International Year of the Salmon Symposium Tokyo, Japan

By Shigehiko Urawa
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Shigehiko Urawa is working at the Hokkaido National Fisheries Research Institute (HNFRI), Fisheries Research and Education Agency in Sapporo, Japan. His research has focused on the distribution and abundance of Japanese chum salmon in the ocean by using genetic stock identification and otolith marks. He has a concern how salmon can adapt their specific migration route and ocean distribution, responding to changing environments. He is also interested in impact of diseases on the survival of salmon in wild conditions. He received his PhD from Hiroshima University on the pathobiology of ectoparasitic protozoans on hatchery-reared Pacific salmon. Hiko worked as deputy director of NPAFC Secretariat for four years from 2006 to 2010. Since 2012 he has been serving as the chairperson of NPAFC Science Sub-Committee (SSC), whose missions include the review of NPAFC Science Plan and the coordination of international workshops/symposia.

Introduction

Chum salmon (*Oncorhynchus keta*) migrate widely in the North Pacific Ocean and adjacent seas and finally return to their natal river for spawning (Urawa et al. 2018a). In Japan, chum salmon enhancement was initiated in the 1880s, and the adult reruns increased from the late 1970s with a peak of 89 million fish in 1996 due to the improvement of hatchery technologies and favorable ocean conditions. Chum salmon are an indispensable fisheries resource in northern Japan, but the recent adult returns have trended decreasing with considerable interannual and regional fluctuations (Figure 1).

Pacific salmon are biologically and economically important for North Pacific rim countries, while they are facing unpredictable future: e.g., the considerable reduction in salmon habitats and survivals may be caused by global warming. The North Pacific Anadromous Fish Commission (NPAFC) and North Atlantic Salmon Conservation Organization (NASCO) are leading to promote a global program "*the International Year of the Salmon (IYS)*" with a focal year in 2019. The IYS is an international framework for collaborative research and outreach to ensure that salmon and their habitats are conserved against increasing environmental variability (IYS Working Group 2016).

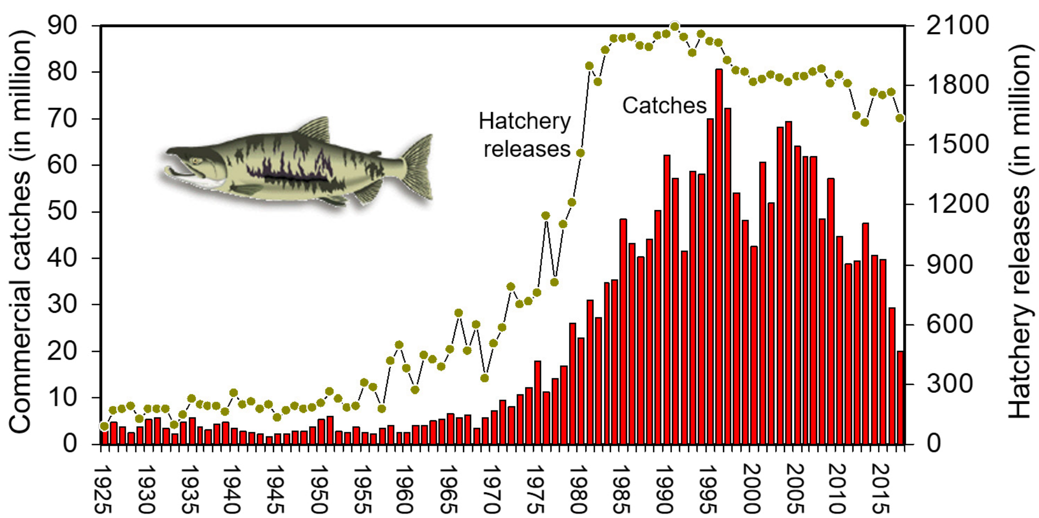

Figure 1. *Hatchery releases and coastal commercial catches of chum salmon in Japan, 1925–2017. Data sources: Hokkaido Fish Hatchery (1951), Hokkaido Salmon Hatchery (1956), NPAFC (2018a, 2018b)*

An IYS Local Symposium on "*Sustainable Management of Chum Salmon in Changing Environments*" was held in Tokyo University of Marine Science and Technology, Tokyo, Japan on March 26, 2018 (Figure 2). The symposium was hosted by the Japanese Society of Fisheries Science (JSFS) with a co-sponsor the Salmon Science Society and endorsed by the IYS North Pacific Steering Committee. The coordinators were H. Araki (Research Faculty of Agriculture, Hokkaido University), K. Miyashita (Field Science Center for Northern Biosphere, Hokkaido University), M. Nagata (Hokkaido Aquaculture Promotion Cooperation), Y. Sasaki (Salmon and Freshwater Fisheries Research Institute, HRO), and S. Urawa (Hokkaido National Fisheries Research Institute, FRA; chairperson) with a support by M. Kaeriyama (Arctic Research Center, Hokkaido University). The official registration included 107 participants from various organizations such as embassy, governments, universities, laboratories, and fisheries and hatchery associations (Photo 1). The program was composed of one keynote presentation and 14 oral presentations in three sessions, followed by a panel discussion (Appendix).

Symposium Purposes

In the opening remarks, the chairperson of symposium organizing committee (S. Urawa) introduced the outline of IYS and the purposes of symposium (Urawa et al. 2018b). In order to endorse effective IYS projects, the present symposium aimed to:

1. comprehend the vision of the IYS program;
2. understand the present status of chum salmon populations and their habitats (IYS Theme 1);
3. assess effects of environmental variability on chum salmon distribution and survival (IYS Theme 2);
4. evaluate new research technologies to advance salmon science (IYS Theme 3); and
5. identify future research topics for the forecast of chum salmon distribution and production, and their sustainable management.

Figure 2. *A poster for IYS local symposium "Sustainable Management of Chum Salmon in Changing Environments" hosted by the Japanese Society of Fisheries Science*

Photo 1. *Over 100 participants were focusing on the sustainable management and research of chum salmon*

Photo 2. *R. Beamish (Pacific Biological Station, DFO) was invited to give the keynote presentation and highlighted international cooperation to understand the mechanism of Pacific salmon production. Photo Credit: M. Kaeriyama*

Keynote Presentation

R. Beamish (Photo 2) made a keynote entitled "*International Year of the Salmon: teaming up internationally to understand Pacific salmon production*". His English was translated into Japanese by Ms. M. Ota. He noted an important unsolved problem is why Pacific salmon production occurs in trends and why there is synchrony in a production of a species over a diversity of ecosystems. There are numerous examples of trends, but the declining trend of chum salmon production in Japan is one of the most important examples. It is the ocean ecosystem that is causing the trends and synchronies and the mechanisms need to be discovered. He hypothesized that a mechanism could be that after the first few months in the ocean there are genetically-based, metabolic thresholds that determine how an individual will continue to use energy for growth and storage. Fish that store lipids for the winter, generally survive better.

It is expected that resilience among wild 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 produce about 40% of the total biomass 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 need to be more resilience based which will require a better understanding of the mechanisms regulating survival in the early marine period. A resilience-based approach to hatchery production is adaptive, experimental and more expensive, but it should be more economically reliable. The International Year of the Salmon provides an opportunity for researchers to work and think together as international teams. If individual researchers show that major advances can be made by teaming up internationally, it may provide the incentive for private funding and future government support (Beamish 2018).

Status of Chum Salmon

T. Saito (Hokkaido National Fisheries Research Institute, FRA) reviewed the status of Pacific salmon in the North Pacific and gave his deliberation for factors affecting the survival of chum salmon. Total commercial catches of Pacific salmon have been almost high levels since the 1990s, while the recent catches show a north-south gradient along latitudes on both Asian and North American sides. In Asia, although Japan had caught a greater proportion of chum salmon from the 1970s to the mid-2000s, Russia currently catches the largest proportion of chum salmon. Chum salmon catches have declined since 2010 along the Pacific coasts of Hokkaido and Honshu in Japan. In contrast, Amur River chum catches have drastically increased since the mid-2000s. He investigated relationships between chum brood-year strengths and sea surface temperatures (SSTs) during their coastal residency for chum stocks originating from the Pacific coasts of Japan and from the Amur River in Russia. His results suggested a common trend that the survival of juvenile chum salmon is positively correlated with coastal SST during their ocean entry. The recent low coastal SST in the spring might reduce the survival of juvenile chum salmon in Japan (Saito and Fukuwaka 2018).

Photo 3. *Y. Miyakoshi (Salmon and Freshwater Fisheries Research Institute) deplored the recent decline trend in chum salmon returns in Hokkaido*

Y. Miyakoshi (Photo 3) also reviewed the current status of chum salmon in Hokkaido. The number of chum salmon returns has been historic high during the 1990s and early 2000s, while it has decreased in the last decade. He speculated that the recent decrease of adult returns might be caused by poor environmental conditions in around Hokkaido and the North Pacific: low SST in spring when juveniles entered the ocean, high SST in fall when adults returned for spawning. For the future enhancement of chum salmon stocks in Hokkaido, he suggested that the procedures of the hatchery programs should be modified to adapt to the recent environmental conditions (Miyakoshi 2018).

T. Tsukagoshi (Photo 4) examined the genetic structure and population traits in Sanriku region (the Pacific coast of northern Honshu). He found three distinct groups: early and late run groups in the Sanriku coast, and inland (the Kitakami River) group. Although the inland group was a small population size, their genetic traits were well reserved. However, in the coastal groups, the genetic diversity among river populations was low maybe due to artificial factors such as egg transplantations. He recommended that conservation strategies should be developed to keep genetic diversity and traits for the sustainable management of chum salmon.

Photo 4. *T. Tsukagoshi (Sanriku Fisheries Research Center, Iwate University) emphasized importance of genetic conservation for the sustainable management of chum salmon*

Effects of Environmental Variability on Chum Salmon

H. Urabe (Salmon and Freshwater Fisheries Research Institute, HRO) presented effects of environmental variability on the reproduction of chum salmon in Japanese rivers. Recent studies have shown that wild chum salmon are widely distributed in northern Japan. He pointed out positive and negative effects of climate change on wild chum salmon through hydrological processes, and channel morphology and river connectivity are prominent factors to maintain wild chum salmon populations. He noted habitat restoration (short-term) and better understanding for impacts of climate change on salmon (long-term) are necessary for future sustainable salmon fisheries (Urabe 2018).

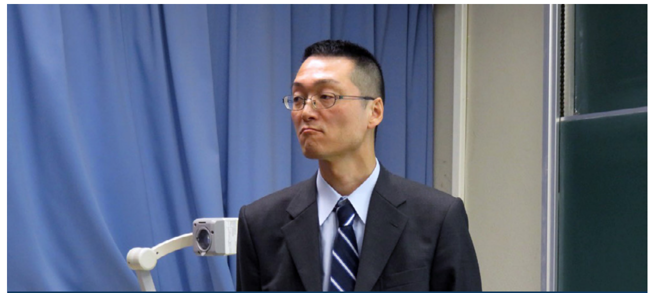

Photo 5. *K. Kasugai (Doto Research Branch, Salmon and Freshwater Fisheries Research Institute) suggested a recent trend of low SST in spring coastal waters might cause the mortality of juvenile chum salmon in eastern Hokkaido*

K. Kasugai (Photo 5) evaluated the effects of coastal environment on the migration and survival of juvenile chum salmon in the eastern coastal waters of Hokkaido. He considered low coastal SST may be a factor causing mortality of juvenile chum salmon because it caused a low return rate of adult fish. Low SST might affect the survival of juvenile chum through (1) shortage of preys caused by restricting the migration of juveniles from the littoral zone to the nearshore area, (2) retardation of fish growth and swimming capacity, and (3) physiological disorders. In addition to field studies, he suggested laboratory experiments under controlled temperature, salinity, feeding regimes are required in order to understand the survival mechanism of juvenile chum salmon in association with low SST in coastal water (Kasugai 2018).

Photo 6. *T. Kawashima (Iwate Inland Water Fishery Technology Center) noted a trend of increase in coastal SST in the Pacific coast of Honshu might reduce the survival of juvenile chum salmon*

T. Kawashima (Photo 6) reported drastic changes in chum salmon returns and possible cause for the reduction of adult returns in the Sanriku coast (Pacific coast of northern Honshu). Chum salmon returns were high level for the 1980–1994 blood year classes and then continued to decrease since the 1995-year class. Their long-term coastal monitoring surveys indicated a positive correlation between the density of juvenile chum salmon and number of their returns. The SST along the Sanriku coast showed a trend of increase, which might reduce the survival of juvenile chum salmon (Kawashima et al. 2018). The trend of coastal SST changes is different depending on regions (Honshu and Hokkaido).

K. Honda (Hokkaido National Fisheries Research Institute, FRA) used daily-increment analysis of otoliths to back-calculate the growth rate of juvenile chum salmon caught in the eastern Pacific coast of Hokkaido (Konbumori). Juvenile chum salmon originating from distant regions tended to grow faster than those originating from neighboring regions (Honda et al. 2017). Additionally, the growth rate of Japanese and juvenile chum salmon caught in the Okhotsk Seas was much higher than that caught in the Konbumori coast (Honda et al. 2018). His results suggested that juvenile chum salmon whose growth rate exceeded a certain level may better survive and reach the Okhotsk Sea.

S. Sato (Hokkaido National Fisheries Research Institute, FRA) reviewed recent high-seas salmon researches. A considerable number of otolith-marked Japanese chum salmon juveniles were found in the Okhotsk Sea by Russian cruise surveys during the fall of 2011–2015 (Chistyakova and Bugaev 2013, 2016). The estimated abundance of Japanese hatchery chum salmon juveniles in the Okhotsk Sea was extremely low (50–75 million fish) in 2013–2015 (Urawa et al. 2018a). There was a significant positive correlation between the estimated abundance of Japanese chum salmon juveniles in the Okhotsk Sea and adult returns by brood-year stocks. In addition, a high positive correlation between CPUE of juvenile Japanese chum salmon juveniles in the Okhotsk Sea and that of ocean age 1 fish in the Bering Sea was found among 2010–2014 brood-year stocks. These results suggest that the year class strength of Japanese chum salmon may be determined during their early ocean life (Sato et al. 2018).

H. Ueno (Photo 7) estimated the potential habitat for chum salmon in the Western Arctic using a bioenergetics model coupled with a three-dimensional lower trophic ecosystem model (3-D NEMURO). For the bioenergetics model, the growth rate of an individual chum salmon was calculated as a function of water temperature, salinity, and prey density, which were obtained from the 3-D NEMURO model results. To evaluate the habitat responses under a global warming scenario, he used the modeled monthly change of water temperature between 2005 (averaged from 2001 to 2010) and 2095 (averaged from 2091 to 2100) under the IPCC SRES-A1B scenario. His analyses suggested that the potential habitat for chum salmon would expand to the north due to the increase in water temperature and prey density. In contrast, south of 71N during summer, the potential habitat would shrink regionally, because the water temperature exceeded the optimal condition (Ueno et al. 2018).

Photo 7. *H. Ueno (Faculty of Fisheries Sciences, Hokkaido University) estimated the potential habitat of chum salmon in the Western Arctic under a global warming scenario by using a bioenergetics model coupled with a three-dimensional lower trophic ecosystem model*

Development of New Technologies to Advance Salmon Science

M. Shimizu (Faculty of Fisheries Sciences, Hokkaido University) is developing endocrine growth indices (insulin-like growth factor IGF-1 and IGF-binding protein IGFBP) for evaluating the growth status of juvenile chum salmon in rivers and coastal waters. His primary results suggested that for the growth of juvenile chum salmon, serum IGF-1 and IGFBP-1b are useful as a positive and negative index, respectively.

M. Yoshimizu (Faculty of Fisheries Sciences, Hokkaido University) reviewed status and control of diseases in chum salmon. Various infectious organisms affect the health condition of hatchery-reared salmon, but their impact on salmon migrating in the ocean has been poorly understood. Potential diseases causing mortality of chum salmon under wild conditions include the bacterial gill disease caused by *Flavobacterium branchiophilum*, bacterial kidney disease (BKD) by *Renibacterium salmoninarum*, furunculosis by *Aeromonas salmonicida*, and protozoan disease by *Ichthyobodo salmonis*. Epidemic prevention and control of diseases are essential for the sustainable management of chum salmon populations (Kasai and Yoshimizu 2018).

T. Kitagawa (Atmosphere & Ocean Research Institute, the University of Tokyo) examined the migration behavior of chum salmon in the Sanriku coast by using an “interactive” data logger technology. This new technology allows the recorded data (temperature and depth) can be exchanged among active data loggers on salmon migrating in the ocean, improving the recovery rate of data records. His future tagging research targets on high-seas chum salmon migrating from the Bering Sea to the coast of Japan to understand their migration behavior and environments (Kitagawa 2018).

Photo 8. *T. Azumaya (Hokkaido National Fisheries Research Institute, FRA) tested various conditions for the successful migration of juvenile chum salmon by using a hydrodynamic model*

T. Azumaya (Photo 8) investigated factors affecting the migration of juvenile chum salmon by using a migration model. This migration model was driven by the active swimming of juveniles and the passive transport by the ocean currents which were outputted by a hydrodynamic model. His model could simulate the migration route of juvenile chum salmon from the Pacific coast of northern Honshu to the Pacific coast of Hokkaido. He confirmed both the passive transport by the ocean currents and the active fish swimming played an important role for the successive inter-island migration of juvenile chum salmon. The model showed that as the speed of active fish swimming became larger, the number of juvenile chum salmon which could reach the coast of Hokkaido increased. The result suggests that the swimming performance of juvenile chum salmon is important for their successful migration and survival. Future model research should examine conditions that juvenile chum salmon can migrate from each coast of northern Japan to the Okhotsk Sea (Azumaya et al. 2018).

H. Araki (Research Faculty of Agriculture, Hokkaido University) tested to apply environmental DNA (eDNA) techniques to ecological studies of chum salmon. First of all, he examined the dynamics of chum salmon eDNA at a hatchery. He detected eDNA from hatchery waters used for eyed eggs and alevins, and the amount of eDNA increased with the fish development (Araki and Mizumoto 2018). He also observed eDNA in river water every hour. The number of DNA copies showed a positive correlation with the number of juvenile chum salmon migrating downstream. Chum salmon eDNA was also detected in the Bering Sea, although there was no spatial correlation between the observed CPUE of chum salmon and amount of DNA copies.

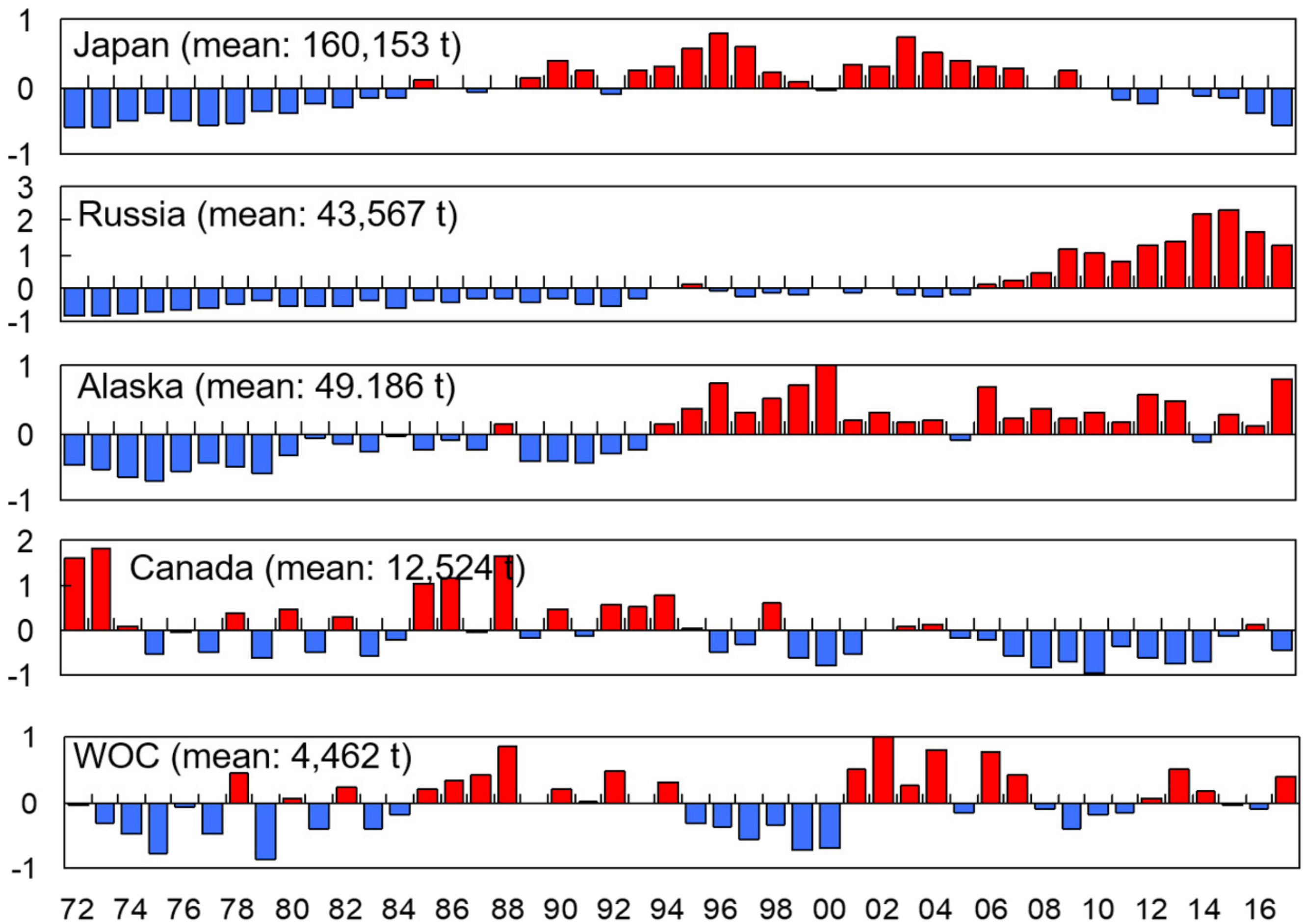

Figure 3. *Chum salmon catch (weight in metric tonnes) anomalies by region, 1972–2017*

Panel Discussion: Future Research for Sustainable Management of Chum Salmon

The catch trend of chum salmon is different by region (Figure 3). In Japan, the annual coastal catch of chum salmon was over the average (160,153 metric tons) between 1985 and 2010, but it was decreasing since 2004, and only 67,645 metric tons in 2017. In contrast, Russian catch rapidly increased since 2006, and 97,699 metric tons in 2017. In Alaska, chum salmon catch has been over the average (49,186 metric tons) since 1994, and 88,023 metric tons in 2017. In Canada, chum salmon catch is almost below the average (12,524 metric tons) since the mid-1990s. In Washington, Oregon, and California, the catch was variable with no clear trend. Thus, the current status of chum salmon populations seems superior condition in northern areas, while variable or depressing in the southern areas (Saito and Fukuwaka 2018).

More than 80% of Asian chum salmon juveniles inhabit the Okhotsk Sea during the first summer and fall. The abundance of juvenile chum salmon recorded high levels (480–553 million fish) in 2012, 2013 and 2015 (Chistyakova and Bugaev 2016). The abundance of Japanese hatchery-origin juveniles was 120 million fish (survival rate: 6.9%) for 2010-year class, 240 million (survival rate: 14.9%) for 2011-year class, but less than 75 million (survival rate: 2.8-4.2%) for the following year classes (2012, 2013, and 2014). There is a significant positive correlation between the abundance of Japanese hatchery chum salmon juveniles in the Okhotsk Sea and adult returns by brood year (Sato et al. 2018). This suggests that the year class strength of Japanese chum salmon may be determined during the early ocean life of juveniles migrating toward the Okhotsk Sea (Urawa et al. 2018a).

It is essential to understand the survival mechanism of juvenile salmon in southern areas associated with a climate change. A cause for the low survival of 2012–2014 year class chum salmon might be relatively cold SST in the coast of Hokkaido during the early coastal life in spring (Kasugai 2018, Miyakoshi 2018, Saito and Fukuwaka 2018); and following rapid increase of SST in early summer (Saito and Fukuwaka 2018), which disturbed their growth and migration. On the other hand, on the Pacific coast of Honshu, there was a significant negative correlation between the coastal SST and the survival of chum salmon (Kawashima et al. 2018). The relationship between the

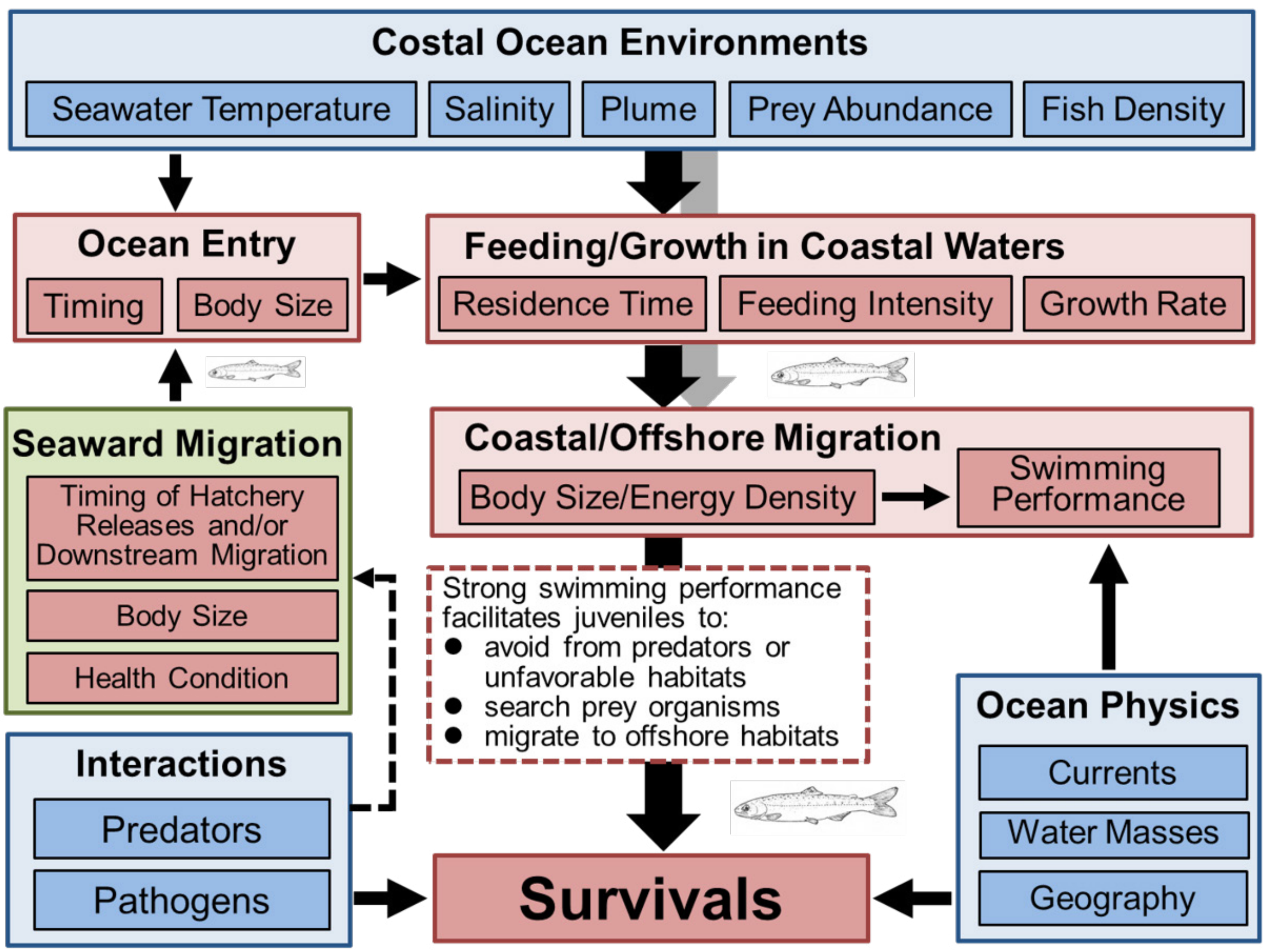

Figure 4. *A conceptual scheme for understanding the survival mechanism of juvenile chum salmon during the early ocean life (Urawa et al. 2018a)*

survival rate of Hokkaido chum salmon and the coastal SST of the Okhotsk Sea during July was positive below 13°C but turned negative over 13°C (Kaeriyama et al. 2018). Recent unusual changes of SST in the coastal waters around northern Japan may affect the migration and survival of juvenile chum salmon.

The growth rate of juvenile chum salmon in the coastal waters may be an important factor in understanding their migration and survival (Honda et al. 2018). Simulations with a migration model indicate that the swimming speed of juvenile chum salmon affects their successful migration from Honshu to the coast of Hokkaido (Azumaya et al. 2018). The swimming performance (migration speed and endurance) may be a key factor in understanding the oceanic migration and survival of juvenile chum salmon (Figure 4; Urawa et al. 2018a). Juvenile chum salmon need a strong swimming performance to migrate quickly in order to avoid lethal water temperatures in the coastal waters of Japan. Strong swimming performance may also facilitate juvenile salmon to search prey organisms, avoid from predators, and successfully migrate to their offshore destination such as the Okhotsk Sea.

Beamish (2018) suggested an increased focus on maintaining hatchery production in changing ocean environments. A new approach would be resilience-based and more adaptive to changing habitat conditions. Hatchery production would be continuously experimental to improve the early marine survival. An increased scientific interest is needed in optimizing hatchery production in the changing ocean ecosystems.

Future research subjects for the sustainable management of chum salmon are the followings:

1. Understanding the survival mechanism of juvenile chum salmon through field studies and alternative approaches: experimental verifications for growth and survival of juveniles under controlled conditions; models to identify conditions of juveniles for their successful migration to the Okhotsk Sea; IYS collaboration on the stock assessment of juvenile salmon in the Okhotsk Sea;

2. An innovation of hatchery techniques to increase the early marine survival;

3. Conservation of diversity and biological traits in regional populations;

4. Rehabilitation of river environments for the conservation of wild salmon;

5. Control of pathogenic organisms; and

6. Sustainable adaptive management of Pacific salmon based on the ecosystem approach.

The International Year of the Salmon is a good opportunity for researchers to work together to discover how best to manage chum salmon and other Pacific salmon in the changing ocean ecosystems.

Photo 9. *Presenters and participants continued their argument for the resilience of salmon and researchers even during a dinner time*

Photo 10. *Younger generations were encouraged by the world-famous salmon scientists. They are indispensable for future salmon research and management*

Acknowledgments

The symposium coordinators are deeply grateful to the presenters, participants, volunteers, and interpreter for their significant contributions (Photo 9). Especially, the younger generation is a treasure to lead future salmon research (Photo 10). We also express our gratitude to the Japanese Society of Fisheries Science and the North Pacific Anadromous Fish Commission (NPAFC) for their support. The symposium proceedings will appear in the Aquabiology Vol. 40 (August and October issues of 2018) by courtesy of the publisher, Seibutsu Kenkyusha Co. Ltd., Tokyo, Japan.

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Chum salmon harvested on the coast of Hokkaido. Photo Credit: Y. Miyakoshi

Appendix. Program for 2018 IYS Local Symposium

Sustainable Management of Chum Salmon in Changing Environments
A local symposium associated with the International Year of the Salmon (IYS)

Date: March 26, 2018 (9:00–17:30)
Venue: Meeting Unit 4, Lecture Room Building (3rd floor), Shinagawa Campus, Tokyo University of Marine Science and Technology (4-5-7 Konan, Minato-ku, Tokyo 108-8477, Japan)

Program

09:00–09:10	**Opening Remarks** *Shigehiko Urawa (Hokkaido National Fisheries Research Institute, FRA)*
I. Keynote Presentation *(Chair: Shigehiko Urawa)*	
09:10–10:00	International Year of the Salmon: Teaming up internationally to understand Pacific salmon production *Richard J. Beamish (Department of Fisheries and Oceans Canada)*
10:00–1010	coffee break
II. Status of Chum Salmon *(Chair: Kazushi Miyashita)*	
10:10–10:30	Status of Pacific salmon production in the North Pacific Ocean *Toshihiko Saito (Hokkaido National Fisheries Research Institute, FRA)*
10:30–10:50	Status of chum salmon populations in Hokkaido *Yasuyuki Miyakoshi (Salmon and Freshwater Fisheries Research Institute, HRO)*
10:50–11:10	Genetic structure and population traits of chum salmon in Sanriku (Pacific coast of northern Honshu) *Hideharu Tsukagoshi (Sanriku Fisheries Research Center, Iwate University)*
III. Effects of Environmental Variability on Chum Salmon *(Chair: Mitsuhiro Nagata)*	
11:10–11:30	Effects of environmental variability on reproduction of chum salmon in rivers *Hirokazu Urabe (Salmon and Freshwater Fisheries Research Institute, HRO)*
11:30–11:50	Effects of environmental variability on migration and survival of juvenile chum salmon in the coastal waters of Hokkaido *Kiyoshi Kasugai (Salmon and Freshwater Fisheries Research Institute, HRO)*
11:50–13:00	lunch time
13:00–13:20	Abundance and habitats of juvenile chum salmon and their adult returns in the Sanriku coast *Takuya Kawashima (Iwate Fisheries Technology Center)*
13:20–13:40	Survival conditions of juvenile chum salmon on the basis of their growth characteristics *Kentaro Honda (Hokkaido National Fisheries Research Institute, FRA)*
13:40–14:00	Status of Japanese chum salmon and their habitat environments in the high-seas ocean *Shunpei Sato (Hokkaido National Fisheries Research Institute, FRA)*
14:00–14:20	Effects of ocean variability on the distribution and abundance of chum salmon *Hiromichi Ueno (Research Faculty of Fisheries, Hokkaido University)*
14:20–14:40	coffee break
IV. Development of New Technologies to Advance Salmon Science *(Chair: Yoshitaka Sasaki)*	
14:40–15:00	Development of growth indices for juvenile chum salmon *Munetaka Shimizu (Faculty of Fisheries Sciences, Hokkaido University)*
15:00–15:20	Control of diseases for the sustainable management of chum salmon *Hisae Kasai (Faculty of Fisheries Sciences, Hokkaido University)*
15:20–15:40	Migration behavior of chum salmon evaluated by data logger technologies *Takashi Kitagawa (Atmosphere & Ocean Research Institute, University of Tokyo)*
15:40–16:00	Migration routes of juvenile chum salmon simulated with a hydrodynamic model *Tomonori Azumaya (Hokkaido National Fisheries Research Institute, FRA)*
16:00–16:20	Application of environmental DNA to population studies of chum salmon *Hitoshi Araki (Research Faculty of Agriculture, Hokkaido University)*
16:20–16:40	coffee break
V. Panel Discussion *(Chair: Masahide Kaeriyama, Arctic Research Center, Hokkaido University)*	
16:40–17:20	**Future Research for Sustainable Management of Chum Salmon**
17:20–17:30	**Closing Remarks** *Kazushi Miyashita (Field Science Center for Northern Biosphere, Hokkaido University)*