# Morioka Salmon Workshop

## 盛岡サケワークショップ

**February 8 to 10 2016**

bridging fisheries research and education for sustainable salmon fishery

持続的なサケ類漁業のための水産研究と教育の架け橋として

# Program and Abstracts

# プログラム・講演要旨集

**VENUE**

**Hotel Metropolitan Morioka New Wing**

**ホテルメトロポリタン盛岡 ニューウイング**

主催：岩手大学

# MORIOKA SALMON WORKSHOP

bridging fisheries research and education for sustainable salmon fishery

February 8 to 10, 2016

Hotel Metropolitan Morioka New Wing, Morioka, Iwate Prefecture, Japan

## BACKGROUND AND PURPOSE

Iwate University decided to establish a new graduate school and undergraduate course of fisheries science to promote rehabilitation of the fisheries industry in Sanriku-region heavily damaged by a massive earthquake and devastating tsunami on March 11, 2011. Sanriku fisheries industry is largely relying on salmon catch. The purpose of this workshop, open for public, is to help launch a new fisheries science education in Iwate University for promotion of salmon research to help sustain Sanriku fisheries industry.

## SCHEDULE

| | | |
|---|---|---|
| February 8 (Mon) | 8:45 – 20:30 | Workshop and evening welcome reception |
| February 9 (Tue) | 9:30 – 15:50 | Workshop and poster session |
| February 10 (Wed) | 8:45 – 17:30 | Field tour, coastal hatcheries and tsunami sites |

**TOPICS** (with English and Japanese interpretation for all oral presentations and panel discussions)
The workshop includes the following topics and sessions.

Plenary lecture

1. Pacific salmon production: management education
    a. North America
    b. Russia
    c. Japan
2. Salmon biology: enhancement education
    a. Genetics
    b. Physiology
    c. Ecology
3. Panel discussion
4. Salmon and fisheries education
    a. Ecosystem
    b. Socio-economics
    c. Regional program
    d. Global marketing
5. Poster presentation
6. Wrap-up panel discussion

## ORAL PRESENTERS

Please save your power point presentation on a USB memory stick and give it to the receptionist at the registration desk at the workshop. A rap-top computer may be used to check your presentation on a separate desk. Please submit your power point material at least 90 min before your presentation.

| **If your presentation time is:** | **Bring your presentation to the registration desk by:** |
|---|---|
| February 8, morning | February 8 by 8:30 a.m. |
| February 8, afternoon | February 8 by 11:00 a.m. |
| February 9, morning | February 8 by 17:00 p.m. |

**Presentation time slot for:**
Plenary Oral Presentation; 40 min
Contributed Oral Presentations; 25 min including 20 min talk and 5 min question/discussion

## POSTER PRESENTERS

Please set up your poster (B1 size; 728x1030 mm or 28.66x40.55 inches) at registration on Monday, February 8, between 8:00 and 8:30 a.m.

Posters should be removed on Tuesday, February 9, by 16:00. Posters not removed by 16:00 may be discarded by the hotel.

## PROGRAM

**Presenter*

February 8

| | | |
|---|---|---|
| 8:45 – 8:50 | Welcome note | Hitoshi Yashiro |
| 8:50 – 9:05 | Opening Remarks | Syuiti Abe |
| 9:05 – 9:45 | Plenary lecture (convener: Toru Nagasawa) | **Planning for the future of Pacific salmon Production**: Richard J. Beamish |
| 9:45 – 10:00 | | – Break – |

**Session 1, Pacific salmon production: management education** (conveners: Toru Nagasawa, Marc Trudel)

| | | |
|---|---|---|
| 10:00 – 10:25 | a. North America | **The use of marine ecosystem metrics for preseason forecasts of salmon harvest**: Andrew K. Gray*, Joe Orsi, Jim Murphy, Alex Wertheimer, and Emily Fergusson |
| 10:25 – 10:50 | a. North America | **Applying genetic markers to manage sustainable fisheries for salmon in Alaska**: James E. Seeb* |
| 10:50 – 11:15 | b. Russia | **Russian salmon production: past, present, future**: Alexander Zavolokin* |
| 11:15 – 11:40 | c. Japan | **Status of chum salmon populations and research program for their rehabilitation in the Pacific coast of northern Japan**: Shigehiko Urawa* |
| 11:40 – 13:00 | | – Lunch – |
| 13:00 – 13:25 | c. Japan | **Recent status of chum and pink salmon stocks in Hokkaido, northern Japan**: Yasuyuki Miyakoshi* |
| 13:25 – 13:50 | c. Japan | **Chum salmon (*Oncorhynchus keta*) production in the Sanriku-region, Japan**: Gen Ogawa* and Kodai Yamane |
| 13:50 – 14:15 | d. NPAFC coordination | **NPAFC coordination: fisheries enforcement and scientific research on salmon in the North Pacific**: Nancy Davis* and Vladimir I. Radchenko |

**Session 2, Salmon biology: enhancement education** (conveners: Yoshitaka Nagahama, Graham young)

| | | |
|---|---|---|
| 14:15 – 14:40 | a. Genetics | **Fisheries genetics in the era of genomics**: Lisa W. Seeb* |
| 14:40 – 15:05 | a. Genetics | **Ocean distribution and abundance of Japanese and other stocks of chum salmon in the summer Bering Sea estimated by genetic methods**: Shunpei Sato* and Shigehiko Urawa |
| 15:05 – 15:15 | | – Break – |

| | | |
|---|---|---|
| 15:15 – 15:40 | b. Physiology | **Reforming hatchery rearing practices to improve effectiveness of supplementation and conservation hatcheries for Pacific salmon and steelhead (*Oncorhynchus* sp.)**: Penny Swanson*, Jon Dickey, Mollie Middleton, and Donald Larsen |
| 15:40 – 16:05 | b. Physiology | **Atlantic salmon aquaculture in Norway**: Birgitta Norberg*, Anna Wargelius, Eva Andersson, Tom Hansen, Per Gunnar Fjelldal, Lene Kleppe, Rolf Brudvik Edvardsen, and Geir Lasse Taranger |
| 16:05 – 16:30 | b. Physiology | **Physiological mechanisms of imprinting and homing migration in Pacific salmon**: Hiroshi Ueda* |
| 16:30– 16:55 | c. Ecology | **Migration and survival of salmon in a changing climate:** Marc Trudel* and Strahan Tucker |
| 16:55 – 17:10 | | – Break – |

**Session 3, Panel discussion**

| | |
|---|---|
| 17:10 – 18:15 | Syuiti Abe (convener), Andrew K. Gray, Alexander Zavolokin, Shigehiko Urawa, Lisa W. Seeb, Penny Swanson, Marc Trudel |
| 18:30 – 20:30 | – Welcome reception – |

February 9

**Session 4, Salmon & fisheries education** (conveners: Noriyuki Tanaka, Penny Swanson)

| | | |
|---|---|---|
| 9:30 – 9:55 | a. Ecosystem | **Ecosystem-based sustainability science of Pacific salmon and paradigm shift of fisheries education**: Masahide Kaeriyama* |
| 9:55 – 10:20 | b. Socio-economics | **Interdisciplinary learning in fisheries and aquaculture:** Kathrine Tveiterås* |
| 10:20 – 10:45 | c. Regional program | **Structuring research programs to address industry priorities and ensure technology transfer: the US Regional Aquaculture Center program model:** Graham Young* |
| 10:45 – 11:00 | | – Break – |
| 11:00 – 11:25 | d. Global marketing | **Sustainability of diversification by salmon producing countries in global salmon markets**: Ikutaro Shimizu* |
| 11:25 – 11:50 | d. Global marketing | **Searching for new market strategy for Iwate chum salmon:** Gakushi Ishimura* |
| 11:50 – 13:00 | | – Lunch – |

**Session 5, Poster session**

13:00 – 14:30

| | | |
|---|---|---|
| 14:30 – 14:45 | | – Break – |

**Session 6, Wrap-up (Panel discussion)**

| | | |
|---|---|---|
| 14:45 – 15:45 | | Noriyuki Tanaka (convener), Richard J. Beamish, Toru Nagasawa, Akihisa Urano, Kathrine Tveiterås, Graham Young, Birgitta Norberg, Gakushi Ishimura |
| 15:45 – 15:50 | Closing comments | Kohei Yamauchi |

February 10

**Field tour, coastal hatcheries and tsunami sites** (an interpreter will be accompanied)

No charge for tour participation, but need 1,500 JPY for lunch.

| | |
|---|---|
| 8:45 | Bus will leave the Hotel Metropolitan New Wing in Morioka |
| | — Tohoku Express Way to Kunohe IC |
| 11:00 | Pass by Kuji city |
| 11:30 | Akka River hatchery |
| 12:00 | Lunch at Eboshi-so |
| 12:30 | Leaving Eboshi-so |
| 13:10 | Taro tsunami site |
| 13:30 | Leaving Taro tsunami site |
| 14:00 | Pass by Miyako city |
| 14:10 | Tsugaruishi River hatchery |
| 14:50 | Leaving Tsugaruishi to Morioka |
| 17:30 | Arriving the Hotel Metropolitan New Wing in Morioka |

*Arriving time may be changed according to traffic condition.

## POSTER PRESENTATIONS

**Pacific salmon production**

Poster- 1 **A comparison of the returns of chum salmon released from net-pens and rivers in Nemuro Bay, eastern Hokkaido, northern Japan**: Kiyoshi Kasugai*, Hiroyuki Sakamoto, Yasuyuki Miyakoshi, and Mitsuhiro Nagata

Poster- 2 **Effect of turbidity in rearing water on the early life stages of chum salmon *Oncorhynchus keta***: Kouhei Kishi*, Rei Onodera, Yuriko Matsubayashi, and Hisayuki Arakawa

Poster- 3 **Observations of salmon run up through river mouth with morphological change**: Yuriko Matsubayashi* and Naoto Sawa

Poster- 4 **Target strength measurement of free-swimming fish in a controlled large experimental tank: A case study on TS measurement of whole marine life stages in chum salmon**: Hokuto Shirakawa*, Kenji Minami, Yohei Kawauchi, Makoto Tomiyasu, Huamei Shao, Yuta Maruoka, Yuichi Tsuda, Akira Shinohara, Motoki Kobayashi, Takeru Umetsu, Hideharu Tsukagoshi, Syuiti Abe, and Kazushi Miyashita

Poster-5 **Age composition and behavior of homing chum salmon, *Oncorhynchus keta*, in Otsuchi Bay**: Sigenori Nobata*, Takashi Kitagawa, Kaede Saito, Yoshinori Aoki, Katsufumi Sato, Yoshio Takei, and Susumu Hyodo

**Salmon biology**

Poster- 6 **Genetic evaluation of chum salmon, *Onchorhynchus keta*, river population after tsunami disaster in Fukushima and Miyagi Prefecture**: Takeru Kudo and Masamichi Nakajima

Poster- 7 **Genetic differentiation of chum salmon in the Sanriku-region, Japan, inferred from microsatellite DNA analysis**: Hideharu Tsukagoshi*, Sayuri Terui, Gen Ogawa, Shunpei Sato, and Syuiti Abe

Poster- 8 **Genetic population structure of masu salmon in the Sanriku-region, Japan, inferred from microsatellite DNA analysis**: Hideharu Tsukagoshi*, Sayuri Terui and Syuiti Abe

Poster- 9 **Next-generation sequencing (NGS)-based development of polymorphic microsatellite DNA markers of pink salmon in the Sanriku-region, Japan, for their genetic characterization**: Sayuri Terui*, Hideharu Tsukagoshi, Shunpei Sato, and Syuiti Abe

Poster-10 **Diversity of the intestinal microflora in chum salmon (*Oncorhynchus keta*)**: Keiko Shimizu*, Hiroaki Kasai, Yukie Inomata, Noriko Wakabayashi, and Shunsuke Moriyama

Poster-11 **Changes of insulin-like growth factor mRNA levels of chum salmon fry**: Shunsuke Moriyama*, Eri Inaba, Hiroko Okamoto, Haruna Amano, Keiko Shimizu, Hiroaki Kasai, and Tadahide Kurokawa

Poster-12 **Proteomic response of chum salmons to thermal acclimation**: Takuya Satoh*, Tetsuro Yamashita and Syuiti Abe

Poster-13 **Homing chum salmon with unusually yellowed body caught in the Sanriku coast**: Hiroshi Kawajiri*, Ken-ichi Ohmoto, Yukio Sawajiri, Takuya Satoh, and Syuiti Abe

Poster 14 **Migration history of masu salmon *Oncorhynchus masou masou* in Miyako bay, Iwate, Japan, as inferred from otolith microchemistry**: Keisaku Ariga* and Tsuyoshi Sasaki, Carlos Augusto Strussmann, Tatsuya Kawakami, and Tsuguo Otake

**Salmon and fisheries education**

Poster-15 **Using masu salmon to support aquatic marine environmental education for endogenous watershed development**: Shimon Mizutani* and Tsuyoshi Sasaki

# ORAL PRESENTATIONS

Topic Session: Plenary lecture

**Planning for the future of Pacific salmon production**

Richard J. Beamish
Fisheries and Oceans Canada, Pacific Biological Station, 3190 Hammond Bay Road, Nanaimo, British Columbia, Canada, V9T 6N7 (richard.beamish@dfo-mpo.gc.ca)

Canada's hatchery program that began in the late 1970s was expected to double the average annual Pacific salmon catch by 2000, while assuming that Canada's percentage of the total catch by all countries would be about the same. Neither of these expectations happened because the population dynamics of Pacific salmon changed and the capacity of the ocean to produce salmon was not known. The lesson is that the future production of Pacific salmon production needs to be based on models of future population dynamics. We know that production is related to the number of juveniles entering the ocean, but ocean predators, fish health and finding food quickly and easily also are important. Understanding the mechanisms that regulate marine survival is no longer something that would be nice to know; the understanding is the only way Pacific salmon production can be optimized in the future climate.

Topic Session: 1. Pacific salmon production: management education - a. North America

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

Andrew Gray*, Joe Orsi, Jim Murphy, Alex Wertheimer, and Emily Fergusson
NOAA-Fisheries, Alaska Fisheries Science Center, 17109 Point Lena Loop Road, Juneau AK, 99801, USA (andrew.gray@noaa.gov)

**The views expressed are those of the author and do not necessarily represent those of NOAA*

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 quantitative forecast of total pink salmon harvests in Southeast Alaska is provided to industry and fishery managers by oral presentations and web pages. In the case of Chinook salmon, recent declines of Yukon Chinook salmon, in particular the US/Canada treaty managed Canadian-origin Yukon Chinook Salmon, have triggered closures of commercial, sport, and personal use fisheries, and severe restrictions on subsistence fisheries and Chinook salmon bycatch in the US federally managed eastern Bering Sea groundfish fisheries. A time series of juvenile Chinook salmon abundance was constructed for the Canadian-origin (Upper Yukon) stock group of the Yukon River from late-summer pelagic rope trawl surveys in the northern Bering Sea during the Bering Aleutian Salmon International Survey (BASIS) 2003-2015. Juvenile abundance is significantly correlated ($r = 0.88$, $p < 0.001$) 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 allows a reasonably accurate forecast of future adult returns of Canadian-origin Chinook to the Yukon River and has potential to provide pre-season management guidance for Yukon River Chinook fisheries and possibly Chinook bycatch management in the eastern Bering Sea groundfish fisheries.

Topic Session: 1. Pacific salmon production: management education - a. North America

**Applying genetic markers to manage sustainable fisheries for salmon in Alaska**

Jim Seeb*

School of Aquatic and Fisheries Science, University of Washington, Seattle, Washington 98195, USA (E-mail: jseeb@uw.edu)

The state of Alaska is home to some of the largest runs of both hatchery and wild salmon in North America. On one hand, there are different fisheries issues between Alaska and Sanriku; on the other hand, the rapid progress made in Alaska to apply genetic markers to manage fisheries can provide important insights as Sanriku fisheries are revitalized. The Alaska Department of Fish and Game maintains a large genetic laboratory that conducts DNA analyses on over 100,000 individual salmon each year. Salmon species of primary interest include chum salmon, sockeye salmon, pink salmon, and Chinook salmon. Evaluating levels of genetic variability provides insights into hatchery breeding programs and is used to assess the impacts of hatchery stocks on wild stocks. One tool, called parental-based tagging, uses the presence of genetic marks to assign migrating fish back to their hatchery of origin. Natural genetic variation that differentiates stocks of each species provides an important tool to 1) track migration on the high seas, 2) assess stock-specific bycatch in marine fisheries that target other species, and 3) assess stock composition in near-shore fisheries that intercept fish from many different regions. All of these applications improve sustainable management of salmon stocks. I'll review examples of these applications and focus on the use of genetic data to shape fisheries that harvest sockeye salmon in Bristol Bay in the Eastern Bering Sea.

Topic Session: 1. Pacific salmon production: management education - b. Russia

**Russian salmon production: past, present, future**

Alexander Zavolokin*

Pacific Scientific Research Fisheries Center, Vladivostok, Russia (E-mail: aleksandr.zavolokin@tinro-center.ru)

Over the past three decades, Russian salmon fisheries have been in favorable conditions. Commercial catch increased from 76-189 th. t in 1980s to 168-551 th. t in 2000-2010s resulting from increasing salmon populations. Pink salmon dominated the total salmon catch (63 %) followed by chum (14%), sockeye (3%), coho (1%), chinook (0.3%), and cherry (<0.01%).

Species-specific interannual trends showed different patterns. Pink, chum, and sockeye tended to increase from 1980s to 2010s. Chinook salmon gradually decreased. Coho salmon tended to decrease from 1980s to the mid-2000s and sharply increased in 2007-2015. In 2009-2015, salmon production was at high level with record catch of pink (425 th. t in 2009), chum (142 th. t in 2015), sockeye (51 th. t in 2013) and coho (14 th. t in 2014 and 2015).
Kamchatka and Sakhalin are the main salmon regions in Russia. In 1970-2010s, their percentage in the total harvest averaged 72% (25% eastern Kamchatka, 20% western Kamchatka, 27% eastern Sakhalin).

Most Russian salmon stocks are comprised of wild populations. Share of hatchery salmon is relatively small. Number of fish released from Russian salmon hatcheries varied but did not change greatly in 1970-2010s (0.5-1.0 bln ind.). This contributed about 10-15% to national salmon fisheries.

Pink and chum were the major hatchery fish. They averaged 50.6% and 48.5% of the total fish released. In 2000s, number of chum salmon increased and reached 0.6 bln ind. (60%). Most Russian salmon hatcheries (43 of 65) are located in the Sakhalin-Kuril region.

Russia has a large potential for artificial reproduction of Pacific salmon and plans to expand hatchery program. Sakhalin, Primorye and Khabarovskiy region are considered to be reasonable areas for salmon hatcheries.

Topic Session: 1. Pacific salmon production: management education - c. Japan

**Status of chum salmon populations and research program for their rehabilitation in the Pacific coast of northern Japan**

Shigehiko Urawa*
Hokkaido National Fisheries Research Institute, Fisheries Research Agency, Sapporo 062-0922, Japan (E-mail: urawa@affrc.go.jp)

Chum salmon (*Oncorhynchus keta*) are an important biological and economic resource for North Pacific rim countries. All-nation commercial catch of chum salmon increased from approximately 130,000 tons (40 million fish) in the 1970s to over 400,000 tons (116 million fish) in 1996. Since then, the annual catch has fluctuated between 280,000 tons (85 million fish) and 370,000 tons (107 million fish). Japan has accounted for over 50% of total chum salmon catch on annual basis, but the recent coastal catch has a trend of decreasing. In contrast, Russian chum salmon catch has drastically increased since the mid 2000s, making up 42% of total catch in 2014.

According to an increase of annual otolith-marked chum salmon releases from Russian (n=343 million fry in 2012) and Japanese hatcheries (n=240 million fry in 2012), Chistyakov and Bugaev (2013) reported 211 otolith marked juvenile chum salmon caught in the Okhotsk Sea during October and early November 2012. Among them, 169 fish (79%) originated from hatcheries in Honshu and Hokkaido, including all regional populations in Japan. Thus their findings proved the migration model that Japanese juvenile chum salmon migrate into the Okhotsk Sea by autumn. The recovery rate of Japanese otolith-marked fish was variable among regional populations: highest in the Hokkaido Okhotsk region, and lowest in the Honshu Pacific region.

In Japan, the recent decrease of chum salmon catch is evident along the Pacific coast of Hokkaido and Honshu, including Sanriku area. To rehabilitate chum salmon production in these regions, the Fisheries Agency of Japan has been promoting a research program since 2013. The program is planned to test a working hypothesis that significant mortalities of juvenile chum salmon occur during their early migration toward the Okhotsk Sea. Key hatcheries are encouraged to release otolith-marked chum salmon fry at particular timing and body size. Fish are sampled at several stations along the Pacific coast of Hokkaido to identify the stock-specific migration route and timing, growth patterns, predation, and habitat environment. Preliminary results have indicated that juvenile chum salmon released from hatcheries in the Sanriku area come alongside the west Pacific coast of Hokkaido in early and mid June, and migrate through the southeast coast of Hokkaido between late June and early July. Large juvenile chum salmon (over 10 cm in fork length) migrate ahead in coastal waters around 9-11ºC, and smaller ones follow them after several week delay. The sea surface temperature (SST) is affected by the Coastal Oyashio (cold current), occasionally increasing over 13ºC in a short period. Sharp fluctuation of coastal SST may disturb the growth opportunity and migration of juvenile chum salmon, resulting in their mortalities before reaching the Okhotsk Sea. To improve the survival of hatchery released chum salmon, I suggest the following considerations: 1) critical time/body size of juveniles, which allow them to migrate from specific coastal water to the Okhotsk Sea, 2) growth and migration speed of juveniles in coastal water, and 3) fluctuation of coastal SST and prey abundance.

Topic Session: 1. Pacific salmon production: management education - c. Japan

**Recent status of chum and pink salmon stocks in Hokkaido, northern Japan**

Yasuyuki Miyakoshi*

Salmon and Freshwater Fisheries Research Institute, Hokkaido Research Organization, Eniwa, Hokkaido 061-1433, Japan (*Email: miyakoshi-yasuyuki@hro.or.jp)

Hokkaido is the main area of salmon production in Japan. Chum salmon returns to Hokkaido rapidly increased during the last quarter of the 20th century. Since the 1990s, chum salmon returns to Hokkaido remained at historic highs, averaging 51 million fish per year from 1994 to 2007. Since 2008, however, returns to Hokkaido have decreased averaging 40 million fish per year. Different fluctuation trends have been observed among regions within Hokkaido; returns of chum salmon to the Okhotsk coasts have remained high, but in contrast, returns to the Pacific coasts have been decreasing in the last 6 years. Pink salmon returns to Hokkaido also increased rapidly since the 1990s. Even-year pink salmon returns increased in the 1990s but decreased since the 2000s. Odd-year returns increased during the 2000s. However, both even- and odd-year returns are rapidly decreasing since 2012. Chum and pink salmon stocks have been enhanced by hatchery programs; in particular, the Hokkaido hatchery program for chum salmon constitutes one of the largest salmon hatchery programs in the world. The management system for hatchery programs has been established and almost constant numbers of hatchery-reared juveniles are released. As the hatchery programs will likely be the main management tool in the future in Japan, re-evaluation of the current hatchery programs may be needed in order to recover and sustain the chum and pink salmon stocks in Hokkaido.

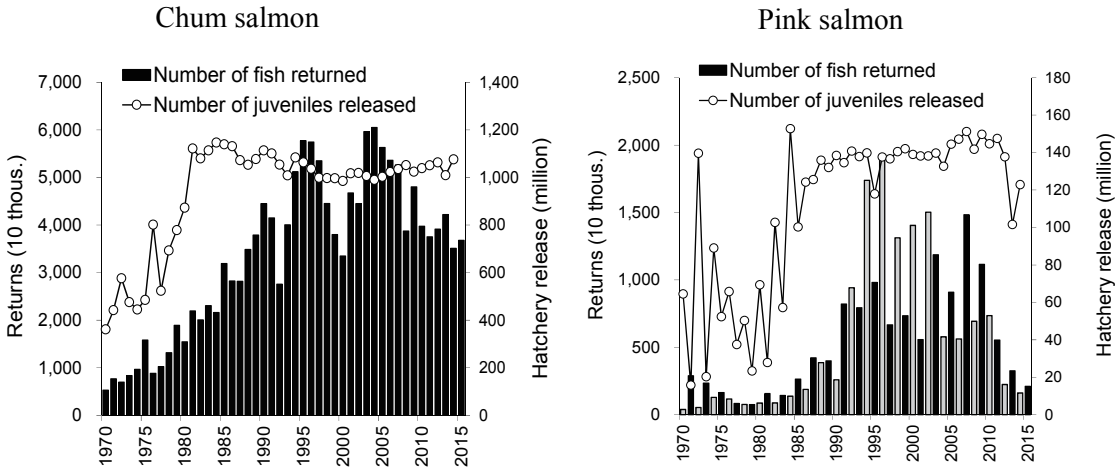


Fig. Number of returns and releases of chum and pink salmon in Hokkaido

Topic Session: 1. Pacific salmon production - c. Japan

**Chum salmon (*Oncorhynchus keta*) production in the Sanriku-region, Japan**

Gen Ogawa* and Kodai Yamane

Iwate Fisheries Technology Center, Kamaishi, Iwate 026-0001, Japan (E-mail: g-ogawa@pref.iwate.jp)

The Sanriku-region spans Aomori, Iwate and Miyagi Prefectures on the Pacific coast of northern Honshu Island in Japan. The region's characteristic saw-tooth shaped coastline with many bays renders the environmental condition suitable for growing juvenile chum salmon (*Oncorhynchus keta*). Chum salmon production in Iwate Prefecture is the 2nd highest in Japan (approximately 10 percent) and the hightest in the Sanriku-region (approximately 80 percent). Such high level of salmon production has been maintained mostly by artificial propagation programs for the past half century. The number of chum fry released has increased from 46 million fish in 1964 (1963 brood) to 420 million in 1988 (1987 brood). Subsequently, annual release of approximately 440 million fry continued until 2010 (2009 brood). Chum salmon catch, including river and inshore set net catch, in Iwate was 0.2 million fish in 1964 to over 10 million fish from 1984 onwards, associated with the increased release of chum fry, and reached the largest, approximately 24 million fish, in 1996. Then, the homing adult fish tended to decrease in recent years, resulting in the smallest catch of approximately 2.8 million in 2011 since the start of full scale hatchery operations in 1992. On March 11, 2011, a massive earthquake and devastating tsunami destroyed most of coastal salmon hatcheries. Although some of the hatcheries were restored by autumn 2011, the number of chum fry released decreased to 291 million fish in 2012 (2011 brood). During 2012 to 2015, the chum fry releases increased from 291 to 409 million along with the restoration of damaged hatcheries. Chum fry are usually released during March to May every year in Iwate Prefecture. Therefore, it is possible that alevin and fry (2010 brood) in hatcheries hit by the 2011 tsunami mostly would not have survived, which might have causally affected chum salmon runs of particular year classes in subsequent years. We surveyed the age composition of upriver migrating adult chum salmon in three representative rivers in Iwate Prefecture. Here we report the results of our surveys and discuss the effects of the earthquake and tsunami on the current and future chum salmon runs.

Topic Session: 1. Pacific salmon production: management education - d. NPAFC coordination

**NPAFC coordination: fisheries enforcement and scientific research on salmon in the North Pacific**

Nancy D. Davis* and Vladimir I. Radchenko
North Pacific Anadromous Fish Commission, Suite 502, 889 West Pender Street, Vancouver, BC, V6C 3B2, Canada (E-mail: ndavis@npafc.org)

The North Pacific Anadromous Fish Commission (NPAFC) is an intergovernmental organization dedicated to the conservation of Pacific salmon and steelhead trout in international waters of the North Pacific. The member countries are Japan, Korea, Russia, Canada, and United States. Since its formation in 1993, the mission of NPAFC has been to coordinate efforts among the member countries for two purposes: to enforce the ban on illegal salmon fishing in the Convention Area and to share statistics and results of ocean salmon research. In the area of fisheries enforcement, NPAFC has a role in coordinating the activities of its member countries with the goal to detect and eliminate illegal, unreported, and unregulated fishing for salmon in the North Pacific. Annual joint planning and scheduling meetings and information sharing through NPAFC has been a successful deterrent to illegal fishing. NPAFC also serves to coordinate research activities of member countries in support of the scientific aspects of the NPAFC Convention. The Commission coordinates and supports the activities of several scientific groups that manage a number of responsibilities including member-wide salmon catch and hatchery statistics, exchange of genetic stock identification techniques and sample collections, and coordination of salmon otolith marking plans among the members' agencies. Scientists from member countries design and evaluate the NPAFC science plan, and scientific results are reported at open symposia and workshops. The Commission produces publically available bulletins and technical publications based on these scientific meetings. Every year, the NPAFC Secretariat hosts a 6-month paid internship at its office in Vancouver to help early-career professionals and recent graduates gain experience and knowledge in operations of the Commission and to provide an opportunity to test their interest in international governmental organizations, management, fisheries, biology, ecology, and fisheries enforcement. Currently, NPAFC has a new initiative under consideration—the International Year of the Salmon—as a way to bring concerns of ocean salmon conservation to the forefront of research and public awareness.

Topic Session: 2. Salmon biology: enhancement education - a. Genetics

**Fisheries genetics in the era of genomics**

Lisa Seeb*

School of Aquatic and Fisheries Science, University of Washington, Seattle, Washington 98195, USA (E-mail: lseeb@uw.edu)

The field of fisheries genetics has advanced dramatically in the last decade. Next generation sequencing (NGS) methods exponentially increased the number of available genetic markers, creating the new field of fisheries genomics. The emergence of NGS quickly led to many new opportunities including improved resolution for stock identification and identification of adaptively important genes and genomic regions; many of these improvements were facilitated by dense linkage mapping. Simultaneously, improvements in genotyping approaches have allowed screening of an unprecedented number of individuals and number of markers and enabled the expansion of techniques such as parental-based tagging (PBT) and individual assignment (IA). I will review the most widely used molecular based applications in fisheries management with a focus on recent examples that demonstrate advances powered by genomics. I will also provide a look into the future of the field. While it remains impossible to foresee all future advancements, fisheries genomics will continue to provide increasingly important information to improve management and sustainability of salmonid resources.

Topic Session: 2. Salmon biology: enhancement education - a. Genetics

**Ocean distribution and abundance of Japanese and other stocks of chum salmon in the summer Bering Sea estimated by genetic methods**

Shunpei Sato* and Shigehiko Urawa

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Stock-specific ocean distribution and abundance of chum salmon (*Oncorhynchus keta*) are important information to manage chum salmon resources. Genetic stock identification (GSI) is a powerful tool for estimation of stock origins of chum salmon. In this study, we estimated stock origins, ocean distribution patterns, and abundance of Japanese and other stocks of immature chum salmon in the summer Bering Sea by GSI using single nucleotide polymorphism (SNP) markers. Salmon research cruises were conducted by R/V *Hokko maru* between late July and early August in 2007, 2009, and 2011-2014. A total of 1,532-3,308 fish was annually collected from 17 fixed monitoring stations in the central Bering Sea (52º 30’ N-58º 33’ N, 174º 49’ E-174º 49’ W) using a surface trawl net. Stock contributions (Japan, Russia, and North America) of immature chum salmon were estimated by a conditional maximum likelihood using a SNP baseline dataset from 158 populations in the Pacific Rim. GSI estimated composition was 28.6-42.6% Japanese, 55.2-68.9% Russian, and 2.2-8.7% North American stocks during six survey years. Stock-specific CPUE (catch per unit effort) of immature chum salmon suggests that the abundance of Russian stocks were higher than that of Japanese stocks in the summer Bering Sea. Furthermore, the abundance of Japanese stocks in 2014 was lower than that in the other survey years. The stock-specific CPUE also suggests that the abundance of Japanese stocks in northeast area was higher than that in southern and western Bering Sea areas. On the other hand, the abundance of Japanese stocks in the northeast area in 2014 decreased compared with that in other survey years. Our results suggest that immature Japanese chum salmon is widely distributed in the central Bering Sea, however, the distribution pattern seems nonrandom. The results also suggest that the abundance of Japanese stocks tends to reduce in the recent summer Bering Sea.

Topic Session: 2. Salmon biology - b. Physiology

**Reforming hatchery rearing practices to improve effectiveness of supplementation and conservation hatcheries for Pacific salmon and steelhead (*Oncorhynchus* sp.)**

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Salmon and steelhead hatcheries are used throughout the Pacific Northwest Region of the United States to supplement commercial harvest and conserve declining wild populations that have been listed as endangered under the US Endangered Species Act (ESA). But, it is widely recognized that salmon and steelhead reared in hatcheries can have lower survival and reduced reproductive success when spawning in nature compared to wild fish, and can have negative ecological and genetic effects on native wild fish. The reduced fitness of hatchery fish has been attributed to a combination of inadvertent genetic selection and environmental factors in the hatchery (e.g. embryo incubation temperatures, diet, growth regimes, and rearing densities). In this presentation I will describe results from hatchery monitoring programs and laboratory experiments aimed at understanding how environmental factors and hatchery rearing practices affect the diversity life history phenotypes of fish released from hatcheries, and contribute to reduced survival and reproductive success. The goal of this work is to improve the effectiveness of both supplementation and conservation hatcheries by modifying hatchery rearing protocols.

Topic session: 2. Salmon biology: enhancement education – b. Physiology

**Atlantic salmon aquaculture in Norway**

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Aquaculture of Atlantic salmon (*Salmo salar* L.) has had a tremendous development, from a production of some thousands of tons in the 1970´s to 1.2 million metric tons in 2014. At present, the total revenues from salmon culture exceed those from fisheries, which makes aquaculture one of the major sources of income in Norway.

Production of salmon for the market is mainly carried out in open sea cages, and a number of challenges are present. Past and present research has focused on production biology and technology, fish health - in particular vaccine development and control of sea lice, feed resource utilization, local impact on the environment and genetic interactions with wild stocks.

Research in physiology has been of great importance for the development of effective and sustainable production technologies. For example, smolt production was greatly improved by use of photoperiod manipulation. Research on basic and applied reproductive physiology has been crucial in providing optimal conditions for broodstock management and production of large salmon in sea cages. Early on, the use of photoperiod control of timing of maturation was attempted to obtain eggs out of season. The discovery that continuous light applied on sea cages in winter both improved growth and block sexual maturation was a major contribution which has had a large impact, economically as well as on feed utilization and fish welfare.

Wild Atlantic salmon have a life history where eggs are spawned and hatched in rivers that each have their own specific stock. After smoltification, the young salmon migrates to the sea for several years before returning to its river of origin to spawn. Increased concern about genetic interactions between farmed salmon and wild stocks, and that these interactions may lead to reduced fitness and survival of those stocks, has prompted a large effort within genetics and genomics, in order to establish the true impact of farmed salmon on wild stocks, and to mitigate possible negative effects by producing sterile salmon that will not be able to breed with wild fish. To this end, large scale production of triploid salmon has been carried out and their special environmental and nutritional requirements have been investigated. Through genome sequencing, the gene that regulates puberty was recently discovered. Also, using new genomic tools, attempts are being made to generate vaccines that can be delivered and will induce sterility by blocking gonad development already at the embryonic stage. Clonal lines have been established and will be of great importance for elucidating regulatory mechanisms e.g. for sex differentiation and early maturation.

Topic Session: 2. Salmon biology: enhancement education - b. Physiology

**Physiological mechanisms of imprinting and homing migration in Pacific salmon**

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The amazing abilities of Pacific salmon to migrate long distances from the ocean to their natal streams for spawning have been investigated intensively, but there are still many mysteries because of difficulties to follow their whole life cycle and to wait their sole reproductive timing for several years. In my laboratory, we have tried to clarify physiological mechanisms of imprinting and homing migration using anadromous chum salmon (*Oncorhynchus keta*) in the north Pacific Ocean as well as lacustrine sockeye salmon (*O. nerka*) and masu salmon (*O. masou*) in Lake Toya and Lake Shikotsu, Hokkaido, Japan, where the lakes serve as a model "ocean". Three different approaches from behavioral to molecular biological researches have been conducted using these model fish. First, the homing behaviors of adult chum salmon from the Bering Sea to Hokkaido as well as lacustrine sockeye and masu salmon in Lake Toya were examined by means of physiological biotelemetry techniques, and revealed that salmon can navigate in open water using different sensory systems. Second, the hormone profiles in the brain-pituitary-thyroid (BPT) and brain-pituitary-gonad (BPG) axes were investigated in chum salmon and lacustrine sockeye salmon during their imprinting and homing migration by means of molecular biological techniques, and demonstrated that thyrotropin-releasing hormone and salmon gonadotropin-releasing hormone play leading roles in imprinting and homing migration, respectively. Third, the olfactory functions of salmon were studied by means of electrophysiological, behavioral, and biochemical techniques, and clarified that dissolved free amino acid compositions in natal streams are crucial for olfactory imprinting and homing, and suggested that olfactory memory formation during juvenile imprinting and retrieval during adult homing of chum salmon may be controlled by the BPT and BPG hormones, respectively, and can be clarified using N-methyl- D-asparate receptor's essential subunit NR1 as a molecular marker. These findings are discussed in relation to physiological mechanism of imprinting and homing abilities of Pacific salmon.

Topic Session: 2. Salmon biology: enhancement education - c. Ecology

**Migration and survival of salmon in a changing climate**

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The North Pacific Anadromous Fish Commission was created in 1992 to promote the protection and conservation of Pacific salmon in the North Pacific Ocean. Since that time, worldwide catches of Pacific salmon has increased by 30%. However, this increase is not widespread, as commercial catches of Pacific salmon has declined in Canada by a factor of five during the same time. To understand regional differences in salmon production and survival, it is first necessary to determine where salmon migrate in the ocean. Here we review some of the progress that has been achieved to understand salmon migration in the marine environment and to examine the relationship between salmon survival and ocean conditions.

Topic Session: 4. Salmon & fisheries education – a. Ecosystem

**Ecosystem-based sustainability science of Pacific salmon and paradigm shift of fisheries education**

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Pacific salmon (*Oncorhynchus* spp.) play important roles not only for seafood resources of human, but also as ecosystem services in the Subarctic North Pacific ecosystems. Their production dynamics are influenced by natural factors (e.g. the long-term climate change) and human impacts (e.g. global warming effect, overfishing, and hatchery program). Marine-food should be reproducible resources for human. However, world fish catches have peaked since the 1990s despite increase in aquaculture production, causing destruction of aquatic ecosystem, marine pollution, and threats to marine food security. In this century, marine ecosystem conservation and stable marine-food product are most important issues for human beings with increase in human population and impacts such as global warming.

I have researched on the ecology of Pacific salmon; i) life history, ii) trophic dynamics and feeding habitats, iii) population dynamics including the population density-dependent effect, iv) relationship between long-term climate change and carrying capacity, v) biological interaction between wild and hatchery populations, and vi) influence on their transportation of the marine-derived nutrients to the land ecosystem, for the past decades. I will present my research outcome on biological interactions between Pacific salmon and aquatic- and land-ecosystems including 1) the long-term climate change and salmon production dynamics, 2) influence of the super tsunami and coastal environments (Oyashio and Tsugaru warm currents) on the Sanriku chum salmon population, 3) their feeding habit and trophic level in the ocean ecosystems, 4) influence of the global warming on salmon, and 5) ecological service of salmon for the land-ecosystem.

Paradigm of the fishery science should be shifted from the technology of fish catching, which has introduced the “fishing down marine food webs”, overfishing, biological interaction between wild and hatchery-produced salmon, and aquatic-ecosystem crash, to the sustainability science of ecosystems and organisms in the ocean, in order to achieve the human well-been in the future generation. Educations on dietary and the understanding of symbiosis with the global ecosystem are also the most important issues. We should think about “*The Limits to Growth*” in the earth, and account for future limitations in ocean carrying capacity and for expected fluctuations in the carrying capacity in response to ecosystem changes. Therefore, the framework of ecosystem-based risk management including the adaptive management and the precautionary principle would be extremely important for the conservation of Pacific salmon.

Topic Session: Session 4, Salmon & fisheries education, b. Socio-economics

**Interdisciplinary Learning in Fisheries and Aquaculture**

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Fisheries and aquaculture are growing in complexity. This requires the intersection of diverse expertise in order for the sector to develop in sustainable manners. The core argument in this presentation is that education aimed at the seafood sector should mirror this request. First, candidates should master to learn from insights from a range of disciplines. Second, candidates should be trained in multi- and interdisciplinary problem solving.

The presentation draws on experiences from the degree programs in Fisheries and Aquaculture Science at the Norwegian College of Fishery Science, UiT the Arctic University of Norway. These are applied educational and training programs. Fisheries and Aquaculture Candidates are not biologists, nor economists or sociologists. Instead, they are the multi- and interdisciplinary minds who can fulfill the expectations of both the industry and the society at a large. However, given the way in which academic disciplines are constituted as discrete discourses, adopting an interdisciplinary approach in the context of higher education is not without problems. The paper discusses strengths and weaknesses with the interdisciplinary approach, and ends by suggesting vital mechanisms for fostering interdisciplinary learning in fisheries and aquaculture.

Topic Session: 4. Salmon & fisheries education - b. Regional program

**Structuring research programs to address industry priorities and ensure technology transfer: the US Regional Aquaculture Center program model**

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Several acts of the US Congress starting in the mid-1800s led to the establishment of a public higher education system available to all citizens (The Land-Grant/Morrill Acts) that emphasized the needs of an agricultural and rapidly industrializing society. The Smith-Lever Act of 1914 established a nationwide system of professionals trained in agricultural extension: the application of scientific research and new knowledge to agricultural practices through farmer education. Although the scope of extension has broadened considerably, the extension model has played and continues to play a key role in the development and competitiveness of US agriculture and other industries. The need for an explicit mechanism to ensure that new knowledge from research is communicated to and acted upon by end-users is a core philosophy of a number of US national and regional programs that are focused on supporting regional commercial development. This applies to the Regional Aquaculture Center (RAC) program, established in 1986. However, within federally-funded research and development programs, aspects of the RAC program are unique in that: i) the aquaculture sector has a central role in determining priority areas for scarce research funds; and ii) aquaculture extension specialists are actively involved in all aspects of the research, from proposal preparation to delivery of information and other products to end-users. These two aspects ensure that the research conducted is directly relevant to industry needs (the research team often includes members from industry), and that timely, efficient and well-planned technology transfer occurs. The emphasis on assessing the longer term impacts of research and outreach efforts are an additional aspect of the RAC program. The organizational structure of the WRAC program will be described, along with examples of how specific industry-research-extension partnerships have provided knowledge-based solutions to critical problems. Throughout this presentation, the essential role of well-trained and engaged extension specialists in ensuring technology transfer will be emphasized.

Topic Session: 4. Salmon and fisheries education - d. Global marketing

**Sustainability of diversification by salmon producing countries in global salmon markets**

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Salmon are one of the most popular fish around the world. They were valuable fish as same as cod and herring traditionally. Salmon fishery was very important in the northern hemisphere. Salmon were transplanted from the northern hemisphere to the southern hemisphere. Salmon aquaculture has been expanding to the present in the world. A total production of salmon was 4 million metric tons in the global today. Though 30 % of the total was produced by capture, 70 % was produced by aquaculture. Salmon supply in global markets has been controlled by aquaculture. Not only global demand but also global price of salmon has been influenced by salmon aquaculture production.

Large-scale countries of capture production are Russian and USA. Medium-scale countries of capture are Japan and Canada. In contrast, large-scale countries of aquaculture production are Norway and Chile. Medium-scale countries of aquaculture are UK, Iran and Turkey. Because farmed salmon by Norway and Chile are distributing to global markets all year around, unstable supply of farmed salmon is afraid of causing economic confusion to global markets. Salmon aquaculture has developed a necessary industry in global markets. However, they have many issues as follows; influence of Peruvian fishmeal prices, production costs, environmental load, parasitic sea lice and diseases (ISA).

In March of 2011, the great east Japan earthquake and the giant tsunami destroyed almost fish processing firms and salmon stocks in Sanriku coastal area, Tohoku district. And then large amounts of Chilean coho salmon were imported to Japan. However, the price of coho salmon supplied largely to Japanese market slumped and the influence decreased fishery market prices. Meanwhile, the production of Chilean farmed rainbow trout decreased by disease in 2013 and the price of Chilean trout elevated in Japanese market by the decrease of imported amounts. Many kinds of salmon are distributing in global markets. The variability of salmon aquaculture production with large market share internationally has influenced not only salmon price but also fishery commodities prices with small market share domestically. One of the big issues in global salmon markets is current oligopolistic structure based on production concentration by major salmon aquaculture countries.

It is necessary for salmon price stability to control oligopolistic expansion by giant salmon farming countries (Norway and Chile). It is important for medium-scale and small-scale countries of farmed salmon production not only to find solutions of aquaculture issues by their cooperation but also to promote a brand of salmon and sustain production of brand salmon each country. At the same time, it is important for salmon capture countries not only to make effort to improve stabilization of salmon resources but also to control IUU fishery and promote natural brand of salmon. It is necessary for each country to sustain diversification of salmon production system by aquaculture and capture.

Topic Session: 4. Salmon and fisheries education - d. Global marketing

**Searching for new market strategy for Iwate Chum Salmon**

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This presentation explores the market strategy of Chum Salmon (*Oncorhynchus keta*) landings in Iwate by aiming to achieve the locally-grown and locally-consumed principle. As the most dominated salmon species in landing in Iwate region, with the dramatically decreased in landings and “low price equilibrium” due to substitutions in the market from oversea, the development of new market strategy for Chum Salmon from Iwate is one of the key issues for the region. We describe unique possibilities of Iwate Chum Salmon for the meal programs for local elder care facilities, and argue the new market strategy for Iwate Chum Salmon.

# POSTER PRESENTATIONS

Topic Session: 1. Pacific salmon production: management education – c. Japan

**A comparison of the returns of chum salmon released from net-pens and rivers in Nemuro Bay, eastern Hokkaido, northern Japan**

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To examine the effectiveness of marine ranching of chum salmon for the improvement of commercial coastal catches and river catches, marked fish were released from net-pens and rivers in the Nemuro Bay, eastern Hokkaido, northern Japan. Between 100,000 and 130,000 chum salmon fry fertilized in early November were reared in the Okunishibetsu hatchery, 110 km from the Nishibetsu River mouth, and were marked by clipping either the left or the right ventral fin in 2006 and 2007. Left ventral fin-clipped fry (LV) were transplanted to the net-pens in the Betsukai fishery port, 0.7 km away from the mouth of the Nishibetsu River, in mid-April, and were released in the Betsukai fishery port after rearing for one month. Right ventral fin-clipped fry (RV) were released from the hatchery 6–7 d after transplanting LV to the net-pens. Surveys for returned marked fish were conducted in 20 set-nets along the coast of Nemuro Bay, a small set-net in the Betsukai fishing port, and salmon weir in the Nishibetsu River 2–5 years after release. No differences were observed in the periods of coastal catch and maturation between the two groups of marked fish. Estimated coastal return rates of LV were about twice those of RV. However, river catch rates against total returns of RV were 6–7 times those of LV. Our results suggested that marine ranching for chum salmon could not sustainably improve adult salmon catch in rivers, although it might increase coastal catches.

Topic Session: 1. Pacific salmon production: management education – c. Japan

**Effect of turbidity in rearing water on the early life stages of chum salmon *Oncorhynchus keta***

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The production of healthy fry is required to stem the sudden decline, since 2010, in the return rates of chum salmon, *Oncorhynchus keta,* in northeastern Japan. Both ground and river water are used in hatchery production; however, significant mortalities have been observed when river water with a high turbidity was used in the rearing tanks. Therefore, temporal changes in the turbidity of the river water were recorded and the effect of particles in the water on hatching, growth and survival of salmon fry were examined.

At the Ugegawa River salmon hatchery, where river water is used for rearing, turbidity was high in Spring and after rainfall. The highest turbidity recorded was ~350 mg/L, resulting in significant mortality of salmon fry. Chlorophyll *a* concentrations also increased with increasing turbidity; however, there is no change of dissolved oxygen levels. In this high turbidity water, the mean particle diameter was ~60 μm.

Normally, hatching of fertilized egg in clear water is >90% at an accumulated temperature (°C) of 610 degree-days. However, hatching declined when sedimentary particles were deposited on the eggs: the greater the number of particles, the lower the hatching rate. A sedimentary deposit of 233 mg/cm$^2$ resulted in a hatching rate of ~30 % at an accumulated temperature of 660 degree-days.

Survival was >95% when salmon fry were maintained for 3 days in water with a turbidity of 20,000 mg/L; however, there is no significant difference between clear and turbid conditions ($P$>0.05). However, when juveniles were cultured for 1 month at a turbidity of 4,000 mg/L, body size was significantly smaller than those reared in clear water.

Mortalities were high in the rearing tanks when turbidity in the Ugegawa River reached 350 mg/L, where the average particle size was ~60 μm. This is much larger than the size of the particle used in our laboratory experiments (~5 μm), and indicates the need for further research on the effects of turbidity vis-à-vis particle size.

Topic Session: 1. Pacific salmon production: management education – c. Japan

**Observations of salmon run up through river mouth with morphological change**

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Salmon is one of the most important fish resource in Iwate prefecture, Japan. To conserve salmon resource, fishing cooperatives and hatcheries carry out salmon stocking. However, return rate of chum salmon in Iwate have declined during past 20 years. Although there are numerous cause of declining, there are questions with stocking relevant to declining. Morphological character of river mouth is one of the questions of stocking. It has reported that return rate at rivers with feature of deposition trend and river mouth clogging are lower than of others. However, although studies have been made of influence of coastal environment, such as temperature, salinity and landscape, to spawner salmon behavior, there is little report with effect of morphological trend of river mouth to salmon run up. Purpose of our work was to examine how river mouth clogging and morphological trend of rivers effect salmon run up. Because chum salmon, *Oncorhynchus keta*, have majority of salmon catch in Iwate, in this study, our target fish is chum salmon.

For the purpose of our work, we carried out observation of run up salmon behavior and morphological change of river mouth of Fudai River in Fudai village. Fudai River is on of rivers whose river mouth is in Iwate coastal area; moreover have deposition trend around river mouth. River mouth of Fudai River clog easily with high wave, therefore hatchery of Fudai take measure to open river channel when river mouth clog.

We carried out observations from October 19 through 22 and October 26 through 29. We counted salmon number, which pass through river mouth. At the same time, we observe morphology of river mouth. We divide river mouth morphology in observation period to three types; type1 is shallow and wide river mouth, type 2 is deep and narrow river mouth and type3 is river channel passing through concrete debris. We compared time-series number of running salmon over three types. As a result, number of running up salmon changed according to river mouth morphology. With type1, shallow river channel, number of salmon increased with tide elevation, moreover, with type2, number of salmon was lowest in three types of river mouth.

Topic Session: 1. Pacific salmon production: management education – c. Japan

**Target strength measurement of free-swimming fish in a controlled large experimental tank: A case study on TS measurement of whole marine life stages in chum salmon**

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Acoustic survey based on species-specific acoustic intensities (i.e. target strength: TS) contributes to the speedy abundance (or biomass) estimation of important fisheries resources and the temporal-spatial behaviors in the wide area. In order to deduce quantitative information such as the fish number per unit volume, an important requirement is to know the value of target strength appropriate to those fish that have contributed to the received signal. This study introduces our new ex situ experiment for target strength measurement on chum salmon in whole marine life stages. Live chum salmon *Oncorhynchus keta* were investing at two acoustic frequencies (38 and 120kHz) to know the how they relate to frequency of an underwater acoustic / to fish size. The TS measurements were conducted at the large experimental tank (Ca: W:10m x D:5m x H:6m, 300t) filled by seawater in Hakodate Research Center for Fisheries and Oceans, southern Hokkaido, Japan. Hatchery-reared fish (juvenile: 0-plus and 1-plus) were obtained from Sanriku Fisheries Research Center in Iwate University, and adult chum salmons were caught by a set net off Osatube, southern Hokkaido, Japan. In this presentation, we will also discuss about a future survey to estimate spatial distribution, biomass and vertical/ horizontal swimming behavior of the marine life stage chum salmon using measured target strength of this system.

**Topic Session:** 1. Pacific salmon production: management education - c. Japan

**Age composition and behavior of homing chum salmon, *Oncorhynchus keta*, in Otsuchi Bay**

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Chum salmon, *Oncorhynchus keta*, return to the natal rivers using the olfaction 3 to 5 years after the birth. In Otsuchi Bay, three natal rivers flow to the inner part, and all hatcheries and natural spawning sites have damaged tremendously by the tsunami at 11th, March in 2011 when the fry migrate downstream in the river, resulting in death of many fry. Therefore, it has been anticipated that the number of homing adults would be low and the behavior would be defective. We have examined whether salmon can choose the natal river straightforward among a few rivers, or leave the bay to choose others, and how environmental disturbance in the river affects the homing behavior. The ultrasonic transmitter was loaded to salmon caught in the center of bay, and released in the inner part. The acoustic signals from released fish were detected by receivers arranged in two rows, and the migration pathway was deduced based on the record. Age of test fish was determined based on the narrow space of annuli, and the maturation level was deduced using plasma concentration of sex steroid hormone. The study has been performed every winter from 2013.

Annually, about half of homing salmon are four years old, and others are almost 3 and 5 years old. In 2013, however, the ratio of 3 years fish which entered the sea just before or after the Tsunami was extremely low as well as that of 4 years in 2014. On the other hand, about half of homing was 4 years in 2014 in river that fry were artificially released even after the Tsunami.

Homing behaviors of released salmon were classified into four patterns; 1) straightforward river entry, 2) river entry after accesses to either river a few times, 3) movement toward the bay mouth, and 4) movement toward the bay mouth after accesses to either river (Fig. 1). The ratio of river entry was low in November (ca. 15%) and increased in December (ca. 50%). Nevertheless, river entry of 4 years old attacked by the Tsunami remained to be low in Dec. (ca. 28%) although the number of sample was low.

In conclusion, the homing ratio is extremely low in the generation attacked by the Tsunami. In indented Sanriku coast, the homing adults search for their natal river through trial and error processes. New knowledge indicates that artificial propagation largely contributes to a stable salmon catches in Sanriku area.

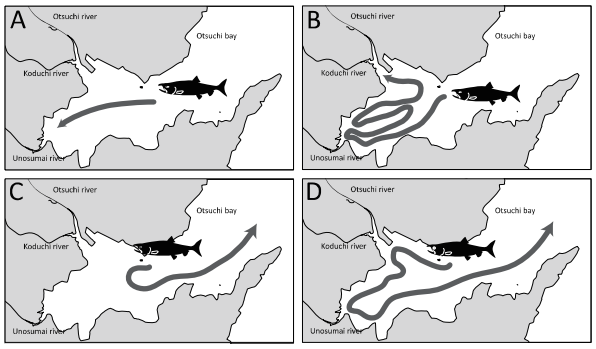


Fig. 1 Imaginary pictures of 4 behavioral patterns of homing salmon in the Otsuchi Bay. (A) straightforward river entry, (B) river entry after multiple accesses to rivers, (C) movement to the bay mouth without access to rivers, and (D) movement to the bay mouth after multiple accesses to rivers.

Topic session: 2. Salmon biology: enhancement education – a. Genetics

**Genetic evaluation of chum salmon, *Onchorhynchus keta*, river population after tsunami disaster in Fukushima and Miyagi Prefecture**

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Chum salmon (*Onchorhynchus keta*) is one of the most important fish resources in Tohoku Region that facing Pacific Ocean side in Japan. The reproduction of chum salmon largely depend on the artificial propagation. The anadromous fish were caught for the artificial reproduction nearby estuary. On 11th March 2011, the tsunami attack have destroyed and terminated many facilities for salmon culture in Fukushima and Miyagi Prefecture, and many facilities can't resume operation still now. Therefore most of salmon which are going upstream at present in such areas are offspring from natural spawning. In 2014-2015 season, salmon which come back to their own river consist of three different cohorts, which are 3years old (born at 2012, after Tsunami disaster), 4 years old (born at 2011, at the year of Tsunami disaster) and 5 years old (born at 2010, before Tsunami disaster). It is expected that the comparison of these cohorts can identify the genetic change due to tsunami disaster and the effect of captive breeding in each river.

In this study, genetic characteristics of chum salmon were compared among three cohorts in three rivers, Ukedo River (Fukushima), Hirose River (Miyagi) and Chitose River (Hokkaido) for the identification of the effect of Tsunami and captive breeding using microsatellite DNA markers.

Total of 216 individuals were examined which collected from three rivers, Ukedo R., Hirose R. and Chitose R., and nine microsatellites were used for the genetic characterization. Average heterozygosity (*H*e and *H*o), Average number of allele per locus and effective size of population (*N*e) were compared. Population differences were examined used by Arlequin. *N*e's were estimated by NeEstimator and LDNe.

Significant genetic differences and variabilities were observed among rivers and cohorts. Four years old cohort indicated the highest genetic variabilities in two of three rivers, and three years cohort indicated the lowest genetic variabilities in three rivers. These tendencies were observed in *N*e's in common at all examined rivers. These results suggest that tsunami disaster does not greatly damaging the genetic diversities in the river populations of chum salmon in the southern coast of Tohoku Region.

Topic Session: 2 . Salmon biology - a. Genetics

**Genetic differentiation of chum salmon in the Sanriku-region, Japan, inferred from microsatellite DNA analysis**

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Genetic approach is expected to provide important information for conservation and fisheries resource management of salmon for their sustainable use. However, genetic features of chum salmon *Oncorhynchus keta,* which is an important fisheries resource around the Pacific Rim, remain to be elucidated for those horning to rivers in the Sanriku-region, Pacific coast of northern Honshu, Japan, southernmost region of their natural distribution range. We conducted the population genetic study of Sanriku chum salmon, using more than 3,500 fish collected from 24 hatcheries, i.e. 11 in the coastal region and 13 in the tributaries of the Kitakami River in Iwate prefecture, with nine polymorphic microsatellite DNA markers. Our microsatellite DNA analysis of Sanriku chum salmon revealed three groups of coastal early-run, coastal late-run and Kitakami samples, and genetic differentiation from samples of Hokkaido and other regions in Japan. Pairwise population $F_{ST}$ analysis showed genetic differentiation within the coastal early-run and Kitakami groups, but not within the coastal late-run group. These findings suggest anthropogenic effects such as artificial transplantation to shape the observed population structure of Sanriku chum salmon, besides geographical and temporal factors.

Topic Session: 2. Salmon biology - a. Genetics

**Genetic population structure of masu salmon in the Sanriku-region, Japan, inferred from microsatellite DNA analysis**

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Understanding of the genetic characteristics in masu salmon, *Oncorhynchus masou*, endemic to the Far East is important for planning their conservation and fisheries resource management for sustainable use. We examined the genetic population structure of masu salmon in the Sanriku-region, Pacific coast of northern Honshu, Japan, using more than 200 fish of 10 samples from five rivers and five coastal areas in Iwate Prefecture, with 15 polymorphic microsatellite DNA markers. Sanriku masu salmon were genetically differentiated from salmon of Hokkaido and other regions in Japan. Cluster analysis of the Sanriku river samples revealed two genetic groups, northern and southern groups. In addition, pairwise population $F_{ST}$ estimates inferred distinct genetic differentiation among the river samples in the Sanriku region. Moreover, STRUCTURE analysis showed no genetic differentiation between coastal and river samples. These results suggest that masu populations examined herein were reproduced in the Sanriku-region, and that they contributed as the region's fisheries resources, although hatchery operations have been minimal so far for Sanriku masu salmon.

**Topic Session:** 2. Salmon biology - a. Genetics

**Next-generation sequencing (NGS)-based development of polymorphic microsatellite DNA markers of pink salmon in the Sanriku-region, Japan, for their genetic characterization**

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Pink salmon, *Oncorhynchus gorbuscha,* are the most abundant, having widest natural distribution range, among Pacific salmon species. They virtually have high commercial value around the North Pacific. However, the genetic characteristics of this species mostly remain to be elucidated with competent molecular genetic markers for their effective resource management and sustainable use. A total of 13 novel polymorphic microsatellite markers in pink salmon were isolated using NGS approach. We estimated the genetic characteristics of Sanriku pink salmon, Pacific coast of northern Honshu, Japan, using the even- and odd-year samples from two coastal sites in Sanriku (set net catch) and three rivers in Hokkaido, with a total of 15 microsatellite DNA markers including the above 13 novel and two previously reported makers. The observed allelic richness and heterozygosity in Sanriku pink salmon were comparable to the values observed in fish from Hokkaido. Principal component analysis showed genetic differentiation between even- and odd-year samples in both Sanriku and Hokkaido pink salmon. However, pairwise $F_{ST}$ estimates and principal component analysis of Sanriku and Hokkaido pink salmon inferred no significant genetic differentiation between them. The present finding suggested a high gene flow between Sanriku and Hokkaido pink salmon populations. Otherwise, the Sanriku pinks are mostly from non-spawning populations of northern origin simply migrating along the northeastern coast of Honshu, as pink salmon spawning has rarely been reported in the Sanriku region to-date.

Topic Session: 2. Salmon biology - b. Physiology

**Diversity of the intestinal microflora in chum salmon (*Oncorhynchus keta*)**

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*Introduction*

Intestinal bacteria were recently reported to play a fundamentally important role in various fish, yet their diversity remains incompletely characterized for chum salmon (*Oncorhynchus keta*) fry. Because salmon cultivation can be problematic, we studied the variation of intestinal bacteria in chum salmon fry associated with diet and growth conditions using molecular fingerprinting methods and sequence analysis.

*The intestinal microflora of chum salmon fry in the Sanriku coast*

Chum salmon fry were collected from two bay areas in 2012 and 2013, and the diversity of the 16S rRNA gene of the intestinal bacteria was analyzed using a 454-sequencer. Our results indicated that lactic acid bacteria affiliated with the genus *Leuconostoc* were detected as the dominant species in fry collected in both years and from both sampling sites. Real-time PCR analysis revealed that larger fry contained high numbers of lactic acid bacteria. The data suggests that healthy fry in the bay area contain higher numbers of lactic acid bacteria affiliated with the genus *Leuconostoc*.

*The intestinal bacteria of chum salmon fry under various rearing conditions*

Chum salmon fry were reared under sparse (10 kg/m3) or dense (40 kg/m3) conditions. Dissolved oxygen was lower in the dense group and their body size was significantly smaller. Lactic acid bacteria affiliated with the genus *Carnobacterium* were the dominant species in the sparse group. On the other hand, some anaerobic bacteria were frequently detected in the dense group. Chum salmon fry were reared under low (8°C) or high (15°C) temperatures. One fifth of the high-temperature group fry died during the experiment. When the intestinal bacteria of each group were analyzed using DGGE, *Mycoplasma* bacteria were frequently detected in the high-temperature group. We discovered significant inter-subject variability and differences between intestinal community compositions. Characterization of this immensely diverse group of flora is the first step in elucidating its role in the health of chum salmon fry.

Topic Session: 2. Salmon biology – b. Physiology

**Changes of insulin-like growth factor mRNA levels of chum salmon fry**

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Chum salmon fry (*Oncorhynchus keta*) were reared in freshwater (FW), mimicking conditions of a hatchery enhancement program. In Iwate Prefecture, over 400 million salmon fry are released from a hatchery every year, but the homing rate has been lower than 1% in recent years. This may be due to high mortality and predation on salmon fry staying inside the bay after being released from the hatchery. Our previous study showed different response of insulin-like growth factor (IGF-I) mRNA expression to ambient salinities between salmon fry retained in FW and in those transferred to SW. To enhance the homing rate of salmon, the objective of this study was therefore to examine growth and physiological variables associated with seawater adaptability and growth, monitoring IGF-I in the gills and liver, as well as the major endocrine regulators of these processes in chum salmon fry while maintaining the fry for several weeks in FW and SW. By about 10 days after transfer from FW to SW, hepatic was lower than that of fish kept in FW, whereas by about 30 days following transfer to SW, hepatic IGF-I mRNA expression increased relative to FW fish. In gill, however, IGF-I mRNA expression of fish transferred from FW to SW became higher than that of FW fish as early as 14 days following transfer. These results suggest that the development of the osmoregulatory system is prioritized in early growth soon after entry into the seawater.

(This work was supported by AFFRC, Japan.)

Session 2. Salmon biology - b. Physiology

**Proteomic response of chum salmons to thermal acclimation**

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Chum salmon (*Oncorhynchus keta*) is a major fishery resource in the Sanriku region. The number of salmon returning to Sanriku rivers is subjected to considerable annual variation. Whereas the exact reason for such variation mostly remains unknown, possible causal factors are thought to include the rise of sea temperature associated with climate change and retention of coastal warm water mass, besides other ecological changes and anthropogenic modifications. To conserve stable chum salmon stocks in the Sanriku region, creation of salmon with thermal tolerance will be helpful. However, no information for thermal acclimation of chum salmon has been available so far. Here, we investigate changes in sarcoplasmic protein abundance in response to temperature acclimation (10$^{o}$C and 18$^{o}$C). Comparative analysis of 2D-PAGE gel reveled 31 spots were differentially abundance between two acclimated groups. Among those spots, 20 were involved in glycolysis, molecular chaperone, amino acid metabolism and iron homeostasis. In terms of glycolytic enzyme, phosphoglycerate kinase and glyceraldehyde-3-phosphate dehydrogenase abundance increased in 18$^{o}$C-acclimation group, but L-lactate dehydrogenase A chain abundance decreased. These results suggested that thermal acclimated salmon had the high capacity of ATP production by glycolysis, which may enhance an anaerobic ATP generation due to inadequate oxygen supply caused by thermal acclimation.

Topic Session: 2. Salmon biology: enhancement education – b. Physiolosy

**Homing chum salmon with unusually yellowed body caught in the Sanriku coast**

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A male chum salmon (*Oncorhynchus keta*) with yellowed body color differed from ordinary nupital coloration was caught by set net at Uge coast in the northern Iwate Prefecture in the mid-November, 2015. The yellow discoloration was observed in entire abdominal part of the fish from lower jaw to caudal fin, periorbital region and oral cavity. The number of such discolored salmon was about 10 out of 232,000 fish captured in fishing period from September to December, 2015. Although the incidence was extremely low, the discolored salmon mostly occurred from the mid-October to mid-November. Similarly yellowed male chum salmon were captured in the Miyako Bay of the central Iwate coast in November 2010 and October 2014.

External appearance and autopsy findings of salmon caught in 2014 included: (i) yellowed whole body with significantly discolored gelatinous periorbital region, (ii) discoloration of vertebrae, gill lamellae, scale, muscle, and liver in yellow, with hypertrophic spleen, (iii) pale gill color suggesting a decrease of red blood cells, and (iv) yellowish blood plasma and coelomic fluid. These symptoms were similar to those of aquacultured yellowtail (*Seriola quinqueradiata*) with jaundice, suggesting that the autopsied salmon also developed jaundice.

The above external and autopsy findings of (i) and (ii) were also true for the Uge coast salmon. In addition, such unusually yellowed chum salmon have been reported previously in the Okhotsk Sea coast of Hokkaido and the Sea of Japan coast of Akita Prefecture. Further physiological, genetic and ecological studies must be needed to elucidate the mechanism underlying the observed yellow discoloration of chum salmon, besides the confirmation of the incidence, jaundice and sex-specificity in occurrence.

Topic Session: 2. Salmon biology - c. Ecology

**Migration history of masu salmon Oncorhynchus masou masou in Miyako bay, Iwate, Japan, as inferred from otolith microchemistry.**

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The migrate on history of masu salmon *Oncorhynchus masou masou* caught in Miyako Bay, Iwate Prefecture has not been sufficiently elucidated. Knowledge on the migration history of masu salmon is necessary for the sustainable use of resources and promotion of conservation activities in the watershed. We studied the migration history of adult masu salmon caught in the sea off Miyako Bay by X-ray electron probe microanalysis of the otolith elemental composition. Results of the analysis of otolith Sr:Ca ratios showed that the start of sea life could be inferred from an increase of Sr:Ca ratio. High Sr:Ca ratios were observed near the otolith nuclei in some individuals and low ratios in others. For some individuals, the Sr:Ca ratio of the otolith rises at approximately 400 μm, and declines and rises after approximately 800 μm. Those facts might reflect that some masu salmon migrate immediately downstream to the ocean after hatching and then traverse rivers and oceans several times before returning to the river.

Topic Session: 4. Salmon & fisheries education – c. Regional program

**Using masu salmon to support aquatic marine environmental education for endogenous watershed development**

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This study specifically examines "food," symbolizing connections between people and nature. An "intrinsic value" is defined as a spatiotemporal relation between people and nature (forest, rivers, oceans). Improving sympathy by raising awareness of "intrinsic value" engenders regional endogenous development. Therefore, we launched the "Heigawa Masu Salmon MANABI Project" to support the development and practice of environmental education programs on the theme of watersheds from headwaters to an estuary in Miyako, Iwate Prefecture, an area affected by the Great East Japan Earthquake.

For this study, we examined the following hypotheses.

1) Understanding of "intrinsic value" and sympathy improvement through experiential exchange activities cause consumer lifestyle changes.

2) Deepening the relation to watersheds will increase the watershed community resilience, leading to endogenous development in support of realizing a sustainable society.

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## 盛岡サケワークショップ概要とプログラム

持続的なサケ類漁業のための水産研究と教育の架け橋として

**背景と目的**：２０１１年３月の東日本大震災及び大津波により壊滅的な被害を受けた三陸沿岸の水産業復興のため、岩手大学は新たに水産系大学院および学部コースを設置することとした。三陸沿岸の水産業はサケ漁に大きく依存している。このため本ワークショップは、サケ類研究の推進により三陸水産業の復興と持続的発展を図ろうとする岩手大学における水産教育の支援のために、その成果を役立てることを目的とする。

**日時**：２０１６年2月０８日～１０日

**場所**：ホテルメトロポリタン盛岡ニューウイング、岩手県盛岡市

**日程**：

２月０８日（月）　８：４５~２０：３０　ワークショップ及び歓迎レセプション
２月０９日（火）　９：３０~１５：５０　ワークショップ及びポスターセッション
２月１０日（水）　８：４５~１７：３０　フィールドツアー

### プログラム

**内容と講演題目（各演題は英日同時通訳）**：２月０８日（第１日目）

| | | |
|---|---|---|
| **歓迎の辞** | 八代　仁 | 8:45 –　8:50 |
| **開催趣旨説明** | 阿部周一 | 8:50 –　9:05 |
| **基調講演**（座長　永澤　亨） | Richard J. Beamish | 9:05 –　9:45 |
| | – 休憩 – | 9:45 – 10:00 |
| **セッション１　太平洋サケ類の生産について：資源研究と教育**（座長　永澤　亨、Marc Trudel） | | |
| a. **北米のサケ類生産** | Andrew K. Gray、James E. Seeb | 10:00 – 10:50 |
| b. **ロシアのサケ類生産** | Alexander Zavolokin | 10:50 – 11:15 |
| c. **日本のサケ類生産** | 浦和茂彦 | 11:15 – 11:40 |
| | – 昼食 – | 11:40 – 13:00 |
| c. **日本のサケ類生産** | 宮腰靖之、小川　元 | 13:00 – 13:50 |
| d. NPAFC **の役割** | Nancy Davis | 13:50 – 14:15 |
| **セッション２　サケ類の生物学的研究について：増養殖研究と教育**（座長　長濱嘉孝、Graham Young） | | |
| a. **遺伝学的研究** | Lisa W. Seeb、佐藤俊平 | 14:15 – 15:05 |
| | – 休憩 – | 15:05 – 15:15 |
| b. **生理学的研究** | Penny Swanson、Birgitta Norberg<br>上田　宏 | 15:15 – 16:30 |
| c. **生態学的研究** | Marc Trudel | 16:30 – 16:55 |
| | – 休憩 – | 16:55 – 17:10 |
| **セッション３　パネルディスカッション** | 阿部周一（座長）、Andrew K. Gray<br>Alexander Zavolokin、浦和茂彦<br>Lisa W. Seeb、Penny Swanson<br>Marc Trudel | 17:10 – 18:15 |
| | – 歓迎レセプション – | 18:30 – 20:30 |

**内容と講演題目（各演題は英日同時通訳）**：２月０９日（第２日目）

**セッション４　サケ類及び水産分野の教育について**（座長　田中教幸、Penny Swanson）

| | | |
|---|---|---|
| a. **生態系に関する教育** | 帰山雅秀 | 9:30 – 9:55 |
| b. **水産業の社会経済学的教育** | Kathrine Tveiterås | 9:55 – 10:20 |
| c. **水産業における地域連携教育** | Graham Young | 10:20 – 10:45 |
| | – 休憩 – | 10:45 – 11:00 |
| d. **グローバル経済教育** | 清水幾太郎、石村学志 | 11:00 – 11:50 |
| | – 昼食 – | 11:50 – 13:00 |
| **セッション５　ポスターセッション** | | 13:00 – 14:30 |
| | – 休憩 – | 14:30 – 14:45 |
| **セッション６　パネルディスカッション** | 田中教幸（座長）、永澤　亨 | 14:45 – 15:45 |
| **とまとめ** | Richard J. Beamish、浦野明央 | |
| | Kathrine Tveiterås、Graham Young | |
| | Birgitta Norberg、石村学志 | |
| 閉会の辞 | 山内晧平 | 15:45 – 15:50 |

**フィールドツアー（英日同時通訳１名随行）**：２月１０日（第３日目）

| | |
|---|---|
| さけ・ますふ化場及び沿岸被災地など現地視察及び意見交換 | 8:45 – 17:30 |

岩手大学

三陸水産研究センター

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