta*) in Amur Basin

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In response to the direct and potential impacts of climate change on aquatic ecosystems and fisheries, and to restore or expand the available habitat for Pacific salmon, we conducted a systematic investigation and assessment of the history and current status of chum salmon habitat in China's Amur River basin. We evaluated the habitat suitability for chum salmon in different river systems, such as the Amur, Wusuli and Songhua Rivers. Different types of rivers, such as the Huma River (Amur River tributary) and the Tangwang River (Songhua River tributary), were selected as the key areas for habitat restoration and population reconstruction. We then analyzed and monitored certain aspects of the habitat, such as water temperature, water depth, water velocity, sediment in spawning grounds, hatcheries and migration passageways. To address some of the problems associated with chum salmon spawning grounds, we used restoration techniques including bottom clearing, sediment rehabilitation, gravel addition, biological community improvement and other ecological restoration techniques, in order to restore the original appearance and ecology of the spawning grounds. During the anadromous migratory period of chum salmon, we captured the reproductive groups in the middle reaches of the Amur River and transported them large distances to the middle reaches of the Tangwang River (Songhua River tributary) and the upstream reaches of the Huma River (Amur River tributary). Electronic tagging, underwater robots, aerial photography, underwater photography and other advanced scientific and technological methods, were used for continuous fixed-point observation to track the habitat status of key areas during the breeding season. We then estimated the range and location of the spawning areas, hatchery areas and the migratory channel for chum salmon. and then get the scientific information about the process on initiative goes back, habitat selection, natural spawning in the selected rivers. Experimental results showed that more than 95% of chum salmon returned to the excellent spawning grounds even after being transported to these areas from distances about 600 km and 1,800 km. The F1 generation was successfully propagated in the lower reaches of the Tangwang River, which was artificially restored, and the lower reaches of the Huma River. The natural successful spawning rate was greater than 80%, and was assisted by the artificial reproduction of chum salmon. We expect to achieve the desired ecological restoration results and recovery functionality of chum spawning grounds.

Poster Presentation-9

Topic 4. Management systems

Homing ability of Japanese chum salmon that discriminate their natal river system and natal tributary, as revealed by otolith mass marking

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Chum salmon fry are stocked in several tributaries of a river system to manage the chum salmon resource, and homing adults are captured in each tributary for hatchery broodstock. It is important to understand whether chum salmon discriminate their natal tributary as well as their natal river system to conduct effective hatchery programs. Three hatcheries exist in the Gakko River system of Yamagata Prefecture, Japan—the Minowa hatchery on the Ushiwatari River, the Masukawa hatchery on the Takibuchi River, and the Takase hatchery on the Takase River. The Ushiwatari and Takibuchi Rivers are second tributaries of the Gakko River system, and flow into the Araisawa River. The Araisawa and Takase Rivers are first tributaries of the Gakko River system. The confluence of the Araisawa River with the Gakko River is 2.3 km from that of the Takase River. Seven marking groups of chum salmon juveniles with specific otolith-thermal-marking depending on their natal tributary (hatchery) were released through each hatchery discharge channel in 2009–2011. The number of chum salmon juveniles released and the mean body weight of the seven marking groups ranged from 82 thousand–1.8 million (weight, 1.0–1.7 g), respectively. Returning adults were captured between October and January at weirs of each of the three tributaries. In addition to daily catches, 100 adults (50 males and 50 females) were sampled every 19 days; age was determined from scales, and otoliths were checked to identify the hatchery of origin (released tributary) in 2011–2015. The escapement of each marking group (age 3–5 years) was estimated for each tributary by multiplying the ratio of the marking group to the total sample number with the number of fish caught in each tributary. Natal tributary selectivity (number of adults caught estimated in the natal tributary/total number of adults caught in the three tributaries) of the marking groups was 49–100%. However, the percentage of the marking group originating from Minowa and Masukawa hatcheries that returned to the Takase River was 0–3%. In addition, the percentage of the marking group originating from Takase hatchery that returned to the Ushiwatari and Takibuchi Rivers was 0–17%. These results suggest that chum salmon returning to the Gakko River system can discriminate their natal first tributary (Araisawa River/Takase River) within a narrow space, and they often stray into a second tributary level (e.g., chum salmon originating from the Minowa Hatchery run into Takibuchi River).