Summary of Scientific Sessions and Workshops and List of Best Presentations at PICES-2014

Science Board Symposium (S1)
Toward a better understanding of the North Pacific: Reflecting on the past and steering for the future

Co-Convenors: *Thomas Therriault (SB), Angelica Peña (BIO), Elizabeth Logerwell (FIS), Chuanlin Huo (MEQ), Jennifer Boldt (MONITOR), Kyung-Il Chang (POC), Toru Suzuki (TCODE), Steven Bograd (AICE), Hiroaki Saito (COVE), Phillip Mundy (SOFE), Igor Shevchenko (Russia)*

Invited Speakers:
Iris Hendriks (University of the Balearic Islands, Spain)
Akihide Kasai (Kyoto University, Japan)
Jacquelynne King (Pacific Biological Station, Canada)

Backgroud

For more than two decades, PICES has been the forum for scientists to develop a better understanding of North Pacific ecosystem structure and functions and a place to reflect on what changes are occurring. Two integrative scientific programs have been at the core of PICES activities: CCCC (Climate Change and Carrying Capacity) and FUTURE (Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems). While they have advanced our knowledge of the patterns and mechanisms of ecosystem change in the North Pacific, many unknowns remain. FUTURE is developing a predictive capability for North Pacific ecosystem change, but many fundamental scientific questions remain that are beyond its scope. PICES-2014 was an opportunity for a diverse scientific community to assess the current understanding of marine ecosystems in the North Pacific, to broadly discuss scientific questions that are not being adequately addressed, and to identify the fundamental scientific questions that remain to be answered.

Summary of presentations

Hae Jin Jeong (Seoul National University, R Korea) gave the keynote lecture on "*Red tides in North Pacific coastal waters: What have we learned and what else do we need to know?*" He reviewed trends in the outbreak of red tides and nutrients (DIN) in north Pacific countries, Korea, Japan, China and Russia, which showed that, generally, a reduction in nutrient concentration leads to a reduction in red tide outbreaks. He showed that, however, trends differ among species of phytoplankton due to differences in location, depth (offshore or inshore), and transport. He also explained that differences in behavior of phytoplankton species, such as vertical migration and mixotrophy, are important considerations, as are direct and indirect biological interactions such as predator-prey, inhibition and competition. He concluded the presentation by predicting that with ocean warming (and consequently deeper thermocline and reduced wind-driven upwelling), decreased nutrients, and increased sewage treatment outflow we should expect to see slow-growing, fast-swimming species dominate red tide outbreaks. Finally, he provided insight into future research needs to better understand red tides in North Pacific coastal waters.

The first of three invited speakers was Iris Hendriks (Instituto Mediterráneo de Estudios Avanzados, Spain). She spoke about "*Pathways of Arctic Ocean acidification*". She introduced the topic by explaining that although it is often argued that polar oceans are in great danger of experiencing increased ocean acidification there is much that is not known about the multiple pathways for acidification and the vulnerability of Arctic organisms. In fact, at the large scale, the Arctic shows lower CO_2 concentrations in the ocean compared to global levels, especially during summer. This is generally understood to be because of uptake of CO_2 during ice-edge phytoplankton blooms, sea ice melting and freshwater input (from melting ice caps and rivers). Although which processes and pathways will dominate and whether they will buffer or amplify the effects of increased CO_2 differs from region to region in the Arctic. More refined models are needed to reduce this

uncertainty. In addition, more experimental research is needed on the vulnerability of Arctic organisms to ocean acidification. In closing, Dr. Hendriks concluded that the Arctic Ocean is at a crossroads where freshening of the ocean and biological responses will likely be key drivers of the ecosystem response to acidification and she recommended increased international collaboration and more process-oriented studies to better understand drivers and pathways.

The second invited speaker was Jacquelynne King (Fisheries and Oceans Canada, Canada), she gave a thought-provoking talk on the relationship between PICES' current Science Program, FUTURE, and its predecessor, CCCC. She also provided a summary of the evaluation FUTURE has recently undergone and made recommendations for ways to go forward. Recognition of the need to develop an integrated Science Program and the need to link PICES efforts to the international GLOBEC program lead to the formation of the CCCC program. Dr. King highlighted some of the major accomplishments of the CCCC task teams. An evaluation of the CCCC program, published in 2008, indicated that the most progress was made in the area of climatology and physics. The least was made at the ecosystem level. Dr. King then reviewed how FUTURE was developed through the work of a Science Plan writing team and the Implementation Plan writing team. She pointed out that FUTURE had most questions focused on the ecosystem level and the structure was designed with the goal of making FUTURE more integrated with PICES than CCCC had been. Turning attention to the present and the road ahead, Dr. King reviewed the work underway, in terms of new Working Groups established to address the science questions of FUTURE. She also summarized the findings of the 2014 FUTURE Evaluation Panel Report which described positives and also needs for improvement. She described the change in governance structure recommended by the Evaluation Panel. She also made several suggestions for FUTURE Expert Groups, such as re-focusing on NEMURO. Finally she advocated for the return of intersessional workshops for Expert Groups. In closing she encourage the PICES community to improve international collaboration specific to FUTURE and to prioritize science questions pertinent to FUTURE, closing with a quote from Lewis Carroll: "If you know where you are going, any road will get you there".

The third invited speaker was Akihide Kasai (Kyoto University, Japan) who spoke on "*High fishery production supported by complex coastal ecosystems*". One of the over-arching themes of his presentation was that organisms that can take advantage of complexity in the environment will succeed. The other theme was that one needs to pay attention to estuarine and river areas for conservation of marine fish species. To illustrate these two themes, Dr. Kasai provided an integrated and interesting synthesis of a large body of research on temperate seabass in Tango Bay and Yura River estuary in central Japan. The research of Dr. Kasai and his students showed that seabass use different habitats depending on their life history stage: hatching offshore and then moving to coastal areas, estuaries and rivers as they age. Furthermore they show that the use of estuaries and rivers varies among portions of the population with important implications for feeding and growth. This is a unique life history and emphasizes that the seabass population is supported by the adaptive use of complex ecosystems.

In addition to the three excellent invited presentations, the symposium program included submitted talks on a range of research topics pertaining to the overarching symposium theme of "…a better understanding of the North Pacific".

Shin-ichi Ito (Tohoku National Fisheries Research Institute, Japan) gave a presentation on "*Formation of offshore ecological hotspots and its fluctuation in the western North Pacific*". He introduced his presentation with the question "Why is the western North Pacific rich in productivity and diversity?" He then presented the hypothesis that the Kuroshio current transports larvae offshore where a quasi steady jet (the Isoguchi Jet) produces offshore ecological hotspots and transports larvae and juveniles such that they can utilize these hotspots. Survey and remote-sensing data support this hypothesis but there are a few remaining issues to investigate, related to the challenge of investigating the impacts of fluctuations in limited local key areas to large marine ecosystems, an area ideal for FUTURE related work.

Jack Barth (Oregon State University, USA) talked about "*What goes on beneath the waves and when we're not*

watching". He provided numerous examples of new ways of measuring small-scale oceanographic processes and features below the surface of the ocean. Instruments such as gliders, yo-yo-ing moorings and robotic platforms provide measurements to supplement ship-based observations, for instance during winter when it can be difficult to conduct a ship survey. A large amount of data at small scales can often be collected with these types of instruments. Dr. Barth concluded by saying that the overall goal of collecting these data is to evaluate the effect of meso- and submesoscale events on large-scale dynamics, and emphasizing the need to continue ship-based work and process studies.

Emanuele Di Lorenzo (Georgia Institute of Technology, USA) gave a presentation on "*Forecasting North Pacific climate and ecosystem changes: Advances and challenges*". He discussed cases where advances have been made in understanding Pacific climate variability and change over the last few decades. In brief, advances have been made concerning eastern and western boundary climate connections with a forecast potential of 3-10 years. In addition, advances have been made regarding the tropics and north Pacific climate connection with a forecast potential of around 1 year. As an example of the challenges in forecasting due to the relationship between mean climate state and the dynamics of climate variability, Dr. Di Lorenzo discussed the 2014 ENSO event, which did not materialize as forecast perhaps because the mean climate state has changed.

Elena Dulepova (Pacific Research Fisheries Center (TINRO-center), Russia) talked about "*Northwestern Pacific subarctic marine ecosystems structure and possible trends of it changing in nearest future*", reporting on what is known now about the ecosystems of the Okhotsk Sea and the western Bering Sea (in terms of structure, dynamics and functioning) and if/how will these systems change into the future. The research she discussed is based on a large volume of ecosystem survey data, from more than 500 TINRO research cruises in total. The knowledge gained from these surveys includes biomass distribution across trophic levels, fish species composition and abundance (benthic, epipelagic and mesopelagic), biocenotic zoning of nekton, and zooplankton species composition and biomass. Dr. Dulepova then talked about what determines the current dynamics of biota in these seas. TINRO's research suggests that natural factors are the main cause: climate and oceanography, ecosystem interactions (bottom-up and top-down control) and population factors. Finally, looking to the future, Dr. Dulepova explained that the ecosystems appear to be in a period of large-scale change in the trends of many natural processes (geophysical, climatic and oceanographic), although predicting the direction of coming changes is difficult if not impossible. She closed her presentation with a quote from Robert Andres Millikan (Nobel Prize in Physics 1923) "Fullness of knowledge always means some understanding of the depths of our ignorance" and the observation that the more we study an ecosystem the more questions we have about its structure and function.

Sinjae Yoo (Korea Institute of Ocean Science & Technology, R Korea) gave a presentation entitled "*How much do we know about the 88-91 regime shift in the southwestern East Sea ecosystem?*" He presented research that suggests that this shift was unique in that it was a step change caused by a synergy of climate change and anthropogenic forcing. He introduced his presentation by explaining that there was an increase in zooplankton biomass and chlorophyll concentration in 89/90 in the East Sea that was consistent with shifts in a number of climate indices. The likely cause was an increase in nutrient (Nitrogen concentrations) through atmospheric deposition, but equally if not more importantly, from increased river discharge volume, increased nutrient loading in rivers such as the Changjiang River and changes in circulation.

Robert Blasiak (The University of Tokyo, Japan) gave a presentation from the world of economics and game theory about "*Hegemony and shared dominance in marine capture fisheries*". His research focus is on using game theory to describe the potential for transboundary cooperation in the high seas. He developed game theoretic models for a range of situations from one where no one party (or "player") dominates to others with shared small-group dominance, two-player dominance and single-player dominance. He found that the greater the number of dominant players, the more international agreements were reached, illustrating his model results with real-world examples.

Anela Choy (Pacific Islands Fisheries Science Center, USA) talked about "*Projected responses of the central North Pacific pelagic ecosystem to climate-induced changes in micronekton communities*". Mid-trophic

micronekton (small fish, crustaceans and cephalopods) are key prey for large pelagic fish in the central North Pacific. The objective of Ms. Choy's research was to evaluate the importance of groups of micronekton using an updated Ecopath with Ecosim food web model with more specific groups of micronekton categories. Simulations and sensitivity analyses showed examples both of direct impacts of changes in micronekton abundance (*i.e*., predator abundance decreases when micronekton abundance decreases) and indirect impacts such as competition (*i.e*., predator abundance increases when micronekton abundance decreases). Simulations also showed that changes in crustacean and squid micronekton groups caused the largest negative responses in predator abundance.

Aigo Takeshige gave a presentation on "*Estimation of the future change of anchovy recruitment in response to global warming off western coast of Kyushu, Japan*". The background of Dr. Takeshige's research is the hypothesis that connectivity between spawning and nursery grounds is important for anchovy recruitment. The objective of his work is to examine how climate change impacts hydrodynamic and biological conditions and thus anchovy recruitment and the fishery. He developed a coupled hydrodynamic and particle tracking simulation, used with predicted future environmental change under the IPCC A2 scenario. He found that larval distribution shifted northward, away from offshore areas, with climate change due to increased transport, changing the connectivity between spawning and nursery grounds. Using mixed layer depth as a proxy for food availability, he also showed that food limits growth rate with the higher temperatures predicted by the climate scenario.

Jake Rice (Fisheries and Oceans, Canada) wrapped up the symposium with a talk entitled "*So now people believe that the ocean is changing – And so is the climate. NOW what?*" He touched on a variety of themes including policy, processes underlying climate linkages, trajectories and rates of climate change, consequences and adaptation and the PICES FUTURE program.

List of papers

Oral presentations

Red tides in North Pacific coastal waters: What have we learned and what else do we need to know? (Keynote)
Hae Jin Jeong

Pathways of Arctic Ocean acidification
Iris E. Hendriks, Melissa Chierici and Carlos M. Duarte (Invited)

Formation of offshore ecological hotspots and its fluctuation in the western North Pacific
Shin-ichi Ito, Taku Wagawa, Shigeho Kakehi and Takeshi Okunishi

What goes on beneath the waves and when we're not watching
John A. Barth

Looking back to go forward (Invited)
Jacquelynne King

Forecasting North Pacific climate and ecosystem changes: Advances and challenges
Emanuele Di Lorenzo, Nathan Mantua and Mathew Newman

Northwestern Pacific subarctic marine ecosystems structure and possible trends of it changing in nearest future
Elena P. Dulepova

How much do we know about the 88-91 regime shift in the southwestern East Sea ecosystem?
Sinjae Yoo, Chan Joo Jang, Joo-Eun Yoon and Soonmi Lee

High fishery production supported by complex coastal ecosystems (Invited)
Akihide Kasai

Hegemony and shared dominance in marine capture fisheries
Robert Blasiak and Nobuyuki Yagi

Projected responses of the central North Pacific pelagic ecosystem to climate-induced changes in micronekton communities
C. Anela Choy, Phoebe Woodworth-Jefcoats and Jeffrey J. Polovina

Estimation of the future change of anchovy recruitment in response to global warming off western coast of Kyushu, Japan
Aigo Takeshige, Shingo Kimura, Yoichi Miyake, Hideaki Nakata and Takashi Kitagawa

So now people believe that the ocean is changing – And so is the climate. NOW what?
Jake Rice

Poster presentations

Effects of volcanism on sockeye salmon Oncorhynchus nerka abundance in Kamchstka River
Victor F. Bugaev

Impact of climate change on the egg and larval transport of Japanese anchovy Engraulis japonicas off western coast of Kyushu, Japan
Shingo Kimura, Aigo Takeshige, Yoichi Miyake, Hideaki Nakata and Takashi Kitagawa

Interannual variability of chlorophyll associated with mixed layer depth changes in the East Sea (Japan Sea)
Chan Joo Jang, Youngji Joh and Sinjae Yoo

BIO Topic Session (S2)
Strengths and limitations of habitat modeling: Techniques, data sources, and predictive capabilities

Co-Convenors: *Enyuan Fan (China), Elliott Hazen (USA), Sei-Ichi Saitoh (Japan), William Sydeman (USA), Yutaka Watanuki (Japan)*

Invited Speakers:
Hiroto Murase (National Research Institute of Far Seas Fisheries, Japan)
Martin Renner (University of Washington, USA)

Background

Habitat modeling is a powerful tool used to identify key factors affecting the distribution of marine organisms and underlying mechanisms, to predict optimal fishing grounds, to evaluate human impacts on ecosystems, and to project distribution shifts in the face of climate change. Given their broad application and utility, evaluation of the strengths and weakness of various modeling approaches is becoming increasingly important. Environmental data primarily come from satellite-based SST, SST gradient, SSH, Chl-*a* and their variation across time, and geographic features such as shelf breaks. Distribution data are collected from various sources, including ship-based line transect surveys, animal tracking, fisheries activities (log data, satellite-based fishing light distribution) and hence contain inevitable biases, including the selection of the survey line and season, tagging location of tracked animals, sample sizes, and type of the fishing activities. Biases are also inherent in the models being used – Generalized linear and additive models (GLMs and GAMs), Random Forests, boosted regression approaches, and Maximum Entropy modeling (MaxEnt). The intention of the session was to examine factors causing biases, identify the direction of biases, discuss techniques for mitigating or accounting for biases, and create a best-practices guide for using habitat modeling approaches to predict the distribution of marine organisms in dynamic marine environments.

Summary of presentations

This session was a welcome addition to common themes explored in PICES meetings and focused on mechanisms of habitat modeling analysis rather than focusing on a specific type of study organism. It was well-attended and there was a variety of topics in the presentations, focusing on different ecosystems, trophic levels (coral to whales) and at many different scales – from fine-scale predictions to basin-wide.

In his invited lecture, Dr. Hiroto Murase discussed many of the pros and cons between habitat and mechanistic models. The former is good for understanding static pictures while the latter is better for understanding processes. He used an ensemble of statistical models to predict Sei whale abundance in the west Pacific and found a range of both predictive accuracy and overall predicted spatial scales. The take-home message was that for sei-whale sightings data, Machine-learning models (Random Forests and Boosted Regression Trees) and

generalized additive models (GAMs) performed best (sequentially). However, satellite tracks from Sei whales did not seem to match well with the modeled habitat highlighting the need for examining both datasets.

The second invited lecture by Dr. Martin Renner focused on the North Pacific seabird database using climatological sightings data. He, like Dr. Murase, used a suite of models, and found that model success varied quite a bit. In fact, the ensemble model performed more poorly than some of the individual models. In addition, Martin presented that kriging may outperform kernel density for filling the gaps between observations.

Dr. Chris Rooper gave a presentation on the habitat modeling of deep sea corals in the Gulf of Alaska and Bering Strait. Given the zero-inflated nature of the data, he modeled presence / absence and abundance separately in what is termed a hurdle model. He also used a camera sled to groundtruth the trawl catches of corals, finding that the camera sled did a better job sampling corals than the benthic trawls.

Dr. Bill Sydeman gave a talk for Jarrod Santora on mechanistically modeling krill hotspots in the California Current. He showed that ROMS-model based predictions of krill patch size, intensity and persistence were centered at 37° latitude, and intensity and persistence both related well to seabird densities that foraged in the California Current. The contrast between mechanistic, individual based models presented by Bill and the statistical models presented by the other speakers highlighted the need to look at both approaches in concert.

Dr. Hiroko Sasaki gave a talk on predicting zooplankton abundance as a function of the environment. She focused specifically on arctic and Pacific copepods and used GAMMs to predict their distribution relative to environmental variables with year as a random covariate. Interestingly, the habitat envelopes of the two groups of copepods were quite similar, with Pacific copepods having a slightly stronger relationship with temperature.

Dr. Irene Alabia gave a talk on habitat suitability models for neon flying squid in the western Pacific. Rather than using a single model, she used a model ensemble and like Dr. Murase compared the results from each of the models. The ensemble models were chosen and weighted based on the prediction-based validation. There was also quite a bit of variability among years in model success, potentially because of the nature of the resource (less *vs*. more densely aggregated).

Dr. Yoon-Kyung Lee presented on a GIS based habitat map for common squid. Her research used a more qualitative method with strong predictive success to sum up the correlations among environmental variables and common squid CPUE on a pixel-by-pixel basis. The weighting of each parameter was decided based on the frequency of catch and each environmental variable and ultimately the habitat envelope data were summed into a habitat probability index.

Dr. Yukiko Inoue presented bycatch models of wandering and black-browed albatross using tag-based and fisheries bycatch data. As bycatch is a function of species distribution and fishing effort, multiple models were used sequentially. Distribution was predicted as a function of environmental variables and predicted for islands without tracking data. Bycatch was predicted in two models: as a function of environmental variables and gear type. Unfortunately, the models showed that bycatch mitigation techniques did not show an across the board reduction in bycatch but more data are likely needed to make a conclusive decision.

Dr. Patrick O'Hara gave a talk on predicting Cassin's Auklet habitat relative to environmental stressors of microplastics and oil. His models were very robust in predicting both survey and tracking-based distribution of birds. When overlaying the modeled habitat with microplastics, there was little overlap but vessel traffic was directed through important areas. Cassin's Auklets are of conservation concern for Canada and there are ongoing efforts for spatial management around Triangle Island to protect this important population.

The final talk was given by Dr. Hiromichi Igarashi who created a near-real time model of neon flying squid using ROMS model output. He used a suite of modeling techniques, and created a complex super-ensemble, regressing the suite of models against CPUE rather than the common approach of weighted averaging. Using

an EOF on the super-ensemble output he was able to decompose the results based on spatio-temporal scale into fine, medium, and large scale. He then was able to highlight how the various scales improved in their predictive capacity, in addition to the single vs. super-ensemble, as a function of good and bad fishing years.

Conclusions

- The suite of modeling techniques presented, with some authors using up to 10 different models highlights the importance of comparing model results. As technological capability continues to increase, more complex multi-model ensembles can improve our predictive capacity.
- In addition, the talks examined multiple trophic levels from copepods up to marine mammals highlighting the need for statistical habitat modeling.
- Finally, the difference between mechanistic (individual-based models) *vs*. statistical (many presented here) was highlighted by a number of speakers. In fact, the possibility of combining these approaches, *e.g*., using the habitat model output as an input for mechanistic models was suggested by one of the speakers. This has the potential to greatly improve our capabilities in predicting habitat, including for use in near-real time management of fisheries resources.

This session shows the successes of the Spatial Ecology plan by the AP-MBM and will contribute to the 3-year report.

List of papers

Oral presentations

Application of habitat models to highly mobile marine animals – Cetaceans in the North Pacific as case studies (Invited)
Hiroto Murase, Toshihide Kitakado, Yu Kanaji, Hiroko Sasaki, Yoko Mitani, Koji Matsuoka, Makoto Okazaki and Naohisa Kanda

Crossvalidating approaches to modeling habitat and distribution of seabirds at-sea (Invited)
Martin Renner

Distribution modeling for deep-sea corals and sponges in Alaska
Chris Rooper, Mark Zimmermann, Mike Sigler and Jerry Hoff

Modeling temporal variation in krill "hotspots": Size, intensity, persistence and coherence with krill predators
Jarrod A. Santora, Jeffrey Dorman and William J. Sydeman

Prediction of zooplankton community Spatial-Temporal patterns in the Chukchi Sea – Case study using habitat modeling approach
Hiroko Sasaki, Kohei Matsuno, Atsushi Yamaguchi, Yutaka Watanuki and Takashi Kikuchi

Comparison of habitat suitability models for neon flying squid (Ommastrephes bartramii) in western and central North Pacific
Irene Alabia, Sei-Ichi Saitoh, Hiromichi Igarashi, Yoichi Ishikawa, Norihisa Usui, Masafumi Kamachi, Awaji Toshiyuki and Masaki Seito

GIS-based potential habitat mapping for Todarodes pacificus (common squid)
Yoon-Kyung Lee, Inhye Park, Sang-Woo Kim, Jong-Kuk Choi, Saro Lee and Joo-Hyung Ryu

Is seabird bycatch rate affected by the seabird distribution? Estimation of seabird distribution for bycatch risk assessment
Yukiko Inoue, Makoto Okazaki, Maria P. Dias, Cleo Small and Hiroshi Minami

Cassin's Auklet at-sea distribution and exposure to stressors such as ship-source oil pollution and microplastics
Patrick D. O'Hara, Ken Morgan, Jamie McDevitt-Irwin, Jean-Pierre W. Desforges, Peter S. Ross and Sean Boyd

A multi-model ensemble prediction of habitat suitability index (HSI) models for neon flying squid in central North Pacific by using 3-D ocean data assimilation product
Hiromichi Igarashi, Toshiyuki Awaji, Masafumi Kamachi, Yoichi Ishikawa, Norihisa Usui, Masaaki Iiyama, Yosuke Onoue, Mitsuo Sakai, Yoshiki Kato, Irene Alabia, Sei-ichi Saitoh and Masaki Seitoh

Poster presentations

Developing the suitable operation prediction model of neon flying squid in the central North Pacific using Satellite images and VMS
Yang Liu, Sei-Ichi Saitoh, Hiroki Takegawa and Toru Hirawake

Effect of 3-D physical structures on spatial distributions of Japanese common squid in the coastal waters of southwestern Hokkaido, Japan
Xun Zhang, Sei-Ichi Saitoh, Toru Hirawake, Satoshi Nakada, Koji Koyamada, Toshiyuki Awaji, Yoichi Ishikawa and Hiromichi Igarashi

Habitat model development of Japanese common squid in Japan Sea using satellite remotely sensed data
Mariko Dehara, Sei-Ichi Saitoh and Toru Hirawake

Predicting the potential invasion in Korean waters of the saltmarsh grass Spartina alterniflora from China – A joint proposal by KIOST and Nanjing University
Keun-Hyung Choi and Changyong Wang

BIO/MEQ Topic Session (S3)

Tipping points: defining reference points for ecological indicators of multiple stressors in coastal and marine ecosystem

Co-sponsored by the International Council for the Exploration of the Sea (ICES) and Integrated Marine Biogeochemistry and Ecosystem Research (IMBER)

Co-Convenors: *Rebecca G. Martone (USA), Ian Perry (Canada), Jameal Samhouri (USA), Motomitsu Takahashi (Japan), Maciej Tomczak (Poland / ICES), Chang Ik Zhang (Korea)*

Invited Speakers:
Phil Levin (NNOAANW Fisheries Science Center, USA)
Tetsuo Yanagi (Research Institute for Applied Mechanics, Kyushu University, Japan)

Background

Many coastal and marine ecosystems, ranging from reefs to estuaries to pelagic systems, are exposed to multiple stressors, which can lead to rapid changes with significant, long-term consequences that are often difficult to reverse. Changes in ocean climate, the abundance of key species, nutrients, and other factors drive these shifts, which affect ocean food webs, habitats, and ecosystem functions and people's livelihoods and well-being. Determining indicators of ecological changes due to multiple stressors and defining reference points for those indicators are key steps for managers to avoid ecological degradation and loss of keys goods and services. Setting ecological reference points in ecological systems presents a challenge to resource managers because (a) reference points are often difficult to determine due to the complexity of natural systems, including the presence of thresholds, tipping points, and non-linearities; (b) the paucity of theoretical modeling and empirical understanding needed to address these complexities, identify ecological thresholds and develop early warning indicators means that managers must make decisions based on high levels of uncertainty; and, (c) many institutional and governance structures do not allow managers the necessary flexibility to take up this information and react within relevant timeframes. The aim of this session was to address these pressing challenges, and explore promising approaches to tackling them with the goal of catalyzing new research and management innovation. In particular, the convenors sought presentations that (i) define the conceptual basis for reference points and management objectives surrounding reference points; (ii) use theoretical, modeling and observational approaches to identify potential reference points for indicators of changes in marine ecosystems; (iii) incorporate risk and sources of error (measurement, model, process) in such analyses; (iv) discuss how reference points may be used in helping to manage marine ecosystems, specifically in relation to the decision-making process related to evaluating and deciding on acceptable levels of risk. Discussions were guided by the FUTURE science themes, with special attention to examining climate and anthropogenic drivers of ecological change, and identifying early warning indicators to enable forecasting

to avoid crossing ecological thresholds. The outcomes are expected to contribute to the work of PICES Working Group 28 on *Development of Ecosystem Indicators to Characterize Ecosystem Responses to Multiple Stressors.*

Summary of presentations

The session provided a very interesting overview of how tipping points pertain to marine species and ecosystems. It was well-attended and there was a great diversity of presentations, featuring many different geographies and at many different scales – from ecosystem-wide changes in response to tipping points to threshold responses of individual animals and fisheries stocks.

In his Invited Presentation, Dr. Phillip Levin addressed the important topic of how to respond to regime shifts in social-ecological systems. He focused on the importance of integrated ecosystem assessments (IEAs), and how they can be applied to counteract regime shifts. He suggested that the first question to answer as part of an IEA is whether the existing regime is desired, and then further broke this question down into 3 parts. First, do people see the world the same way? Dr. Levin illustrated that people do not necessarily view the world the same way using a folk taxonomy example, and suggested that regime shifts are likely not to be perceived the same way either. Second, Dr. Levin posed the question: does anyone care if a regime shifts? Using the example of regime shifts from kelp forests to sea urchin barrens and back again, he illustrated how different groups of people are likely to have different preferences for each regime. The third question Dr. Levin addressed focused on defining the target regime. Via the lens of eelgrass restoration, Dr. Levin described a novel approach for determining public preferences for different ecosystem configurations. Overall, he argued that portfolios of indicators need to be accompanied by portfolios of reference points that reflect people's preferences for alternative ecosystem configurations.

Dr. Jake Rice asserted that the one thing managers should avoid is to make a tipping point a target. This argument stems from the fact that rapid changes in the ecosystem happen near tipping points, and those changes may not be desirable. However, Dr. Rice showed that identifying tipping points is analytically challenging. Nonetheless, he made a strong case for managers to: avoid tipping points with high probability, emphasize that objective even more so than an objective of achieving targets, and avoid optimizing along a single ecosystem dimension (*e.g.*, a single fishery).

Dr. Rebecca Martone provided an overview of a multi-institutional collaborative project called "Ocean Tipping Points." The project includes scientists and lawyers from universities, government agencies, and NGOs and consists of synthesis and application components. The synthesis component includes compilation of a global database of marine ecosystem shifts (n > 100 studies, few from the western Pacific), a meta-analysis of nonlinear relationships in pelagic systems, a law review that demonstrated that regulations incorporating thresholds yield better environmental outcomes, and a management review of 50 case studies of current management contexts showing that explicit use of tipping points in management yields improved environmental outcomes. The application components focus on coral reefs in Hawaii, USA, and the herring food web in Haida Gwaii, BC, Canada.

Dr. Maciej Tomczak described an impressive body of work showing that overexploitation, changes in climate, and nutrient loading combined to cause a shift from a cod-dominated to a sprat-dominated Baltic ecosystem. Dr Tomczak defined this phenomenon as a regime shift, *i.e.*, a food web reorganization and redirection of energy flow pathways. He used a network indicator called Redundancy to suggest that resilience has declined in the Baltic over time, in response to an overall forcing index (inclusive of changes in climate, fishing, *etc*.).

Dr. Takahashi and colleagues presented the results from an expert judgment survey to determine relative risks of coastal and marine habitats in the Eastern, Central and Western Regions of the Seto Inland Sea. Results indicate regional variation within the Seto Inland Sea to a suite of stressors. Coastal engineering and development affects strongly all ecosystems across the regions. Commercial activities, including fishing, have stronger impacts in the eastern waters. Nutrient input and HABs have higher risk in the central and eastern

areas. Dr. Takahashi presented spatially explicit temporal data that corroborate many of the outcomes from the expert judgment survey. For example, tidal flats and seagrass beds have decreased in areas of the Seto Inland Sea. Stressor-specific risk scores indicate regional variability linked to population density and geographical features in the Seto Inland Sea. Future comparisons with results from global models and other regional models will help identify gaps and biases in expert judgement. These results can help identify priorities for research and management of cumulative impacts to ecosystems at regional spatial scales.

Dr. Ian Perry presented work in the Salish Sea examining the drivers of change acting on the Strait of Georgia in the Salish Sea, British Columbia. Using redundancy analysis, Dr. Perry identified regime-like transitions of the Strait of Georgia since 1970. Dr. Perry then presented an examination of potential predictors for typical system behaviours prior to significant shifts in the system, including variance, autocorrelation at lag-1, and conditional heteroskedasticity. Standard deviation and the autocorrelation are not correlated with the regime shifts and thus do not act as good predictors. Interestingly, conditional hetero-skedasticity of SST and North Pacific Gyre Oscillation within the moving window of 37 months was well-correlated with the regime shift and possibly could be used as an early warning indicator. Dr. Perry described some of the challenges associated with choosing which indicators, which predictors for early warnings of regime shifts, choice of time period (*e.g.*, moving windows), and how to identify significance. Early warning indicators appear promising, but the real world is more messy than simulated data. Several indicators are likely necessary, particularly lower trophic level biological variables, and combining these in a probability approach might be good way forward.

Dr. Bill Sydeman focused on the importance of understanding how changes in community structure relate to changes in ecosystem functions and processes, with emphasis on tipping points of mid-trophic level invertebrates and fishes and meso-predators. Meso-predators may serve as indicators of variability in ecosystem function as they may be the most responsive to the forage fish community variability. Dr. Sydeman showed that there are many non-linear responses of ecosystems to changes in mid trophic level (MTL) fish, (*e.g.*, changes in breeding success of seabirds) and that shapes of the relationships can be used to determine which indicators might be more sensitive to ecosystem changes. The global model for seabird breeding success indicates a threshold that around the mean long-term trend. Dr. Sydeman then explored whether there is variability in the threshold numerical response between forage fish abundance and seabirds, either among predator species, prey species or the parameter examined. Interestingly, among some predator and prey species the threshold holds but for other species there are different relationships, but despite this variation North Pacific seabird threshold range is similar to the global model. Furthermore, the threshold tends to hold for different parameters; however, there is high uncertainty associated with this because of data limitations. Ultimately, predator-prey threshold relationships may provide insight to ecosystem state shifts. Future work on population-level responses, multi-species predator–prey numerical responses, and how differences in mean abundance or life history characteristics (*e.g.*, diet specialization) might affect the threshold, will be useful to understand threshold responses in ecosystem indicators.

Dr. Wen Yu presented on the effects of acute gamma radiation on the survival and physiological indices of the Chinese black sleeper. Existing studies from UNSCEAR (2008) indicate that fish are the most sensitive species based on LD50 reference points but few focus on data from marine fish and there are no data in China. By examining the Chinese black sleeper, Dr. Yu's study fills important gaps in our understanding of the response of marine species to radiation, particularly as it may be more susceptible to pollution and is economically important. Dr. Yu presented the results of a dose-response experiment that examined 5 irradiated groups and a control groups, with 60 individuals per group. Preliminary results indicate that with the 3 higher levels of irradiation, 100% mortality occurred within a few days, while the lowest level of radiation was similar to the controls. The calculated LD_{50} was 7.1 (6.3–7.9) Gy, which is lower than the 10–25 Gy summarized from UNSCEAR. Future research will include additional experiments to confirm these results, along with research on other local species and tests of the effects of chronic radiation.

Mr. Kyung-Su Kim described his research on the combined effects of elevated CO_2 and temperature on the physiological conditions of olive flounder larvae, *Paralichthys olivaceus*. Using a MFC controller and mixing chambers Mr. Kim described the experimental settings, including 3 different CO_2 concentrations, based on

current day 2100 mild and strong emissions based on IPCC predictions and 2 temperatures, optimum and high temperature. Both total length and wet weight increased with CO_2 at lower temperatures, but variable responses occurred when CO_2 was combined higher temperatures. Skeleton malformation occurred more frequently with higher CO_2 conditions, and bone density decreased with increasing CO_2 conditions. Results from histomorphology did not show any malformation in tissues under higher CO_2 conditions. Dr. Kim's study illustrated that CO_2 and temperature have variable interactive effects on growth (positive) and bone density (negative), suggest that these types of studies are necessary to tease apart the multiple effects of stressors on condition, which may have implications for population dynamics and ecosystems.

For his invited presentation Dr. Tetsuo Yanagi described eutrophic and oligotrophic processes in the Seto Inland Sea and their relation to the Satoumi concept. Eutrophication (TN:TP) in recent years has decreased in the Seto Inland Sea and fish stocks have also seen similar declines, suggesting regime shifts related to changes in productivity driven by nutrient inputs. Dr. Yanagi explored models of phytoplankton population dynamics using relationships with different strengths of non-linearity for a variety of parameters. The relation between fish catch and nutrient concentration is non linear and there is hysteresis due to sediment pollution. Oligotrophic conditions may lead to changes in stratification and ability of fish to eat sinking phytoplankton, leading to hypoxia and possibly a new regime. Dr. Yanagi then suggested that there is a possibility to move from oligotrophic conditions back to eutrophic conditions with higher productivity, which is the preferred state, and introduced the Satoumi concept. The Satoumi concept developed by Dr. Yanagi supports the idea that coastal seas can have high biodiversity and productivity under human interactions, where both over and under- use can lead to low biodiversity and productivity. For example, decreases of eelgrass beds in the Seto Inland Sea led to decrease of fish catch by set nets, which in turn led local fishermen to create eelgrass beds. Now both eelgrass beds and fish catches by set nets are increasing. Currently Dr. Yanagi has a new project supported by the Ministry of the Environment to develop coastal management method to realize the sustainable coastal sea, in which physical, biological, social sciences, and governance will support integrated, community-based management, to realize clean, rich and prosperous seas.

Dr. Kazumi Wakita presented research on the diversity of perceptions and utility of marine ecosystem services. With an online survey of 1100 residents of japan, Dr. Wakita examined people's perceptions of different ecosystem services and the utility or satisfaction experienced by different people could be used as a basis for decision making. In addition, she explored the how utility that residents derive from marine ecosystem services affect their behavioural intentions for marine conservation, assuming that where there is higher the perceived indispensability, the greater the utility, and the higher the indispensability the greater its influence on enhancing behavioural intensions for marine conservation. Using factor analysis and structural equation modeling to determine the causal relationships between perceived value and their intensions of behaviour for conservation of marine biodiversity, Dr. Wakita uncovered 3 hidden factors including (1) Essential Benefits, including food, life satisfaction, health, *etc*.; (2) Indirect Benefits, which was primarily composed of provisioning services and regulating services; and, (3) Cultural Benefits. Dr. Wakita found that cultural benefits were most important in driving behavioural intentions for marine conservation. Essential benefits also contributed to behaviour assessments, whereas indirect benefits were not significant. Essential benefits had highest indispensability, followed by indirect benefits, while cultural benefits scored lower on indispensability. These results indicate that indispensability does not correlate with conservation behaviors. Focusing on the landlocked Nagano residents, Dr. Wakita also performed factor analysis to examine the scarcity principle. The same 3 factors were identified, but their contents were different. Perception of marine ecosystem could vary reflecting scarcity of the services in their place of residents, which will be different for different communities. Dr. Wakita's talk emphasizes the need for more attention for cultural aspects of marine ecosystem services.

Dr. Christopher Aura assessed the magnitude and interrelationships of seasonal phytoplankton bloom occurrence at the Japanese scallop farming area of Okhotsk Sea, Hokkaido Japan. To define tipping points, Dr. Aura and colleagues defined different bloom types, including the spring bloom, ice bloom, and open water bloom, using time series data sources including chla, sea ice, surface wind stress. By identifying the mechanism of bloom occurrence, Dr. Aura was able to identify that a decline of wind stress leads to increased ice edge blooming and decreased open water bloom variability. In addition, using PCA and Pearson correlation

matrices, he found that there are distinct relationships between scallop landings, sea ice cover, and bloom variability. Where there is a strong negative relationship between sea ice days and open water bloom, while open water blooms are positively correlated with scallop landings. Thus, tipping points can be described by wind stress and solar radiation.

Dr. Jameal Samhouri and colleagues explore what has happened once a tipping point has been crossed, where multiple pressures shift systems over ecological thresholds and lead to different ecosystem states.. Dr. Samhouri described how examining systems that have crossed tipping points may help guide the recovery of ecosystems, specifically working toward the development of theory to reassemble marine systems. Dr. Samhouri examined what types of ecosystem reassembly strategies are currently in use, what strategies are likely to be the most effective using a theoretical model, and finally, determined if and where the most effective strategies that have been identified from models are being used. Dr. Samhouri identified three main reassembly strategies, where lower trophic levels recover first, higher trophic levels recover first, or simultaneous recovery occurs. Using a theoretical toy model of a generalist predator and multiple prey species, Dr. Samhouri asked whether who goes first matters in terms of ecosystem reassembly, specifically examining these three strategies. Simultaneous recovery (to equilibrium) of both predator and prey is fastest while predator first is the slowest, but predator first is the most direct in terms of amplification volume, without noisy transient dynamics. From the literature, the least common strategy is where highest trophic level recovery first, suggesting that the most effective strategies, specifically simultaneous reassembly and lower trophic level first, are the most common. Additional future work examining stochastic dynamics and multiple trophic levels in the system may help identify how regimes shift and the possibility of priority effects under more realistic scenarios.

Dr. Kulik presented work examining potential reference points for mean trophic level of macrofauna in the Sea of Okhotsk. Trophic level, a common indicator of fisheries status, can be determined by stable isotope ratio of nitrogen, but this depends both on seasonal delivery of nitrogen with spring blooms and on the age of the consumer. To address this variability, Dr. Kulik used an adjusted mean weighted average trophic level (muTL) of every catch, using information on weight at length from fishery data and stable isotope ratio information from data of species in the benthic-pelagic zone. Using trophic level of 67 fish, 6 squid and 5 decapod species and 148 species from Fishbase, Dr. Kulik and colleagues estimated muTL from 9926 trawls in pelagic waters from 1984–2013 and from 6321 bottom trawls from 1977–2010. Dr. Kulik examined spatial and temporal variation of muTL using Generalized Additive Models with splines for coordinates, horizon of trawling, years and months. Dr. Kulik's results indicate that there is deviation from the global mean of muTL in pelagic waters over time in the Sea of Okhotsk, and during the period of 2003–2013, he estimated that the linear rate of increase in muTL of catches was 0.007 per year. Spatial variation also occurs in muTL, with deeper pelagic waters showing lower than average muTL in the pelagic fisheries, but for bottom trawls, the deeper pelagic waters demonstrate higher than average muTL. This research illustrates the need to understand spatial and temporal variation in reference points of indicators in order to understand ecosystem shifts.

Dr. Yusheng Zhang and colleagues described the fate and potential impacts from radionuclides in the NW Pacific following the Fukushima Nuclear Disaster (FND). Transfer of radionuclides can occur from water to fish through the food web and directly through contact with water. On a series of cruises beginning in June 2011, Dr. Zhang and colleagues collected tissue samples from 3 species - squid, saury, and dolphin fish. They used these samples to analyze radionuclide concentrations of ^{134}Cs, ^{137}Cs, and ^{110m}Ag, using the gamma spectrometry method. All radionuclides were detected in all 3 collected species of marine animals, including ^{134}Cs and ^{110m}Ag, which are important indicators of nuclear accident pollution and aren't usually seen. Squid showed higher concentrations than saury and dolphinfish, though radionuclide contents varied among tissue types. Dr. Zhang also developed spatial maps of exposure, indicating where the nuclide samples were found and their magnitudes, and examined temporal patterns in radionuclide concentrations in tissues. Concentrations of most radionuclides in squid peaked in November 2011, and dropped precipitously, except for ^{90}Sr, which showed a very different temporal pattern. Dolphin fish radionuclide concentrations also exhibited declines over time. Dr. Zhang indicated that though radionuclide concentrations in marine animals increased following FND, they were lower than the limit reference point for seafood safety.

Dr. Hyeong-gi Kim presented work regarding thermal influence on nematodes, the most numerous metazoans worldwide and a potentially informative indicator group because of their abundance, occurrence in a wide range of habitats, habitat specificity, and a broad range of feeding types and generation times. Dr. Kim focused on the effects of thermal discharge from nuclear power plants on nematode communities in Gori coastal waters of the southern East Sea / Sea of Japan. The nematode community consisted of 6 dominant species, but a much larger number of species were extremely rare. Most nematodes were non-selective deposit feeders, and sediment type was a dominant factor determining nematode community composition. Interestingly, bottom temperature was not significantly correlated with the abundance of most nematodes.

Mr. Delvan Neville from Oregon State University discussed reference points in the context of radioecology. In this field, reference points are referred to as Derived Consideration Reference Level. Mr. Neville determined distribution of radionucleotides in the bodies of several Northern California Current marine species including *Thunnus aluluna* (albacore tuna). Concentrations were generally low, such that only a 10,000-fold increase in ^{137}Cs would exceed safe limits. Pink shrimp and several other species exhibited much larger responses than those seen in tuna.

Some overall comments:

- Tipping points are an integrative concept for social-ecological systems and pertain to many issues of strong interest to PICES, including climatic shifts, changes in top predator abundances, ecosystem responses to multiple pressures, and more.
- However, a clear definition is challenged by this same feature. It seemed that the implicit and most general definition that emerged in S3 focused on the existence of a nonlinear change in a dynamical system. Defined this way, tipping points can occur in individual animals in response to environmental challenges (eg, radiation, CO2), to harvested fish stocks because of spawner-recruit relationships, and to entire food webs and ecological communities because of nonlinear predator-prey and competitive interactions.
- Early warning indicators of tipping points may be difficult to identify and anticipating or forecasting tipping points may not be possible. However, retrospective analysis and modeling can illustrate general lessons and rules of thumb, as well as help identify potential trajectories of recovery and guide management actions.
- Tipping points are inherent to social-ecological systems, but do not in and of themselves tell us anything about objectives and targets. Rather, knowledge of tipping points can help guide decisions about objectives and targets.
- While desired states of the social ecological system are important to consider for decision making, it is the biophysical system that defines what states are possible. Thus while it is important to define desired states within the tipping points framework, it is important to manage expectations about what is possible to achieve.

We are seeing an increasing amount of integration of social-ecological effects within ecosystems PICES activities across the North Pacific. This is a good sign for the FUTURE program.

List of papers

Oral presentations

Marine ecosystem regime shifts: Challenges and opportunities for Ecosystem-Based Management (Invited)
Phil Levin

Tipping points and decision-making: Why they matter, why they are hard, and practical things to do
Jake Rice

Embedding the science of tipping points into ocean management
Rebecca Martone, Carrie Kappel, Courtney Scarborough, Mary Hunsicker, Ben Halpern, Kimberly Selkoe, Phil Levin, Jameal F. Samhouri, Crow White, Ashley Erickson, Ryan Kelly, Lindley Mease, Margaret Caldwell, Larry Crowder and Rod Fujita

Ecological network indicators of ecosystem status and change in the Baltic Sea
Maciej T. Tomczak, Johanna J. Heymans, Johanna Yletyinen, Susa Niiranen, Saskia A. Otto and Thorsten Blenckner

Regional variations in ecosystem responses to anthropogenic activities and natural stressors in the Seto Inland Sea
Motomitsu Takahashi, Sachihiko Itoh, Naoki Yoshie and Kazuhiko Mochida

Potential early warning indicators of marine ecosystem changes in coastal British Columbia, Canada
R. Ian Perry

Seabird indicators and "tipping points" in North Pacific marine ecosystems
William J. Sydeman, Sarah Ann Thompson, Julie A. Thayer, Marisol Garcia-Reyes, Heather Renner, John F. Piatt, Stephanie Zador and Yutaka Watanuki

The effects of acute gamma irradiation on the survival and the physiological and biochemical indexes of Chinese black sleeper, Bostrichthys sinensis
Wen Yu, Tao Yu, Yusheng Zhang and Feng Lin

The combined effects of elevated CO2 and temperature on the physiological condition of the olive flounder larvae Paralichthys olivaceus
Kyung-Su Kim, JeongHee Shim and Suam Kim

Eutrophication and oligotrophication processes in the Seto Inland Sea and their relationships to the Satoumi concept (Invited)
Tetsuo Yanagi

Diversity of perceptions and utility of marine ecosystem services
Kazumi Wakita, Zhonghua Shen, Taro Oishi, Nobuyuki Yagi, Hisashi Kurokura and Ken Furuya

Assessment of the magnitude and interrelationship of seasonal phytoplankton bloom occurrence at the Japanese scallop (*Mizuhopecten yessoensis*) farming area of Okhotsk Sea, Hokkaido, Japan
Christopher Mulanda Aura, Sei-Ichi Saitoh, Yang Liu and Toru Hirawake

Ordered re-assembly of marine ecosystems
Jameal F. Samhouri, Adrian C. Stier and Phil Levin

Potential reference points for mean trophic level of macrofauna in the Sea of Okhotsk
Konstantin M. Gorbatenko, Vladimir V. Kulik and Artem E. Lazshentsev

The bioconcentration of artificial radionuclides by marine animals after the Fukushima nuclear accident in the Northwest Pacific
Wu Men, Jianhua He, Wen Yu, Fenfen Wang, Wuhui Lin and Yusheng Zhang

Seasonal and spatial variations in nematode assemblages affected by thermal influence of a nuclear power plant in Korea (East Sea, Pacific Ocean)
Hyeong-gi Kim, Hyun soo Rho and Chul-woong Oh

Characterization of absorbed dose from natural and anthropogenic radionuclides for the purpose of establishing reference points within the marine environment
Delvan R. Neville and Kathryn A. Higley

Poster presentations

DNA damage (Comet Assay) as biomarker of Cd exposure in bivalve mollusks *Modiolus kurilensi* and *Corbicula japonica*
Valentina V. Slobodskova, Sergey P. Kukla, Viktor P. Chelomin and Elena V. Zhuravel

Sulfonamide antibiotics in the Northern yellow Sea are related to resistant bacteria: Implications for antibiotic resistance genes
Guangshui Na, Hui Gao, Ruijin Li, Jinqiu Du, Ziwei Yao and Chuanlin Huo

Growth rate comparison of Pacific oyster, Crassostrea gigas, reared in situ in a high-CO_2 mesocosm environment
JeongHee Shim, Hakbin Hwang, Jae-Hyun Lim, Sang-Jun Lee and Jung-no Kwon

Valuation of ecosystem diversity maintenance service in marine protected areas: Shandong case
Shang Chen, Shengjie Tu, Tao Xia, Zhengxiang Gao and Tao Zhang

BIO/MONITOR/TCODE Topic Session (S4)
Use of long time series of plankton to inform decisions in management and policy concerning climate, ecosystems and fisheries

Co-Convenors: *David Checkley (USA), Sanae Chiba (Japan)*

Invited Speakers:
Martin Lindegren (DTU National Institute of Aquatic Resources, Denmark)
Abigail McQuatters-Gollop (SAHFOS, UK)

Background

Plankton plays key roles in the pelagic ocean. Planktonic plants, invertebrates and the early developmental stages of vertebrates are important for trophic and population dynamics of exploited protected species; the flux of energy and material, including carbon; and as indicators of ecosystem status. Phytoplankton has been both sampled *in situ* and observed remotely, from satellites. Zooplankton has been collected by nets. Increasingly, optics, acoustics, and 'omics' are used. Sampling programs worldwide now span decades, often with ancillary data. From these, time series of plankton abundance have been created, with varying levels of taxonomic and geographic resolution. Often, such programs have been in support of fisheries management. Increasingly, however, they are also relevant to management and policy decisions affecting ecosystems and climate. In turn, such programs require justification for their continuation. Examples include the California Cooperative Oceanic Fisheries Investigations (CalCOFI), the Global Alliance of Continuous Plankton Recorder Surveys (GACS), and many other plankton sampling programs worldwide. The objective of this session was to learn how time series of plankton have been, are being, and might be used to inform decisions in management and policy concerning climate, ecosystems, and fisheries. Presentations were invited on both time-tested uses of plankton time series and on novel, untested uses.

Summary of presentations

Despite of being scheduled on the last day of the symposium, this session attracted a good audience of persons who shared the common interests in future continuity of plankton monitoring and effective use of plankton time series in policymaking for societal benefits. The presentation topics covered time series observations in Canada, Japan, Korea, USA and the North Atlantic although we unfortunately missed papers from China and Russia. As "Communication" is the one of the keywords of PICES FUTURE, we hope this session gave insight into effective strategies for better communication between the PICES scientists and policy makers.

The invited speaker, Dr. Martin Lindegren and collaborators, reported the study on the complex mechanisms through which climate forcing affects tropic control (bottom-up, top-down or wasp-waist) of the food-web dynamics in the Southern California Current System (SCCS) using CalCOFI and fisheries data. They found that bottom-up control and climate forcing are the predominant modes of regulation, with interacting top-down effects asserting a regulatory role only during periods of limiting resources and/or unfavorable climate conditions in the SCCS. Their study indicated the usefulness of long-term efforts to monitor multiple biotic variables to provide a holistic view to study for climate forcing and trophic interactions, processes that are indispensable for the sustainable and ecosystem-based management of living marine resources.

The invited speaker, Dr. Abigail McQuatters-Gollop, reported accomplishments of over the 70 years of basin-scale monitoring with the Continuous Plankton Recorder (CPR) led by the Sir Alister Hardy Foundation for Ocean Science (SAHFOS) in the North Atlantic. The NA CPR survey has revealed the biomass and functional changes in the plankton community in response to climate forcing and human activities. She introduced SAHFOS's strategies for communication with policy makers to convey the importance of the long-term marine ecosystem monitoring for fisheries and climate change management, and the usefulness of the ecosystem index as a tool for such the communication.

The talk of Dr. Sanae Chiba focused on the current problems in future continuity of plankton monitoring programs in Japan. She reported on presentations and discussions at the international workshop "Toward the Better Collaboration between Scientists and Policy Makers", which was held in Tokyo and aimed to defined the major obstacles in continuing the present monitoring and seek a better strategy to facilitate collaboration between scientists and policy makers to promote ocean research. Although Japan has extensive networks of biological monitoring conducted by the Fisheries Research Agency and others, many of those programs are facing financial issues. She pointed out the need for time- and cost-effective methods of monitoring and analysis, e.g., bench-top VPR and CPR, and for increasing awareness of the importance of plankton time series to policy makers and public.

Dr. Anthony Koslow and Ms. Melaina Wright proposed the abundance of ichthyoplankton taxa as an Essential Ocean Variable (EOV) to be observed globally. EOVs are being considered by the Global Ocean Observing System (GOOS), based on recommendations in the Framework for Ocean Observing, the product of a working group following Ocean Obs'09. Fish communities are a highly valued component of marine ecosystems and are sensitive to natural environmental variability and a range of human stressors: overfishing, habitat loss, pollution and eutrophication, and potentially ocean acidification and deoxygenation. To test whether limited collections of ichthyoplankton adequately capture trends in larval fish abundance, the authors sub-sampled CalCOFI data. Time series based on a transect of stations often elucidated significant trends of ichthyoplankton seen in the complete CalCOFI data set.

Dr. Soonmi Lee and her collaborators presented a modeling study of phytoplankton variability in Korean waters, with particular focus on atmospheric nitrogen deposition and its effects on phytoplankton composition. They found that the combined effects of reduction in the vertical water mixing and increase in the atmospheric nitrogen would result in the relative increase in smaller phytoplankton although influence of the former is greater. This implies that the ongoing warming trend and increase of atmospheric nitrogen deposition due to the human activities in the continental East Asia might result in a change in phytoplankton assemblage structure in the Korean waters.

Dr. Sonia Batten reported on the North Pacific CPR survey, which started in 2000. She introduced the effective strategies needed to transition from newly started plankton time series to an established long-term program, such as the timely, quick and regular publication of observation results, even when there are only a few years of data, and use of the consortium framework to secure research partnerships and funding. Globalization is another key to demonstrate the importance of plankton time series. International CPR community established the global network, Global Alliance of CPR Survey (GACS) in 2011, enabling the global comparison of marine ecosystem variability. She also reported the new technologies and tools that add value to the conventional CPR survey, e.g., a temperature sensor on the CPR and molecular-level analysis of sampled plankton.

Dr. Harold Batchelder presented on n behalf of Dr. William Peterson, who could not attend the meeting. Dr. Batchelder described the 20-y Newport Line zooplankton time series off Oregon and how that study has been used successfully to observe interannual variation of the ecological states and in regional fisheries management. Dr. Peterson and others developed a matrix of the annual scores of multiple climate, physical and biological indicators, with which interannual variations in the "good" and "bad" years for salmon catch are easily visible. This matrix was found useful for managers and policy makers to learn the importance of studying basin-scale mechanisms in order to understand variability of regional fisheries. Meanwhile, the uncertain future of research time series may still lead to reluctance by managers to rely on them for the long term.

Dr. Ian Perry and his collaborators reported on long-term monitoring of zooplankton off the coast of British Columbia, Canada. The Department of Fisheries and Oceans (DFO) has been collecting biological oceanographic samples as part of various historical and ongoing monitoring programs off the west coast of British Columbia, Canada since the late 1970s. The Zooplankton Database was developed at the Institute of Ocean Sciences in 1997. It has grown to include samples back to 1957 (Sta. P weather ship) and contains

information such as life stages and size classes, uncommon elsewhere and useful for models of predator-prey interactions that use size-based approaches. The Zooplankton Database has enabled summaries used regularly in DFO activities, including the State of the Ocean reviews, salmon survival dynamics, and indicators of ecosystem conditions.

Dr. David Checkley focused on the value, challenges and possible solutions of maintaining continuity of plankton time series, and gave overall comments on the session. The value of many plankton time series was initially for fisheries management but evolved over time for observing long-term variation of marine ecosystems associated with fishing and climate. Challenges include flat budgets, competing demands for funds, and increasing costs of sample collection and analysis. Possible solutions include increases in efficiency of sample collection and analysis, using advanced technologies, and increased funding from both governments and users in light of the increasing value of plankton time series to inform management and policy decisions. A highlight of the session was a focus on the value of communicating results to users, including decision makers and the general public. Ultimately, plankton time series serve societal needs and thus their value must be clear and compelling to all users.

List of papers

Oral presentations

Climate variability and Interacting Trophic Control in the Southern California Current (Invited)
Martin Lindegren, David M. Checkley, Jr., Mark D. Ohman, J. Anthony Koslow and Ralf Goericke

Big YES to sustainable ecosystem management and why NO to sustainable monitoring efforts? – Gap between demand and supply in Japanese case
Sanae Chiba

Design of ocean observation systems: Sampling requirements to monitor fish population and community trends as Essential Ocean Variables
J. Anthony Koslow and Melaina Wright

Understanding the mechanisms of the interannual variability of phytoplankton in the Ulleung Basin, East Sea: A modeling study
Soonmi Lee, Sinjae Yoo, Chanjoo Jang and Momme Butenschon

The role of plankton time-series in managing our seas in a climate of macroecological change (Invited)
Abigail McQuatters-Gollop

The North Pacific Continuous Plankton Recorder survey
Sonia Batten

How the 20 year Newport Line zooplankton time series is used to inform fisheries management
William Peterson, Jay Peterson, Jennifer Fisher and Cheryl Morgan (Harold Batchelder on behalf of William Peterson)

Long term zooplankton monitoring and database programs in British Columbia – Understanding the dynamics of a changing ocean
Moira Galbraith, David Mackas and R. Ian Perry

Taking stock
David M. Checkley, Jr.

FIS Topic Session (S5)
Ecosystem considerations in fishery management of cod and other important demersal species

Co-sponsored by the International Council for the Exploration of the Sea (ICES)

Co-Convenors: *Gordon H. Kruse (USA), Sukgeun Jung (Korea), Alexei Orlov (Russia), Xianshi Jin (China), Jacquelynne King (Canada), Kenneth Drinkwater (Norway / ICES)*

Invited Speakers:
Kenneth Drinkwater (Institute of Marine Research, Norway)
Robyn Forrest (Pacific Biological Station, Canada)
Yasunori Sakurai (Hokkaido University, Japan)

Background

Pacific cod (*Gadus macrocephalus*) sustain important commercial fisheries throughout the North Pacific Ocean and, historically, Atlantic cod (*Gadus morhua*) have supported some of the most valuable commercial fisheries in the North Atlantic Ocean. Their dynamics have been linked to fishing, climate and other commercially important demersal species. Cod are also extremely important ecologically. As predators, they have been implicated in the decline or lack of recovery of shrimp, king crab, capelin and herring. As prey, they are important forage for pinnipeds; some research implicates seal predation in the lack of recovery of some Atlantic cod stocks, and other studies implicate Pacific cod in the lack of recovery of Steller sea lions in the western Gulf of Alaska and Aleutian Islands. Multispecies models demonstrate co-variation of cod with other important demersal species, as well as explicit tradeoffs in cod and forage fish populations with implications on the joint setting of catch quotas. Moreover, cod recruitment and spatial distribution can be strongly influenced by climate-driven changes in oceanography on decadal and shorter time scales, implying that catch levels must be adjusted for bottom-up changes in productivity. For these and other reasons, ecosystem considerations must be taken into account in cod fishery management. By drawing upon insights gained from different systems, as well as from studies of other important co-occurring demersal species (*e.g.*, walleye pollock, small yellow croaker), this session will deepen our understanding of the roles of cod in the marine ecosystem and their implications on fishery management. Contributions were sought that consider stock identification, stock assessment and population dynamics, effects of climatology and oceanography on recruitment and biomass, trophodynamics, movements and distribution with respect to oceanographic features, multispecies models and their implications on management strategies, and other ecosystem approaches to the management, including aquaculture alternatives. Presentations on marine ecosystems in the North Pacific and North Atlantic were welcomed.

Summary of presentations

During this session, 16 oral presentations were given; no posters were presented. Three invited speakers kicked off the session. The first invited talk was presented by Ken Drinkwater of ICES. He began his talk with a review of the relationships between Atlantic cod and gadid relatives in the North Pacific. Pacific cod and walleye pollock emerged as a result of migrations of Atlantic cod to the Pacific during a warm periods 3.5 and Myr ago, respectively. Ken went on to provide an extensive review of Atlantic cod throughout their range in the North Atlantic Ocean. He reviewed climate-related changes in cod distribution, as well as variable relationships of cod recruitment to temperature and spawning biomass with latitude.

The second invited talk was presented by Yasunori Sakurai, who provided an overview of decades of his research on reproductive characteristics and strategies of Pacific gadid fishes. Two reproductive modes were identified. Species, such as Atlantic cod and walleye pollock, produce separate pelagic eggs at intervals of a few days. Other species, such as Pacific cod and saffron cod, lay slightly adhesive demersal eggs in a single spawning event within a minute. Sakurai-san went on to discuss the importance of experimental studies on reproductive characteristics, including the need to examine reproductive strategies and early life stages under conditions experienced during climate regime shifts and global warming.

The final invited speaker, Robyn Forrest, reported on efforts to understand variability in Pacific cod catches in British Columbia, as well as fishery management strategies that are robust to uncertainties in these processes. A number of hypotheses have been proposed to explain cycles in cod catches, including environmental drivers, predator–prey cycles, and density-dependent survival. Recent analyses with updated datasets were unable to pinpoint the exact underlying mechanism(s), because of large historical changes in fishery management, difficulties in ageing, and uncertainties in abundance estimates. A management strategy evaluation explored the tradeoffs of three alternative harvest control rules with respect to these uncertainties.

Contributed talks covered a wide range of topics from population-level processes to multispecies and ecosystem models. At the population-level Maria Rabchun discussed a genetic study of Pacific cod from six areas of the Sea of Okhotsk and Bering Sea using two genetic markers: mtDNA and the gene Cyt b. Two haplotypes of Cyt b were unique to samples collected in Tauiskaya Bay (northern Sea of Okhotsk) and the northern Kurils, whereas a control region of mtDNA revealed a haplotype that was unique to Tauiskaya Bay only and another haplotype that was specific to the Southern Kurils and northern Bering Sea. Nadezhda Aseeva reported on a comprehensive study of the parasites of Pacific cod, which affect their commercial value. The frequency of infestation and species diversity of parasites decrease with increasing latitude. Olga Novikova reviewed the fisheries for saffron cod in the Russian Far East. Commercial catches of saffron cod averaged 27.0 thousand tons during 2003–2013. More than two-thirds of the harvest is taken from the Sea of Okhotsk and western Bering Sea. The fishery is prosecuted Danish seine and trawls, as well as fixed net gear types.

Three contributed papers addressed various aspects of reproduction. Libby Logerwell presented two papers on behalf of her colleagues, Sandi Neidetcher and Kimberly Rand. Sandi studied spawning phenology and geography of Pacific cod in the Aleutian Islands and eastern Bering Sea. Temporal and spatial analyses of visual maturity samples revealed that the spawning season spans late February to mid April and most spawning occurs between 100 and 200 m depth. Specific spawning concentrations were identified in the Aleutian and Pribilof Islands, as well as the shelf break near Zhemchug Canyon in the eastern Bering Sea. Kimberly analyzed the movements of cod that were tagged north of Unimak Island in the eastern Bering Sea and recovered by commercial fisheries. Results showed that cod are widely distributed across the eastern Bering Sea during summer and demonstrate homing tendencies during spawning migrations in late winter and early spring. Minkyoung Bang investigated relationships between water properties and biological characteristics of walleye pollock from the East Sea/Sea of Japan, a stock that collapsed in the 1990s and 2000s. Fish size decreased and gonadosomatic index (GSI) increased with warmer temperatures according to an alternating pattern of temperatures: warm phase in 1971–1980, cool phase in 1981–1987, warm in 1988–1993, and cool in 1994–2003. Higher GSI during low abundance in the 2000s compared to high abundance in the 1970s and 1980s provided some evidence of density-dependent effects.

A series of presentations examined effects of environment on gadids. Zhe Li received the FIS-committee's best oral presentation award for his talk on effects of temperature and ontogeny on vertical movement of newly hatched Pacific cod larvae. Larval cod were reared at various temperatures in experimental columns in the laboratory during the initial 3 d post hatch period. Larvae swam upward in the column. Specific gravities of the larvae generally did not change over the initial 3 d, but decreased with ontogenetic development. Results suggest that Pacific cod larvae maintain vertical position initially by upward swimming and thereafter by near-neutral buoyancy.

Heeyong Kim discussed relationships between the Siberian High and formation of Yellow Sea bottom cold water (YSBCW). Pacific cod catches are lowest when YSBCW is restricted to the center of the Yellow Sea and highest when YSBCW covers the entire seafloor of the Yellow Sea. Sukgeun Jung demonstrated that climate regime shifts and subsequent ecological impacts can occur asynchronously between upper and deep layers of the ocean. Consistent with a sharp increase in temperature at 50–100 m in the Ulleung basin of the East Sea/Sea of Japan during 1987–1989, commercial catches of epipelagic species shifted from cold-water to warm-water species. On the other hand, cold bottom water intensified in 1992–1993 and was followed by a shift in benthopelagic species from warm-water to cold-water species.

Pat Livingston explored ecosystem factors responsible for synchrony in recruitment patterns of Pacific cod and walleye pollock in the eastern Bering Sea. Despite a comprehensive review of similarities and differences in life history, no single factor explains these patterns in recruitment. Mikhail Stepanenko considered factors responsible for good and poor recruitment of pollock in the Bering Sea. Strong year classes did not seem to occur during warm or cold periods, but rather during transitions between these two conditions. A connection between zooplankton and survival of young-of-the-year pollock was suggested. Rapid changes between warm and cold conditions and vice versa may be associated with increased diversity of zooplankton size groups, perhaps favoring feeding and survival. Franz Mueter gave a presentation for Elizabeth Siddon, which further explored relationships between pollock growth/survival and zooplankton. Modeling evidence was provided that a spatial mismatch between juvenile walleye pollock and growth 'hot spots' contribute to poor recruitment while a higher degree of overlap results in higher recruitment. Moreover, results indicated that climate-driven changes in prey quality and composition can impact growth of juvenile walleye pollock, potentially severely affecting recruitment variability.

Presentations were also given on ecosystem and multispecies modeling. Konstantin Gorbatenko developed a mass-balance food web model for the northeastern part of the Sea of Okhotsk. This large model involved 3994 inequalities for 166 equations with 2034 flows. Although an exact solution could not be obtained, a least-squares solution provided a basis for further investigation. The uncorrected food web model showed that aggregate flows to Pacific cod and walleye pollock are about 1.6% of primary production. Finally, Gordon Kruse gave a presentation on behalf of Tadayasu Uchiyama on a multispecies predator-prey model of major groundfish species, including Pacific cod and walleye pollock, in the eastern Bering Sea. Multispecies models were able to reconstruct patterns of major groundfishes revealed by trawl surveys. However, reference points, such as virgin biomass and MSY, estimated by multispecies models were lower than the sum of those estimates from single-species models. Temperature also affected the strength of predation. Model results supported the hypothesis that colder bottom temperatures provide a larger refuge to juvenile pollock from predators. Temperature effects were largest for arrowtooth flounder predation on age-1 pollock.

Excellent discussions were held after each half-day session. Participants recommended that a cross-basin and cross-ocean comparison of cod stocks may help elucidate underlying mechanisms (*e.g.*, roles of temperature and fishing) on cod population dynamics. Interest was also expressed to conduct additional work on cod through the PICES FIS committee. Possibilities include the formation of a working group or the conduct of a workshop. The convenors will further explore these possibilities in the future. Finally, the convenors are exploring the possibility to publish papers from session S5 as a special journal issue. All participants agreed that this well-attended session was extremely successful.

List of papers

Oral presentations

Population dynamics of Atlantic cod (*Gadus morhua*) and the roles of climate and fishing (Invited)
Kenneth F. Drinkwater

Overview of reproductive characteristics and strategies among the Pacific gadid fishes (Invited)
Yasunori Sakurai

Searching for robust management procedures for Hecate Strait Pacific cod (*Gadus macrocephalus*): A data-limited stock with highly uncertain dynamics (Invited)
Robyn Forrest, Kendra Holt, Sean Cox and A. Rob Kronlund

Comparison of short-term and long-term climate changes on catch fluctuations of Pacific cod, *Gadus macrocephalus*, in the yellow Sea
Heeyong Kim and Daehyun Kim

Observations of seasonal movement of a single tag release group of Pacific cod in the eastern Bering Sea
Kimberly M. Rand, Elizabeth A. Logerwell, Peter Munro, Sandra K. Neidetcher and Daniel G. Nichol

Effects of water temperatures on the size and GSI variations of walleye pollock (*Gadus chalcogrammus*) in the East Sea
Minkyoung Bang, S. Kang, J.-H. Park and S. Kim

Spawning phenology and geography of Aleutian Islands and eastern Bering Sea Pacific cod (*Gadus macrocephalus*)
Sandra K. Neidetcher, Thomas P. Hurst, Lorenzo Ciannelli and Elizabeth A. Logerwell

Effects of temperature and ontogeny on vertical movement ability of newly hatched larvae of the Pacific cod *Gadus macrocephalus*
Zhe Li, Jun Yamamoto and Yasunori Sakurai

Review of the saffron cod *Eleginus gracilis* (Tilesius) fishery in the seas on Russian Far East
Olga V. Novikova

Asynchronous responses of fish assemblages to climate-driven ocean regime shifts between the upper and deep layer in the Ulleung Basin of the East Sea from 1986 to 2010
Sukgeun Jung

Exploration of ecosystem factors responsible for coherent recruitment patterns of Pacific cod and walleye pollock in the eastern Bering Sea
Patricia A. Livingston, Kerim Aydin, James Ianelli and Grant Thompson

Molecular genetic study of the population structure as a basis for Pacific cod fishery management in the Russian Far East
Maria A. Rabchun, Svetlana Y. Orlova, Alexey M. Orlov and Nikolay S. Mugue

An ecosystem-based assessment of the Bering Sea pollock recruitment and spatial distribution
Mikhail A. Stepanenko and Elena V. Gritsay

Spatial match-mismatch between juvenile walleye pollock (*Gadus chalcogrammus*) and zooplankton prey in the eastern Bering Sea may contribute to recruitment variability
Elizabeth Calvert Siddon, Trond Kristiansen, Franz J. Mueter, Kirstin Holsman, Ron Heintz and Edward Farley

Carbon flows through Gadidae species in the ecosystem of the Northeastern part of the Sea of Okhotsk estimated in a carbon flow mass balance model
Konstantin M. Gorbatenko, Vladimir V. Kulik, Artem E. Lazshentsev, Alexander V. Zavolokin and Victor A. Nadtochy

Development of multispecies models to investigate predator-prey interactions and temperature mediated predation rates of Pacific cod and other groundfish in the eastern Bering Sea
Tadayasu Uchiyama, Gordon H. Kruse and Franz J. Mueter

Parasitology of Pacific cod
Nadezhda L. Aseeva

FIS/FUTURE Topic Session (S6)
Climate change impacts on spatial distributions of marine fish and shellfish

Co-Convenors: *Anne Hollowed (USA), Sukyung Kang (Korea)*

Invited Speaker: *Elvira Poloczanska (CSIRP, Australia)*

Background

Changes in fish and shellfish distributions are an important indicator of climate change and are being incorporated into national climate change assessment. However, fishing also affects fish and shellfish distributions and fishing effort is changing in many ecosystems. Changes in distributions will also affect fisheries, shifting the resource toward or away from fishing ports. Papers were invited that examined the combined effort of climate change and fishing on fish and shellfish distributions and the impact of these changes on fisheries. Specifically, papers were encouraged that 1) develop and use analytical approaches for separating the effect of fishing and climate, 2) evaluate life history and fishery traits that are associated with shifting distribution, and 3) examine the effect of shifting distributions on fisheries, fishing communities, resource economics, and international allocation.

Summary of presentations

The ½-day session was held on October 24 in Yeosu, Korea. The session was co-convened by Dr. Anne Hollowed (USA) and Dr. Sukyung Kang (Korea). A total of 13 presentations (9 orals and 4 posters) were made during the session. Anne Hollowed started the session with a brief introduction and objectives of this session, as well as future expectations.

An invited talk by Elvira Poloczanska reviewed the analyses of observed and projected shifts in marine life under climate change, and covered the global and regional maps of the expected direction and rate of shifts of climate migrants. Saldivar-Lucio presented the impacts of different climate temporal scales on the Pacific sardine life cycle. Matthew R. Baker discussed the projected climate impacts on the distribution and volume of marine ecoregions and implications for species interactions. Shin-ichi Ito reported global warming effects on Pacific saury. He used three-box ocean domain model for ocean environment and NEMURO.FISH model for ecosystem-based bioenergetics. James Christian presented results from 5th coupled model intercomparison project on albacore tuna habitat. Xiaozhe Pan used generalized additive model (GAM), generalized linear model (GLM) and Maximum entropy model (MaxEnt) to determine present distributions of yellowtail and used IPCC-SRES B1 scenario for future distribution. Fluctuations of the Greenland halibut stocks in the Okhotsk Sea under influence of circulation patterns change were reported by Nadezhda L. Aseeva. Gordon H. Kruse presented the temporal changes in spatial distribution of Bristol Bay red king crab in the eastern Bering Sea. Sukgeun Jung presented latitudinal shifts in the distribution of commercially important fish species in Korean waters under climate change.

List of papers

Oral presentations

Analyses of observed and projected shifts in marine life (Invited)
Elvira Poloczanska, Jorge García Molinos, Michael Burrows and the NCEAS marine biological impacts of climate change working group

Incorporating North Pacific climate signals in long-term fishery management
Romeo Saldívar-Lucio, Aida Martínez-López, Emanuele Di Lorenzo, Germán Ponce-Díaz, Jacquelynne King, Gordon McFarlane, Christian Salvadeo, Daniel Lluch-Cota and José Alberto Zepeda-Domínguez

Projected climate impacts on the distribution and volume of marine ecoregions and implications for species interactions
Anne B. Hollowed, Matthew R. Baker, Albert Hermann and Kirstin Holsman

Global Change effects on Pacific saury distribution and its effects on fisheries
Shin-ichi Ito, Kosei Komatsu, Takeshi Okunishi, Akinori Takasuka, Naoki Yoshie, Takahiko Kameda, Sohsuke Ohno, Kazuyoshi Watanabe, Takashi Setou and Hiroshi Kuroda

Expansion of albacore tuna habitat in the northeast Pacific Ocean under anthropogenic warming
James Christian and John Holmes

Predicting present and future distributions of yellowtail in the Japan Sea
Xiaozhe Pan, Sei-Ichi Saitoh and Yongjun Tian

Fluctuations of the greenland halibut stocks in the Okhotsk Sea under influence of circulation patterns change
Nadezhda L. Aseeva

Temporal changes in spatial distribution of Bristol Bay red king crab in the eastern Bering Sea and their implications for fisheries management
Jie Zheng, M.S.M. Siddeek and Gordon H. Kruse

Latitudinal shifts in the distribution of commercially important fish species in Korean waters during the last 30 years: A consequence of climate change
Sukgeun Jung, Ig-Chan Pang, Joon-ho Lee and Ilsu Choi

Poster presentations

Climate-change driven range shifts of anchovy biomass projected by bio-physical coupling individual based model in the marginal seas of East Asia
Sukgeun Jung, Ig-Chan Pang and Joon-ho Lee

The impacts of marine environment change on sustainable aquaculture model for Japanese scallop in southern Hokkaido and Aomori prefecture, Japan using RS/GIS and OGCM
Yang Liu, Sei-Ichi Saitoh, Christopher Mulanda Aura and Toru Hirawake

Effect of global warming on the life history and population dynamics of Japanese chum salmon
Masahide Kaeriyama, Hyunju Seo, Yu-xue Qin and HyeSeon Kim

Changes in distribution and composition of major fish species in alternating pattern of warm and cool years in Korean waters
Sukyung Kang, Kwangho Choi, Jisuk Ahn, Jae Dong Hwang, Dong Woo Lee and Suam Kim

FIS/TCODE/FUTURE Topic Session (S7)
Recent assessments of climate change impacts on marine ecosystems

Co-sponsored by the International Council for the Exploration of the Sea (ICES) and Intergovernmental Panel on Climate Change (IPCC)

Co-Convenors: *Anne Hollowed (USA), Sukgeun Jung (Korea), Hans-O. Pörtner (Germany), Jake Rice (Canada / ICES)*

Invited Speakers:
Richard Feely (Pacific Marine Environmental Laboratory NOAA, USA)
Hans-O. Pörtner (Alfred-Wegener-Institute, Germany)
Meryl J. Williams (AsiaPacific-FishWatch, Australia/Malasia)

Background

The Intergovernmental Panel on Climate Change (IPCC) will release the full reports of Working Groups 1, 2 and 3 in 2014. Other organizations have recently completed similar assessment reports that focus on specific geographic regions or fishing sectors. Collectively these reports will mark a major milestone by updating our knowledge of the observed and projected implications of climate change on the earth. Of particular interest to PICES and ICES will be the findings of the reports with respect to impacts on marine ecosystems. This session encouraged presentations that summarize the key findings of the IPCC. It also encouraged talks that will provide guidance and insight on future directions for climate change research within the ICES and PICES communities.

List of papers

Oral presentations

Ocean acidification: Trouble for ocean ecosystems (Invited)
Richard A. Feely, Simone Alin and Nina Bednarsek

Climate change impacts on the world's oceans: A sectoral analysis by IPCC AR5 (Invited)
Hans-O. Pörtner

Fisheries of the North Pacific: Pathways to food security and nutrition (Invited)
Meryl J. Williams

The linkage between the yellow Sea algae bloom burst in 2008 and regional climate change
Hongjun Song on behalf of Fangli Qiao

North Pacific climate change impacts as projected by a suite of CMIP5 model output
Phoebe Woodworth-Jefcoats and Jeffrey J. Polovina

Top predators as indicators of climate change: Statistical techniques, challenges and opportunities
Elliott L. Hazen, Rob Suryan, Steven J. Bograd, Takashi Yamamoto, Emanuele Di Lorenzo, Jeff Polovina, William J. Sydeman, Kevin Weng, Rolf Ream and Yutaka Watanuki

Decadal scale variation in phosphate concentration in the Oyashio and Kuroshi-Oayashio Transition waters, western North Pacific from 1955 to 2010
Kazuaki Tadokoro, Hiroshi Kuroda and Tsuneo Ono

IPCC 5th Assessment Report WG 3 – Drivers, Trends, and Mitigation: Where is the ocean?
Jake Rice

Effects of climate change on marine ecosystems in Polar Regions
Anne B. Hollowed and Andrew Constable

Effects of Climate Change on Marine ecosystems and fishery resources in the Northwestern Pacific
Suam Kim

Plankton in a changing climate: Coastal and polar cases study
Hongjun Song and Rubao Ji

Chapter 30 the Ocean, Working Group II, IPCC fifth assessment report
Ove Hoegh-Guldberg, Rongshuo Cai, Elvira Poloczanska, Peter G. Brewer, Svein Sundby, Karim Hilmi, Victoria J. Fabry and Sukgeun Jung

Assessment of climate trends and projections and their associated impacts on the Pacific coast of Canada
James Christian, Robin M. Brown, Michael Foreman, Karen Hunter and Kim Hyatt

Impacts of climate change on U.S. oceans and marine resources: Technical input to the third U.S. National Climate Assessment
Roger B. Griffis, Jennifer Howard and Anne B. Hollowed

Vulnerability and adaptation strategies of pteropods due to ocean acidification and hypoxia
Nina Bednarsek, Richard A. Feely, J.C.P. Reum, B. Peterson, J. Menkel, S.R. Alin and B. Hales

Poster presentations

Marine climate change impacts and adaptation report card for Australia
Elvira Poloczanska, Anthony J. Richardson and Alistair J. Hobday

Projecting impacts of rising water temperature on the distribution of seaweeds around Japan under warming scenarios
Shintaro Takao, Naoki Kumagai, Hiroya Yamano, Masahiko Fujii and Yasuhiro Yamanaka

North Pacific upper-ocean changes projected by CMIP5 models
Chan Joo Jang, Dongwon Yi, Jihyeon Lee, Ho-Jeong Shin and Yong Sun Kim

Changes of distributions and composition of nutrients in the Changjiang Estuary after the normal storage of Three Gorges Reservoir
Baodong Wang, Zicheng Wang, Ming Xin, Xia Sun, Qinsheng Wei and Bo Yang

MEQ Topic Session (S8)
Marine debris in the Ocean: Sources, transport, fate and effects of macro- and micro-plastics

Co-sponsored by the Group of Experts on Scientific Aspects of Marine Pollution (GESAMP) the International Council for the Exploration of the Sea (ICES) and the Northwest Pacific Action Plan (NOWPAP)

Co-Convenors: *Won Joon Shim (Korea), Peter S. Ross (Canada), Olga Lukyanova (Russia), Sangjin Lee (NOWPAP), Peter Kershaw (GESAMP), Jesus Manuel Gago Piñeiro (Spain / ICES)*

Invited Speakers:
Marcus Eriksen (5 Gyres Institute, USA)
Francois Galgani (Institut Fran¸cais de Recherche pour l'Exploitation de la Mer (IFREMER), France)
Sunwook Hong (Our Sea of East Asia Network (OSEAN), Korea)
Hideshige Takada (Tokyo University of Agriculture and Technology, Japan)

Background

Marine debris is increasingly recognized as a threat to biota in the ocean, which can have a range of socio-economic impacts from coastal areas to the open ocean. The majority of marine debris consists of synthetic polymers, or 'plastics', which readily float on the ocean surface or are suspended in the water column. Microplastics may be attributed to the intentional manufacture of commercial products or the fragmentation of plastic products. They can increase the bioavailable fraction of marine litter and act as a vector for the delivery of intrinsic or adsorbed toxic chemicals to exposed biota. Floating, submerged and beached debris have been documented in marginal seas and the adjacent coastal zone of the North Pacific Ocean. In addition, the North Pacific Ocean Gyre is known to accumulate floating debris in what has become known as the "Great Pacific Garbage Patch". Marine debris represents trans-boundary pollution which can also deliver associated chemicals and invasive organisms to regions far removed from source. The objective of this session is to present status and trend information for marine plastic debris pollution and its environmental consequences in the PICES region. Papers are invited that assess macro- or micro-plastic debris 1) hotspots in the PICES

region, 2) source and input pathways, 3) long-range transport, 4) role as sink or source of associated toxic chemicals, and 5) biological and ecological effects. Recommendations on how to address growing problems associated with marine debris will be also considered.

List of papers

Oral presentations

Patterns of microplastic distribution in the global ocean and inland environments (Invited)
Marcus Eriksen

Litter in the Mediterranean Sea within the European Marine Strategy Framework Directive (MSFD): Indicators for descriptor 10, GES and monitoring (Invited)
Francois Galgani

Microlitter: Recommendations for monitoring from the MSFD
Jesus Gago, Richard C. Thompson, Francois Galgani and T. Maes

Results and lessons learned from joint beach debris surveys by Asian NGOs (Invited)
Yong Chang Jang, Sunwook Hong, Jongmyoung Lee, Jong Su Lee, Sang Hee Hong, Won Joon Shim, Martin Thiel, Fujieda Shigeru, Tai-di Chang, Kanyarat Kosavisutte and Trieu Thuy Ha

Hazardous chemicals in plastics in marine environments and their potential effects on marine organisms (Invited)
Hideshige Takada, Kosuke Tanaka, Rei Yamashita and Yutaka Watanuki

Marine litter problem at the Russian Far East and approaches for solution
Iana Blinovskaia

Distribution, sources and abundance of Marine debris in the coastal area of southern part of Primorsky Krai (Russia)
Nikolai Kozlovskii

Sequential monitoring of beach litter at multiple sites using webcams
Tomoya Kataoka, Hirofumi Hinata and Shin'ichiro Kako

Inverse estimation of marine-debris outflows using webcam observation data
Shin'ichiro Kako, Atsuhiko Isobe, Tomoya Kataoka and Hirofumi Hinata

Distribution and impacts of micro- and macro-plastics in coastal British Columbia, Canada
Peter S. Ross, Jean-Pierre W. Desforges, Jean Fong, Moira Galbraith and Wendy Szanizlo

Producing fragmented micro-and nano-plastics from expanded polystyrene with an accelerated mechanical abrasion experiment
Won Joon Shim, Young Kyoung Song, Sang Hee Hong, Mi Jang, Gi Myung Han and Seung Won Jung

Analysis of a beach as a time-invariant linear input/output system of marine litter
Tomoya Kataoka, Hirofumi Hinata and Shigeru Kato

Chemicals of concern in plastic marine debris: Hexabromocyclododecanes in expanded polystyrene Products
Sang Hee Hong, Won Joon Shim, Manviri Rani, Mi Jang, Najat Ahmed Al-Odaini, Gi Myung Han and Young Kyoung Song

Leaching characteristics of Hexabromocyclododecane from expanded polystyrene buoy fragments in marine water
Manviri Rani, Won Joon Shim, Mi Jang, Gi Myung Han, Young Kyoung Song and Sang Hee Hong

Persistent organic pollutants adsorbed on microplastic from two beaches in China
Weiwei Zhang, Zhifeng Zhang, Xindong Ma, Yan Wang and Ling Qu

Transport of marine debris from the 2011 tsunami in Japan: Model simulations and observational evidence
Jan Hafner, Nikolai Maximenko and Gisela Speidel

Selective transport of microplastics and mesoplastics by drifting in coastal waters
Atsuhiko Isobe, Kenta Kubo, Yuka Tamura, Shin'ichio Kako, Etsuko Nakashima and Naoki Fujii

Poster presentations

Monitoring of traditional and emerging BFRs in expanded polystyrene (EPS) from various countries
Manviri Rani, Sang Hee Hong, Mi Jang, Gi Myung Han and Won Joon Shim

Expanded polystyrene buoy as a moving source of toxic chemicals to marine life: Enrichment of hexabromocyclo-dodecanes in mussel
Mi Jang, Sang Hee Hong, Manviri Rani, Gi Myung Han, Young Kyoung Song and Won Joon Shim

Compositions and distributions of microplastic in Korean beaches
Young Kyoung Song, Mi Jang, Gi Myung Han, Sang Hee Hong, and Won Joon Shim

A Nile Red staining method for microplastic identification and quantification
Young Kyoung Song, Sang Hee Hong, Mi Jang, Gi Myung Han and Won Joon Shim

Potential threat of microplastics to neustonic zooplankton in surface waters of the Southern Sea of Korea
Jung-Hoon Kang, Oh-Youn Kwon, Bu-Gyeong Choi and Won Joon Shim

Estimation of used buoy debris outflow from oyster aquaculture with Material Flow Analysis
Su Yeon Hong, Yong Chang Jang, Jongmyoung Lee, Sunwook Hong and Chan Won Lee

Conceptual difference of flow and stock of marine debris and its implications to setting of policy goals and indicators
Yong Chang Jang, Sunwook Hong, Jongmyoung Lee, Hyun Woo Choi and Won Joon Shim

Abundance of packaging debris on beaches increases as non-recycled amount increases: A case in Korea
Yong Chang Jang, Jongmyoung Lee, Sunwook Hong, Jong Su Lee, Su Yeon Hong and Won Joon Shim

The distribution of floating macro- and micro-plastics in the open ocean and Large Marine Ecosystems
Peter J. Kershaw, Courtney Arthur, Marcus Eriksen, Jésus M. Gago Piñeiro, Kara Lavender Law and Laurent Lebreton

Sources, fate and effects of micro-plastics in the marine environment – A global assessment
Peter J. Kershaw, A. Andrady, C. Arthur, J. Baker, H. Boumann, S. Gall, V. Hidalgo-Ruz, A. Koehler, K.L. Law, H. Leslie, J. Potemra, P. Ryan, W.J. Shim, H. Takada, R. Thompson, A. Turra, D. Verthaak and K. Whyles

POC/MONITOR Topic Session (S9)
Variability in advection and its biological consequences for Subarctic and Arctic ecosystems

Co-Sponsored by the International Council for the Exploration of the Sea (ICES)

Co-Convenors: *Franz Mueter (USA), Enrique Curchitser (USA), Kenneth Drinkwater (Norway / ICES), Sen Tok Kim (Russia), Hiroshi Kuroda (Japan) Sei- Ichi Saitoh (Japan)*

Invited Speakers:
Georgina Gibson (International Arctic Research Center, University of Alaska Fairbanks, USA)

Background

The advection of water masses and their associated nutrients and plankton is critical to biological processes within the subarctic gyres and on the productive shelf regions bordering the gyres. Cross-shelf and along-shelf advection and vertical fluxes regulate the supply of nutrients and plankton to these shelves, thereby affecting the productivity and species composition of the prey organisms that support higher trophic levels. Moreover, the advection of larvae to suitable nursery areas has been linked to the recruitment success of fish and shellfish species in many regions, including the subarctic waters of both the Pacific and Atlantic. Interannual variability in advection has long been understood as an important source of biological variability, while variability at shorter time scales (days to weeks) has only recently received more attention due to the increased availability of high-frequency observations and the development of high resolution models. This session explored how variability in the fluxes of nutrients, plankton, and early life stages of fish at all scales affects marine ecosystem dynamics in the Subarctic and Arctic.

Summary of presentations

The session consisted of 15 oral presentations spanning most of the subarctic Pacific from the Western Subarctic Gyre, the Oyashio Region and the Sea of Okhotsk to the Aleutian Islands, Bering Sea, Chukchi Sea and the Canadian Basin. In addition, two presentations addressed advective processes in the Atlantic Arctic. An invited presentation by Dr. Georgina Gibson (University of Alaska) highlighted interannual differences in the transport of zooplankton onto the eastern Bering Sea shelf in response to differences in wind forcing, particularly in the direction of the prevailing winds. In spite of these differences, consistent transport pathways in the vicinity of submarine canyons were identified using an individual-based particle tracking model.

Several presentations examined the impact of reduced sea ice on the biological pump and on CO_2 fluxes in the Chukchi Sea and Canada Basin. Reduced ice results in less light limitation, enhanced stratification due to increased warming and freshwater discharge, and changes in nutrient inputs through enhanced upwelling and eddy activity. However, the combined effects of these changes on primary production remain uncertain. Observations of biological fluxes using sediment traps, combined with modeling, suggest that mesoscale eddies originating at the Beaufort shelf break are associated with enhanced production and export of biogenic materials from the surface to the deep Northwind Abyssal Plain (Harada *et al.*). Fluxes were highest at the onset of winter (Nov/Dec) in 2010 and 2011, but very limited fluxes were observed in 2012. Much of the biogenic fluxes consisted of resting spores and vegetative valves of diatoms, including many ice-associated species (Onodera *et al.*). The lack of pronounced biogenic fluxes in 2012 was likely associated with an intensification and westward shift of the oligotrophic waters of the Beaufort Gyre (Onodera *et al.*). Measurements of primary production in 2004 and 2009 suggested that reduced primary production was associated with stronger stratification, while enhanced primary production was observed around the edges of an eddy due to upward vertical fluxes of nutrients (Yun *et al.*). In addition to changes in production, vertical fluxes associated with the biological pump, as well as horizontal advection, contribute to the role of the Bering Sea shelf and the northern Chukchi Sea shelf as important CO_2 sinks (Futsuki *et al.*).

Tsukazaki *et al.* (presented by I. Imai) highlight the importance of resting stages of diatoms to seed both the ice-associated spring bloom and the phytoplankton bloom. Resting stage cells reflect the species composition in the water column and occur in densities as high as 7 million cells per cm^3 of water. Cells are re-suspended to seed the water column in the spring or summer and are embedded in the ice when it forms in the fall. Spring bloom dynamics at the melting ice edge were examined by Fujiwara et al. (presented by S.-I. Saitoh). Earlier ice retreat was associated with larger phytoplankton in the ice-associated spring bloom averaged over the 14 days following ice retreat. This was attributed to under-ice blooms utilizing nutrients in the surface water, followed by rapid thermal stratification after the ice melts. In contrast, when the ice retreats early, thermal stratification occurs more gradually and higher nutrient concentrations may have resulted in blooms of larger diatom species.

Zooplankton distributions in the Chukchi Sea differ among water masses with most groups more abundant in Bering Sea and Anadyr water compared to Alaska coastal waters and with higher abundances in recent years (2008, 2010) compared to an earlier period (1991/92, Sasaki *et al.*). Enhanced zooplankton production was also observed in an eddy originating off the western Aleutian Islands in early 2010. The cold-core eddy entrained colder Alaska Stream waters in late winter and propagated southeast for 5 months prior to sampling (Saito *et al.*). Advection associated with the summer monsoon over Asia affect zooplankton dynamics in Peter the Great Bay (Zuenko and Nadtochy). A weaker summer monsoon was associated with stronger stratification in the bay and reduced onshore advection of predatory species (*e.g.*. *Sagitta elegans*). Although the stronger stratification resulted in reduced production, zooplankton appeared to have sufficient food and the abundances of coastal, non-predatory zooplankton species actually increased, presumably because of reduced predation.

Two presentations addressed the role of advection in transporting fish eggs and larvae. Walleye pollock off Northeast Sakhalin Island spawn in very cold waters over the shelf, rising into the warmer surface layer and drifting south in the East Sakhalin current as they develop (Kim *et al.*). Eggs and larvae may be entrained in the East Sakhalin counter current to reach their (unknown) nursery grounds. Mueter *et al.* contrasted advection from the Subarctic to the Arctic between the Pacific and Atlantic Oceans and compared life history adaptations of fish in each region to these contrasting patterns, concluding that it is unlikely that major fish populations will expand into the Pacific Arctic in the foreseeable future, whereas species in the Atlantic are well positioned to take advantage of new and expanding open water areas.

Phytoplankton dynamics in the western Pacific were the subject of two other presentations. Fujiki et al. showed that phytoplankton in the western Subarctic Gyre are nutrient stressed during summer, even though macronutrients were not limiting. Incubation experiments revealed continued growth after iron enrichment. Therefore the magnitude and duration of the phytoplankton bloom in the western subarctic gyre appears to be controlled by the availability of iron. Kuroda *et al.* advance a compelling and well supported hypothesis for the

advective processes that contribute to the intense spring bloom observed off the east coast of Hokkaido Island. According to this hypothesis, East Sakhalin Current water exits the Sea of Okhotsk through Kunashiri Strait forming coastal Oyashio water. The water includes iron-rich waters from the Amur River and mixes with Oyashio water to support the intense spring bloom.

Finally, Drinkwater reviewed outflows from the Arctic to the Subarctic in the Barents Sea, Fram Strait and through the Canadian Archipelago. Outflows through the latter consist of 40–60% Pacific source waters, affecting stratification and advecting Arctic zooplankton species (*Calanus hyperboreus*) as far south as the Gulf of Maine and Mid-Atlantic Bight. Similarly, outflows from Fram Strait continue through Denmark Strait and can affect stratification and the timing of the bloom in both the East Greenland and West Greenland currents. These outflows also export plankton from the Arctic, including large numbers of ice algae, and may have carried the Pacific phytoplankton Neodenticula seminae into the Atlantic in the late 1990s and early 2000s.

Clearly, vertical and horizontal fluxes of freshwater, nutrients and plankton are important to understanding the dynamics of subarctic-Arctic interactions. While much progress has been made in understanding fluxes of salt, heat and nutrients, resolving biological fluxes and their spatio-temporal patterns of variability will require sampling and higher temporal and spatial resolution in combination with modeling. As the invited presentation demonstrated, short term wind events and meso-scale eddies can have important and disproportional influences on the advection of nutrients and plankton (Gibson *et al.*).

List of presentations

Oral presentations

The relative importance of advective *vs.* in-situ processes to mesozooplankton biomass on the Eastern Bering Sea shelf (Invited)
Georgina A. Gibson, Albert Hermann, Kenneth Coyle, Katherine Hedstrom and Enrique Curchitser

Catastrophic reduction of sea-ice in the Arctic Ocean - its impact on the marine ecosystems in the polar region
Naomi Harada, Katsunori Kimoto, Jonaotaro Onodera, Eiji Watanabe, Makio C. Honda, Michio J. Kishi, Takashi Kikuchi and Yuichiro Tanaka

Seasonal cycle of phytoplankton community structure and photophysiological state in the western subarctic gyre of the North Pacific
Tetsuichi Fujiki, Kazuhiko Matsumoto, Yoshihisa Mino, Kosei Sasaoka, Masahide Wakita, Hajime Kawakami, Makio C. Honda, Shuichi Watanabe and Toshiro Saino

Siliceous phytoplankton flux reflecting oceanographic variation in the southern Northwind Abyssal Plain
Jonaotaro Onodera, Eiji Watanabe and Naomi Harada

A biological contribution to partial pressure of CO_2 in the western Arctic Ocean and Bering Sea
Ryosuke Futsuki, Toru Hirawake, Amane Fujiwara, Takashi Kikuchi, Shigeto Nishino, Daisuke Sasano, Masao Ishii, Hiroshi Uchida and Sei-Ichi Saitoh

Current status of primary production in the western Arctic Ocean
Mi Sun Yun, Bo Kyung Kim, Eun Jin Yang, Sung-Ho Kang, Terry E. Whitledge, Mike Gong and Sang H. Lee

Distribution of viable diatom resting stage cells in bottom sediments and water columns in the Chukchi Sea: Importance as seed populations of spring bloom
Chiko Tsukazaki, Ken-Ichiro Ishii, Kohei Matsuno, Atsushi Yamaguchi and Ichiro Imai

Assessment of the relationship between timing of sea-ice retreat and phytoplankton community size structure derived from remote sensing in the Bering and Chukchi Sea shelf region
Amane Fujiwara, Toru Hirawake, Koji Suzuki, Ichiro Imai and Sei-Ichi Saitoh

Spatial and temporal changes of zooplankton community in the Chukchi Sea
Hiroko Sasaki, Kohei Matsuno, Atsushi Yamaguchi, Yutaka Watanuki and Takashi Kikuchi

Cross-shelf advection as a mechanism of regional climate change influence on plankton community in the coastal waters
Yury Zuenko and Victoria Nadtochy

Pacific and Atlantic gateways to the Arctic for plankton and fish
Franz J. Mueter, Seth Danielson, Harald Gjøsæter and Kenneth F. Drinkwater

Reproduction of walleye pollock (*Theragra chalcogramma*) and some oceanographic parameters of their habitat off eastern Sakhalin Island, Sea of Okhotsk
Sen Tok Kim, I.N. Mukhametov, G.V. Shevchenko and V.N. Chastikov

Distribution, transport pathway and modification of the Coastal Oyashio water, off the Hokkaido coast, in the Northwestern Pacific
Hiroshi Kuroda, Yuko Toya, Taku Wagawa, Akira Kuwata, Shin-ichi Ito and Shigeho Kakehi

Hydrography of an Aleutian eddy in the developing phase and the potential influence to lower trophic level ecosystems
Rui Saito, Ichiro Yasuda, Kosei Komatsu, Hiromu Ishiyama, Hiromichi Ueno, Hiroji Onishi, Atsushi Yamaguchi, Takeshi Setou and Manabu Shimizu

Some effects of advection between the Arctic and Subarctic
Kenneth F. Drinkwater

POC/TCODE FUTURE (S10)
Regional climate modeling in the North Pacific

Co-Convenors: *Chan Joo Jang (Korea), Kyung-Il Chang (Korea), Enrique Curchitser (USA), Michael Foreman (Canada), Shin-ichi Ito (Japan), Angelica Peña (Canada), Hyodae Seo (USA)*

Invited Speakers:
Enrique Curchitser (Rutgers University, USA)
Eun Soon Im (Singapore-MIT Alliance for Research and Technology (SMART), Singapore/USA)
Hyun-Suk Kang (National Institute of Meteorological Research, Korea)
Hyoun-Woo Kang (KIOST-PML Science Office, UK)
Kei Sakamoto (Meteorological Research Institute, Japan)
Hyodae Seo (Woods Hole Oceanographic Institution, USA

Background

Regional climate models are a key scientific tool for understanding climate change at regional to local scale, which is highly relevant to considerations for many socio-economic impacts. Despite the apparent limitations associated with errors in forcing fields and uncertainties in downscaling techniques, regional climate models continue to provide critical information for regional climate change by filling the gap between projections by global climate models and demand for developing adaptation and mitigation strategies at highly resolved scales. This session calls for papers addressing the recent efforts for regional climate modeling such as developing novel approaches for dynamic downscaling, comparison between regional and global climate model results, detection and evaluation of regional climate changes in the North Pacific Ocean simulated by regional and global climate models, assessment of their uncertainty, and coupling of regional climate models with other Earth system model components such as biogeochemical and ecological models. The intent of the session was to assemble and share existing expertise in recent efforts to regional climate models by providing a platform to discuss their limitations and reliability.

Summary of Presentations

About 40 persons attended and 15 presentations were made. Unfortunately, two presentations from China and Russia were cancelled, and four other countries' members contributed the oral presentations. In addition, three poster presentations were made. The session started with a brief introduction of the session by Dr. Chan Joo Jang: needs of regional climate models to investigate the current and future states of coastal ocean and marine ecosystems.

The first invited talk by Enrique Curchitser showed three examples (two eastern boundary upwelling systems and one western boundary current) of the NCAR Community Earth System Model (CESM) application using the nested high-resolution ROMS model. The examples demonstrated the need for better representation of

oceanic mesoscale processes such as the coastal upwelling and the local ocean currents for the improved simulation of regional and global climate. The presentation also discussed the issue related to the interpolation of near-shore wind in the coupled model along the eastern boundary upwelling zones to which the coastal upwelling is sensitive. The second invited talk by Hyodae Seo showed an excellent model application to investigate effects of eddy-wind interactions in the California Current System on the eddy kinetic energy and Ekman pumping. Interactions between eddy current and wind showed quite large damping impacts on the eddy activity in the California Current System, and this was nearly entirely due to the eddy-induced surface current effect on wind stress as opposed to the eddy-induced surface temperatures. Third invited talk by Hyun-Suk Kang introduced current status and the future perspective of the upcoming Coordinated Regional Downscaling Experiment (CORDEX) and its achievements for the East Asia domain. CORDEX is a WCRP-sponsored research program that aims to provide a coordinated regional model evaluation framework, a climate projection framework, and an interface to the applicants of the climate simulations in climate change impact, adaptation, and mitigation studies. Fourth invited talk by Eun-Soon Im introduced another CORDEX participating model: the MIT Regional Climate Model (MRCM). The talk showed the importance of the improved schemes for atmospheric deep convection and clouds and coupling of a biosphere simulator in MRCM for the simulation of precipitation in the Maritime Continent and the West African Monsoon. Fifth invited talk by Hyoun-Woo Kang showed an application of a regional marine system model on the northwestern Pacific and the variability of Yellow and the East China Seas, with the emphasis on the impacts of tides and river discharge on the biogeochemistry. The sixth invited talk by Kei Sakamoto showed an example of high resolution operational model in Seto-Inland-Sea and its extension to the around Japan model. There are many excellent contributed talks and dominated by young scientists especially from the Republic of Korea. The contributions of young Korean scientists gave us perspectives of further and continuing developments of regional climate modeling.

List of papers

Oral presentations

Climate—Boundary current interactions: Stories from East and West (Invited)
Enrique Curchitser, Justin Small, William Large, Raphael Dussin, Katherine Hedstrom and Brian Kaufman

Regional coupled modeling of the eddy-wind interactions in the California Current System (Invited)
Hyodae Seo

Climate change projection for the western North Pacific Ocean by dynamical downscaling
Chul Min Ko, Chan Joo Jang, Ho-Jeong Shin and Yong Sun Kim

Regional climate change projection for the northwest Pacific marginal seas
Gwang-Ho Seo, Yang-Ki Cho, Byoung-Ju Choi and Kwang-Yul Kim

CORDEX and its recent progress for East Asia (Invited)
Hyun-Suk Kang, S. Hong, J.-Y. Jung, M.-S. Suh, S.-K. Oh, D.-H. Cha and S.-K. Min

Introducing the MIT Regional Climate Model (MRCM) and its application to climate studies worldwide (Invited)
Eun-Soon Im and Elfatih A.B. Eltahir

Projected change in the East Asian summer monsoon from dynamical downscaling: Moisture budget analysis
Chun-Yong Jung, Chan Joo Jang, Hyung-Jin Kim and Ho-Jeong Shin

An assessment of ocean climate reanalysis by the Data Assimilation System of KIOST
Young Ho Kim, Chorong Hwang and Byoung-Ju Choi

Application of a regional marine system model on the northwestern Pacific and the variability of the yellow and the East China Seas (Invited)
Hyoun-Woo Kang, Hanna Kim, Jae Kwi So, Momme Butenschon and Icarus Allen

Development of a Seto-Inland-Sea model toward operational monitoring and forecasting (Invited)
Kei Sakamoto, Goro Yamanaka, Hiroyuki Tsujino, Hideyuki Nakano, Norihisa Usui and Shogo Urakawa

A biogeochemical model for the British Columbia continental shelf
Angelica Peña, Diane Masson and Michael Foreman

Transport of Todarodes pacificus winter cohort into the Yellow Sea in the early life states
Ji-Young Song, Joon-Soo Lee, Jung-Jin Kim and Ho-Jin Lee

Impact of horizontal model resolution on air-sea CO_2 exchange in the California Current

Jerome Fiechter, Enrique Curchitser, Christopher Edwards, Fei Chai, Nicole Goebel and Francisco Chavez

Seasonality and linear trend of circulation around Korea derived from multi-platform observations
Sung Yong Kim

Regime-dependent nonstationary relationship between the East Asian winter monsoon and North Pacific Oscillation
Gyundo Pak, Young-Hyang Park, Frederic Vivier, Young-Oh Kwon and Kyung-Il Chang

Poster presentations

Characteristics of physical elements during a typical algae bloom in the Yellow Sea
Xu Shanshan, Dong Mingmei, Yu Ting and Miao Qingsheng

Regional efficacy of ocean heat uptake under a CO_2 quadrupling
Ho-Jeong Shin, Ken Caldeira, Chan Joo Jang and Yong Sun Kim

Analysis of HadGEM2-AO historical and climate forecasting experiments
Haejin Kim, Cheol-Ho Kim and Hong-Ryeol Shin

MarWeb Topic Session (S11)
Ecological and human social analyses and issues relating to Integrated Multi Trophic Aquaculture

Co-Convenors: *Masahito Hirota (Japan), Jianguang Fang (China), Mitsutaku Makino (Japan), Grant Murray (Canada), Naesun Park (Korea), Mark Wells (USA)*

Invited Speakers:
Thierry Chopin (University of New Brunswick, Canada)
Mark Flaherty (University of Victoria, Canada)
Susanna Nurdjaman (Bandung Institute of Technology, Indonesia)
Suhendar I Sachoemar (Agency for the Assessment and Application of Technology (BPPT), Indonesia)

Background

Several recent studies and reports suggest that increased aquaculture production is essential if we are to meet the growing world demands for marine protein. However, the rapid current development of intensive fed aquaculture (*e.g.*, finfish and shrimp), in both developed and developing countries, has generated concerns about the environmental impacts of these often monospecific practices. To help address such issues, Integrated Multi- Trophic Aquaculture (IMTA) has been attracting global attention as a means to conduct aquaculture activities, while at the same time improving/rehabilitating coastal environmental conditions and improving the well-being of the people living in coastal areas. By integrating fed aquaculture with inorganic and organic extractive aquaculture (seaweed and invertebrates), the wastes of one resource become a resource (fertilizer or food) for the others. This "ecosystem-like" approach provides nutrient bioremediation capabilities, mutual benefits to the co-cultured organisms, economic diversification by production of other value-added marine products, and increased profitability and food security for the local community. This session seeks contributions and case studies of how to implement and conduct IMTA activities, in particular that reduce negative impacts to the quality of the local environment and improve the well-being of the local human communities. Examples of activities in tropical and semi-tropical locations are particularly welcome, as well as examples of general methods and approaches that can be applied in many different environments. This session is a contribution of, and towards, the work of the PICES Project on Marine Ecosystem Health and Human Well-Being (MarWeB).

Summary of presentations

This Topic Session started with the introduction by Dr. Masahito Hirota of FRA Japan, saying the objective of this session is to seek how to implement and conduct IMTA effectively, and contribute to PICES-MAFF

MarWeB Project. 7 presentations were made in this Topic Session. About 25 participants actively discussed the social and ecological aspects of IMTA.

The first invited speaker, Dr. Thierry Chopin of Univ. New Brunswick, Canada, talked about the IMTA concept and the history of IMTA. He introduced many IMTA cases demonstrating that IMTA is extremely flexible in terms of component species, location, objectives, etc. Combination with agricultural crops such as rice is also a type of IMTA. He spoke about the Wando area in Korea, where IMTA also is being conducted. Finally, he discussed variety of ways of utilizing IMTA for more efficient nutrient recycling in the sustainable society, including a social system of Nutrient Trading Credit (NTC) that is similar to carbon trading credit (CTC).

The second invited presenter, Dr. Mark Flaherty of the University of Victoria, Canada, spoke about the social aspects of IMTA. In BC, Canada, there is only one IMTA operation, but it moved forward only because it did not use salmon. There is great social resistance in some quarters to the commercial aquaculture of salmon. Even in the case of many coastal communities, especially that of the First Nations, that have low indicators of human well-being, believe that the wild salmon fishery is more important and oppose commercial salmon aquaculture. However, some First Nations communities embrace aquaculture is an important source of jobs and economic development. Based on the interview study in BC, he discussed how improved understanding of IMTA by First Nation people can be facilitated.

Prof. Mark Wells, University of Maine, USA, talked about the ongoing MAFF-funded IMTA experimental study in Karawang, Indonesia. The IMTA in this case is Shrimp/Tilapia, Gracilaria,and Anadara. Based on the results of the IMTA pond experiment, there were no negative effects on the production of shrimp/tilapia. The effects on water quality (N, P, Si, Chl) was also discussed. He reported the shrimp-only pond was damaged by the white-spot disease, while IMTA pond was not. Though it is tempting to suggest that IMTA may have contributed to white spot resistance, there is no direct evidence for this effect.

After the coffee break, the invited speaker, Prof. Suhendar Sachoamer from BPPT Indonesia, presented the Blue Economy Policy and dissemination activities of IMTA in Indonesia. In Indonesia, the huge issue is the erosion of land because of the destruction of the mangrove forest for making shrimp aquaculture pond and abandon of the ponds after the white-spot disease. IMTA can be a tool to rehabilitate the diseased aquaculture pond, to re-create jobs for coastal communities, and to protect the coastline against the erosion.

The final invited speaker, Dr. Susanna Nurdjaman from the Nandung Institute of Technology, Indonesia, presented the many issues relating to the aquaculture in Indonesia, such as diseases, mangrove destruction, coastal water degradation, biosecurity, etc. She emphasized the difficulty of changing the mindset of the local people. But the concept of Sato-Umi (harmony of coastal human life and the coastal ecosystem biodiversity) can be a clue. Finally, she presented her future plan on the material circulation model.

Mr. Emmanuel Sweke of Hokkaido University, Japan, presented a social-ecological systems study on the coastal fisheries in the Eastern part of Hokkaido, Japan. Using data from the Akkeshi area and the Erimo area, he discussed cumulative effects from the climate change (sea surface temperature), boat size, demography, local people's perception to the local fisheries.

The discussion, was chaired by Prof. Wells. The influences from legal regulations, societal perception of IMTA, acceptability by the commercial farmers, differences between Asia and the Western World, effects and scale of nutrient reduction, *etc*., were discussed.

Dr. B.A. Venmathi Maran presented a poster in this session on how climate change may affect parasites of marine fishes and the implications for Korean aquaculture. He highlighted how parasitic crustaceans belonging to the Subclass Copepoda are well documented in other coastal regions, but very little is known about parasitic copepods infecting marine fish on the Korean peninsula.

The second poster in this session, given by Dr. Konstantin A. Drozdov, was on the accumulation of lactate in the coelomic fluid of sea urchins under conditions of hypoxia. This accumulate, from the anaerobic digestion of glucose, is an indicator that sea urchins are capable of anaerobic metabolism.
Some overall comments:

- The social dimension acceptance of IMTA differs greatly between developed and developing nations, with the latter strongly ready to adapt to accept new methods that can be demonstrated to have limited negative environmental effects, while strong resistance to IMTA is routed in some developed nations, fueled in large part by media rather than scientific dissemination.
- Implication of IMTA is far easier in developing nations due to the highly restrictive regulatory environment in some developed nations (Canada in particular).
- Regulations surrounding IMTA must be followed by enforcement for the environmental benefits to develop. This may be problematic in some developing nations.
- Assessing the environmental benefits of IMTA in developed, or well-developed nations is assessed on the environments in which the IMTA is placed (that is, assessing area's beyond the individual IMTA footprint). Sampling individual IMTA facilities (within or immediately adjacent to the IMTA footprint) is logistically difficult due to their position in dynamic physical environments. In contrast, IMTA in developing nations more often occurs in pond-type facilities, or embayments with very high-density aquaculture, so more a balanced nutrient input/removal is needed *within the IMTA system footprint* to achieve the desired environmental benefits.

List of papers

Oral presenations

Integrated Multi-Trophic Aquaculture (IMTA): An environmentally, economically and societally responsible aquanomic approach to farming the sea with many variations (Invited)
Thierry Chopin

Obtaining a social license for IMTA: Challenges and opportunities in British Columbia, Canada (Invited)
Mark Flaherty

The effect of multi-trophic aquaculture on nutrient loading in fish and shrimp ponds, Karawang Indonesia
Mark L. Wells, Mitsutaku Makino, Suhendar I. Sachoemar and Masahito Hirota

Dissemination of SATO UMI for sustainable aquaculture development in Indonesia (Invited)
Suhendar I. Sachoemar, Tetsuo Yanagi, Mitsutaku Makino, Mark L. Wells, Masahito Hirota and Ratu Siti Aliah

Implementation of SATO UMI concept at pond aquaculture in Karawang, Indonesia (Invited)
Susanna Nurdjaman, Tetsuo Yanagi and Suhendar I. Sachoemar

Social-ecological studies towards the integrated management of local fisheries in North- Eastern Hokkaido, Japan
Emmanuel A. Sweke, Rotaro Okazaki, Yumi Kobayashi, Mitsutaku Makino and Yasunori Sakurai

Poster presentations

Accumulation of lactate in the coelomic fluid of sea urchins under stress suggests the switching-on of anaerobic glycolysis
Konstantin A. Drozdov, Anatoliy L. Drozdov and Lidia T. Kovekovdova

BIO Contributed Paper Session

Co-Convenors: *Angelica Peña (Canada), Atsushi Tsuda (Japan)*

Background

The Biological Oceanography Committee (BIO) has a wide range of interests spanning from molecular to global scales. BIO targets all organisms living in the marine environment including bacteria, phytoplankton, zooplankton, micronekton, benthos and marine birds and mammals. This year, the BIO paper session (October 23, chaired by Drs. Angelica Peña and Atsushi Tsuda) included 10 oral (half day session) and 15 poster presentations from 5 PICES member countries and from Taiwan. About 30 participants attended the BIO paper session (oral), and discussions after the presentation were fruitful. Especially, new genetic based methods such as 'omics' studies using a NGS (next generation sequencer) and nanomolar level measurements of nutrient concentrations seem to promise new directions within Biological Oceanography.

List of papers

Oral presentations

***Pseudo-nitzschia* diversity in the North Pacific from Continuous Plankton Recorder surveys**
Rowena Stern, Vera Trainer, Stephanie Moore and Sonia Batten

Determination of nanomolar concentration phosphate in seawater using a long-path liquid waveguide capillary cell (LWCC)
Eun-Ju Park, Dong-Jin Kang, Sung-Rok Cho, Tae-Keun Rho and Eun-Soo Kim

New approach for primary productivity assessment in the Bering Sea
Kirill Kivva

Age determination and growth rate of *Mactra chinensis* (Bivalvia, Mactridae) by external rings and chondrophore growth bands
Jung-Yeon Kim, Ho Jin Bae and Chul-Woong Oh

Responses in macrozooplankton population to water mass exchange and the spring phytoplankton bloom in the Oyashio region
Yoshiyuki Abe, Atsushi Yamaguchi, Yuichiro Yamada, Kohei Matsuno, Rui Saito, Hiromichi Ueno, Kosei Komatsu, Takashi Setou, Manabu Shimizu and Ichiro Imai

Comprehensive transcriptome study to develop the molecular resources of the copepod (*Calanus sinicus*) for their potential ecological applications
Hongjun Li and Qing Yang

Effects of water temperature on distribution and life cycle of northern shrimp at the southwest coast of Kamchatka
Oksana G. Mikhailova

Population structure and life history of *Neomysis awatschensis* (Crustacea: Mysidae) in Jeju Island, Korea
Jaeyong Bae and Wongyu Park

Estimation of prey consumption by sei, Bryde's, common minke and sperm whales in the western North Pacific taking into account uncertainties
Tsutomu Tamura, Kenji Konishi, Koji Matsuoka and Takashi Hakamada

Poster presentations

Comparison of benthic community structure and installed area on two artificial reef types
Ji-Hyun Lee, Wan Ki Kim, Yong Soo Son and Chae-Sung Lee

A method for simultaneous determination of chlorophyll and pheopigments using a spectrofluorometer
Cho-Rong Moon, Dong-Jin Kang, Sung-Hyun Kahng and Eun-Soo Kim

Decadal change of spatial distribution of Steller sea lions around Ishikari-Bay, Sea of Japan
Kaoru Hattori, Akihiko Wada and Orio Yamamura

Persistent organic contaminants in tissue and organs of fulmar Fulmarus Glacialis from the coast of Eastern Kamchatka and the Kuril Islands
Vasiliy Tsygankov, Margarita Boyarova and Olga Lukyanova

Detecting the phytoplankton non-uniform distribution around the warm core rings
Haruka Nishikawa, Yumi Yamashita, Yoshikazu Sasai and Hideharu Sasak

Evaluation of incubation volume effect on in-situ *Euphausia pacifica* grazing rates on natural food assemblages
Ah-Ra Ko, Se-Jong Ju, Eun-Jin Yang and C. Tracy Shaw

Tracking seasonal dietary shift of *Euphausia pacifica* in the Yellow Sea using stomach contents and lipid biomarkers
Ah-Ra Ko, Se-Jong Ju and Hye Seon Kim

Diet of chaetognaths *Sagitta nagae*, *S. crassa* in Yellow sea inferred from gut content and signature fatty acid analyses
Hyun Jin Yoon, Ah-Ra Ko, Joong Ki Choi and Se-Jong Ju

Monsoon-driven hydrographic features affect thaliacean distribution in the Taiwanese waters, western North Pacific Ocean
Wen-tseng Lo, Zhen-heng Liao and Hung-yen Hsieh

Exploring the variability and role of functional diversity on copepod communities of the western subarctic North Pacific
Carmen García-Comas, Sanae Chiba, Hiroya Sugisaki, Taketo Hashioka and S. Lan Smith

How water resources management can impact on coastal ecosystem: Implications from watersheds connected to coastal bays
Nam-Il Won

Phenology of calanoid copepod: *Calanus pacificus* associated with sea surface temperature in the western subarctic North Pacific
Tomoko M. Yoshiki, Sanae Chiba, Tadafumi Ichikawa, Hiroya Sugisaki and Sonia Batten

Abrupt change in phytoplankton community in the Kuroshio region of the East China Sea associated with the Kuroshio frontal eddy
Naoki Yoshie, Kohei Sakamoto, Miwa Nakagawa, Eisuke Tsutsumi and Xinyu Guo

Top predators partition the Bering Sea
Andrew W. Trites, B. Battaile, K.J. Benoit-Bird, A. Harding, S. Heppell, B. Hoover, D. Irons, N. Jones, K. Kuletz, C. Nordstrom, R. Paredes and D. Roby

Grazing pressure of the size-fractionated copepod community on phytoplankton and protozoan preys at a fixed station, southeastern coast of Korea
Bome Song, Hyung-Ku Kang, Woo Yul Yi and Joong Ki Choi

FIS Contributed Paper Session

Co-Convenors: *Xianshi Jin (China), Elizabeth Logerwell (USA)*

Background

This session invited papers addressing general topics in fishery science and fisheries oceanography in the North Pacific and its marginal seas, except those covered by Topic Sessions sponsored by the Fishery Science Committee (FIS).

List of papers

Oral presentations

Shelf Habitat and EcoLogy of Fish and Zooplankton (SHELFZ) of the Chukchi Sea 2013
Elizabeth A. Logerwell, Kimberly M. Rand, Leandra de Sousa, Alexi Pinchuk, Sandra Parker-Stetter, John Horne, Johanna Vollenweider and Ron Heintz

Spatiotemporal variation of benthic communities associated with weathervane scallop (*Patinopecten caurinus*) beds off Alaska
Jessica R. Glass and Gordon H. Kruse

Toothed whale interactions with longline fisheries in Alaska and economic implications
Megan J. Peterson, Franz J. Mueter, Courtney Carothers, Keith R. Criddle and Alan C. Haynie

Spatial-temporal variation in feeding pattern and trophic position of Pacific salmon in the North Pacific Ocean
Yuxue Qin and Masahide Kaeriyama

Comparison of anchovy biomass estimates measured by trawls, egg production methods and hydro acoustics in the Chesapeake Bay and the Korea Strait
Sukgeun Jung and Edward D. Houde

Interannual variations in abundance and distribution of Japanese jack mackerel *Trachurus japonicas* larvae in the shelf-break region of the East China Sea during late winter and spring
Chiyuki Sassa, Motomitsu Takahashi, Yoshinobu Konishi and Youichi Tsukamoto

Vertical distribution of common squid (*Todarodes pacificus*) paralarvae in the northern East China Sea
Hwa Hyun Lee, Suam Kim and Chul Park

A spatially explicit account of California fisheries as ecosystem services
John C. Field, Rebecca R. Miller, Jarrod A. Santora, Rosemary Kosaka and Cindy Thomson

Pollock fishery and stock assessment
Oleg Bulatov

Poster presentations

Short term exposure of migratory coho salmon *Oncorhynchus kisutch* to increased CO_2 concentrations impairs olfactory sensitivity to homing cues
Junho Eom, Nolan Bett, Wes Didier, David Close and Sang-Seon Yun

Pelagic ecosystem monitoring in British Columbia, Canada
Jennifer L. Boldt, Stéphane Gauthier, Henrik Kreiberg, Doug Bertram, Jaclyn Cleary, George Cronkite, Linnea Flostrand, Jackie Detering, Vanessa Hodes, John Holmes, Moira Galbraith, Kyle Garver, Chris Grandin, John Holmes, Stewart Johnson, Jacquelynne King, Sean MacConnachie, Bruce McCarter, Chrys Neville, Linda Nichol, R. Ian Perry, Dennis Rutherford, Nathan Taylor, Mary Thiess, Matt Thompson, Marc Trudel and Greg Workman

MEQ Contributed PaperSession

Co-Convenors: *Chuanlin Huo (China), Darlene Smith (Canada)*

Background

Papers were invited on all aspects of marine environmental quality research in the North Pacific and its marginal seas, except those covered by Topic Sessions sponsored by the Marine Environmental Quality Committee (MEQ).

List of papers

Oral presentations

Arrival of Fukushima radioactivity in North American continental waters
John N. Smith, Robin M. Brown, Marie Robert, William J. Williams and Richard Nelson

Legacy POPs: Are they finally fading from marine foodchains?
John E. Elliott, Aroha Miller, Kyle H. Elliott, Melanie F. Guigueno and Sandi Lee

POPs biotransport by Pacific salmon to the Russian coast of the Northwestern Pacific
Olga Lukyanova, Vasiliy Tsygankov, Margarita Boyarova and Nadezhda Khrisoforova

Comparison of oil exposure methods to filter feeding bivalve
Andrew Jin Yi Loh, Un Hyuk Yim, Sung Yong Ha, Joon Geon An and Won Joon Shim

Poster presentations

Assessment of marine environment quality in Peter the Great Bay (the Sea of Japan)
Tatyana A. Belan, Alexander V. Moshchenko, Boris M. Borisov, Tatiana S. Lishavskaya and Alexander V. Sevastianov

Marine environmental impacts of the Japanese nuclear power plant "Fukushima-1" accident in the Far Eastern seas
Eugene V. Karasev, Emiliya L. Chaikovskaya and Tatiana S. Lishavskaya

Toxic elements in seaweed *Undaria pinnatifida, Laminaria saccharina, Cystoseira barbata, Costaria costata* from the Peter the Great Bay (Japan Sea)
Lidia T. Kovekovdova, Denis P. Kiku and Irina S. Kasyanenko

Investigation of content of artificial radionuclides in the commercial crustacea in the North West part of the Japan Sea
Galina S. Borisenko and Yury G. Blinov

Monitoring of mercury in the Russian Far Eastern Seas
Mikhail V. Simokon and Irina S. Kasyanenko

Integrative assessment of sediment contamination by toxic organic contaminants in an enclosed bay in South Korea
Gi Myung Han, Sang Hee Hong, Won Joon Shim, Sung Yong Ha, Nam Sook Kim, Joon Geon An and Un Hyuk Yim

Effects of solvents on the photooxidation of phenanthrene and identification of its photoproducts
Ravi Shankar, Un Hyuk Yim, Song Yong Ha, Joon Geon An and Won Joon Shim

Summer variations in interleukin-1α-like substance levels in phagocytes of holothurian *Eupentacta fraudatrix* in Peter the Great Bay, Sea of Japan
Liudmila Dolmatova and Olga Ulanova

POC Contributed Paper Session

Co-Convenors: Kyung-Il Chang (Korea), Michael Foreman (Canada)

Background

Papers were invited on all aspects of physical and biogeochemical oceanography and climate in the North Pacific and its marginal seas, except those covered by Topic Sessions sponsored by the Physical Oceanography and Climate Committee (POC).

Summary of sessions

The session consisted of nineteen oral presentations and thirteen posters covering a wide range of physical and biogeochemical oceanographic research. There were no oral cancellations. Drs. Kyung-Il Chang, and Michael Foreman chaired sub-sessions over the two-day presentation period. The first half of the session on Thursday afternoon included interesting talks related to: i) analyses of summer turbulence measurements in the East China Sea (Furuichi), ii) analyses of internal tide and vertical mixing observations in the southwestern East Sea (Seo), iii) modal analyses of internal observations and numerical simulations near the Korea Strait entrance to the East/Japan Sea (Lee), iv) analyses of tidal observations off the east coast of Sakhalin Island (Maryina), v) an analysis of cross-shelf patterns in upwelling along the central and northern regions of California (Jacox), vi) vertical particle motions near mesoscale eddies and the effect of submesoscales (Chang) vii) numerical simulation of water-borne virus transport between salmon farms in the Discovery Islands region of British Columbia (Foreman), viii) internal tide and other interactions between coastal and open sea waters (Navrotsky), ix) analyses of satellite sea surface salinity measurements in the East Sea (Lim), and x) a comparison of satellite altimetry and pressure-recording inverted echo-sounders in the North Equatorial Current (Jeon).

The second half of the session on Friday morning was no less diverse in its topic coverage. Gao presented an analysis of decadal changes in pCO_2 and ocean acidification in the western Arctic Ocean; Park investigated variability in flows through the Kerama Gap induced by mesoscale eddies; Kuzin simulated past and future river runoff into the Eastern Siberian shelf and its subsequent dispersion in the Arctic Ocean; Ustinova studied climatic variability in ice coverf and other features in Tatar Strait; Park investigated long-term trends in sea surface temperature in the South China Sea; Hannah presented an overview of and recent results in the World Class Tanker Safety Initiative in British Columbia; Trusenkova presented analyses of model simulations of deep currents in the Japan/East Sea; Lobanov discussed the analysis of observations showing the cascading of dense water along the Peter the Great Bay slope; and Suga discussed spatially intensive observations from a biogeochemical mooring that was part of the western North Pacific Integrated Physical-Biological Ocean Observation Experiment.

High-frequency motions like internal tides and associated vertical mixing, and sub-mesoscale phenomena presented by some speakers are important issues for marine ecosystems, although the speakers did not consider any ecosystem implications. PICES needs to pay more attention to these topics.

The best early career scientist presenter award in a POC-related session was given to Michael G. Jacox (co-authors Andrew M. Moore, Christopher Edwards and Jerome Fiechter) for his talk "*Climate variability and the 3-dimensional structure of coastal upwelling*" in the POC Paper Session. The best poster award was given to Ho-Jeong Shin (co-authors Ken Caldeira, Chan Joo Jang and Yong Sun Kim) for "*Regional efficacy of ocean heat uptake under a CO_2 quadrupling*" in Topic Session S10 [See the end of Sessions Summaries for a list of all presentation awards.].

List of papers

Oral presentations

Observations of turbulence in the summer East China Sea
Naoki Furuichi, Hironori Higashi, Hiroshi Koshikawa, Toru Hasegawa, Kou Nishiuchi and Haruya Yamada

Properties of internal tides and vertical mixing observed on the continental slope of the southwestern East Sea
Seongbong Seo, Young-Gyu Park, Jae-Hun Park, Chang-Soo Hong, Dong Guk Kim and Jae-Hak Lee

Second-mode semi-diurnal internal tides on the continental slope of the southwestern East/ Japan Sea
Hee-Yeol Lee, Jae-Hun Park, Chanhyung Jeon, Seongbong Seo, Young-Gyu Park and Sung-Dae Kim

Investigation of wave processes on the eastern shelf of Sakhalin Island influenced by tidal currents (Sea of Okhotsk)
Evgeniya Maryina and Margarita Grishina

Climate variability and the 3-dimensional structure of coastal upwelling
Michael G. Jacox, Andrew M. Moore, Christopher Edwards and Jerome Fiechter

Vertical motions of fluid particles near Mesoscale Ocean eddies and the effect of submesoscales
Yeon S. Chang and Young-Gyu Park

Simulating water-borne disease transmission among salmon farms in the Discovery Islands, Canada
Michael Foreman, Kyle Garver, Dario Stucchi, Ming Guo, Peter Chandler, John Morrison and Darren Tuele

On the physical and biological interactions between coastal and open sea waters
Vadim Navrotsky, Valeriy Liapidevskii, Vyacheslav Lobanov, Elena Pavlova and Fedor Khrapchenkov

Improvement and seasonal variations of sea surface salinity data in the East Sea derived from Aquarius/SAC-D images
Jin-Wook Lim, Sang-Woo Kim, Chung-Il Lee and Hee-Dong Jeong

Sea surface height variability from satellite altimetry and pressure-recording inverted echo sounders in the North Equatorial Current region
Chanhyung Jeon, Jae-Hun Park, Dong Guk Kim, Eung Kim, Dongchull Jeon and D. Randolph Watts

Decadal changes of pCO_2 and ocean acidification in the Western Arctic Ocean
Zhongyong Gao, Liqi Chen, Heng Sun, Zhenglin Xiao and Di Qi

Variability of the flow through the Kerama Gap between the East China Sea and the Northwestern Pacific induced by mesoscale eddy activities
Hanna Na, Jae-Hun Park, Mark Wimbush, Hirohiko Nakamura, Ayako Nishina and Xiao-Hua Zhu

Simulation of river runoff in Eastern Siberia and the propagation of this river water in the Arctic
Viktor Kuzin, Gennady Platov, Elena Golubeva and Natalya Lapteva

Features of climatic variability in the Tatar Strait (Japan/East Sea)
Elena I. Ustinova and Yury D. Sorokin

Long-term warming trend of sea surface temperature in the South China Sea
A-Ra Choi, Young-Gyu Park and Jae-Hun Park

An overview of the oceanographic component of the World Class Tanker Safety Initiative
Charles Hannah, Patrick Cummins, Michael Foreman, Diane Masson, Pramod Thupaki, Svein Vagle and Di Wan

Modeling of deep currents in the Japan/East Sea
Olga Trusenkova

Cascading of dense water along Peter the Great Bay slope in the northwestern Japan Sea
Vyacheslav Lobanov, Aleksandr Sergeev, Igor Gorin, Pavel Scherbinin, Aleksandr Voronin, Dmitry Kaplunenko, Oleg Popov, Timofei Gulenko and Svetlana Ladychenko

Western North Pacific Integrated Physical-Biogeochemical Ocean Observation Experiment: Summary of the intensive observation around the biogeochemical mooring S1 (S1-INBOX)
Toshio Suga, Ryuichiro Inoue, Shinya Kouketsu, Shigeki Hosoda, Taiyo Kobayashi, Kanako Sato, Hiroyuki Nakajima, Makio Honda, Tetsuichi Fujiki, Kazuhiko Matsumoto, Takeshi Kawano and Toshiro Saino

Poster presentations

Regeneration of a warm anticyclonic ring by cold water masses within the western subarctic gyre of the North Pacific
Sachihiko Itoh, Ichiro Yasuda, Hiromichi Ueno, Toshio Suga and Shigeho Kakehi

Properties of altimetry-derived transport of the Oyashio on the A-line, off the southeastern coast of Hokkaido, Japan
Hiroshi Kuroda, Taku Wagawa, Yugo Shimizu, Shin-ichi Ito, Shigeho Kakehi, Takeshi Okunishi, Sosuke Ohno and Akira Kusaka

Distribution and seasonal variation of the halocline in the world ocean
Hiromichi Ueno and Katsura Yasui

Vertical structure of current velocity measured by a lowered acoustic Doppler current profiler in the southwestern part of the East Sea in July 2005
Chang-Woong Shin and Dong Guk Kim

Observation of an anticyclonic warm core eddy east of Japan
Vincent Faure, Ryuichiro Inoue, Shinya Kouketsu, Toshio Suga, Shigeki Hosoda and Kanako Sato

Variation of Sea Surface Salinity on the Southwestern coast of the East Sea since the first half of the 20 Century
Hee Dong Jeong, Sang Woo Kim, Jin Wook Lim, Yong Kyu Choi, Jeong Min Shim, Kee Young Kwon and Yong Hwa Lee

Hydrological factors in Prostor Bay (Iturup Island, the Sea of Okhotsk) influencing Pacific Salmon during their early marine life stage
Kirill Kivva and Sergey Lapin

Recent climatic tendencies over the Kamchatka Peninsula and adjacent waters
Lubov N. Vasilevskaya, Olga A. Shkaberda and Elena I. Ustinova

Summer surface salinity variability in the yellow and East China Seas: ENSO effects
Chan Joo Jang and Taewook Park

Changes in seasonal air temperatures and precipitation in the Far North-East of Russia
Julia V. Stochkute and Lubov N. Vasilevskaya

Processes leading to the second-year cooling of the 2010-12 La Niña event, diagnosed using GODAS
Licheng Feng, Rong-Hua Zhang, Zhanggui Wang and Xingrong Chen

Coordinated international activities on the climate study of ocean-atmosphere interactions
Nico Caltabiano and Valery Detemmerman

Cyclone statistics in northwest Pacific and relationships with climate factors
Wei Lixin, Ting Qin, Bin Cheng and Timo Vihma

FIS Workshop (W1)
Dynamics of pelagic fish in the North Pacific under climate change

Co-sponsored by the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC)

Co-Convenors: *Gerard DiNardo (USA), Suam Kim (Korea), Sei-Ichi Saitoh (Japan), Cisco Werner (USA)*

Invited Speaker:
Patrick Lehodey (Space Oceanography Division, CLS, France)

Background

The goal of the workshop was to initiate a discussion of the scientific framework needed to assess the dynamics of pelagic fish under climate/environmental variability. We discussed the overlapping PICES and ISC science missions as well as possible elements of a future multi-year joint effort. Climate variability affects pelagic fish distributions and migration, and ultimately pelagic fisheries. The level of impact depends on the persistence, direction, and magnitude of the variability. Survival and growth rates of pelagic fish are linked to oceanographic conditions, and changes to these conditions can have dramatic impacts on the composition of species assemblages within pelagic ecosystems, as well as the persistence and magnitude of individual pelagic fish populations. Understanding the links between environment and pelagic fish behavior, growth, recruitment, and production are paramount to understanding and ultimately predicting the impacts of climate variability. Commercially and ecologically important pelagic fishes occupy surface waters of the North Pacific Ocean, from coastal shelf to open ocean ecosystems. Many of these species undertake large-scale feeding, spawning, and ontogenetic migrations linked to seasonal changes in water masses. For example, Pacific bluefin tuna use waters off Japan as a nursery habitat, undertaking an ontogenetic movement eastward to waters off North America where they remain as subadults for 2–3 years. Additionally, many pelagic species have environmental thresholds and preferences that limit the spatial distribution of a species. The most important environmental factors include oxygen, salinity and temperature, and because these factors generally exhibit persistent

spatiotemporal patterns, the general distribution of pelagic fishes is known. Knowledge of these relationships allows for the incorporation of climate change into stock assessments, which forms the basis for fisheries management.

Summary of the workshop

The 1.5 day workshop was held on October 16–17 in Yeosu, Korea immediately preceding the PICES-2014 Annual Meeting. The workshop was co-convened by Drs. Gerard DiNardo (USA), Suam Kim (Korea), Sei-Ichi Saitoh (Japan) and Cisco Werner (USA). A total of 22 participants attended the workshop and 11 presentations were made. The session started with a brief introduction of the workshop goals and objectives, as well as future expectations.

An invited talk by Patrick Lehodey reviewed the spatial Eulerian ecosystem and population dynamics model SEAPODYM, and its application to several tuna species (Pacific skipjack, yellowfin, bigeye and swordfish, and south Pacific and North Atlantic albacore). Gerard DiNardo presented the structure and function of ISC, as well as current stock assessment modeling structures used to assess highly migratory species (HMS) stock status and condition. Suam Kim reviewed the structure of PICES, summarized the routine processes to form expert groups, and provided details on the function, membership and leadership of various Expert Groups (including Sections, Working Groups, Advisory Panels and Study Groups among others) using existing examples within PICES. Cisco Werner presented a review of the CLIOTOP (CLimate Impacts on Oceanic TOp Predators) and related programs (http://www.imber.info/index.php/Science/Regional-Programmes/CLIOTOP) and discussed the present state of predictive capabilities for the dynamics of top predator populations and oceanic ecosystems that combines fisheries and climate (i.e., environmental) effects. Enrique Curchitser discussed advances and present capabilities of basin-scale modeling, focusing on the links between physical and ecosystem components, from lower trophic levels (biogeochemistry, primary and secondary producers) through to the spatially explicit inclusion of fish populations and fishing fleets. Cisco Werner presented the results of a study by Dr. Steve Teo and colleagues that examined the relationship between observed spatial and temporal patterns in albacore tuna catch-per-unit-effort (CPUE) and oceanographic conditions in North Pacific open-ocean and coastal waters. Joon-Taek Yoo reported on differences in the abundance and growth of larval Pacific anchovy relative to sea temperatures in waters off southern Korea. Gerard DiNardo presented the results of a study by Anela Choy using an Ecopath with Ecosim (EwE) model for the response of micronekton to climate-induced variability in the area of the central North Pacific occupied by the Hawaii-based pelagic longline fishery. Daisuke Hasegawa presented results from an examination into the causes for the historically low catch of blue marlin off the south east coast of Ryukyu Islands in December 2012, suggesting a possible link between meanders caused by large low-pressure areas at the northern edge of the North Pacific Sub-Tropical Counter Current system. Eunjung Kim presented results from a simulation study on the distribution of skipjack tuna in relation to Fish Aggregating Devices (FADs) during ENSO. Ari Shin reported on the influence of environmental factors on the biology and catch of Pacific Bluefin tuna in waters adjacent to Jeju Island using Korean fishery statistics coupled with climate and oceanographic information.

After the oral presentations, a group discussion focused on the requirements to establish a joint ISC-PICES research program to assess the dynamics of pelagic fish under climate/environmental variability and integration of the dynamics into stock assessment models.

Workshop recommendations

With a goal of establishing a joint ISC-PICES cooperative science plan to enhance our understanding of pelagic ecosystems and advance fishery stock assessment models, participants recommended the formation of a one-year Study Group to:

- Improve the understanding of the science activities of each organization;
- Identify collaborations within PICES scientific committees and expert groups that will complement the proposed Study Group, and be consistent with FUTURE;

- Identify areas of common interest;
- Develop a framework for cooperation between ISC and PICES that lists categories of joint activities and the rational for each, including the benefits to each organization from the joint activity.

List of presentations

Oral presentations

An ecosystem and optimisation framework for fish population dynamics assessment under the influence of fishing and climate (Invited)
Patrick Lehodey, Inna Senina, Anne-Cecile Dragon, Anna Conchon, Olivier Titaud, John Hampton, Simon Nicol, Teja Arief Wibawa, Beatriz Calmettes, John Sibert, Hidetada Kyiofuji, Mélanie Abécassis, Olga Hernandez and Philippe Gaspar

The International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean
Gerard T. DiNardo

Review of PICES/FUTURE and relation to ISC
Suam Kim

A review of CLIOTOP and related research programs in the North Pacific
Francisco E. Werner

Modeling the Pacific Ocean: Present capabilities and challenges for the next decade in relation to pelagic ecosystems
Enrique Curchitser

Oceanographic influences on albacore distribution in the Northeast Pacific: Importance of open ocean and coastal frontal zones
Steven L.H. Teo, Yi Xu, Karen Nieto, Sam McClatchie and John Holmes

Abundance and growth of larval Pacific anchovy in different water masses and relationship between its growth and sea temperature in the southern waters of Korea
Joon-Taek Yoo and Su-Kyung Kim

Projected responses of the central North Pacific pelagic ecosystem to climate-induced changes in micronekton communities
C. Anela Choy, Phoebe Woodworth-Jefcoats and Jeffrey J. Polovina

Prominent meanders of the Sub-Tropical Counter Current and pelagic fish catch
Daisuke Hasegawa, Satoshi Mitarai and Koichi Hirate

Simulation study on the distribution of skipjack tuna in relation to Fish Aggregating Devices (FADs) during ENSO
Eunjung Kim and John R. Sibert

The relationship between ecological characteristics of Pacific bluefin tuna (*Thunnus orientalis*) fisheries and environmental factors around Jeju Island
Ari Shin, Sang Chul Yoon and Suam Kim

FIS Workshop (W2)

Linkages between the winter distribution of Pacific salmon and their marine ecosystems and how this might be altered with climate change

Co-sponsored by the North Pacific Anadromous Fish Commission (NPAFC)

Co-Convenors: *James Irvine (Canada/NPAFC), Elizabeth Logerwell (USA/PICES)*

Invited Speakers:
Katherine (Kate) Myers (University of Washington, USA)
Hiromichi Ueno (Hokkaido University, Japan)

Background

In 2014, a formal framework developed by the joint PICES-NPAFC Study Group on *Scientific Cooperation in the North Pacific Ocean* was endorsed by both organizations http://www.pices.int/members/study_groups/SG-

SC-NP.aspx. The framework identified two major scientific topics of joint interest to NPAFC and PICES:

- Effects of climate change on the dynamics and production of Pacific salmon populations; and
- Oceanographic properties and the growth and survival of Pacific salmon.

Summary of the workshop

Approximately 25 people heard 11 oral presentations and contributed to active discussions throughout the day.

In the first invited presentation, Dr. Kate Myers, speaking on behalf of scientists from the USA, Canada, Japan, and Russia described Pacific salmon and steelhead: life in a changing winter ocean. Dr. Myers reviewed major research findings from salmon research in the high seas from the 1950's through to the present time. She recommended the development of databases to house winter survey biological and catch data as well as relevant ocean conditions and suggested that NPAFC and PICES could collaborate on developing quantitative multispecies, multistage models to help identify key factors influencing winter distribution, thereby improving our understanding of potential future climate change effects.

In the second invited presentation, Dr. Hiromichi Ueno described findings by Japanese researchers investigating temporal and spatial variations in growth factors of Pacific Salmon. Dr. Ueno explained the importance of eddies in the Gulf of Alaska in advecting nutrients off shore. Predatory zooplankton densities, indicators of salmon prey abundance, varied in association with PDO in most areas. In the Bering Sea, these modelled densities were consistent with salmon catches, and appeared to be correlated with estimates of salmon carrying capacity.

Dr. Jim Irvine reviewed the critical period concept for Pacific salmon in a presentation by Dr. Marc Trudel and himself. This concept, developed by Dr. Hjort 100 years ago, does not appear to have been adequately tested and Drs. Trudel and Irvine proposed an approach to do so, applying it to coho salmon from the Strait of Georgia. Evidence provided suggested that the early marine period was critical, but later periods in life may not be, at least for these fish.

Although Dr. Svetlana V. Naydenko was unable to attend, Dr. Alex Zavalokin was able to give her detailed presentation summarizing Russian winter research on salmon in western north Pacific. Pink and chum salmon catches were strongly dependent on western subarctic circulation patterns. Both species were caught to depths exceeding 100m and pink salmon were more surface orientated at night than during the day. Food was found to be not limiting during winter/spring and salmon fed on a wide variety of prey.

Dr. Sonia Batten described findings from pioneering work by Dr. David Welch on thermal limits of salmon. Seasonal southern limits for the distribution of steelhead, sockeye, pink, chum, coho, and Chinook salmon may be at the point where food availability just supports temperature-determined metabolic processes. Large areas of the North Pacific are projected to be lost to salmon as a result of global warming. The impact of warming is likely to be most severe for west coast North American stocks. As distributions shift into the Bering Sea in response to warming, it is unclear whether the migration of salmon returning to southern areas will be impeded by the Alaskan Peninsula. Experiments with archival tags are a potential means of evaluating how return migration pathways are affected by SST.

Dr. Shigehiko Urawa summarized results from winter surveys in the North Pacific and Bering Sea in his presentation on the winter distribution and trophic conditions of chum and pink salmon and how these may be altered with climate change. Interestingly, the SSTs where pink and chum have been caught were caught were relatively consistent within locations among winters, but the fish caught in the Gulf of Alaska were in consistently warmer waters than those in the western North Pacific. Ocean age-1 chum salmon had much lower lipid contents than older fish, suggesting critical conditions of young fish during their first winter. The total lipid contents of chum and pink salmon in the Gulf of Alaska were significantly lower than those in the western NPO. The degree of impact of future climate warming may differ among regional stocks and ages of salmon.

Dr. Alex Zavolokin described factors affecting the winter mortality of pink salmon from the Okhotsk Sea. Data from fish produced from the 2007 and 2008 spawning years were examined, the first brood year having a low marine survival and the second a much higher survival. Scale circuli spacings were measured for juvenile fish in the fall and maturing pink salmon the following summers. For low surviving progeny of the 2007 spawning, mean circuli spacings of juvenile pink salmon were lower than those of maturing salmon, while for salmon from the better surviving next year, circuli spacings were similar for juvenile and maturing salmon. This suggests that the low survival of fish in the first year was the result of high mortalities of slow growing salmon. Similar second year growth rates of both brood years implied that the high mortality the first year was not due to starvation, but perhaps predation.

Dr. Ed Farley's presentation on the Impact of climate variability and change on winter survival of Bristol Bay sockeye salmon was given by co-author Dr. Phil Mundy. The sizes of juvenile sockeye salmon were strongly correlated with back-calculated sizes of juvenile sockeye salmon from adults (survivors) that returned to Bristol Bay 2 and 3 years later. Results suggested that juvenile sockeye salmon that reached ~ 180–250 mm in length during late summer had a 50 percent chance of survival through adulthood; juvenile sockeye salmon were <115 mm had less than a 5% chance of survival. Evidence supported climate driven control of sockeye salmon populations in Bristol Bay through mechanisms operating in the marine environment during winter. Climate drivers likely interact with other factors to determine year class strength.

In the final presentation of the workshop, Dr. Shoshiro Minobe provided preliminary projections of changing habitat of suitable sea surface temperature (SST) for salmon using climate model outputs from the Coupled Model Intercomparison Project Phase 5 (CMIP5). Using SST data from a 2011 publication, Dr. Minobe described effects of climate warming on zooplankton and salmon habitats with a model not available to the earlier researchers. Similar findings were nevertheless found as in the earlier publication – salmon will migrate to the north and west due to SST warming; effects may be larger during spring-autumn than winter; Chinook salmon may be impacted the most while Coho and Steelhead may benefit at least initially from warming; and sockeye are expected to decrease. Dr. Minobe plans to re-run this model with more precise salmon habitat descriptions (temporally and spatially).

Several presentations from the workshop are expected to be presented at the 2015 NPAFC Symposium on climate effects on Pacific salmon, further evidence of the benefits of collaborations between NPAFC and PICES scientists.

List of papers

Oral presentations

Pacific salmon and steelhead: Life in a changing winter ocean (Invited)
Katherine W. Myers, James R. Irvine, Elizabeth A. Logerwell, Shigehiko Urawa, Svetlana V. Naydenko, Alexander V. Zavolokin and Nancy D. Davis

Temporal and spatial variation in growth factors of Pacific Salmon
Hiromichi Ueno, Moeko Otani, Maki Noguchi Aita, Michio J. Kishi and Masahide Kaeriyama

Is winter a critical period for Pacific salmon? A critical review of the "critical-period" hypothesis
Marc Trudel and James R. Irvine

Russian research on winter dwelling of Pacific salmon in the central and western parts of the Subarctic Front zone
Svetlana V. Naydenko

Distribution of Pacific salmon in the North Pacific Ocean and adjacent seas, with particular emphasis on winter
David W. Welch, Yukimasa Ishida, Kazuya Nagasawa and Sonia Batten

Distribution and trophic conditions of chum and pink salmon in the North Pacific Ocean during winter under climate change
Shigehiko Urawa, Toshiki Kaga, Tomonori Azumaya, Shunpei Sato, Masa-aki Fukuwaka and Terry Beacham

Winter mortality of Okhotsk Sea pink salmon in the ocean
Alexander V. Zavolokin and Elena V. Strezhneva

Impact of climate variability and change on winter survival of Bristol Bay sockeye salmon
Edward Farley, Greg Ruggerone, Phil Mundy, Ellen Yasumiishi and Beverly Agler

Does physical environmental variation influence winter salmon habitat?
Shoshiro Minobe

MEQ Workshop (W3)

Mitigation of harmful algal blooms: Novel approaches to a decades long problem affecting the viability of natural and aquaculture fisheries

Co-Conventors: *Ichiro Imai (Japan), Changkyu Lee (Korea), Charles Trick (Canada), Mark Wells (USA)*

Invited Speaker:
David Kidwell (National Ocean Service, NOAA, USA)

Background

Harmful Algal Blooms (HABs) have substantial economic, societal, and human health impacts in coastal waters worldwide, from equatorial to high latitude environments. Our increasing reliance on the economic services of coastal waters is threatened by the apparent increasing frequency and severity of HABs globally. Currently, clay dispersal in Korean waters is the only pragmatic operational program for mitigating HAB effects on coastal aquaculture operations. The trade-off, namely smothering of benthos with rapid sedimentation of clays, is not acceptable in many nations, leaving them with few if any mitigation strategies. The aim of the workshop was to develop independent evaluation of mitigation strategies that are effective, transformative and sustainable for individual PICES member countries, and to provide a framework to advance the scientific collaborations and funding strategies to move mitigation research into the 20th century.

On October 17, 2014, the Section on *Ecology of Harmful Algal Blooms* convened a workshop dedicated to understanding the possible methods of the mitigation of HAB events. Historically S-HAB has considered factors concerning the taxonomy, toxicity and environmental factors that lead to the formation of HABs but often society requests a means to mitigate existing or established blooms.

The session was attended by about 25 individuals representing all PICES member countries. Many early career scientists attended the workshop and actively presented their work and participated in extensive discussions.

Mr. David Kidwell (invited) from the US National Ocean Services) was the first speaker. This division of NOAA was established as an interagency task force with the mandate to advance the study, detection and mitigation of HAB events in US coastal waters. Mr. Kidwell provided the particpants with a broad understanding on the limits and risks of mitigation. By using examples, he helped to define the levels of acceptable activities within the legal framework of the coastal resources. It became important to understand that there was a considerable gap between the practical and legal activities of mitigation and the visions and activities of researchers. One key take home message is that the vision of research activities needs to fall within the legal options for the research to be valuable. "Enlightened" research options can be valuable and successful but will never provide the needed mitigation if protocols exceed the regulatory limits.

Mr. Kidwell summarized the procedures that are currently in use. If funding for mitigation comes from the US government, the National Environmental Policy Act (NEPA) standard must be met. NEPA considers the environmental impacts of proposed mitigation actions (along with a wide range of environmental perturbations) and helps review reasonable alternatives to those actions. Each project or protocol is then ranked. There are 3 levels of rankings to meet NEPA requirements:

a. Categorical exclusion (CE) – the researcher must indicate that significant impacts are not likely.
b. Environmental assessment (EA) – the researcher must indicate that significant impacts possible.
c. Environmental impact statement (EIS) – the researcher indicates that significant impacts likely.

Each resulting ranking establishes the level of pre- and post-mitigation that must be followed. The amount of analysis, effort and public engagement increases greatly between CE and EA. Environmental impact statements (EIS) can take years just to be able to perform the mitigation and thus needs to be avoided for both pragmatic (blooms are not that long lasting) and financial considerations.

The most well understood example of active mitigation projects was the provision of clay flocculation – a process that binds the plankton cells and deposits them to the sediments where the cells decompose. Even though this is the most common approach to bloom mitigation there are clear unknowns related to this protocol. This type of project must consider water quality and standards of the Clean Water Act – a daunting task. Other unknowns include the needed size of the operation, the supply of the clay and the composition and size of the clay aggregates. There may also be issues of the quality of the clay (contribution of trace metals to the water). The clay method is only useful in shallow waters. This brings out its own consequences. Sedimentation-based protocols must also consider habitat factors by maintaining a 100 m buffer around coral reefs, bird and turtle nesting areas, wetlands, submerged aquatic vegetation beds, etc. There are also a number of longer-term monitoring requirements are required.

Individual participants contributed strongly to the session. Kyung Ha Lee (Korea) shared his work using addition of a predator that would consume the HAB species – reducing the biomass through consumption and respiration. His talk "Feeding by the heterotrophic protists on the red-tide ciliate *Mesodinium rubrum*" documented the role of a single-celled ciliated protozoan predator. Predator and prey growth and ingestion rates were determined in the lab, yet the efficiency of the predation in a bloom situation remains unknown. Also unknown is the eventual sink of the eaten/uneaten cells and whether anoxia could be the highly undesirable final product.

The third example protocol could be the addition of viruses to control the integrity of cells in a mono-specific bloom. There are several established unknowns in this protocol most deal with uncertain efficiencies and Mr. Kidwell indicated that even at their highest attack efficiency the viral attach usually remains spatially localized and not effective throughout the bloom.

Natsuko Nakayama (Japan; "Prospect for the biological control of *Heterocapsa circularisquama* bloom by inoculating frozen bottom sediment with viruses") used frozen sediments containing viruses to control *Heterocapsa circularisquama* blooms. Virus can be maintained in sediment for 2 years and there was significant reduction in the survivor of the natural bloom species. The process was encouraging and extensive debate on whether adding new biological agents was deemed feasible under current regulations.

JinJoo Kim *et al*. (Korea; "Isolation and physiological characterization of a new algaecidal virus infecting a harmful dinoflagellate, *Prorocentrum minimum*") summarized viruses affecting a number of HAB organisms representing different groups. Here they documented 6 genera of phycodnaviruses – groups of viruses infecting eukaryotic algal hosts from both fresh and seawater. Ecologically, all of the genera are important ecological components in aquatic environments. In addition, the presenters provided practical advice of preparing virus for possible use in HABs mitigation - such as virus storage at 4°C appears to be best for virus longevity, whereas freezing is very ineffectual in providing long term viral stock storage.

Imai *et al*. (Japan; "Biocontrol of harmful flagellate biomass blooms by utilization of harmless diatoms through germination of resting stage cells in coastal sea") reintroduced the participants with the work of Pratt (1966) In Narragansett Bay. In this older study, the undesirable fish killing species, *Heterosigma akashiwo*, only bloomed when diatoms were scarce. They concluded that by seeding the waters with diatoms, the diatoms would outcompete the fish-killing species and there would be no negative bloom formed. Their findings were promising, but the method needs to be repeated and optimized. For example, at what stage of the bloom is seeding by the competing species most effective? In addition, does initiating a diatom bloom result in unconsumed biomass that results in reduced oxygen? There was also a concern that after the diatom bloom, particularly if the biomass remains in the water column, alternative species such as EDABs might form – certainly an unintended consequence.

The theme of phytoplankton competition was also considered in the presentation by An Suk Lim (Korea; "Inhibition of swimming speed and growth of the harmful dinoflagellate *Cochlodinium polykrikoides* by diatoms"). Diatoms often replace *Cochlodinium* blooms in its declining stages. In the experimental model presented the goal was to explore possible negative effects of diatoms (*Skeletonema costatum*, *Thalassiosira decipiens*, *Chaetoceros* sp.) on the growth of *C. polykrikoides*. In the competition, some diatoms physically reduced the migration of *Cochlodinium*, presumably inhibiting access to the nutrients below the thermocline. Other species directly had an impact on growth rates and swimming speeds – but the mechanism is not clear.

In contrast to mitigating existing blooms, Chang-Hoon Kim (Korea; "Removal of aquaculture discharges responsible for HABs development by the polychaete-assisted integrated culture") provided extensive examples on how, using alternative trophic species, blooms vcan be managed by managing the formation of primary producers and their consumption by co-managed species. This setup is a preemptive approach to nutrient management and thus removes the possibility of unused nutrients to initiate a bloom that needs to be managed. In the example systems an additional high quality bi-product (polychaetes) will be formed. The polychaete assisted integrated culture, either in a flow through and semi-recirculation system, improved water quality significantly. To initiate the cycle, polychaetes were fed fish feces, uneaten feed, and commercial diet – products that would have eventually been oxidized to nutrients that would feed the bloom-forming species. It is a management plan that would assist in the control of nutrients through the management of nutrient flow.

Douding Lu (China) provided the final presentation titled "*Heterosigma akashiwo* blooms in stratified water of the East China Sea". Here, he reported that *H. akashiwo* blooms are associated with stratified water in East China Sea (spring 2011). The process of *H. akashiwo* bloom development differs from massive *Prorocentrum* blooms. Flagellate blooms may become more frequent in coming years as pelagic seed banks serve as incubators of massive blooms and the water column becomes presumably more stable. Discharge from dams (pattern) has changed over the past several years. This may change the nutrient ratios in the Yangtze River and nearby coastal areas. Wild fish kills occurred due to *Heterosigma* in North China Sea several years ago.

As a group, alternatives were discussed:

1. One variant of the clay addition that was discussed was the suspension of sediments to create a highly turbid pelagic water column, adsorbing to and removing cells or contribution fresh viruses to inhibit cell growth. This procedure certainly has a direct negative effect on the benthic species. There were some unknowns. Was the sediment as stick as the clay? Did suspension of the sediments just release the stored nutrients into the euphotic zone – thus ensuring that a bloom would initiate?

2. Is it possible to design a surfactant or polymer that might be specific and useful for certain blooms? This may allow us to get around the problem that there is impact of clay on benthos. This new compound should be economically viable. A compound that has a short half-life and is cheap is ideal. This would be an ideal application for NEPA considerations.

3. At present there are chemical methods to bloom mitigation. Each one comes with a significant risk and concern. We remain unclear what the known unknowns are with regards to chemical methods (inorganic and organic), *e.g*. "phoslock", hydrogen peroxide, allelopathic compounds, or barley-extracts (leeches out something – a lignin). These chemicals can have serious effects on the ecosystem. Some of these methods are expensive. So much of our research is on HAB organisms. Key to success is our need to know what impact these compounds has on non-HAB species. Also unknown is the concentration and timing of preparations. Also critical is the need to know the impact of the additions on species of economic importance (aquaculture) that are likely close-by.

Advances in biological methodology were also discussed. While there are many great ideas, there is considerable risk. This type of treatment often does not differentiate between native and HABs. Some positive thoughts involved the application of native algaecidal bacteria. As native species whose life depends on the balance of nutrient input and consumption, the use of viruses and predators concerned many participants, as these organisms appear to be less predictable or "controllable".

List of papers

Oral presentations

Can harmful algal bloom mitigation make the problem worse? Complying with United States environmental laws to advance HAB control and mitigation research (Invited)
David M. Kidwell and Susan Baker

Feeding by the heterotrophic protists on the red-tide ciliate *Mesodinium rubrum*
Kyung Ha Lee, Hae Jin Jeong, Eun Young Yoon, Se Hyeon Jang, Hyung Seop Kim and Wonho Yih

Prospect for the biological control of *Heterocapsa circularisquama* bloom by inoculating frozen bottom sediment with HcRNAV viruses
Natsuko Nakayama, Shinichi Kondo, Naotsugu Hata, Yuji Tomaru, Masami Hamaguchi, Keizo Nagasaki and Shigeru Itakura

Isolation and physiological characterization of a new algicidal virus infecting a harmful dinoflagellate *Prorocentrum minimum*
JinJoo Kim, Chang-Hoon Kim, Young-Sang Suh and Tae-Jin Choi

Biocontrol of harmful flagellate biomass blooms by utilization of harmless diatoms through germination of resting stage cells in coastal sea
Ichiro Imai, Yumi Imai, Takuma Toda, Kazuyoshi Miyamura, Makoto Noda, Ken-Ichiro Ishii and Takashi Nakanishi

Removal of aquaculture discharges responsible for HABs development by the polychaete-assisted integrated culture system
Parandavar Hossein, Sung-Kyun Kim, Byung-Kwon Kim, Kyeong-Hun Kim and Chang-Hoon Kim

Inhibition of swimming speed and growth of the harmful dinoflagellate *Cochlodinium polykrikoides* by diatoms: Implications for its red tide
An Suk Lim, Hae Jin Jeong, Tae Young Jang, Se Hyeon Jang and Peter JS Franks

***Heterosigma akshiwo* blooms in stratified water of the East China Sea**
Douding Lu, Xinfeng Dai, Dongrong Li, Ping Xia and Weibing Guan

MONITOR Workshop (W4)
Networking ocean observatories around the North Pacific Ocean

Co-sponsored by Ocean Network Canada

Co-Convenors: *Kenneth Denman (Canada), Jack Barth (USA), Jae Hak Lee (Korea), Robert Weller (USA), Hidekatsu Yamazaki (Japan)*

Invited Speaker:
Holger Brix (Institute of Coastal Research, Helmholtz-Zentrum Geesthacht, Germany)

Background

Around the North Pacific Ocean, various coastal ocean observatories are operating or under development. These observatories include cabled systems as well as integrated observing systems that employ buoys, AUVs, gliders, moorings, satellite imagery, and other observing tools. In addition there exist several long-term time series programs, and the Argo drifter program. The primary objective of the workshop was to bring together operators of these observatories to discuss how to make progress on the following issues:

- set up plans for coordinated data sharing, data standards, common sampling protocols, and open access on the Internet;
- set out a timeline for developing an integrated (nearly) real-time synthesis of observations in the North Pacific by linking coastal and open ocean observatories as well as Argo;
- define a specific science challenge/question that could be best addressed through a network of observing systems in the Pacific Ocean;
- discussion on requirements for assimilating data from ocean observatories into multidisciplinary models.

Most of these facilities are regional and coastal in scope, making PICES the ideal organization to host such a workshop. The need for such a network of observing facilities was articulated in the conference description of the recent Joint PICES/ICES Workshop on “Global assessment of the implications of climate change on the spatial distribution of fish and fisheries” held in May 2013 in St. Petersburg, Russia: "… observations and model projections (are) needed to develop a global synthesis of the implications of climate change on fish and fisheries".

Between 15 and 20 people attended the workshop (W4). There were seven presentations, followed by a discussion on common issues and the need for a group that would meet annually, and recommendations for how to form such a group. Ocean Networks Canada was a co-sponsor of the Workshop.

Summary of the workshop

The session consisted of one invited 30-minute talk and six contributed 20-minute talks, summarized here in order of presentation.

Jae Hak Lee from the Korea Institute of Ocean Science and Technology described ‘*The status of ocean monitoring in Korea*’. He first reviewed Korean real time ocean monitoring activities stressing the coastal oceans and the integration of many different observing platforms, including a Geostationary Ocean Color Imager launched in 2010. Coverage is 8 times/day over an area 2500 km by 2500 km centered over Korea, with resolution of 500 m by 500 m. Contributing to international programs, Korea has launched 302 Argo floats since 2001 – in the East Sea/Sea of Japan, the Pacific Ocean, and the Southern Ocean – of which ~75 are still active. In the OceanSites program, Korea currently maintains three sites: 1 in the East Sea/Sea of Japan, and two sites in the equatorial western Pacific. Korea is experimenting with subsea and wave gliders, and with deep and bio Argo drifters.

Jack Barth from Oregon Statue University, USA presented a '*Ten-year retrospective of the Northwest Association of Networked Ocean Observing Systems (NANOOS)*' on behalf of Jan Newton (Executive Director) and many other NANOOS colleagues. NANOOS is one of ~10 regional components of the US Integrated Ocean Observing System (IOOS). The five highest stakeholder priorities for NANOOS are: maritime operations, ecosystem impacts (including hypoxia and HABs), fisheries, mitigating coastal hazards, and climate (including ocean acidification). Major observational systems include HF radar for mapping surface currents and waves, buoys in the Pacific Northwest, buoys and moorings in the Columbia River estuary and Puget Sound, long term coastal glider programs, and monitoring beach and near-shore bathymetry. In order to meet the different data delivery needs of a variety of user groups, much effort has gone into development of the online NANOOS Visualization System (NVS), including the NVS Data Explorer.

Mary Grossmann from the Okinawa Institute of Science and Technology, Japan described the OIST Cabled Teleopertional Observatory Performing Undersea Surveillance (OCTOPUS), a new coastal observatory deployed since August 2013 at about 20 m on a coral reef in the nearshore zone off Okinawa. In addition to measuring standard oceanographic and biochemical variables, the focus is on biological imaging with several cameras, a passive hydrophone (for cetaceans and vessel traffic). Results were presented from the Continuous Plankton Imaging System (CPICS), a fixed station Visual Plankton Recorder, deployed in cooperation with Scott Gallager of Woods Hole Oceanographic Institution (USA): 5-minute counts of six predatory plankton groups show day-night transitions, and hourly counts of 10 classes of plankton show strong presence-absence changes with the passage of two typhoons during October 2013.

Hidekatsu Yamazaki of the Tokyo University of Marine Science and Technology, Japan described the Joint Environmental Data Integration System (JEDI), which employs novel observational and modeling technologies to evaluate multi-scale variations of pelagic marine communities and biodiversity under the influence of the Kuroshio and internal waves in coastal habitats. JEDI includes deployment of a cabled observatory and a moving AUV platform MEMO-pen. The cabled observatory, the Oshima Coastal Environmental data Acquisition Network System (OCEANS), was deployed from Oshima Island southwest of Tokyo Bay. Also conducted in cooperation with Scott Gallager of WHOI, OCEANS employs a full suite of physical, biological and chemical instrument systems operating from an underwater cabled node. The AUV has a specially-designed low vibration propulsion system with a pump jet system rather than a rotating propellor, which allows microstructure turbulence measurements and use of a plankton microscope camera (CPICS). Measurements are interpreted in the context of a high resolution numerical model of the area that shows spatial and temporal patterns of internal waves at tidal frequencies in the vicinity of Oshima Island.

Holger Brix (with Burkard Baschek) from the Institute of Coastal Research, Helmholtz-Zentrum Geesthacht, Germany, presented an invited talk on the multi-platform Coastal Observing System for Northern and Arctic Seas (COSYNA), mostly focused on the German Bight in the North Sea west of Hamburg. The mission of COSYNA is the development and testing of analysis systems, consisting of observations and numerical modelling, for the operational synoptic description of the environmental status of the North Sea and of Arctic coastal waters. COSYNA aims to provide knowledge tools that can help authorities and other stakeholders to manage routine tasks, emergency situations and evaluate trends. Types of observations include i) point measurements including buoys, fixed stations and underwater nodes, ii) surface transects on ferries with FerryBox systems and on research vessels, iii) 3D transects with SCANFISH and gliders, and iv) mapping of spatial fields using optical remote sensing (satellite) and radar (HF and X-band). Several of these systems and example observations were presented. Examples of the comparison of regional model results and measurements were presented. The end-to-end sensor to user(s) data flow chart was presented as well as a description of the COSYNA Data Portal. Two applications were presented – offshore 'windparks' and hunting gyres with 3D real time mapping. One outreach project of COSYNA is the Global Coast to link expertise from different coastal observatories around the globe.

Kim Juniper from Ocean Networks Canada (ONC) located at the University of Victoria gave a talk on '*Cabled ocean observatories as tools for studying biodiversity change*'. He presented six Essential Biodiversity Variables (EBVs) developed by the Biodiversity Observation Network of the Group on Earth Observations

(GEO BON): Genetic composition, species populations, species traits, community composition, ecosystem function, and ecosystem structure. Information on all of these variables except the first can now be obtained from cabled observatories. He then presented a number of examples of EBV studies at ONC cabled sites around Vancouver Island and in the Canadian Arctic. Time-series video imagery coupled with oceanographic sensors are used to study temporal and spatial changes in benthic community composition and ecosystem processes in a variety of near-bottom environments: i) hydrothermal vent sulphide worms, ii) a epibenthic megafaunal community in a submarine canyon, iii) epibenthic community responses to severe hypoxia in a coastal inlet, iv) surface-sediment bioturbation rates over a fixed area, and v) seasonal faunal dynamics at a shallow coastal Arctic site. He concluded with two issues that require attention: First, the need for more efficient tools to extract biological data from imagery (ONC has a growing archive of over 10,000 hours of HD video imagery), which include computer algorithms for automated counting of fish and other animals, and 'citizen science' using a video game 'Digital Fishers' to 'pre-analyze' hundreds of video clips. Second, the opportunity for collaboration between ocean observatories using EBVs as a tool for structuring biological observations between different research groups.

Jack Barth from Oregon State University gave a talk on '*Using autonomous underwater gliders to observe continental margins and oceanic boundary currents*'. His results were from the California Current upwelling system, one of four major coastal upwelling systems representing only 1% of global ocean surface area but more than 20% of wild caught seafood. Some summers over the Oregon shelf, hypoxia develops at depths below 30 m causing stress and mortality to sea life. To monitor changes in upwelling and hypoxia, AUV gliders equipped with a CTD and sensors for dissolved oxygen, chlorophyll and CDOM fluorescence, light backscatter and depth-averaged velocity, have been traversing a cross-shelf section twice per week since April 2006. Up to September 2014, there have been 3485 glider-days, and 260,190 vertical profiles covering a horizontal distance of over 82,000 km. The gliders have documented upwelling episodes, development of upwelling fronts, subsurface hypoxia and buoyant fresh water plumes from the Columbia River, etc., even during the passage of severe storms that generated 10-m seas. There are plans to add new sensors, including bioacoustics.

Discussion

During the discussion following the presentations, a number of common issues emerged, which include:

- Excepting dissolved oxygen, biochemical sensors continue to be unreliable for long term deployment.
- For groups who make much of their data available online in 'nearly real time', there appears to be no common automated quality control-quality assurance techniques.
- Groups who make much of their data available online in 'nearly real time' need to develop effective methods for correcting/calibrating the data, after they have been post initially, and for notifying users of these data corrections/updates.
- The usual manner in which data are presented on-line for researchers is completely inadequate for 'operational' users of the data – fisheries managers, environmental quality managers, controllers of safe marine traffic and transport, etc. How different groups attempt to adapt their data displays to their users' needs differs from group to group – again sharing experiences can lead to development of common 'best practices'.
- There is a general sense that obtaining funding for developing and installing ocean observatories is easier than maintaining funding for operating the facilities, partially because we have underestimated the human resources required for long term operation and data management, *e.g.*, operating gliders continuously over many years, rather than for limited time 'missions'.

Recommendation and response

There was broad agreement that the 'operators' of coastal observing system around the North Pacific would benefit from meeting on a regular basis and developing an evolving set of 'best practices' – basically sharing experiences on 'what works and what does not work', and working towards common data formats such as NetCDF file formats, *etc*.

Our formal recommendation was to propose that the PICES MONITOR and TCODE committees set up an Advisory Panel for Developing Best Practices and Common Data Protocols for Coastal Ocean Observing Systems (AP-COOS). Such a structure would allow this AP to hold focused workshops at PICES on topics like those identified above under Discussion Issues. Once this working format has been established, it may be advisable to make contact with similar entities within ICES and IOC.

The proposal was considered by the PICES Governing Council at the end of the 2014 Annual Meeting. Council approved the establishment of an Advisory Panel on North Pacific Coastal Ocean Observing System (AP-NPCOOS), under direction of the Technical Committee on Monitoring (MONITOR) and Technical Committee on Data Exchange (TCODE). Initial Terms of Reference have been drawn up: the Advisory Panel will have Co-Chairs – one from the western N. Pacific and one from the eastern N. Pacific, with 2-4 members from each Contracting Party. The Terms of Reference include: 1. Develop and advise about best practices for coastal ocean observing systems; 2. Convene workshops/sessions to engage those involved in coastal ocean observing systems from around the North Pacific; and 3. Advise on linkages between coastal ocean observing systems and both PICES activities (*e.g*., FUTURE Science Program, North Pacific Ecosystem Status Report) and open-ocean observatories (*e.g*., Argo).

List of papers

Oral presentations

The status of ocean monitoring in Korea
Jae Hak Lee

Ten-year retrospective of the Northwest Association of Networked Ocean Observing Systems (NANOOS)
Jan A. Newton, John A. Barth, David L. Martin, Michael P. Kosro, Jonathan Allan, Emilio Mayorga and many NANOOS Colleagues

OIST Ocean Cube, a new coastal cabled observatory in Okinawa, Japan
Mary M. Grossmann, Satoshi Mitarai and Scott M. Gallager

Joint Environmental Data Integration System: JEDI System
Hidekatsu Yamazaki, Scott Gallager, Hayato Kondo and Kunihisa Yamaguchi

COSyNA, the Coastal Observing System for Northern and Arctic Seas – A regional, European perspective and the global coast (Invited)
Holger Brix and Burkard Baschek

Cabled ocean observatories as tools for studying biodiversity change
S. Kim Juniper and Fabio De Leo

Using autonomous underwater gliders to observe continental margins and oceanic boundary currents
John A. Barth

Poster presentation

NEAR-GOOS Cross-Basin Climate Monitoring Section: First results of a pilot project
Vyacheslav Lobanov, Sho Hibino, Dmitry Kaplunenko, Aleksandr Lazaryuk, Toshiya Nakano, Satoshi Ogawa and Pavel Tishchenko

POC Workshop (W5)

SOLAS into the Future: Designing the next phase of the Surface Ocean-Lower Atmosphere Study within the context of the Future Earth Program

Co-sponsored by the Surface Ocean Low Atmosphere Study (SOLAS)

Co-Convenors: *Minhan Dai (China), Lisa Miller (Canada), Yukihiro Nojiri (Japan)*

Background

For more than a decade, the Surface Ocean-Lower Atmosphere Study (SOLAS) has fostered cutting-edge research in air–sea interactions, promoting communication, coordinating and directing research, and advocating for new projects. SOLAS has facilitated major advances, changing fundamental understanding in

a number of subjects, including the significance of ocean acidification, the roles of dimethylsulfide (DMS) and marine organic matter in atmospheric chemistry, and the importance of sea-ice biogeochemistry in controlling air–sea exchange. At the same time, the significance of earth system science to society has become increasingly apparent, and Future Earth is replacing the International Geosphere-Biosphere Programme as a major SOLAS sponsor. Within this context, SOLAS is plotting a new course for the next 10 years. This workshop is one of a number at various conferences that is soliciting community input into the future of SOLAS. In particular, we are asking the question: In a world where Earth system science is coming under increasing political and public scrutiny, what is and should be the contribution of SOLAS science to society? Ideas and conclusions from this and other, similar workshops will be incorporated into the new SOLAS Science Plan.

Summary of the workshop

The convenors were quite pleased with the participation in this workshop, which had 11 people, allowing for some useful conversations. There was a good mix of people who were completely unfamiliar with SOLAS and those who were involved in the early stages of the program but were not aware of the organization's current directions. Therefore, we met our goal of obtaining additional insights from the community. Among the most important points to come out of the conversation were:

- The production of clouds and aerosols by marine communties are an important global-scale ecosystem service provided by the ocean, and those feedbacks are not yet understood;
- Observatories are the only way to get information at high wind states (a major failure of the first phase of SOLAS), and SOLAS should determine what equipment/observations should be added to observatories (fleets of wave gliders?) to facilitate SOLAS science;
- The rates and horizontal scales of processes in atmospheric and oceanic boundary layers are extremely different , and this scale mismatch between ocean and atmospheric measurements has not been adequately addressed;
- When considering what society is going to need from us in a couple of decades, SOLAS should put more emphasis on geoengineering issues, as SOLAS is the community best equipped to evaluate the effectiveness of ocean-based geoengineering strategies; in particular, our current capacity to evaluate aerosolization effects is much less than for ocean fertilization;
- More consideration needs to be given to identifying local areas where new studies would most effectively improve our global perspective;
- The shift of SOLAS' focus away from DMS and toward organic aerosols as climate controllers is appropriate, because although DMS plays a number of important physiological and ecological roles, more than 20 years of intensive research has not conclusively shown a direct climate link. Future research on DMS cycling should focus on the locations where new measurements would fill the gaps in the climatologies, and on identifying which processes are actually most important in the global sulfur cycle.

W6 participants

Jack Barth (USA)
James Christian (Canada)
Ken Denman (Canada)
Chuanlin Huo (China)
S. Kim Juniper (Canada)
Dong-Jin Kang (Korea)
Lisa Miller (Canada)
Yukihiro Nojiri (Japan)
JeongHee Shim (Korea)
Toru Suzuki (Japan)
Lixin Wei (China)

Best Presentations for Committee/Program-sponsored Topic Sessions or Workshops at PICES-2014

Science Board Best Oral Presentation (S1) on "*Pathways of Arctic Ocean acidification*"

Emanuele Di Lorenzo (School of Earth and Atmospheric Sciences, Georgia Institute of Technology, Atlanta, USA, edl@gatech.edu) on "Forecasting North Pacific climate and ecosystem changes: Advances and challenges" co-authored with Nathan Mantua and Mathew Newman

Science Board Best Poster Presentation (S1) on "*Pathways of Arctic Ocean acidification*"

Chan Joo Jang (Korea Institute of Ocean Science and Technology (KIOST), Ansan, Republic of Korea, cjjang@kiost.ac) on "*Interannual variability of chlorophyll associated with mixed layer depth changes in the East Sea (Japan Sea)*" co-authored with Youngji Joh and Sinjae Yoo

Best Oral Presentation by an early career scientist for the BIO-sponsored Contributed Paper Session

Jaeyong Bae (Pukyong National University, Busan, Republic of Korea, samael318@gmail.com) on "*Population structure and life history of Neomysis awatschensis (Crustacea: Mysidae) in Jeju Island, Korea*" co-authored with Wongyu Park

Best Poster for the BIO-sponsored Contributed Paper Session

Ah-Ra Ko (Korea Institute of Ocean Science and Technology, Ansan, Republic of Korea, scrooge85@kiost.ac) on "*Tracking seasonal dietary shift of Euphausia pacifica in the Yellow Sea using stomach contents and lipid biomarkers*" co-authored with Se-Jong Ju and Hye Seon Kim

Best Oral Presentation by an early career scientist for the FIS-sponsored FIS Topic Session (S5) on "*Ecosystem considerations in fishery management of cod and other important demersal species*"

Zhe Li (Hokkaido University, Hakodate, Japan, lz880526@live.cn) on "*Effects of temperature and ontogeny on vertical movement ability of newly hatched larvae of the Pacific cod Gadus microcephalus*" co-authored with Jun Yamamoto and Yasunori Sakurai

Best Poster for the FIS-sponsored FIS/FUTURE Topic Session (S6) on "*Climate change impacts on spatial distributions of marine fish and shellfish*"

Yang Liu (Hokkaido University, Hakodate, Japan, yangliu315@hotmail.co.jp) on "*The impacts of marine environment change on sustainable aquaculture model for Japanese scallop in southern Hokkaido and Aomori prefecture, Japan using RS/GIS and OGCM*" co-authored with Sei-Ichi Saitoh, Christopher Mulanda Aura and Toru Hirawake

Best Oral Presentation by an early career scientist for the MEQ-sponsored Contributed Paper Session

Andrew Jin Yi Loh (Korea Institute of Ocean Science and Technology (KIOST), Geoje, Republic of Korea, andrew@kiost.ac) on "*Comparison of oil exposure methods to filter feeding bivalve*" co-authored with Un Hyuk Yim, Sung Yong Ha, Joon Geon An and Won Joon Shim

Best Poster for the MEQ-sponsored MEQ Topic Session (S8) on "*Marine debris in the ocean: Sources, transport, fate and effects of macro- and micro-plastics*"

Mi Jang (Korea Institute of Ocean Science and Technology (KIOST), Geoje, Republic of Korea, jangmi@kiost.ac) on "*Expanded polystyrene buoy as a moving source of toxic chemicals to marine life: Enrichment of hexabromocyclododecanes in mussels*" co-authored with Sang Hee Hong, Manviri Rani, Gi Myoung Han, Young Kyoung Song and Won Joon Shim

Best Oral Presentation by an early career scientist for the POC-sponsored Contributed Paper Session

Michael G. Jacox (University of California Santa Cruz, Santa Cruz, U.S.A., mikejacox@gmail.com) on "*Climate variability and the 3-dimensional structure of coastal upwelling*" co-authored with Andrew M. Moore, Christopher Edwards and Jerome Fiechter

Best Poster for the POC-sponsored POC/TCODE/FUTURE Topic Session (S10) on "*Regional climate modeling in the North Pacific*"

Ho-Jeong Shin (Korea Institute of Ocean Science and Technology (KIOST), Ansan, Republic of Korea, hojeong.shin@gmail.com, hjshin@kiost.ac) on "*Regional efficacy of ocean heat uptake under a CO_2 quadrupling*" co-authored with Ken Caldeira, Chan Joo Jang and Yong Sun Kim

Best Oral Presentation by an early career scientist for the MONITOR-sponsored POC/MONITOR Topic Session (S9) on "*Variability in advection and its biological consequences for Subarctic and Arctic ecosystems*"

Hiroko Sasaki (Graduate School of Fisheries Science, Hokkaido University, Hakodate, Japan, hiro_sasaki@salmon.fish.hokudai.ac.jp) on "*Spatial and temporal changes of zooplankton community in the Chukchi* Sea" co-authored with Kohei Matsuno, Atsushi Yamaguchi, Yutaka Watanuki and Takashi Kikuchi

Best Poster for the MONITOR-sponsored Topic Session

None this year.

Best Oral Presentation by an early career scientist for the TCODE-sponsored FIS/TCODE/FUTURE Topic Session (S7) on "*Recent assessments of climate change impacts on marine ecosystems*"

Nina Bednarsek (Pacific Marine Environmental Laboratory, Seattle, USA, nina.bednarsek@noaa.gov) on "*Vulnerability and adaptation strategies of pteropods due to ocean acidification and hypoxia*" co-authored with R.A. Feely, J.C.P. Reum, B. Peterson, J. Menkel, S.R. Alin and B. Hales

Best Poster for the TCODE-sponsored FIS/TCODE/FUTURE Topic Session (S7) on "*Recent assessments of climate change impacts on marine ecosystems*"

Chan Joo Jang (Korea Institute of Ocean Science and Technology (KIOST), Ansan, Republic of Korea, cjjang@kiost.ac) on "*North Pacific upper-ocean changes projected by CMIP5 models*" co-authored with Dongwon Yi, Jihyeon Lee, Ho-Jeong Shin and Yong Sun Kim