Summary of Scientific Sessions and Workshops at PICES-2017

Science Board Symposium (S1)
Environmental changes in the North Pacific and impacts on biological resources and ecosystem services

Convenors: *Hiroaki Saito (SB) ,Se-Jong Ju (BIO), Elizabeth Logerwell (FIS), Keith Criddle (HD), Chuanlin Huo (MEQ), Jennifer Boldt (MONITOR), Emanuele Di Lorenzo (POC), Joon-Soo Lee (TCODE), Steven Bograd (FUTURE), Sukyung Kang (FUTURE), Igor Shevchenko (Russia), Motomitsu Takahashi (Japan)*

Invited Speakers:
Mary Hunsicker (NOAA, USA)
Kirill Kivva (Russian Federal Research Institute of Fisheries and Oceanography (VNIRO), Russia)
Kanae Tokunaga (Ocean Alliance, The University of Tokyo, Japan)
James Thorson (NOAA, USA)

Background

Marine ecosystems around the North Pacific are changing. Over the past decade physical, chemical, and biological processes have been altered by climate change and anthropogenic impacts. In response, species' ranges have shifted, disrupting ecosystem goods and services, including fisheries resources upon which communities around the North Pacific depend. Understanding, characterizing and forecasting ecosystem changes will ensure managers and policy makers have the information needed to maintain ecosystem biodiversity, structure and function, and ultimately sustainable utilization of ocean resources. Assessments that use observation-based indicators of ecosystem conditions coupled with numerical models capable of predicting future marine ecosystem conditions at short (seasonal to interannual), medium (decadal) and long-term (multi-decadal) scales can inform management and policy decisions.

Presentations were related to characterizing and understanding drivers of North Pacific ecosystem change and their impacts to, and resilience of, ecosystem resources and services.

Summary of presentations

The Keynote Speaker was Lev Zhivotovsky (VNIRO, Moscow) who gave a presentation on "*Eco-geographic units across environmentally diverse species' ranges as useful surrogates of the species' management units: Salmonid fishes of the North Pacific as an example*". 'Management units' are central to the fields of conservation biology and population ecology and are important for achieving proper management of fisheries stocks. In salmonids populations, although DNA-based figures may be biased because of small number of samples, *etc*., DNA data are necessary for checking confirmation and modifying the population structures. However, genetic parameters may not be able to distinguish fast population/environmental changes as genetic parameters are slow to evolve. Therefore a proxy of management units can be used by taking multiple population samples and dividing them into 'eco-geographic units' based on environmental/ecological features then testing the selected eco-geographic units for their congruence with genetic data.

Three Invited Speakers gave talks in S1. The first was James Thorson who examined the effects of temperature changes, shifts in size structure and habitat partitioning in the distribution shifts of walleye pollock in the Eastern Bering Sea using a spatio-temporal model. Walleye pollock have shifted north over time, but

bottom temperature and size-structure do not explain the shift. He examined the spatial/temporal/species portfolio effects for various fishes in marine ecosystems. A total portfolio could be a good indicator of the status of fishes.

The second Invited Speaker was Kirill Kivva who characterized regional ecosystems based on the three-dimensional historical observation of physical environments (temperature, salinity, dissolved oxygen) and nutrients (silicate, nitrate and phosphate) in the Bearing Sea and noted that nutrient ratios can be indicative of productivity in the ecosystem.

Sei-Ichi Saitoh discussed future projected impacts of ocean warming on squid habitat in the North Pacific. Because of their short lifespan, squids are good indicators of changes in the environment, which means their response is very quick. Habitat models of squid were built using data sets of temperature, salinity, SSH, net primary production and squid landing. The models predicted a warming ocean that shifted the distribution of squid northward and a decrease in squid abundance.

Invited Speaker, Kanae Tokunaga, presented a study showing that fisheries cooperative associations (FCA) can adapt to changes in fish stock associated with external perturbations (*e.g.*, climate, ocean and weather extremes). The case study of the spiny lobster fishery in Shima peninsula, Japan, revealed that regular and frequent meeting of the FCA can lead to optimization of the fisheries according to well established fisheries economic theory. Specifically, it was shown that during periods of stress on stocks the FCA resorted to using shared fishery grounds to benefit all the fishermen, and then returned to assigned fishery grounds where the fisherman can choose the type of fishing that is most productive to them. This allowed the fishermen to maintain a diversity of fishing gear and at the same time overcome large stresses.

Keith R. Criddle's study showed how durable individual entitlements to shares of the allowable catch increases the probability of fishermen to adapt to changes in stock abundance and fish prices. However, in the presence of large-perturbation, the reduction in portfolio effect associated with durable entitlements reduces resilience to non-stationarities and large perturbations. One key problem is the underlying assumption that the coupled climate/fishery system is stationary, while the real dynamics are likely to be non-stationary. Future research will have to aim at considering the resilience in the context of non-stationary systems.

Katerina Giamalaki's study used a novel approach based on the combining dynamical systems theory and state-of-the-art statistical methods to examine the atmospheric conditions that were important in driving the strong climate transition recorded in the winter of 1976–77. It is found that rather than a slow change in the atmospheric forcing, the change during the winter was initiated by extreme atmospheric pressure patterns (e.g., Aleutian Low). However, the dynamics of these extremes and the causes underlying the prolonged change in the climate state that followed remains undetermined.

Nianzhi Jiao presented a set of research projects and papers that were inspired by the discovery of the Microbial Carbon Pump (MCP). The MCP is an additional process that allows carbon to be stored in the ocean for longer periods, compared to the well- known Biological Pump (BP). MCP leads to refractory dissolved organic carbon compounds (RDOC) that can remain (*i.e.*, sequestered) in the water column for 100s to 1000s of years. Although it is still unclear how this new pathway contributes to CO_2 removal from the atmosphere, it is a promising research avenue that is being pursued in several international efforts include SCOR, PICES and ICES.

Vasilij Mishukov presented the results of concentrations of polynuclear aromatic hydrocarbons (PAHs), macro (Al, Ca, Mg, Na, K, Fe, Mn) and trace (Pb, Cd, Ni, Zn, Co, Cu, Cr) chemical elements, and radionuclide (Cs-

137, Cs -134 and I-131) in atmospheric aerosol samples, collected in Vladivostok and the Sea of Japan. The results showed that trace elements from pollution sources were well correlated with PAHs in Vladivostok. Concentrations of radionuclides in aerosol samples suggested that aerial transportation of radionuclides from Fukushima took 15 days to reach Vladivostok through the route (Pacific-North America-Europe-Siberia/Northern China).

Miho Ishizu showed the results of the long-term pH observations in coastal waters of Japan. The results showed evident acidification with a faster rate than the open ocean. This study emphasizes that ocean acidification should be also seriously considered to understand the future change of the coastal environment.

Jianchao Li's presentation indicated that the growth and condition of juvenile Pacific cod in the Yellow Sea is linked to the hydrological and hydrodynamic variability (such as cold water mass, tide, thermocline dynamics) during the summer and it may also be affected by global episodic climate events.

Hae Kun Jung noted that the fluctuation of local walleye pollock stock, particularly in East/Japan Sea (EJS), could be affected by the global atmospheric and climatic dynamics (Artic Oscillation and Aleutian Low). Walleye pollock variation was significantly affected by the atmospheric and oceanic conditions of the western coast of EJS, a walleye pollock spawning and nursery ground.

John Smith discussed the potential impacts of the 2011 Fukushima accident on marine biota in the eastern North Pacific. Based on the time series observation (under the auspices of the InFORM monitoring program) off British Columbia, the Fukushima signal continued to increase in surface waters (Line P) off British Columbia, Canada, reached a peak in 2016–2107, and then began to level off. Although the Fukushima radionuclide levels in seawater and fish have been relatively low and their impact on the ecosystem has been minimal, it has been a challenge to get acceptance of these results by the public and general community.

List of papers

Oral presentations

Eco-geographic units across environmentally diverse species' ranges as useful surrogates of the species' management units: Salmonid fishes of the North Pacific as an example (Keynote)
Lev A. Zhivotovsky

Measuring density dependence, portfolio effects, and climate-drivers in the North Pacific using spatio-temporal models and causal statistics (Invited)
James T. Thorson

Nutrient fields reveal identity of ecosystems: A case study from the Bering Sea (Invited)
Kirill Kivva

Future projected impacts of ocean warming to potential squid habitat in the North Pacific
Irene D. Alabia, Sei-Ichi Saitoh, Hiromichi Igarashi, Yoichi Ishikawa, Norihisa Usui, Masafumi Kamachi, Toshiyuki Awaji and Masaki Seito

Towards socially and ecologically adaptive fisheries resource governance: A case of spiny lobster fishery in Shima Peninsula, Japan (Invited)
Kanae Tokunaga

Durable entitlements and resilience in fishery social ecological systems
Keith R. Criddle

Mechanisms triggering the 1976-77 regime shift in the North Pacific
Katerina Giamalaki, Claudie Beaulieu, Davide Faranda, Stephanie A. Henson, and Adrian P. Martin

Biological mediated carbon cycling and sequestration in the ocean and climate change: A new dimension and perspective
Nianzhi Jiao, Louis Legendre and Richard Rivkin

Ocean acidification trends in coastal waters in Japan
Miho Ishizu, Yasumasa Miyazawa, Tomohiko Tsunoda, Tsuneo Ono

Ecological impacts of Yellow Sea Cold Water Mass variation on the early life history of Pacific cod (*Gadus macrocephalus*)
Jianchao Li, Rui Wu, Chi Zhang, Yang Liu and Yongjun Tian

The influence of atmospheric condition on fishing grounds of walleye pollock in the East/Japan Sea
Hae Kun Jung, Soon Man Kwon, Kang So Seol, Chung Il Lee

Transport of the Fukushima radioactivity plume to the Eastern North Pacific: impacts on biological resources
John N. Smith, Jay Cullen and Jean F. Mercier

Atmospheric transboundary transport of pollutants in East Asia
Vasilii F.Mishukov, Andrey S.Neroda, Vladimir A.Goraychev

Poster presentations

Influence of temperature changes on the bottom marine biota in the western part of Tatar Strait
Alexander A. Dulenin, Polina A. Dulenina

Forecast for 4 anadromous fish stocks status in the rivers of the mainland part of Tatarsky Strait (Sea of Japan) to the end of the 21st century
Zolotukhin, S. F., T. V. Kozlova, Kanzeparova A. N.

The directivity of the ecosystem processes in the spawning-nursery lake and the optimal spawning escapement
Ekaterina Lepskaya, Tatyana Bonk

Methane fluxes in the North Western Pacific Region
Anatoly I. Obzhirov, Galina I. Mishukova, Vasilii F. Mishukov

The Accident Fukushima's radionuclides in the northwestern Pacific in the summer of 2012
Vladimir Goryachev, Vycheslav Lobanov, Alexander Sergeev, Nataliy Shlyk

Central Arctic Ocean challenge; An emerging opportunity to view the changing North Pacific from above
Hyoung Chul Shin, Hyun-cheol Kim, Sung-Ho Kang and Sei-Ichi Saito

MEQ Topic Session (S2)
Microplastics in marine environments: Fate and effects

Co-Sponsors: GESAMP, NOWPAP

Co-Convenors: *Wonjoon Shim (Korea) Hideshige Takada (Japan) Peter Ross (Canada) Peter Kershaw (GESAMP) Lev Neretin (NOWPAP)*

Invited Speakers:
Seung-Kyu Kim (Incheon National University, Korea)
Daoji Li (East China Normal University, China)
Chelsea M. Rochman (University of Toronto, Canada)

Background

Microplastics are now ubiquitous from the near shore to open ocean, from the sea surface to bottom, and from subtropical to polar seas. Relatively high abundance of microplastics has been reported in the North Pacific Gyre as well as coastal waters of North Pacific region among the world oceans. In addition, with decreasing size, they become more bioavailable to small aquatic organisms down to zooplankton. Ingested microplastics have been found in various taxa across trophic levels. Associated chemicals in microplastics may be transferred to an organism upon ingestion. Microplastics represent trans-boundary pollution which can also deliver associated chemicals and invasive organisms to regions far removed from source. Microplastics are increasingly recognized as a potential threat to biota in the ocean. However, because of their size detecting the presence of microplastics and adverse biological effects, if any, becomes considerably more challenging. The objective of

this session was to present status and trend information for microplastic pollution and its environmental consequences in the PICES region. Papers are invited that assess microplastics 1) hotspots in the PICES region, 2) sources and input pathways, 3) fate and behaviour of microplastics, 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 microplastics will be also considered.

Summary of presentations

The session accommodated one plenary, two invited, twelve oral and seven poster presentations, including seven from early career scientists. About 50 marine scientists and geochemists, marine biologists, bird and mammal researchers, physical oceanographers, researchers from NGOs, policy makers and students attended the session.

A plenary speaker, Dr. Chelsea Rochman, provided a comprehensive overview regarding the issue of microplastics pollution and discussed its ecological and human health impacts. Of the two invited talks, Dr. Daoji Li summarized a microplastic national research project and pollution status in marine and freshwater environments of P.R. China. The other Invited Speaker, Dr. Seung-Kyu Kim, presented a microplastics monitoring study in the Arctic environment at sites along the North Pacific passage. Dr. Won Joon Shim presented a global overview based on the available literature on microplastics abundance, composition, and size distribution across the world, emphasizing especially high concentrations of microplastics in Asia and the North Pacific region, making them global 'hot spots'. Dr. Peter Kershaw from the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) introduced the third phase of the microplastics Working Group 40 activity on harmonization of microplastic sampling and analysis. A vertical distribution of >20 μm microplastics from surface to bottom water which has not been addressed yet was presented by Dr. Young Kyoung Song. Microplastics pollution in two estuarine and coastal environments of several rivers in the Far Eastern part of Russia was presented by Dr. Nikolai Kozlovskii. The first data on higher microplastics abundance in the estuary of the transboundary Tumen River (P.R. China, DPRK and Russia) was especially interesting. Ms. Katerina Vassilenko presented results on the abundance of microfibers in seawater and zooplankton along the eastern Pacific coast of Canada. Trophic transfer of microplastics in zooplankton by predation of salmon and whale was estimated in the Strait of Georgia, Canada. Mr. Seongbong Seo presented modelling results on transport of microplastics with river discharge from five major rivers in the R. Korea. The study assessed microplastics transport near shore and into the marginal seas surrounding the R. Korea and the individual microplastics contribution of rivers to the marine environment were estimated. Mr. Garth Covernton gave a systematic study on microplastic residues in wild and cultured clams in varioushabitats. Ms. You Na Cho presented a market basket survey of microplastic contamination in four bivalve species, including an estimate of the annual uptake of microplastics through consumption of the contaminated bivalve species in the R. Korea. Dr. Patrick O'Hara showed the difference between microplastic and plastic contents in seabirds; concentrations of microplastics in Cassin's auklets' stomachs varied according to breeding and non-breeding seasons. Dr. Youn-Joo An provided an overview of the adverse biological effects of microplastics on freshwater and marine organisms, including recent data on micro- and nanoplastic ingestion by freshwater organisms based on a trophic transfer study in a laboratory. Dr. June-Woo Park presented results of the study on the accumulation and toxic effects of microfibers and the associated chemicals such as phthalates on behavior and biomarker response of sheepshead minnow. Finally, Dr. Lev Neretin from NOWPAP provided an overview of the evolution of the global marine litter policies and summarised results of international and regional activities addressing marine plastic pollution issues.

List of papers

Oral presentations

Contamination and effects of plastic debris in the marine environment (Plenary)
Chelsea M. Rochman

Microplastic in the marine environments, China (Invited)
Daoji Li, Shiye Zhao, Juying Wang, Huahong Shi and Guyu Peng

Microplastics in Arctic surface water and sea ice: 2016 ARAON Expedition (Invited)
Hee-Jee Lee and Seung-Kyu Kim

Global distribution of microplastics: An overview
Won Joon Shim, Sang Hee Hong, Soeun Eo

Monitoring and assessment of marine plastics and microplastics – Towards harmonised methods
Peter J Kershaw, Francois Galgani and Alexander Turra

Vertical distribution and composition of microplastics in Korean coastal waters
Young Kyoung Song, Soeun Eo, Gi Myung Han, Sang Hee Hong, Won Joon Shim

River discharge as a source of plastic litter pollution in the Northwest Pacific Russia
Nikolai Kozlovskii, Anatolii Kachur

Microfiber source characterization in the Northeastern Pacific Ocean
Katerina Vassilenko, Mathew Watkins, Anahita Etemadifar, Marie Noel, Peter S. Ross

Fate of floating debris released from Korean rivers
Seongbong Seo and Young-Gyu Park

Microplastic concentrations in wild and cultured clams and their environment in British Columbia, Canada
Garth A. Covernton, Sarah E. Dudas, Christopher M. Pearce, Helen J. Gurney-Smith and John F. Dower

Assessment of microplastic contamination in commercial bivalves from South Korea
You Na Cho, Mi Jang, Gi Myung Han, Won Joon Shim and Sang Hee Hong

Seasonal variability in vulnerability for Cassin's Auklets exposed to plastic pollution in the Canadian Pacific region
Patrick D. O'Hara,Stephanie Avery-Gomm, Jocelyn Wood, Laurie Wilson, Victoria Bowes, Jean-Pierre Desforges, Peter Ross, Sean Boyd, Ken Morgan

Ecological effect of micro-sized plastics: Research trends and research needs
Youn-Joo An and Yooeun Chae

Assessment of microplastic fibers impacts from the chronic exposure to juvenile sheepshead minnow (*Cyprinodon variegatus*)
Jin Soo Choi, Youn-Joo Jung, Yunwi Heo and June-Woo Park

Applying precautionary principle to microplastics governance framework: Solutions in the absence of "complete" scientific evidence
Lev Neretin

Poster presentations

Ecotoxicity effects of microplastic to the early life stages of large yellow croaker
Fangzhu Wu, Xiaoqun Liu, Jiangning Zeng, Qiang Liu, Wei Huang

Abundance, composition and distribution of microplastics on Korean Beaches
Soeun Eo, Young Kyung Song, Sang Hee Hong, Gi Myung Han, Won Joon Shim

Changes of carbonyl and vinyl index of three plastics by outdoor exposure
Young Kyoung Song, Soeun Eo, Sang Hee Hong, Won Joon Shim

Development of efficient analytical method for microplastics in bivalves
Mi Jang, You Na Cho, Young Kyung Song, Won Joon Shim and Sang Hee Hong

Bioaccumulation of microplastics in sheepshead minnow *(Cyprinodon variegatus)*
Jin Soo Choi, Youn-Joo Jung, Hong gil Yun and June-Woo Park

Spatial characteristics of microplstics in the surface waters along the coast of Korea
Jung Hoon Kang, Oh-Youn Kwon, Minju Kim, Sang Hee Hong and Won Joon Shim

Microplastics in freshwater river sediments in Shanghai, China: Case study of environmental risk assessment in mega cities
Guyu Peng, Pei Xu, Bangshang Zhu, Daoji Li

FUTURE Topic Session (S3)
Below and beyond maximum sustainable yield: Ecosystem reference points

Co-Convenors: *Elliot L. Hazen (USA), Jennifer Boldt (Canada), Robert Blasiak (Japan), Mary Hunsicker (USA)*

Invited Speaker: *Robert Blasiak (University of Tokyo, Japan)*

Background

PICES SG/WG-CERP was tasked with identifying ecosystem reference points that would integrate across committees to achieve FUTURE goals and missions. This topic review session examined a) examples of ecosystem reference points that have been established, and b) methodologies for calculating ecosystem reference points from driver-pressure relationships across PICES ecosystems. The goal of this topic session was to bring together experts from physical, biological, and human dimensions to explore past and future approaches to understand how ecosystem management have and can best set reference points that deal with ecological and societal goals. Reference points for fisheries management are generally determined under a single set of environmental conditions with a single species focus. Almost all forms of resource management rely on reference points in order to manage a species (e.g. BMSY, Potential Biological Removal, and Yield per Recruit). However, ecosystem reference points that have been developed have largely focused on additive relationships but more attention is needed on setting reference points in relation to ecosystem functioning such as climatic forcing and predator-prey relationships. One such example, maximum ecosystem yield (MEY) in the Gulf of Alaska and Bering Sea provides an umbrella on total catch, but still does not account for intraspecific dynamics or climate forcing. The Topic Session involved participation from multiple PICES committees and focused on reviewing examples of ecosystem reference points and methods for defining reference points that have been used internationally.

Summary of presentations

Invited speaker, Dr. Robert Blasiak, gave a talk on "*Towards common ecosystem reference points for North Pacific ecosystems*" during the well-attended Tuesday morning Plenary Session. Dr. Blasiak's topic covered reference point terminology, matching reference points to policy commitments, recent work in reference points, and human dimensions. He pointed out that ecosystem reference points are challenging, for example, management objectives for ecosystems are not always well defined, involve a diverse set of stake holders, and can encompass flora, fauna, abiotic conditions, and target and non-target species. Societal objectives and human dimensions are a key element towards setting goals in identifying appropriate reference points. Societal objectives and social systems, however, are in as much change, if not more, as our ecological systems. Dr. Blasiak's talk was an excellent example of needed connections between biophysical indicators and human dimensions.

Topic Session S3 continued after the Plenary Session and was well attended by over 40 participants. Dr. James Thorson gave a presentation on "*Time varying processes in stock assessment: A bridge to ecosystem-based reference points*". He pointed out several reasons why stock assessment output should be used as ecosystem reference points: ecosystem advice can be compared among ecosystems; stock assessments are ubiquitous worldwide, and they have a strong link to management. Two questions to address when using assessments are: (1) How sensitive are assessments to unmodeled processes and (2) how sensitive are management targets to changing productivity? Dr. Thorson discussed different approaches that can help prioritize which processes are important, such as elasticity analysis to look at a single parameter to see how it affects Fmsy or meta-analysis to compare stocks within a given region to look for synchronous changes.

Dr. Ian Perry provided an overview of WG 28 on *Developing Ecosystem Indicators to Characterize Ecosystem Responses to Multiple Stressors*. Dr. Perry reviewed WG 28 outcomes and recommendations. WG 28 not able to propose a comprehensive indicator; instead reviewed indicators, frameworks to select them, and identified common pressures on North Pacific ecosystems. Suites of indicators vary with region (coastal, open), or objectives or pressures, and WG 28 identified a core set of indicators and a toolbox of others. WG 28 developed quantitative methods for assessing potential impacts of stressors and identifying which pressures were most important. Dr. Perry also pointed out that risk diagrams (exposure *vs* sensitivity) may be useful to assess with defining references points.

Ms. Jung-Hyun Lim gave a presentation on the estimation of potential yield in the Korean waters of the East China Sea. Given decreased catches in Korean waters during 1970–2016, she compared different approaches to estimating potential yield of the ecosystem. Ms. Lim compared potential yield estimated using standardized surplus production models (holistic approach) and an ecosystem modeling approach. Estimates of potential yield were surprisingly similar between the two methods. However, each approach had strengths and weaknesses and in conclusion she recommended using holistic approaches.

Dr. Elliott Hazen presented Dr. Mary Hunsicker's talk on "*Characterizing driver-response relationships and defining ecological thresholds in large marine ecosystems*". He pointed out that many ecosystems have experienced regime shifts, with the main drivers being climate change, harvest, and eutrophication. In pelagic systems, highly nonlinear relationships are common and thus may have detectable thresholds.

After the oral presentations, there was a valuable discussion among Session S3 participants and attendees. It was argued that in order to forecast future states of ecosystem indicators, there is a need to understand the mechanisms underlying changes in indicators. Environmental "rules" may change, therefore, multiple approaches (statistical and numerical) may be needed. Dr. George Sugihara's work may be another useful method that could be used to look for non-linearities in indicators. There is good information on target species but not as much is known about nontarget species (such as small forage species). Long-term process monitoring studies are important to address this gap in ecosystem metrics.

There was some discussion about how to provide advice to managers. One suggestion was that social economic analyses integrate many aspects of ecosystems (social, economic, cultural, science) and provide a package that puts ecosystem aspects into context for human impacts and can bridge the gap to managers. It was also noted that perhaps management processes need to be more dynamic. If there are nonlinear responses to an environmental driver, such as the PDO, the PDO cannot be managed, so to make the linkage to management, the total allowable catch, for example, could be reduced under poor environmental conditions. Ensuring transfer of science to management may differ greatly among PICES member countries, which is likely a charge that the Working Group on *Common Ecosystem Reference Points across PICES Member Countries* (WG 36) will need to address as well.

List of papers

Oral presentations

Towards common ecosystem reference points for North Pacific ecosystems (Plenary)
Robert Blasiak

Time-varying processes in stock assessment: A bridge to ecosystem-based reference points
James T. Thorson

Development of Ecosystem Indicators to Characterize Ecosystem Responses to Multiple Stressors: A summary PICES Working Group 28
R. Ian Perry, Motomitsu Takahashi, Jennifer Boldt, and members of WG28

A study on the estimation of the potential yield in the Korean waters of the East China Sea
Jung Hyun Lim, Hee Joong Kang, Hyun A Kim, Young IL Seo and Chang Ik Zhang

Characterizing driver-response relationships and defining ecological thresholds in large marine ecosystems
Mary E. Hunsicker, Jameal F. Samhouri and Carrie V. Kappel

Poster presentations

The application of Argo profile data and innovative methods in fisheries sciences
Peng Lian, Tao Tian, S.J. Joung

MONITOR Topic Session (S4)
Adverse impacts on coastal ocean ecosystems: How do we best measure, monitor, understand and predict?

Co-Convenors: *Akash Sastri (Canada), Naoki Yoshie (Japan), Jack Barth (USA)*

Invited Speakers:
Yuichi Hayami (Institute of Lowland and Marine Research (ILMR), Saga University, Japan)
Peter Zhadan (V.I. Il'ichev Pacific Oceanological Institute (POI), Russia)

Background

Adverse impacts on coastal ocean ecosystems by, for example, episodic harmful algal blooms and hypoxic events and by increasing ocean warming and acidification, are prevalent in North Pacific coastal waters. These can occur both in semi-enclosed basins and open coastal areas, and in regions with and without strong anthropogenic impact. These adverse impacts share a common characteristics in that they all involve linked physical, biological, and chemical processes as well as, in some cases, human-related actions. To achieve a complete understanding of these negative impacts on coastal ocean ecosystems requires multi-parameter observations from a variety of in-water platforms. Measurements include those from physical, chemical and biological sensors and from discrete water samples and net tows. Time series are necessary to define the time scale of the impact and the seasonal and interannual conditions present at the time of the impact. These critical in-water measurements are often combined with remotely sensed observations and with numerical models to gain further understanding of the origin and evolution of the negative impacts. Contributions that identified adverse impacts on coastal ocean ecosystems in North Pacific coastal waters and that used multi-sensor time series and models to understand and predict these phenomena were desirable.

Summary of presentations

A 1-day topical session on "*Adverse impacts on coastal ocean ecosystems: How do we best measure, monitor, understand and predict?*" was convened with the goal of bringing together studies exploring the linked biological, physical and chemical processes used to monitor the negative impacts of adverse events on coastal ocean systems. The session encouraged contributions which considered adverse impacts in the North Pacific from a trans-disciplinary perspective and those which took advantage of multi-sensor time series. The topics covered by the presentations nicely reflected the session description and spanned basin-scale studies (*e.g.*, remote sensing and watershed-estuarine linkages) to investigations of site- and species-specific responses to adverse conditions. A total of 11 oral and 5 poster presentations were represented by speakers from Russia, Korea, Japan, China, Canada, Argentina and the United Kingdom. The full day oral session was well attended and included presentations from two invited speakers: Dr. Peter Zhadan (Russia); and Dr. Yuichi Hayami (Japan) as well as presentations by 3 early career scientists. The poster session also included 3 early career

scientist presentations. Presentations by early career scientists were of a high quality with Jiyoung Lee (Korea) and Rikuya Kurita (Japan) awarded best oral presentation and poster presentation, respectively, by the MONITOR Committee. Unfortunately, two speakers withdrew their presentations (one in the morning and one in the afternoon) at the last minute.

The morning talks were regionally focused on the western North Pacific with presentations addressing long-term monitoring of coastal benthic populations (sea urchins); broad-scale multinational collaborative programs, and linkages between riverine nutrient input and remote sensing in the Sea of Japan. The topics of the afternoon talks spanned study sites in both the western and eastern North Pacific and explored multi-parameter monitoring programs, *in situ* biological and modelling characterizations of eutrophication and hypoxia in the East China Sea, and novel statistical treatment of biological time-series.

Dr. Peter Zhadan (V.I. Il'ichev Pacific Oceanological Institute, FEB RAS, Vladivostok, Russia) was our first invited speaker. His presentation, "*The mechanisms influencing the timing, success and failure of spawning in natural populations of the sea urchin Strongylocentrotus intermedius in the northwestern Sea of Japan*", described a long-term (2003–2016) study of the reproductive biology of wild sea urchin populations experiencing varying degrees of anthropogenic pressure in the northwestern Sea of Japan (400 km stretch of coastal Russia). The presentation explored relationships between the timing of spawning and multiple environmental factors including phytoplankton biomass, water properties, lunar phase, tides and anthropogenic pressure. The study identified 3 types of populations on the basis of spawning time: 1) late (autumn), 2) early (spring), and 3) equal proportions in autumn and spring. Of the candidate hypotheses tested for explaining spatial patterns of spawning type, only the hypothesis of phenotypic response to pollution, and associated eutrophication, explained the strong association of early spawning associated with proximity to sources of pollution. Increased concentrations of phytoplankton metabolites linked to eutrophication are considered the major factor regulating timing of spawning. A secondary effect of lunar phase was also identified. The study employed sampling of sea urchins to examine gonad maturity status (every 3–7 days) and high resolution video-logging of spawning events (1-minute intervals) and data-logging (10-minute intervals) of environmental variables. During discussion, Dr. Zhadan responded to several questions about phytoplankton concentration and lunar phase, noting that both are important to sea urchin spawning and developmental success. Spawning is fundamentally linked to lunar phase but success is highly correlated to phytoplankton concentration. However, little is known about what type of phytoplankton (*e.g.*, diatoms) are most suited to spawning success. Several audience questions were addressed, differentiating between the influences of phytoplankton concentration and lunar phase on the sea urchin spawning and developmental success.

Dr. Vladimir M. Shulkin (Pacific Geographical Institute FEBRAS, Vladivostok, Russia), presented the second morning talk, entitled, "*Elaboration of Ecological Quality Objectives as a step forward in cooperation to protect the marine environment in the Northwest Pacific*". The presentation highlighted the development and implementation of the general Ecological Quality Objectives (EQOs) in the NOWPAP region. Challenges of this multinational program include: the identification of a major ecological issues in the region, development of potential targets and indicators for regional monitoring, and definition of features and difficulties for EQOs in the NOWPAP region. The presentation highlighted the recognition that there are many environmental issues in the region, some particular to specific nations and that resolution of these issues demands joint efforts from all nations; harmonization of monitoring approaches is essential.

Ms. Anna S. Vazhova (ECS; Pacific Scientific Research Fisheries Center (TINRO-Center), Vladivostok, Russia) discussed "*Seasonal dynamics of nutrients in the river water and its influence on productivity of the coastal zone in the Japan/East Sea*". The presentation explored the impact of riverine nutrient dynamics on productivity of the coastal waters of Amur Bay. She presented a detailed analysis of seasonal nutrient

dynamics, precipitation, water temperature, and dissolved oxygen for 8 rivers during 2016. Seasonal patterns of productivity in the river estuaries were seasonally described, as bottom water hypoxia events developing during the summer are beginning to develop more frequently. Continued monitoring of chemical and physical riverine water properties is needed to further characterize seasonal inputs especially during monsoon flood periods. Discussion following the presentation addressed questions about the importance of industrial input of nutrients and the best sampling locations along each river location relative to the estuary.

Dr. Elena A. Shtraikhert's (V.I. Il'ichev Pacific Oceanological Institute, FEB RAS, Vladivostok, Russia), presentation titled, "*Seasonal and diurnal distributions of the phytoplankton bloom, organic and suspended matter contents indicators in the Amur Bay and adjacent area (Japan/ East Sea) according to satellite data*" also focused on factors contributing to observations of bottom water hypoxia in Amur Bay but considered the physical oceanography of the Bay and water color characteristics using remote sensing (primarily MODIS-AQUA and GOCI_COMS) and hydrometeorological wind speed and direction data from Vladivostok. Remote sensing of Chlorophyll *a* concentration and organic matter content identified seasonal (spring and autumn) phytoplankton blooms and periods of high sediment load associated with the spring flood of the Razdolnaya River spring flood and periods of high precipitation during the summer. Hypoxia situations were associated with water column stratification and spring-time productivity; continental runoff following periods of significant precipitation and overflow of reservoirs located on the Sedanka and Bogataya rivers.

Dr. Tatiana N. Dautova (National Scientific Centre of Marine Biology FEB RAS, Far East Federal University, Russia) was not able to attend the afternoon session and cancelled her talk, "*Coral communities in the North-West Pacific coastal ecosystems: Environmental impacts, future trends and distribution*".

Dr. Yuichi Hayami (Institute of Lowland and Marine Research, Saga University, Japan), was our second invited speaker and presented "*Monitoring based research in Ariake Sea, Japan - To solve the environmental and fisheries problems*". Dr. Hayami offered a detailed synopsis of long-term changes in the physico-chemical properties and biological diversity of the inner Ariake Sea which includes 23 unique endemic species. The inner area has been monitored since the late 1950s and is important for laver culture but has seen serious environmental and fisheries issues such as: increased incidence of red tides and hypoxia, and decreased macrobenthos and shellfish and demersal fish catches. The study area consists of extensive mudflats influenced by freshwater discharge which contributes to conditions of high turbidity (low transparency). Ship-based monitoring of bottom water hypoxia and red-tide occurrence since the mid 1980s has identified a relative increase in both and changes in the seasonal timing of red tides. A significantly reduced laver harvest in 2000 (and first major observation of hypoxia in 2001) motivated increased research and monitoring in the Ariake Sea. Hypoxia events caused by spring-neap tidal variation and winds have been observed annually since 2001 and have been linked to massive shellfish kills in the Ariake Sea. A continuous monitoring program with freely accessible real-time data from three monitoring towers/buoys with automated vertical profiling and additional surface monitoring buoys have been introduced to complement the long-term monthly ship-based monitoring in the region. This presentation highlighted the advantages and need for increased resolution and expansion of monitoring tools as well as the required collaboration local communities and organizations for better understanding the adverse effects of eutrophication in the Ariake Sea. During discussion, Dr. Hayami noted that there are several primary productivity data sets for the Ariake Sea. However, these were mostly collected during the summer. He also addressed questions about the use of real-time monitoring data for the fishing community and noted that it usually takes advantage of SST and SSS data for deciding on the timing of when to initiate laver harvesting.

Dr. Feng Zhou (State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, State Oceanic Administration, PR China) discussed "*Variability and mechanisms of seasonal*

hypoxia off the Changjiang Estuary, China". He provided a history of observations of hypoxia starting in the 1950s in the Changjiang River estuary (East China Sea; ECS) and noted that observations of severe hypoxia began in 2002. High-resolution sampling in the ECS has helped to identify the onset of the hypoxic period in June (2006 survey) but little is known about the annual duration and interannual extent of the hypoxic area. Dr. Zhou explored these unknowns using SSS (as a tracer of diluted waters) to predict the location of hypoxia. A more detailed modeling approach (ROMS) for 2006 was used because a comparison to high sampling effort was possible. This study showed that hypoxia begins in the early summer and was most significant at the end (late August) during the period of strongest water column stratification. Mixing due to variable wind strength is probably responsible for episodic relief from hypoxia and both river and Kuroshio dynamics must be considered for further evaluation of hypoxia in the region. During discussion, Dr. Zhou noted that a case by case approach was required when asked about factors were important for understanding variability in nutrient flux from the river: natural fluctuation *versus* anthropogenic effects.

The presentation by Jiyoung Lee (ECS; Department of Marine Science, & Research Institute of Basic Sciences, Incheon National University, R Korea) entitled, "*Seasonal microbial community composition in the Jinhae Bay hypoxic zone, South Korea*", was awarded the Best Presentation by the MONITOR Committee. This study explored the role of environmental change and seasonal hypoxia on microbial community composition in Korean coastal waters, Jinhae Bay. The study was carried out between June and December 2016 and used a clustering approach to compare vertically stratified microbial composition (16S rRNA gene sequencing) to physico-chemical water properties (temperature, salinity, water column stability and dissolved oxygen) and identified significant shifts in microbial community composition associated with seasonal and spatial hypoxia and surface super-saturation.

Dr. Guimei Liu (National Marine Environmental Forecasting Center, Beijing, PR China) was not able to attend the session and cancelled his presentation, "*A modeling study of hypoxia in the bottom layers off the Changjiang Estuary in summer*".

Mr. Qingsheng Li (Third Institute of Oceanography, State Oceanic Administration, PR China) gave an "*Analysis of eutrophication in Xiamen Bay and its influencing factors*". This presentation considered the potential role of multiple stressors such as sewage disposal, aquaculture, river input, and reclamation as factors influencing the degree and incidence of eutrophication and red tides in Xiamen Bay. An eutrophication index (E) was calculated on the basis of chemical oxygen demand, and nitrogen and phosphorus concentrations for multi-variable sampling during May, July and October 2010. Results of the correlation analysis found a negative relationship between the eutrophication index and river runoff and precipitation and a positive relationship with oil, phytoplankton biomass and TOC (all related to cultural eutrophication). Notable too was the high E value at coastal sites (Maluan Bay) close to sewage disposal and aquaculture facilities.

Dr. Lu Guan (ECS; School of Earth and Ocean Sciences, University of Victoria, Canada) put forward her study entitled, "*Detecting multi-scale temporal dynamics of acoustically estimated zooplankton biomass: A case study of high-resolution ocean observatory system in Saanich Inlet (British Columbia, Canada)*" which focused primarily on a long-term, high resolution time series (2006–2016) of zooplankton biomass in coastal British Columbia. The goal of the study was to identify differing time scales of non-linearity in the time series to identify causation (rather than correlation) to variation physical temporal patterns. Of note was the identification of the two anomalously warm winter periods associated with the ENSO events of 2010 and 2016, which were not evidenced in the zooplankton biomass time series. However, the acoustic-zooplankton time series displayed non-linear dynamics. The empirical dynamical modelling approach identified variation in zooplankton biomass caused by bottom water temperature, salinity and dissolved oxygen on quarterly and monthly time-scales and tidal height (and salinity) on shortly, bi-weekly and weekly timescales. This approach

was also demonstrated to have strong short-term forecasting skill and may be broadly useful for identifying response (or lack of) of other biological time series to adverse events. When asked why this study did not include environmental indices such as chlorophyll *a* and dissolved oxygen, Dr. Guan noted that those time series were not of suitable length for analysis.

Dr. Xiutang Yuan (Department of Marine Biology and Ecology, NMEMC, SOA, PR China), announced his research on "*Winner or loser: Sea cucumber's future in a changing ocean*". His presentation focused on the potential impact of ocean acidification (OA) in the Bohai and Yellow seas on a ubiquitous benthic group, sea cucumbers. This group is particularly useful as a long-term indicator of biological response because they play an integrative role in nutrient recycling and the carbonate cycle; they are also less calcified than other benthic species which have suffered mass extinctions due in part to OA on geologic time scales. This study focused on gonad and early development, physiological responses, bio-energetic trade-offs, and anti-predation behavior to increasing OA. Overall, the presentation identified our limited understanding of the response of sea cucumbers to OA; that measured responses are species-specific; and the overall greater resilience of sea cucumbers to OA relative to other echinoderms, leading to the question of the relative dominance of this group in a future coastal ocean.

Dr. Jennifer Jackson (Hakai Institute, Canada) reported on "*The Hakai Institute Oceanography program: An examination of oceanographic properties from the northern Strait of Georgia to the central British Columbia coast*". She introduced the Hakai Institute Oceanography program and outlined a number of its oceanographic monitoring programs in coastal British Columbia. The monitoring program is centered out of a station on the west coast of British Columbia (Calvert Island) and in the northern Strait of Georgia (Quadra Island) and is wide-ranging in its scope from coastal oceans to near-shore marine ecosystems and coastal watersheds. The small boat sampling program was initiated in 2012 and consists of regular (daily to monthly) water column surveys which include standard physical, chemical and biological sampling. The sampling network is complemented with a sensor array in the Calvert Island area consisting of autonomous temperature loggers, a soon-to-be-deployed MapCO2 mooring, and instrumented ferry system (including CO_2) from Bellingham (Washington, USA) to Ketchikan (Alaska, USA), a cabled observatory platform off Quadra Island and a suite of meteorological stations. The observation network and data collected thus far have proven useful in resolving seasonal and interdecadal variability and submesoscale processes.

List of papers

Oral presentations

The mechanisms influencing the timing, success and failure of spawning in natural populations of the sea urchin Strongylocentrotus intermedius in the northwestern Sea of Japan (Invited)
Peter Zhadan and Marina Vaschenko

Elaboration of Ecological Quality Objectives as a step forward in cooperation to protect the marine environment in the Northwest Pacific
Vladimir M. Shulkin, Anatoly N. Kachur and Alexander V. Tkalin

Seasonal dynamics of nutrients in the river water and its influence on productivity of the coastal zone in the Japan/East Sea
Anna S. Vazhova

Seasonal and diurnal distributions of the phytoplankton bloom, organic and suspended matter contents indicators in the Amur Bay and adjacent area (Japan/East Sea) according to satellite data
Elena A. Shtraikhert, Sergey P. Zakharkov

Monitoring based research in Ariake Sea, Japan -To solve the environmental and fisheries problems (Invited)
Yuichi Hayami

Large variability of hypoxia off the Changjiang Estuary
Feng Zhou, Fei Chai, Daji Huang, Huijie Xue, Jianfang Chen, Peng Xiu, Jiliang Xuan, Jia Li, Dingyong Zeng, Xiaobo Ni and Kui Wang

Seasonal microbial community composition in the Jinhae Bay hypoxic zone, South Korea
Jiyoung Lee, Jae-Hyun Lim, Kesavan Markkandan, Soyeon Kim, Junhyung Park, and IL-Nam Kim

Spatialtemporal variation of nutrients and eutrophication in Xiamen Bay
Qingsheng Li, Cui Wang, Jinlong Jiang, Keliang Chen and Jinkeng Wang

Detecting multi-scale temporal dynamics of acoustically estimated zooplankton biomass: A case study of high-resolution ocean observatory system in Saanich Inlet (British Columbia, Canada)
Lu Guan, Akash Sastri, Chih-hao Hsieh, John Dower, Richard Dewey and Stephane Gauthier

Winner or loser: Sea cucumber's future in a changing ocean
Xiutang Yuan

The Hakai Institute Oceanography program: An examination of oceanographic properties from the northern Strait of Georgia to the central British Columbia coast
Jennifer M. Jackson, Brian P.V. Hunt

Poster presentations

Studies on the bloom timing of moon jellyfish (*Aurelia aurita*) in the nearshore waters of the Hongyanhe River – an estuary of the Liaodong Bay
Chunjiang Guan, Guize Liu, Qing Yang, and Jinqing Ye

High-resolution monitoring of phytoplankton communities using spectral fluorescence signatures
Rikuya Kurita, Kenji Tsuchiya, Shinji Shimode, Tatsuki Toda and Victor S. Kuwahara

Plankton biodiversity, community structure and the physical and chemical environment of Izu-Oshima, Japan: A high resolution and multidisciplinary observational approach
Gabriel R. Freitas, Hidekatsu Yamazaki, Scott M. Gallager, Yoshinari Endo, Masashi Yokota and Takeyoshi Nagai.

The effect of estuarine physicochemical conditions on antibiotic-resistant E. coli migration and competitive ability
Guangshui Na, Linxiao Zhang, Zihao Lu, Hui Gao

Temporal variation in microbial community composition in Gadeok Channel, South Korea
Soyeon Kim, Jiyoung Lee, Jae-Hyun Lim, Junhyung Park, Joo-Eun Yoon, Kesavan Markkandan, and Il-Nam Kim

FIS Topic Session (S5)
Coastal ecosystem conservation and challenge

Convenor: *Xianshi Jin (China)*

Invited Speaker:
Cody S. Szuwalski (University of California, Santa Barbara, USA)

Background

Under the impacts from climate change and human activities, many stocks were depleted, and habitats were degraded, Stock releasement and artificial reefs construction have been widely used in coastal area for restoring the depleted stocks and conservation of the ecosystem, as well as increasing the abundance for recreational fisheries. This session will focus on the studies of methods, results of the conservation measures and effects on fisheries and ecosystem, aiming at sharing the information of advantages and challenges, evaluating the results and ecological effects and management implications.

List of papers

Oral presentations

Managing highly modified marine ecosystems (Plenary)
Cody S Szuwalski

Signature of global warming on dynamics of anchovy *Engraulis japonicas* stock in the Yellow Sea
Xiujuan Shan, Xianshi Jin, Yunlong Chen and Tao Yang

Kelp of Laminaria thickets recovery in dependence on abiotic and biotic environments
Tatiana Krupnova, Yury Zuenko, Irina Tsypysheva, and Vladimir Matveev

Zooplankton communities in the coastal northeast Pacific Ocean: A comparison of a highly productive region and a light-limited high nutrient, low chlorophyll region
Natalie Mahara, Brian P.V. Hunt and Evgeny A. Pakhomov

Improving estimations of fish species abundance and distribution via accounting for the effects of diel vertical movements
Lisha Guan, Xiujuan Shan and Xianshi Jin

DNA barcoding and electronic microarray for common fish species in Shandong coastal waters
Shufang Liu, Xianru Li, Zhimeng Zhuang

Potential influence of oceanic environmental change on seaweed bed distribution in Tsushima Islands
Mitsuo Yamamoto, Aigo Takeshige, Dan Liu and Shingo Kimura

Relationship of energy metabolism and juvenile Pacific salmon survival of during adaptation at sea
Anton Klimov, Aleksey Lozovoy and Irina Zhiganova

Habitat history reconstruction of the Japanese-Spanish mackerel Scomberomorus niphonius in the southern Yellow Sea, inferred from otolith chemistry
Xindong Pan, Chi Zhang, Zhenjiang Ye, Binduo Xu, Yang Liu and Yongjun Tian

Poster presentations

The effect of the lights on reproduction of sea urchin
Vladimir Evdokimov, Inga Matrosova, Galina Kalinina

Improvement of coastal use fee and levy system based on the marine ecosystem in Korea
Jeong-In Chang

Changes on the ecological Carrying Capacity of fleshy prawn (Fenneropenaeus chinensis) in the Bohai Sea
Qun Lin, Xiujuan Shan, Jun Wang and Zhongyi Li

Real-time detection of the red tide dinoflagellate Akashiwo sanguinea using a newly developed ultrasonic acoustic technique
Hansoo Kim, Hyun Jung Kim, Junsu Kang, Mira Kim, Byoung Kweon Kim, Seung Won Jung and Donhyug Kang

POC/FIS Topic Session (S6)
Interannual variability in marine ecosystems and its coupling with climate projections

Co-Convenors: *Yury Zuenko (Russia), Jacquelynne King (Canada), Masami Nonaka (Japan), Hee-Dong Jeong (Korea)*

Invited Speaker:
Elena Ustinova (Pacific Fisheries Research Centre (TINRO-Centre), Russia

Background

PICES has long recognized the importance of climate variability and climate change on marine ecosystems, particularly for multi-decadal scales. However, in fisheries management it is the variability at interannual scale that is of greater immediate interest. This session sought to explore two aspects of interannual scale variability. First, the mechanisms responsible for year-to-year variability in marine ecosystems including fisheries, so one goal of this session was to encourage presentations that shared examples of interannual variability (physics, biology, fisheries) where observations may have provided clues about the responsible mechanisms. A second objective of this session was to engage the climate, ocean and ecosystem modeling communities that are working on interannual to decadal-scales to (1) provide the empirical evidence underlying the assumptions for mechanisms of functional linkages between climate variability and ecosystem response at these temporal

scales, (2) to assess the retrospective skill of coupled bio-physical models at multiple temporal scales, and (3) to identify how parameter uncertainty can be transferred from shorter forecasting frameworks to longer term projection models.

Summary of presentations

Nine presentations were given, including one by Invited Speaker, Elena Ustinova. One presenter, Susanna Nurjaman was unable to attend. Different aspects of observed and modeled interannual variability were discussed, mostly for physical factors and plankton.

Masami Nonaka noted that interannual variability is partially deterministic and partially intrinsic with the former mostly large-scale patterns and the latter mostly meso-scale patterns. While the latter can be described statistically and meso-scale eddies activity correlates well with background current velocity, we cannot determine the evolution of a single meso-scale eddy. The intrinsic component could be considered as uncertainty in forecasts. This component, or uncertainty, generally increases going from the environmental level to the biotic level, and again from the biotic level to human dimensions. Tetjana Ross reported that variability of complicated biotic systems (such as plankton) appears completely intrinsic but it might be understood if species or groups of ecologically similar species are considered separately. For example, Jinhui Wang suggested the need for different models for each Harmful Algal Bloom species. However, Lu Yang found that the more complicated structure of biotic systems does not necessarily mean less predictability as presented, for an example, for zooplankton in the Bohai Sea. To improve our understandings on this point, more observational data are necessary for complicated biotic systems.

Anne Hollowed noted that interannual variability and predictability has a high practical importance, particularly for fisheries management, so some session participants proposed that a topic session devoted to this subject be discussed each year. Other participants recommended that the topic be included in any upcoming symposium theme sessions.

List of papers

Oral presentations

Interannual variability of oceanographic conditions in the North-West Pacific and Far-Eastern Seas and examples of its effects on fisheries (Invited)
Elena I. Ustinova and Yury D. Sorokin

Wind-driven and intrinsic interannual variability in the Kuroshio Extension jet and its eddy activities
Masami Nonaka, Hideharu Sasaki, and Niklas Schneider

On the effect of atmospheric forcing on the upper heat content variability in the Japan/East Sea from 1948 to 2009
Dmitry V. Stepanov, Anatoly Gusev, Nikolay Diansky

Bridging the gap between mechanistic understanding and climate projections: An example based on the Bering Sea Project
Anne B. Hollowed, Alan C. Haynie, Kristin Holsman, Kerim Aydin, Al Hermann, Wei Cheng, Jon Reum, Amanda Faig

What was the major factor that has caused declines in coccolithophore abundance in the North Pacific Subtropical Gyre since 2005?
Joo-Eun Yoon, Il-Nam Kim, SeungHyun Son, Alison M. Macdonald and Ki-Tae Park

What is driving interannual variability in lower trophic levels near Explorer Seamount (Canada)?
Tetjana Ross, Moira Galbraith, Tammy Norgard and Marie Robert

The Climate Change and Trends of Phytoplankton in East China sea
Jinhui Wang, Yutao Qin, Shouhai Liu

Interannual variability in zooplankton community and its relationship with environmental variables in Bohai Bay in China from 2004-2015
Lu Yang, Qiulu Wang, Yan Xu and Haiyan Huang

Influence of the Three Gorges Dam on the East China Sea ecosystem
Christina Eunjin Kong, Sinjae Yoo, Chanjoo Jang

Poster presentations

Spatio-temporal distribution of the specific growth rate of Prorocentrum donghaiense related with SST
Yanlong Chen, Suqing Xu, Yujuan Ma

HD Topic Session (S8/HD-Paper)
Marine ecosystem health and human well-being: A social-ecological systems approach

Co-Convenors: *Keith R. Criddle (USA), Mitsutaku Makino (Japan), Ian Perry (Canada), Mark Wells (USA)*

Invited Speakers:
Suhendar I Sachoemar (Agency for the Assessment and Application of Technology (BPPT), Indonesia)
Charles Trick (Western University, Canada)

Background

Ecosystem-based fisheries management seeks to restore, enhance, and protect living resources, their habitats, and ecological relationships to sustain all fisheries and provide for balanced ecosystems. Progress has been made internationally toward adopting ecosystem based fisheries management of marine systems (EBFM), with PICES member countries contributing through regional applications in the North Pacific. Examples are the Study Group on *Ecosystem-based Management Science and its Application to the North Pacific* (SG-EBM: 2003–2004) and the Working Group on *Ecosystem-based Management Science and its Application to the North Pacific* (WG 19: 2004–2009). Recent initiatives have expanded the concept of ecosystem to include human influences, both positive and negative, which is emerging as coupled marine social-ecological studies (Marine SES). An integrated understanding of how ecosystem changes affect human social systems and their well-being, and *vice versa*, are necessary to improve environmental stewardship. The PICES Study Group on *Human Dimensions* (SG-HD: 2009–2011), Section on *Human Dimensions of Marine Systems* (S-HD: 2011–), and PICES/MAFF project on Marine Ecosystem Health and Human Well-being (MarWeB: 2012–2017) have contributed to ecosystem-based management efforts in the North Pacific. Also, cooperation with other international scientific organizations/ programs have been developing, such as MSEAS 2016 which was co-sponsored by PICES, ICES, Ifremer, *etc*. Key questions that structure these scientific activities are: (a) How do marine ecosystems support human well-being and (b) How do human communities support sustainable and productive marine ecosystems? This Topic Session addressed various aspects of marine socio-ecologic systems, and particularly research that addressed the above two questions.

Summary of presentations

At the beginning of the session, Co-Convenor, Ian Perry, introduced the outline of this session, *i.e*., the morning session was about the summary of the outcomes from the PICES/MAFF project on "Marine Ecosystem Health and Human Well-being (MarWeB)", and the afternoon was devoted to the HD-Paper session. Mitsutaku Makino, the first speaker, presented a summary presentation of the MarWeB project, in which he introduced the concept of *Sato-Umi* and the framework of the project with some of the main results. After his presentation, a short discussion on how to incorporate the local opinions/needs into the project, and the importance of multiple stressors was held.

Invited Speaker, Suhendar Sachoemar (BPPT, Indonesia) discussed the *Sato-Umi*/Gampita activities in Indonesia. As a form of *Sato-Umi*, and as a case study of the MarWeB project, he explained the introduction of the Integrated Multi-Trophic Aquaculture (IMTA) into the shrimp aquaculture in Indonesia, and how it was disseminated to the Indonesian coastal areas. The market demands for the multiple products form the IMTA was discussed on the floor. Dr. Makino, presenting on behalf of Mark Wells, then gave a more detailed report of the IMTA pond experiment conducted in Indonesia. After the presentation, the importance of ammonia as an index for the water quality was emphasized. As the final presentation from the MarWeB project, Invited Speaker, Charles Trick, talked about the participatory community needs assessment activities in Guatemala. After his presentation, a short discussion about the differences amongst the sites (between Guatemala and Indonesia, and between cites in Guatemala) was held. It was emphasized that the community participation and the bottom-up approach for social-ecological systems analysis takes time.

The afternoon was devoted to the HD-paper session which had eight presentations which covered a wide range of topics and academic approaches, and evidenced the breadth and growing depth of PICES human dimensions research. The first talk presented a proposal for large-scale marine special planning (MSP) in the North Pacific. The presenter, Amrtatjuti V. Sereda, is an early career scientist, and very positive and enthusiastic. After the presentation, there was a short discussion on the history and status of MSP in Russia.
The second speaker, Akash Sastri on behalf of S. Kim Juniper, described community observatory activities in British Columbia. The program has installed ocean observing instruments near traditional communities and shares the data stream of ocean conditions with the communities through a webpage. Instrument installation and maintenance entail regular interactions with the communities, including education outreach programs. After his presentation participants discussed the design of citizen science programs and how to engage the community, share the data, and organize effective outreach, *etc*.

Wei Liu, an early career scientist from China, then made a presentation on the index system for the *ecological civilization* in China after which there was some discussion on how to weight or how to design the questionnaire.

Konstantin Osipov, a TINRO-Center officer for scientific communication, discussed the media-coverage and promotion of marine research in Russia. His talk provided valuable information about the difficulties and importance of the science communication, which is one of the main activities of the FUTURE program.

Dr. Makino, on behalf of Stephen Kasperski, reported the ground-truthing of social vulnerability indices of Alaska communities. The presentation reported on comparisons between socioeconomic information derived from secondary data sources with information distilled from in-person ethnographic interviews from several communities in western Alaska. The analysis demonstrated that secondary data on fishing engagement and participation are consistent with interview responses, particularly in larger communities but not very consistent for some demographic and social indicators, especially in smaller communities. This work represents a very important contribution and is relevant to the development of indicator time series for inclusion in NPESR3.

Keith Criddle discussed the permit buyback program in Alaskan salmon fisheries and its economic importance. For sellers, the initial buyback (in 2008) provided a price premium of about $11,000 above the market-clearing permit price. The buyback also created a windfall gain of nearly $30,000 to the value of remaining permits. Because the initial buyback was financed by a federal grant, the buyback represented a transfer payment from U.S. taxpayers to license holders.

Konstantin Zgurovsky, from WWF Russia, reported on collaborative activities with bottom-trawling fishers to protect the vulnerable marine areas in Barents Sea. The collaboration led to the voluntary adoption of modified

trawl doors, roller gear, and low drag-coefficient footropes that, together, reduce the destruction of the bottom ecosystems. Participants discussed that the importance of incentives such as the reduction of the fuel costs are important to implement this new technology widely. Finally, Patrick O'Hara reported on innovative approaches to monitoring non-AIS vessels in in British Columbia. This is quite new topic of ocean monitoring technology, and floor discussions encouraged further development of these approaches.

At the end of the session, the Co-Convenors offered concluding remarks, thanking all the participants and presenters.

List of papers

Oral presentations

PICES-Japan MAFF Project "MarWeB"
Mitsutaku Makino, Ian Perry

Sato-umi concept and sustainable aquaculture implementation in the coastal area of Indonesia (Invited)
Suhendar I Sachoemar, Mitsutaku Makino, Mark L. Wells, Ratu Siti Aliah, Masahito Hirota and Tetsuo Yanagi

Integrated multi-trophic aquaculture in traditional pond aquaculture, Indonesia
Suhendar I Sachoemar, Warih Hardanu, Mark Wells, Mitsutaku Makino, Masahito Hirota, Ian Perry, Ratu Siti Aliah, and Atri Triana Kartikasar

When the nets leave the waters: A community needs assessment for the lost fishing communities of Pacific coastal Guatemala – Balancing ocean and human health (Invited)
Charles G. Trick, Vera L. Trainer, William P. Cochlan, and Julian Herndon

Towards international cooperation in the development of Marine Spatial Plans for the North Pacific: Economic, social, and environmental dimensions
Amrtatjuti V. Sereda and Vyacheslav Lobanov

Development of broadly distributable metrics of ocean conditions using real-time data and marine 'community-observatories' along the British Columbia coast
S. Kim Juniper, Maia Hoeberechts, Marlene Jeffries, and Akash Sastri

An index system for assessment of the performance of construction strategies marine ecological civilization
Wei Liu, Shang Chen, Tao Xia and Linhua Hao

Features of media-covering and promotion of marine and fishery researches in Russia
Konstantin Osipov

Groundtruthing social vulnerability indices of Alaska fishing communities
Anna N. Santos, Kim Sparks, Stephen Kasperski, Amber Himes-Cornell

The economic importance of wild Pacific salmon
Keith R. Criddle

Retrospective benefit-cost analysis of federally-funded buyback programs for Southeast Alaska salmon purse seine permits
Keith R. Criddle and Jennifer Shriver

Results of positive partnership of WWF, scientists and fishermen in the Vulnerable Marine Ecosystems conservation in the Arctic
Konstantin Zgurosvsky and A. Pavlenko

Capturing non-AIS vessel data in Southern Resident Killer Whale (SRKW) critical habitat
Patrick O'Hara, Rosaline Canessa, Norma Serra-Sogas and Laruen McWhinnie

Poster presentations

Fishing alternatives of a local stock of Coonstripe shrimp Pandalus hypsinotus for sustainability of the local communities in southern Hokkaido, Japan
Naoki Tojo, Takaaki Mori and Yasuzumi Fujimori

Seafood consumption and pesticide accumulation in humans in the Russian Far East (Primorsky Kray)
Olga N. Lukyanova, Vasiliy Yu. Tsygankov and Margarita D. Boyarova

POC Topic Session (S9)
Meso-/submeso-scale processes and their role in marine ecosystems

Co-Convenors: *Hiromichi Ueno (Japan), M. Debora Iglesias-Rodriguez (USA), Sachihiko Itoh (Japan), Elena Ustinova (Russia)*

Invited Speakers:
Sergey Prants (V.I. Il'ichev Pacific Oceanological Institute (POI), Russia)
Rob Suryan (Oregon State University, USA)

Background

Mesoscale and submesoscale (~1 to 100 km) currents and fronts such as eddies, streamers, filaments and streaks are ubiquitous features of the ocean. These complex but coherent patterns in the sea surface are often captured by satellite imagery and partially reproduced by high-resolution numerical ocean-circulation/biogeochemical models. While the interior structure of these fine-scale features and its dynamics are still in exploration, it has been well known that there are tight linkages between physics and distribution of marine organisms at these scales, which includes dispersion, patchiness and aggregations of plankton, nekton, birds and mammals. Understanding the structure and physics of these horizontal fine-scale features, their effects on distribution and production of marine organisms, and how they influence the functioning of the marine ecosystem and its services such as fisheries yield and efficiency is necessary in order to assess likely system changes and shifts under a changing climate. This Topic Session's aim was to discuss the interaction between physics, chemistry, biology and fisheries of the ocean at the meso- and sub-mesoscale based on observations and modeling. Presentations included various levels of organization (physics, biogeochemistry, fish/fisheries and other marine predators) from different areas in the PICES region.

Summary of presentations

The session included presentations focusing on the impact of meso-/submesoscale processes on the ecosystem and fisheries as well as on the circulation and water-mass formation. Four oral presentations including two invited presentations were given in the morning session, and nine oral presentations were given in the afternoon session. This session also includes four poster presentations.

The first Invited Speaker, Dr. Sergey V. Prants, reviewed a methodology for computing and analyzing different kinds of Lagrangian maps for a large number of synthetic tracers advected by altimetry-derived or numerically-generated velocity fields. He also introduced a number of examples demonstrating the effectiveness of that tool to analyze evolution of mesoscale eddies, to estimate a risk of contamination of specified eddies by Fukushima-derived radionuclides, and to identify Lagrangian fronts favorable for fishing in the Asian marginal seas and the northwestern Pacific. The second Invited Speaker, Dr. Robert M. Suryan, reviewed highly migratory marine species like seabirds transiting within large marine ecosystems and across entire ocean basins to locate important foraging areas. He also described characteristics of meso- and submeso-scale features targeted by seabirds throughout the North Pacific Ocean, using a combination of satellite-based remote observations and in-situ sampling. Next, Dr. Ayako Yamamoto quantitatively assessed the physical mechanisms that control the transport of mass, heat, nutrients and carbon across the North Pacific and North Atlantic subtropical gyre boundaries using the eddy-rich ocean component of a climate model coupled to a simple biogeochemical model. Dr. Andrey G. Andreev suggested that the mesoscale dynamics, forced by wind stress curl in winter, may determine not only lower-trophic-level organism biomass but also salmon abundance/catch in the Alaskan Stream region.

In the afternoon session, Dr. Annalisa Bracco discussed the submesoscale vertical pump of an anticyclonic eddy and indicated that different submesoscale processes contributed to the vertical transport depending on depth and distance from the eddy center, with frontogenesis playing a key role. Dr. Dmitry V. Stepanov talked about mesoscale eddies and eddy energy sources in the Okhotsk Sea during the winter–spring period, 2005–2009 based on an eddy-permitting ocean circulation model. Dr. Maria N. Pisareva discussed the mesoscale process in the Barrow Canyon – upwelling using timeseries from a mooring deployed from 2002–2004 near the head of Barrow Canyon, together with atmospheric and sea ice data. Dr. Pavel Fayman gave a talk on submesoscale cold-core ($T < 0°C$) eddies observed near the shelf break in Peter the Great Bay in February–March 2010. Dr. Alexander Ostrovskii explored variations of the turbulent eddy diffusivity in the Primorye Current region in the warm season. Dr. Olga Trusenkova discussed the short-term variability of the thermohaline stratification under the seasonal pycnocline in the Primorye Current. Dr. Daisuke Ambe talked about the transportation route and habitat of Japanese eel (*Anguilla japonica*) larvae in association with mesoscale eddy area and submesoscale hydrographic conditions around the habitat of Japanese eel larvae. Dr. Elena Ustinova discussed the problems of the impact of mesoscale processes on migrations and the fishing grounds formation of saury, sardine, and mackerel in the Northwest Pacific. Finally, Dr. Daisuke Hasegawa gave a presentation on the enhanced biological productivity in a warm core ring originally spun off from the Kuroshio Extension in the summer of 2014 migrated to northwest toward the east coast of Japan and then spent about a year at off the Sanriku coast in the Oyashio-Kuroshio transition zone until its extinction in early 2016.

List of papers

Oral presentations

Lagrangian maps as a new tool to simulate transport processes in the ocean (Invited)
S.V. Prants, M.Yu. Uleysky and M.V. Budyansky

Characteristics of meso- and submeso-scale features used by highly migratory marine predators (Invited)
Robert M. Suryan, Rachael A. Orben, Stephanie A. Loredo, Jessica M. Porquez

Roles of the ocean mesoscale in the lateral supply of mass, heat, carbon and nutrients to the Northern Hemisphere subtropical gyres
Ayako Yamamoto, Jaime B. Palter, Carolina O. Dufour, Stephen M. Griffies, Daniele Bianchi, Mariona Claret, John P. Dunne, Ivy Frenger and Eric D. Galbraith

The mesoscale eddy activity in the Alaskan Stream area and its impact on biological productivity
Andrey G. Andreev, Sergey V. Prants, Maxim V. Budyansky and Michael Yu. Uleysky

The submesoscale vertical pump of an anticyclonic eddy
Annalisa Bracco, Yisen Zhong, Jiwei Tian, Jihai Dong, Wei Zhao and Zhiwei Zhang

Mesoscale eddies and eddy energy sources in the Okhotsk Sea during the winter-spring period, 2005-2009
Dmitry V. Stepanov, Vladimir Fomin

On the nature of wind-forced upwelling in Barrow Canyon
Maria N. Pisareva, Robert S. Pickart, Paula S. Fratantoni, Thomas J. Weingartner

Submesoscale eddies in Peter the Great Bay of the East/Japan Sea
Alexander Ostrovskii, Pavel Fayman, Vyacheslav Lobanov, Young-Gyu Park

Variations of the turbulent eddy diffusivity in the Primorye Current region of the northwestern East/Japan Sea in the warm season
Alexander Shatravin, Alexander Ostrovskii, Vyacheslav Lobanov, and Jae-Hun Park

Short-term variability of the thermohaline stratification under the seasonal pycnocline in the Primorye Current zone in the Japan/East Sea
Olga Trusenkova, Alexander Ostrovskii, Alexander Lazaryuk, Vyacheslav Lobanov, Dmitry Kaplunenko, Svetlana Ladychenko

Transportation route and habitat of Japanese eel (*Anguilla Japonica*) larvae in association with mesoscale eddy area
Daisuke Ambe, Daisuke Hasegawa, Makoto Okazaki, Nobuharu Inaba, Takeshi Okunishi, Hiroaki Kurogi, Seinen Chow, Shuhei Sawayama, Tsutomu Tomoda and Tsuyoshi Watanabe

Mesoscale processes influence on migrations and the fishing grounds formation of saury, sardine and mackerel in the Northwest Pacific
Elena I. Ustinova and Viktor N. Filatov

Enhanced biological productivity in a warm core ring
Daisuke Hasegawa, Takeshi Okunishi, Hitoshi Kaneko and Akira Kuwata

Poster presentations

Submesoscale structure in the mesoscale eddies in the western subarctic North Pacific
Yuki Okada, Hiromichi Ueno, Takahiro Tanaka, Sachihiko Itoh

Characteristics of Aleutian eddy and its impact on Chlorophyll distribution
Hiromu Ishiyama, Hiromichi Ueno and Masaru Inatsu

Features of distribution and efficiency of saury fishery in relation to oceanological conditions in South Kuril Region on satellite data in August-November, 2002-2014
Yury V. Novikov, Eugene V. Samko

Near-inertial internal waves observed in the vicinity of an anticyclonic eddy in the southwestern East Sea (Japan Sea)
Suyun Noh and SungHyun Nam

Mesoscale eddies in the East Sea (Japan Sea): Statistical categorization and characterization
KyungJae Lee, SungHyun Nam

Mesoscale and submesoscale coherence from physics to pyhtoplankton
Sachihiko Itoh, Shinya Kouketsu, Hitoshi Kaneko Takeshi Okunishi, Junya Hirai and Fuminori Hashihama

FUTURE Topic Session (S10)
Emerging issues in understanding, forecasting and communicating climate impacts on North Pacific marine ecosystems

Co-Convenors: *Steven Bograd (USA), Sukyung Kang (Korea), Oleg Katugin (Russia) Guangshui Na (China)*

Invited Speakers:
Zhongyong Gao (Third Institute of Oceanography, SOA, China)
Desiree Tommasi (NOAA SWFSC, USA)

Background

'Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems' (FUTURE) is an integrative science program undertaken by the member countries and affiliates of PICES to understand how marine ecosystems in the North Pacific respond to climate change and human activities, to forecast ecosystem status based on a contemporary understanding of how nature functions, and to communicate new insights to its members, governments, stakeholders and the public. While PICES has fostered advances in understanding how environmental and climate variability impacts marine ecosystems, our capacity to forecast these climate-driven impacts, at seasonal to decadal time scales, is less well developed. Similarly, there have been impediments in broadly disseminating results from the FUTURE science program in ways that optimize the utilization of the science. In this session, we provided an assessment of our capacity to forecast climate-driven marine ecosystem changes on seasonal to decadal scales and reviewed strategies for communicating FUTURE and PICES science. Advances in the understanding of climate impacts on marine ecosystems, and a broad dissemination of this information, are essential for preserving a healthy and sustainable North Pacific for FUTURE generations.

Summary of presentations

The ½-day FUTURE Plenary Session was held on September 27 in Vladivostok, Russia. The session was co-convened by Steven Bograd (USA), Sukyung Kang (Korea), Oleg Katugin (Russia) and Guangshui Na (China). A total of 7 presentations (6 orals and 1 poster) was made during the session.

Invited Speaker, Zhongyong Gao (China), reviewed the biogeochemical carbon cycling of the Bering Sea and the Western Arctic Ocean conducted by the Chinese National Arctic Research Expedition (CHINARE) and reported a northward shift of some fish distributions in the Bering Sea. The second Invited Speaker, Desiree Tommasi (USA), presented an overview of advances in seasonal to multi-annual prediction of fisheries relevant environmental variables. Desiree used a suite of case studies to highlight the value of short-term predictions to fisheries management decisions.

Michael Jacox assessed the skill of seasonal sea surface temperature (SST) forecasts in the California Current System (CCS) using output from multiple Global Climate Forecast Systems, and described mechanisms that underlie SST predictability. He also reported implications for regional downscaling of seasonal forecasts and for short-term management of living marine resources. Ian Perry presented the changes of the pelagic plankton and demersal fish communities of Pacific Canada over the past four decades and described some of the potential drivers of these changes. Moojin Kim presented biotic and abiotic impacts on walleye pollock population in Korean waters during the last five decades. Finally, Steven Bograd provided an overview of the FUTURE science program, highlighting recent advances and identifying remaining research gaps.

Following the presentations, Drs. Kang and Bograd led a plenary discussion of ongoing FUTURE activities and ideas for the next PICES integrative science program. To kick off the discussion, the activities and plans of three new FUTURE-relevant Working Groups were summarized: Peter Chandler presented on the Working Group on the *Third North Pacific Ecosystem Status Report* (WG 35), Xiujuan Shan on the Working Group on *Common Ecosystem Reference Points across PICES Member Countries* (WG 36), and Michael Jacox on the Working Group on *Climate and Ecosystem Predictability* (WG 40). The Working Group representatives and Session conveners then facilitated an audience discussion on the activities and future of the FUTURE program. There was broad support to convene regular FUTURE plenary sessions, or a FUTURE Mini-Symposium, at future Annual Meetings as well as joint workshops to allow better communication and collaboration between Expert Groups.

List of papers

Oral presentations

Biogeochemical carbon cycling of Bering Sea and their impacts on the Western Arctic Ocean in the past two decades (Invited)
Zhongyong Gao, Liqi Chen, Min Chen, Heng Sun, Jinlu Tong, Qi Li, Longshan Lin, and Di Qi

Climate predictions to support fisheries management in a changing ocean (Invited)
Desiree Tommasi

Seasonal forecast skill in the CCS and its connection to climate variability
Michael Jacox, Michael Alexander, Steven Bograd, Elliott Hazen, Gaelle Hervieux, and Desiree Tommasi

The pelagic plankton and demersal fish communities of Pacific Canada over the past four decades: Ecosystem variability or change?
R. Ian Perry, Moira Galbraith, Ken Fong, Brenda Waddell, Roy Hourston, Rick Thomson

Biotic and abiotic impacts on walleye pollock (*Gadus chalcogrammus*) population off the east coast of Korea over the last 5 decades
Moojin Kim, Sukyung Kang and Suam Kim

The FUTURE Science Program: Highlights and next steps
Steven Bograd, Sukyung Kang, and FUTURE SSC

FIS/POC Session (S11)
Environmental variability in Arctic and Subarctic ecosystems and impacts on fishery management strategies

Co-Convenors: *Mikhail Stepanenko (TINRO-Center, Russia), Mikhail Zuev (TINRO-Center, Russia), Thomas Helser (AFSC, Seattle, USA)*

Invited Speaker: *Yury Zuenko (Pacific Fisheries Research Centre (TINRO-Centre), Russia)*

Background

Environmental variability in Arctic and Subarctic ecosystems affects the recruitment, abundance, behavior and the seasonal spatial distribution of fish and invertebrate populations which present challenges for fishery management strategies. Understanding environmental driven changes in fish populations can be used to improve predictions of assessed populations and may positively impact recreational fishing, commercial harvest and fishery-dependent coastal communities. This session explores the impacts of environmental variability projections to applied fishery problems in Arctic and Subarctic regions and the development of environmentally enhanced strategies of management.

Summary of presentations

In this ½-day Topic Session, held September 28, reports were presented by Dr. Sei-Ichi Saitoh *et al*. and Dr. Andrei Krovnin *et al*., and by Dr. Yury Zuenko *et al*. who gave a Plenary talk. The presentations of Drs. Lisa Eisner and Thomas Helser were cancelled as they were unable to attend the Annual Meeting.

Dr. Sei-Ichi Saitoh presented a report entitled "*Assessing biodiversity patterns of fish resources in the Eastern Bering Sea*" and concluded, from investigations of biodiversity in the Eastern Bering Sea from 1993–2016 that there exists considerable heterogeneity in communities which has important implications of fishery management.

Dr. Andrei Krovnin reported on "*Changes in recruitment of Pacific cod in the northwestern Bering Sea and their relation to climate variation in the Northern Hemisphere*". VNIRO scientists investigating the annual variation of Pacific cod recruitment found that recruitment depends on changes in environmental conditions and that these changes determined large-scale climate processes in the Northern Hemisphere.

Dr. Yury Zuenko's Plenary presentation was on "*Environmental impacts on zooplankton and pollock fishery in the northern Bering Sea*". The TINRO-Center scientists have found a relationship between temperature conditions and changes in pollock feeding which has an influence on it fisheries in the northern Bering Sea.

List of papers

Oral presentations

Environmental impacts on zooplankton and pollock fishery in the northern Bering Sea (Plenary)
Yury Zuenko and Eugene Basyuk

Assessing biodiversity patterns of fish resources in the Eastern Bering Sea
Irene D. Alabia, Jorge Garcia Molinos, Sei-Ichi Saitoh, Takafumi Hirata, Toru Hirawake and Franz J. Mueter

Changes in recruitment of Pacific cod in the northwestern Bering Sea and their relation to climate variations in the Northern Hemisphere
Andrei Krovnin, Boris Kotenev, Nikolai Antonov and George Moury

Poster presentations

Environmental impacts on the Bering Sea pollock spatial distribution, migrations and evaluating fishery management
Mikhail A. Stepanenko, Elena V. Gritsay

Distribution patterns of cephalopods on the Emperor Seamounts as revealed from bottom trawl catches
Genndayi A. Shevtsov, Mikhail A. Zuev, Aleksandr L. Figurkin, and Oleg N. Katugin

The specifics of gonad maturation and the terms of spawning in saffron cod (*Eleginus gracilis* (Til.)) on the coasts of Kamchatka
Olga Novikova

BIO Topic Session (S12)
Seasonal and climatic influences on prey consumption by marine birds, mammals and predatory fishes

Co-Convenors: *Andrew Trites (Canada), Rob Suryan (USA), Mike Seki (USA), Tsutomu Tamura (Japan)*

Invited Speaker:
Jock Young (CSIRO, Tasmania, Australia)

Background

Prey consumption by mid to upper trophic level marine birds, mammals, and predatory fishes is influenced by changes in prey abundance, prey availability, ocean climate and anthropogenic stressors. However, the extent to which predators can adapt to such changes and still meet their minimum energy requirements is uncertain. Understanding dietary changes of predators under varying environmental conditions is critical to informing prey consumption models and estimating relative contributions of bottom-up vs. top-down forcing in marine systems. Understanding how prey consumption of marine birds, mammals and predatory fishes will respond to climate change is also needed to predict changes in energy flow pathways in ecosystems, and has consequences for conservation initiatives and ensuring the sustainability of commercially important fishery resources. For this session, presentations were requested on topics that address (a) the significance of seasonal changes in prey consumption on energy budgets and ecosystem dynamics, (b) the effects of changes in water temperature and other climatic variables on food requirements, (c) relationships between dietary shifts and population trends, (d) the limits of plasticity in prey selection, and (e) how prey consumption of birds, mammals, and predatory fishes is affected by the recent extreme climatic events—the Blob, El Niño, ice cover changes, *etc*.

Summary of presentations

The session's Plenary Speaker, Dr. Jock Young (CSIRO, Tasmania, Australia), introduced the development and application of a global data base that aims to bring data from different methodologies to examine the impact of ocean warming on three tuna species—yellowfin (*Thunnus albacares*), bigeye (*T. obesus*) and albacore (*T. alalunga*) tuna. He showed how the available data can assist ecosystem-based management models by providing macro-scale understanding of oceanic food webs.

Robert Suryan (replacing Stephani Zador who was unable to attend) reported on factors affecting change in the diets of common murres at nesting colonies in the California Current System. Dynamic local- and basin-scale

drivers including climate indices and water column metrics correlated with temporal changes in prey species consumed, whereas static coastal topography and bathymetry correlated with spatial variability in diets. Furthermore changes in nutrient sources and potentially trophic level (additional analyses are underway) were linked to physical climate drivers. Such climate-diet relationships are important to include when considering spatial and environmental variability in prey consumption models.

Jumpei Okado introduced "*Climate and prey consumption by Rhinoceros Auklets and Japanese Cormorants breeding*". He and his colleagues found that climate change had a significant effect on prey consumption. He also pointed out that diets of auklets are often different between parents and chicks. They estimated prey consumption using samples of stomach contents of adults and bill-loads for chicks collected in 2004–2005 (warm regime) and 2014–2015 (presumed cold regime).

Miran Kim reported on "*Breeding phenology and diet shift of seabirds in South Korea*". She and her team analyzed carbon and nitrogen stable isotopes of chick body feathers on Hongdo Islet to investigate annual change of diet from 2002 to 2016. They found that carbon and nitrogen stable isotope values tended to increase, which may reflect marine environmental change in South Korea. The sea surface temperature in the waters of South Korea has increased slightly in the last 40 years.

Xuelei Zhang reported on an integrated study of marine mammals in the Southeast Asia. Some methods and preliminary results were presented from regional research efforts jointly funded with the China–ASEAN Maritime Cooperation Fund and other partners.

Selina Agbayani presented "*Bioenergetic requirements of migrating eastern North Pacific grey whales in the face of climate change*". She and her co-author derived daily food requirements (*e.g*., kg of amphipods, mysid shrimp, *etc*.) for all age classes of grey whales. Their goal is to predict future mortality rates as a function of varying prey densities due to climate change. They showed how bioenergetic models can be used by managers and policy makers to assess and anticipate the likelihood of climate-induced mortality events occurring.

Tsutomu Tamura reported on the results of "*Estimation of prey consumption by cetaceans in the western North Pacific-Update to Hunt et al. (2000)*". The assessment of prey consumption was based on 1) recently available abundance estimates of cetaceans (after 2000), 2) daily prey consumption rates of cetaceans estimated, 3) estimated biomass of cetaceans by use of average body weight and abundance, and 4) composition of prey species of cetaceans. However, more information is needed on the abundance, body weight and prey composition of cetaceans to address a more realistic strategy for fisheries management and the conservation of cetaceans in future.

Hiroko Sasaki presented on "*Spatial estimation of prey consumption by sei whales in the western North Pacific during the summers of 2008 and 2009*" using a density surface model (DSM) approach. The product of the DSM and individual consumption models yielded a spatial pattern of prey consumption in the survey area.

Andrew Trites introduced simple models used to predict daily energy requirements and prey consumption by marine mammals in the North Pacific. He reviewed all existing estimates of energy requirements for marine mammals to identify species that have well supported estimates—which he then used to derive generalized equations that predict the energy requirements of all pinnipeds and cetaceans as a function of body mass. These new equations are superior to existing generalized equations that have been used in the past to estimate energetic needs, and can be used to derive estimates of prey consumption for species of marine mammal with unknown energy requirements in the North Pacific.

Conclusion

This session drew diverse papers focussed on diets and prey consumption of top trophic level marine birds, mammals and predatory fishes. Four of the papers presented addressed methods to estimate prey consumption of marine mammal species that inhabit the North Pacific. Three of these papers made simplifying assumptions about average energy requirements, while one paper emphasized the importance of determining spatial consumption. Two of the presentations addressed the effects of climate on prey consumption by seabirds, and drew attention to shifts that can occur in sea bird diets. Overall, the collection of presented studies in this session contributed to the efforts of the Section on *Marine Birds and Mammals* to estimate prey consumption of birds and mammals. They provided new methods to estimate prey consumption of marine mammals and gave better understanding and insights into the existing databases of diets and population estimates that can be used to further this effort. The presentations also drew attention to the need to address dietary shifts and effects of climate change on the availability of prey and energy requirements of marine birds. All are important considerations that need to be reflected in future estimates of prey requirements and prey consumption of marine birds and mammals in the North Pacific.

List of papers

Oral presentations

From regional to global-scale understanding of tuna food webs (Plenary)
Jock W. Young (and the CLIOTOP trophodynamics team)

Spatial and temporal variability in diets of common murres
Robert M. Suryan, Amanda J. Gladics, Alessandra J. Jimenez-Yap, Jane E. Dolliver

Climate and prey consumption by Rhinoceros Auklets and Japanese Cormorants breeding in Teuri Island, Hokkaido, Japan
Jumpei Okado, Motohiro Ito and Yutaka Watanuki

Breeding phenology and diet shift of seabirds in South Korea
Miran Kim, Youngsoo Kwon, Mijin Hong, Ho Lee, Hong-chul Park and Na-yeon Lee

Integrated study of marine mammals: An update of the regional project in the Southeast Asia
Xuelei Zhang, Kongkiat Kittiwatanawong, Saifullah Arifin Jaaman

Bioenergetic requirements of migrating eastern North Pacific grey whales in the face of climate change
Selina Agbayani, Andrew W. Trites

Estimation of prey consumption by cetaceans in the western North Pacific-Update to Hunt et al. (2000)
Tsutomu Tamura

Spatial estimation of prey consumption by sea whales in the western North Pacific during the summers of 2008 – 2009: Density surface model approach
Hiroko Sasaki, Tsutomu Tamura, Takashi Hakamada, Koji Matsuoka, Hiroto Murase and Toshihide Kitakado

Simple models to predict daily energy requirements and prey consumption by marine mammals in the North Pacific
Andrew W. Trites

BIO Topic Session (S13)
Joint PICES-ICES Session on Anthropogenic effects on biogeochemical processes, carbon export and sequestration: Impact on ocean ecosystem services

Co-Convenors: *Richard B. Rivkin (Canada), Louis Legendre (France), Nianzhi Jiao (China), Robin Anderson (DFO, Canada)*

Invited Speaker:
Farooq Azam (Scripps Institution of Oceanography, UC San Diego, USA)

Background

Anthropogenic activities influence a suite of oceanic properties, including temperature, circulation patterns, and nutrient inputs and distributions. These activities in turn can alter biogeochemical processes and fluxes that influence marine foodwebs and ecosystem services, for example the biologically mediated ocean carbon pumps, fisheries, and other renewable marine resources. These responses of the ocean to changes in anthropogenic forcings will vary with the magnitude and types of impact, ocean region, and foodweb type. The responses may be local or global in scale. Anthropogenic forcing may alter the magnitude and even the direction of services in complex ways, and understanding how marine systems such as carbon pumps will respond to the changing ocean in the anthropocene requires consideration of cumulative effects of multiple activities.

The first step in the carbon pump process is the transfer of atmospheric CO_2 into the ocean, where it is taken up by phytoplankton, before organic carbon is synthesized, a portion of which is transferred to pelagic and benthic foodwebs (a regional ecosystem service). Some of the organic carbon can be sequestered in the deep ocean or sediments after being exported from the surface, or by transformation into long-lived dissolved organic compounds (a global ecosystem service). Marine carbon export and sequestration currently makes up about 50% of the anthropogenic CO_2 and is hence among the most important earth-ecosystem services provided by the oceans. Biologically mediated carbon cycles also support other important ecosystem services such as aquaculture and fisheries which may also be altered.

This session invited contributions from researchers who use observational, experimental, and modeling approaches to characterize and assess the effects of changing ocean biogeochemical processes and fluxes on the biologically mediated ocean carbon pumps and other ecosystems services, including fisheries and other renewable marine resources. The purpose of this topic session was to address the main focus of the joint PICES/ICES Working Group on *Climate Change and Biologically-Driven Ocean Carbon Sequestration*.

List of papers

Oral presentations

Localized high abundance of Marine group II archaea in the subtropical Pearl River Estuary: Implication for their niche adaptation
Chuanlun Zhang, Wei Xie, Haiwei Luo, Senthil K. Murugapiran, Jeremy A. Dodsworth, Songze Chen, Ying Sun, Brian P. Hedlund, Peng Wang, Huaying Fang, Minghua Deng

Anthropogenic blue carbon: Assessing the contribution of seaweed aquaculture for carbon uptake and storage
M. Robin Anderson and Richard B. Rivkin

Viruses, carbon sequestration and the biological pump
Curtis A. Suttle

Climate change, phytoplankton export and carbon equestration
Uta Passow

A model simulation of future biogeochemical conditions along the British Columbia Continental Shelf
Angelica Peña, Isaac Fine, and Diane Masson

Changes in plankton assemblages and role of microbial loop in biogeochemical carbon cycles associated with coastal upwelling in the Ulleung Basin, East Sea

Jung-Ho Hyun, Eun-Jin Yang, Jae-Hoon Noh, Kyeong-Hee Kim, Sung-Han Kim, Jin-Sook Mok, Dongseon Kim, Sinjae Yoo

Response of spring diatoms to CO_2 availability in the western North Pacific
Koji Suzuki, Hisashi Endo, Koji Sugie and Takeshi Yoshimura

Silicate weathering and CO_2 consumption rates: new insights from rivers of the Primorskii Krai (Russia)
Galina Yu. Pavlova, Pavel Ya. Tishchenko, Pavel Yu. Semkin and Elena A. Vakh

Acidification of the interior of the Japan/East Sea
Pavel Tishchenko, Vyacheslav Lobanov, Dmitriy Kaplunenko, Tatyana Mikhajlik, Kyung-Ryul Kim, and Dong-Jin Kang

Development and applications of high throughput metagenomics technologies to marine biogeochemistry
Jizhong Zhou

Microbes and ocean biogeochemical processes
Richard B. Rivkin and M. Robin Anderson

Poster presentations

DOM and its optical characteristics on the East Siberian Arctic shelf: The spatial distribution and its inter-annual variability (2003-2016)
Svetlana P. Pugach, Irina I. Pipko, Alexey S. Ruban, Igor P. Semiletov

BIO Contributed Paper Session

Co-Convenors: *Se-Jong Ju (Korea), Debora Iglesias-Rodriguez (USA)*

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. In this session, all papers on biological aspects of marine science in the PICES region were welcome. Contributions from early career scientists were especially encouraged.

Summary of presentations

The BIO Paper Session at PICES-2017 had decent participation, with a total of 7 oral presentations and 6 poster presentations. Oral sessions were held over a half day and well attended (over 30 participants). Presentations spanned a wide range of biological issues focusing around phytoplankton (1), zooplankton (4), benthos (1), and marine birds and mammals (2). Similarly, poster presentations covered a broad spectrum of biological topics. The convenors recognized that this regular session provides important opportunities for PICES scientists to present their results and for early career scientists to participate in PICES activities.

Dr. Kazuaki Tadokoro discussed the geographical variation of community structure and biodiversity of Bacillariophyceae (diatom) in the western North Pacific Ocean using the data collected by the Japan Meteorological Agency from 1950 to 1990. Two hundred and seventy-one species were noted and 4 communities (with two subarctic and two subtrophic groups) were geographically classified. While the higher number of species appeared north of 40°N in the coastal area, a higher number of cells was found in the subtropical area.

Ms. Garam Kim presented on the feeding impact of the different developmental stages of *Calanus sinicus* on phytoplankton from the northern East China Sea to understand an ecological role of *C. sinicus* through *in-situ* gut pigment content analysis. Results confirm that the feeding of copepodites, particularly with the highest value at stage CV, is more active than that of adults. However, no significant correlations were observed between feeding of *C. sinicus* and environmental factors.

Mr. Takuya Ohnishi talked about the development of a new method to evaluate *in-situ* starvation of female *C. sinicus* by identifying differentially expressed genes under starvation. This study suggested that the expression level of Vitellogenin gene, a precursor of egg yolk protein, can be an indicator for starvation and can also be useful for predicting egg production of female *C. sinicus*.

Dr. Shinji Shimode compared egg sizes and egg production rates (EPR) between two most dominant planktonic families, Eucalanidae (12 species) and Calanidae (9 species). Result indicate that the subtropical and tropical surface species of the two families are "K" reproductive strategists, *i.e*., larger egg sizes and lower EPR, while the ontogenetic vertical migration species are "r" reproductive strategists, *i.e*., smaller egg sizes and high EPR.

Mr. Lianggen Wang showed the distribution and impacts of prey composition and abundance (mainly copepods) of Chaetagonatha (Sagittidea) using net sampling data. Among 24 taxa identified, 6 species (*Flaccisagitta enflata*, *Serratosagitta pacifica*, *Mesosagitta minima*, *Ferosagitta ferox*, *Pterosagitta draco* and *Krohnitta pacifica*) were dominant at about 58% of total abundance with seasonal variations. He concluded that the abundance and distribution of chaetognaths could be coupled with those of their potential prey in the tropical oceanic zones.

Mr. Jungsoo Park talked about the role of the phycospheric bacteria community for the growth of a promising biofuel feedstock *Tetraselmis striata* (KCTC1432BP). A total of 26 bacterial strains were isolated and identified from the phycosphere of *T. striata* mass culture. Among these strains, *Pelagibaca bermudensis* (KCTC 13073BP) was found to enhance the growth of biofuel feedstock *T. striata* without any negative effects on the native seawater bacterial communities.

Ms. Soeon Ahn presented the results of potential habitat range and habitat preference for the Indo-Pacific bottlenose dolphin population around Jeju Island using a Maxent model to conserve this endangered species from environmental changes. The model results predicted that the northern part of Jeju coastal waters would be a highly suitable habitat with water depth as a key factor in affecting their distribution. However, model results were not well matched with sighting data. She suggested that this discrepancy could be the result of recently increased human activities, particularly construction of wind power mills, which was not accounted for in the model.

List of papers

Oral presentations

Geographical variation of community structure of *bacillariophyceae* (diatom) in the western North Pacific Ocean
Kazuaki Tadokoro, Tsuyoshi Watanabe

Feeding impact of the planktonic copepod *Calanus sinicus* on phytoplankton in the northern East China Sea in late spring
Garam Kim and Hyung-Ku Kang

Identification of gene markers associated with starvation in female *Calanus sinicus* Brodsky (Calanoida: Copepoda)
Takuya Ohnishi, Junya Hirai, Shinji Shimode and Atsushi Tsuda

Egg sizes and life histories of the two planktonic copepod families Eucalanidae and Calanidae
Shinji Shimode, Kazutaka Takahashi, Minamo Hirahara, Mana Mikawa, Tomohiko Kikuchi and Tatsuki Toda

Seasonal variation of arrow-worm (Chaetognatha: Sagittidea) assembages and impact of small copepods in the south-central South China Sea
Lianggen Wang, Feiyan Du, Xuehui Wang, Yafang Li, Jiajia Ning, Lei Xu

Understanding of mutualistic interaction between marine phytoplankton (*Tetraselmis striata*) and bacteria (*Pelagibaca bermudensis and Stappia* sp.) in phycosphere
Jungsoo Park, Myung-Soo Han

Environmental predictors of habitat suitability and spatial distribution of Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) in Jeju waters
Soeon Ahn, Sinjae Yoo and Hyun Woo Kim

Poster presentations

Diatom biogeography: Abundance and species diversity of a major phytoplankton group in Korean coastal waters during winter
Seung Won Jung

Seasonal and year-to-year variations in the surface copepodid population and egg production rate of *Eucalanus californicus* (Copepoda: Calanoida) in Sagami Bay, Japan
Yusuke Ikawa, Masumi Inui, Tomohiko Kikuchi, Tatsuki Toda and Shinji Shimode

Coastal currents and effects of freshwater discharge on zooplankton aggregations in the Sea of Okhotsk
Natalia Shlyk, Konstantin Rogachev and Eddy Carmack

Transcriptome profling of *Galaxea fascicularis* and its endosymbiont *Symbiodinium* reveals chronic eutrophication tolerance pathways and metabolic mutualism between partners
Jianming Chen

Zooplankton production parameters in the north-western Bering Sea in the present period
Elena Dulepova

Pathologic survey of protozoan parasites in different marine bivalve hosts in the south coast of Korea using PCR and histology
Hye-Mi Lee, Hyun-Sil Kang, Young-Ghan Cho, Hee-Jung Lee, Kwang-Sik Choi

FIS Contributed Paper Session

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

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

Multiple-trait genetic evaluation of the Pacific white shrimp *Litopenaeus vannamei* in China
Jie Kong and Sheng Luan

Growth and survival of jack mackerel *Trachurus japonicus* juveniles in the Tsushima Warm Current Motomitsu Takahashi, Chiyuki Sassa, Satoshi Kitajima and Youichi Tsukamoto

An overview of the culturing and breeding of *Fenneropenaeus chinensis* in China
Xianhong Meng, Jie Kong, Qingyin Wang,Kun Luo, Sheng Luan, Qiang Fu and Xiaoli Shi

Gonadal abnormalities in walleye pollock *Theragra chalcogramma*
Kristina Zhukova, Andrey M. Privalikhin

Scales of variability in forage fish populations: Comparing interpretations of ichthyoplankton and sedimentary records
Ryan R. Rykaczewski, Brendan D. Turley and Rebecca G. Asch

Ichthyoplankton succession and assemblage structure in the Bohai Sea during the past 30 years since the 1980s
Xiaodong Bian, Xianshi Jin, Ruijing Wan

Development of a growth prediction model for Japanese scallop along the Okhotsk coast of Hokkaido, Japan using RS and FRA-ROMS
Yang Liu, Sei-Ichi Saitoh, Hiroshi Kuroda, Shouyi Yuan and Yongjun Tian

Long-term dynamics of the greenland halibut population in the Okhotsk Sea
Nadezhda Aseeva

Seasonal distribution of commercial concentrations of saffron cod (*Eleginus gracilis* (Til.)) on the shelf of West Kamchatka
Olga Novikova

Poster presentations

Denitrification effect, substrate enzymatic activities and microbial information in an integrated vertical-flow marine constructed wetlands
Yueyue Li, Yanyan Wang, Keming Qu and Zhengguo Cui

Histological observation of hermaphroditism of chum salmon *Oncorhynchus keta* (Walbaum, 1792)
Zhukova Kristina, Sergey S. Ponomarev

Development of habitat suitability index models of demersal fishes off the eastern coast of Japan
Hiromichi Igarashi, Yoichi Ishikawa, Yusuke Tanaka, Takehisa Yamakita, Misako Matsuba, Yumiko Yara and Katsunori Fujikura

Estimation of trawl selectivity for four cephalopod species in the Yellow Sea
Peng Sun, Yongjun Tian, Runlong Sun, Zhenlin Liang

Evaluation of the increasing trend of Japanese sardine *Sardinops melanostictus* recruitment in the waters north and west off Kyushu island, Japan
Akira Hayashi, Kei Suzuki, Soyoka Muko, Tohya Yasuda, Mari Yoda, Hiroyuki Kurota, Seiji Ohshimo, Motomitsu Takahashi

Development of stereo camera methodologies to improve pelagic fish biomass estimates and inform ecosystem management in marine waters
Jennifer Boldt, Kresimir Williams, Chris Rooper, Rick Towler, Stéphane Gauthier

Migrations of rat-tail and greenland halibut in the Okhotsk Sea
Vladimir Tuponogov and Nadezhda Aseeva

Environmental influence on Pacific Halibut *Hippoglossus stenolepis* spatial distribution and migration in the Eastern Okhotsk Sea
Roman Novikov

MEQ Contributed Paper Session

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

Background

The Marine Environmental Quality Committee (MEQ) has a wide range of interests spanning from regular research area to emerging marine environmental issue. 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). The Section on *Ecology of Harmful Algal Blooms in the North Pacific* (S-HAB) and Working Group on *Emerging Topics in Marine Pollution* (WG 31) had their own workshop and topic session, respectively, so the number of contributions for the MEQ-P session was not as many as in previous years. A total of 13 papers were approved and scheduled in this session before the Annual Meeting, in which 4 papers were selected for oral presentations, and 7 papers were arranged for Posters.

Summary of presentations

The MEQ Paper Session at PICES-2017 had good participation and was well attended. Oral presentations for this ½-day session were given during the morning of September 29. The topics included the assessment of the radionuclide distribution in Northwest Pacific, monitoring of marine bioresources safety in the Far Eastern Seas, sediment accretion and carbon sequestration in estuary, as well as ecotoxicology. Posters were displayed during the evening of September 28. Topics covered a wide variety of aspects, including assessment of contamination in the coastal zone, anthropogenic impact of chemical and biological contaminations, Persistent Organic Pollutants, heavy metals and radionuclides in marine environment of the North Pacific.

The convenors recognized that this regular session provides important opportunities for PICES scientists to present their studies not only in specific areas, but on other marine environmental issues, and for early career scientists to participate in PICES activities. The convenor also recognized that all the participants to the session showed the interest and concern about the marine ecosystem status of North Pacific.

List of papers

Oral presentations

Yessotoxins: History, existence, risk and warning
Renyan Liu, Yubo Liang and Lei Liu

Monitoring of marine bioresources safety in the Far Eastern Seas
Mikhail V. Simokon, Lidia T. Kovekovdova

Environmental evolution of Fukushima-derived 134Cs in the Northwest Pacific
Wu Men, Wen Yu, Yusheng Zhang, Jianhua He, Fenfen Wang, Yiliang Li, Feng Lin, Fangfang Deng and Jing Lin

Sediment accretion and carbon sequestration in tidal flat of Liaohe estuary
Jinqiu Du, Daoming Guan, Ziwei Yao, Guangshui Na and Hui Gao

Poster presentations

Assessment of contamination in the coastal zone around Vladivostok and benthos status in 2016
Alexander V. Moshchenko, Tatyana A. Belan, Boris M. Borisov, Tatyana S. Lishavskaya and Alexander V. Sevastianov

Oxygen regime in the rivers flowing into the Japan/East Sea as an indicator of anthropogenic impact
Anna S. Vazhova

Soft bottom macrozoobenthos of Peter the Great Bay and chemical contamination of marine environment
Alexander V. Moshchenko, Tatyana A. Belan, Boris M. Borisov, Tatyana S. Lishavskaya and Alexander V. Sevastianov

Levels of artificial radionuclides in squid from northwestern Pacific after Fukushima accident
Wen Yu, Jianhua He, Mathew P. Johansen, Yusheng Zhang, and Wu Men

Spatio-temporal variation of radiocesium in sea sediment East of Japan after the Fukushima Dai-ichi Nuclear Power Plant accident
Daisuke Ambe, Shigeho Kakehi, Mikiko Tanaka, Toru Udagawa, Yuya Shigenobu, Kazuaki Tadokoro, Daisuke Hasegawa, Shizuho Miki and Takami Morita

Persistent Organic Pollutants in black-tailed gull eggs from South Korea
Gi Myung Han, Sang Hee Hong, Mi Jang, Lian Hong, Won Joon Shim, Un Hyuk Yim

An in-situ monitoring system for gamma radionuclides in seawater
Jianhua He, Wen Yu, Wu Men, Yusheng Zhang

POC Contributed Paper Session

Co-Convenors: *Emanuele Di Lorenzo (USA), Yury I. Zuenko (Russia)*

Background

Papers were invited on all aspects of physical 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).

List of papers

Oral presentations

Recent reduction of dissolved oxygen in the North-western Pacific and Japan Sea
Dmitry Kaplunenko, Vyacheslav Lobanov, Pavel Tischenko, Sergey Sagalaev, Sho Hibino, Toshiya Nakano, Shi Xuefa and Liu Yanguang

Evaluation of climatological mean surface winds over the Korean Waters simulated by CORDEX regional climate models
Wonkeun Choi, Ho-Jeong Shin, Chan Joo Jang and Heeseok Jung

Timing of unprecedented climate in Korea: A linear projection
Ho-Jeong Shin, Chan Joo Jang and Il-Ung Chung

Regional variation of heat transfer to deep sea during the recent warming hiatus
Yong Lin, Peifu Cong, Shuxi Liu

Increasing Pacific decadal variability under greenhouse forcing
Giovanni Liguori, Emanuele Di Lorenzo

The influence of seasonal upwelling and downwelling on a coastal fjord: An example from Rivers Inlet, Canada from 1951 to 2017
Jennifer M. Jackson, Brian P.V. Hunt, Frank Whitney

Poster presentations

Okhotsk troposphere cyclone as the general factor for ice cover formation in Tatar Strait and in the Okhotsk sea
L. Muktepavel, T. Shatilina, G.Tsitsiashvili, I. Tsypysheva, T. Radchenkova

Mean sea-level rises and coastal vulnerability along the Korea coasts
Kwang-Young Jeong, Tae-soon Kang, Hyung-min Oh, Songmin Do, Eunil Lee

Interannual variation of solar heating in the Chukchi Sea, Arctic Ocean
Yushiro Tsukada, Hiromichi Ueno, Naoki Ohota, Motoyo Itoh, Eiji Watanabe, Takashi Kikuchi, Shigeto Nishino, Kohei Mizobata

Sea ice detection for the Bohai Sea using MODIS IST data
Lijian Shi, Mingsen Lin, Bin Zou, Tao Zeng, Yarong Zou

Development of a medium range ocean prediction model for the seas around Korea
Heeseok Jung, Chan Joo Jang and Sukyung Kang

Argos drifters reveal amplification of tidal currents in the Oyashio
Konstantin Rogachev and Natalia Shlyk

SST variations in the Northwest Pacific related to West Pacific Teleconnection Pattern
Anna A. Artemyeva

The transition of the sea surface temperature long-term trend in the Yellow and East China Seas in the late 1990s: Effects of the North Pacific regime shift
Yong Sun Kim, Chan Joo Jang and Sang-Wook Yeh

Oceanographic conditions in the northwestern Japan Sea based on satellite information and data from the regular 'TSUGARU' transect in winter 2000-2015
A. A. Nikitin, B. S. Djakov and A. V. Kapshiter

GP - General Poster Session

Poster presentations

The great 2011 Tohoku tsunami on the Mexican Coast: Spectral analysis and energy parameterization
Oleg Zaitsev, Alexander B. Rabinovich and Richard E. Thomson

Investigation results of pollution of Uglovoy Bay in winter of 2017 (Peter the Great Bay, Japan/East Sea)
Oleg V. Losev, Valery I. Petukhov, Evgeniya A. Petrova

***Echinocardium cordatum* from the Sea of Japan is not the same species as from North Sea**
Salim Dautov, Svetlana Kashenko

Research of the cetacean sighting survey in the northern part of the Sea of Okhotsk in 2015-2016
Pavel Gushcherov, Petr Tiupeleev, Vitaliy Samonov and Tomio Miyashita

Intraspecific differentiation of *Alaria esculenta* (*Phaeophyceae, Laminariales*) from southeastern Kamchatka based on molecular-phylogenetic and cytochemical study
Anna V. Klimova, Nina G. Klochkova and Tatyana A. Klochkova

Distribution and Diffusion of an Invasive Solitary Ascidian, *Ciona intestinalis*, in South Korea
Donghwan Kim, Michael D. Ubagan, Sungjun Bae, Taekjun Lee, Philjae Kim, Dong gun Kim, Tae Joong Yoon and Sook Shin

Effects of the Salinity on the egg development and the larval settlement in various temperatures of *Ciona intestinails* (*Ascidiacea: Phlebobranchia: Cionidae*)
Minkyung Kim, Donghyun Kim, Ju-un Park, Tae Joong Yoon, Dong gun Kim, Sook Shin

Morphology, phylogeny and life history of *Chattonella marina* from the East China Sea
Xinfeng Dai, Hongxia Wang, Pengbin Wang, Ping Xia and Douding Lu

Contribution of atmospheric circulation in the change of the thermal regime of the north-eastern coast of Russia in the period 1950-2013
Julia V. Stochkute, Lubov N. Vasilevskaya, Denis N. Vasilevsky

The Responses of phytoplankton and bacterial communities along the salinity gradients in the Seomjin River estuary
Minji Lee, Seungho Baek, Changho Moon

Study on the outbreak and extinction mechanisms of marine harmful microalga *Cochlodinium polykrikoides* in Southern Sea of Korea in 2016
Yunji Kim, Seung Ho Baek, Minji Lee and Soonmo An

Distribution of mesozooplankton during spring and autumn across the frontal zone of South Sea, Korea
Minju Kim, and Jung-Hoon Kang

Geochemical characteristics of the sediment pore water in the Northeastern Equatorial Pacific
Taehee Lee, Kyeong-Hong Kim, Ju Won Son, Young Baek Son

Marine environmental situation and Blue Bay remediation in Xiamen
Keliang Chen, Hongzhe Chen, Senyang Xie, Xiaohua Wang

A staining method to determine marine microplanktonic organism viability and investigate the efficacy of a ship's ballast water treatment system
Seung Ho Baek, Bonggil Hyun, Kyoungsoon Shin

Disturbance of seals by anthropogenic activity at the haul out of Piltun Bay (Sakhalin Isl.)
Peter A. Permyakov and Alexey M. Trukhin

Impacts of ocean warming on China's fisheries catches: An application of 'mean temperature of the catch' concept
Cui Liang, Weiwei Xian, and Daniel Pauly

Pacific herring distribution and some features of biology in the northwestern Bering Sea in 2010-2015
Sergey V. Loboda

MONITOR/TCODE Workshop (W1)
The role of the northern Bering Sea in modulating the arctic II: International interdisciplinary collaboration

Co-sponsor: *NPRB*

Co-Convenors: *Matthew Baker (USA), Lisa Eisner (USA), Kirill Kivva (Russia)*

Invited Speaker:
Maria Pisareva (Polar Oceanography Group, P.P. Shirshov Institute of Oceanology RAS, Russia)

Background

The northern Bering Sea is at the confluence of the North Pacific and Arctic Ocean. Physical processes in the northern Bering Sea link currents, productivity regimes, and species distributions and interactions ranging from North Pacific ecosystems to the Arctic. The processes in this region influence the state and ecosystem structure in the southern Chukchi Sea ecosystem as well as the functioning of other Arctic regions. While the Pacific Arctic Region has received great attention during the past few years, scientific efforts in the Northern Bering – Southern Chukchi Sea region are mostly conducted at the national level. International collaboration and data integration remain limited. This workshop was proposed as the second of two consecutive workshops to bring together researchers representing different scientific programs to synthesize knowledge, share data, and discuss further opportunities for cooperation at the international level. The aim of this 1-day workshop was to build on themes addressed in a workshop (see POC Workshop W9 in Session Summaries) held at PICES-2016. The format included invited talks followed by discussion in the morning on the following themes: (1) the physical environment and chemical fluxes, (2) plankton distribution and dynamics, (3) fish populations and dynamics, and (4) recent modeling efforts in the region. In the afternoon, participants worked through facilitated sessions to: (1) consolidate existing and identified data, (2) strategize opportunities for further data integration and coordinated analysis, (3) identify new data streams, new participants, and new research efforts to include, and (4) determine opportunities for long-term data sharing in the region. Participants were asked to submit applicable Ecological Time Series Observations (ETSOs) and identify available data and metadata on new data streams, including satellite observations, glider and mooring data, oceanographic cruise data, bottom, midwater, and surface trawl data, acoustic surveys, and bathymetric and multibeam data. The workshop goal was to increase collaboration and build linkages and synergies among scientists and researchers on both sides of the northern Bering and Chukchi seas as well as among a diverse suite of national and international research efforts operating in this region.

Summary of presentations

Maria Pisareva (Polar Oceanography Group, P.P. Shirshov Institute of Oceanology (IO) RAS, Russia) provided the first invited talk, entitled "*Flow of Pacific Water in the Chukchi Sea: Results from RUSALCA expeditions*" focused on Chukchi Sea circulation patterns and water masses, atmospheric forcing, conditions in the Bering Strait and the current state of the RUSALCA program. The talk introduced the Chukchi Sea as an important transition zone for Pacific water and Pacific summer water as a source of heat in the Pacific Arctic and a source of freshwater in the Beaufort Gyre, whereas Pacific winter water provides a source of nutrients in the Pacific Arctic and ventilates the halocline. Dr. Pisareva also introduced data station and transect information from the SBI and ICESCAPE programs as well as the 12 biophysical cruises and mooring deployments conducted by RUSALCA (www.arctic.noaa.gov/rusalca/). Her talk discussed the current patterns, variation in water masses, wind stress and model outputs from a MITgcm primitive equation model.

The second invited speaker, Zhixuan Feng at the Woods Hole Oceanographic Institution, USA, was unable to participate in the conference. His research is focused on coupled hydrodynamic–ecological modelling in the northern Bering and Chukchi seas and his talk was entitled: "*Modeling the sympagic-pelagic-benthic coupling processes in the St. Lawrence Island Polynya region, northern Bering Sea*".

Matthew Baker, presented recent research conducted with NOAA, entitled, "*Visualization of species distribution patterns in warm and cold phases to understand the transition between subarctic and arctic systems*". His analysis used a series of successive multi-year warm and cold phases to provide insight on how individual species respond to climate forcing and how species might respond to directional shifts in climate. The results contrasted community variance and distribution patterns in demersal and pelagic piscivores, planktiovores and benthivores to inform late summer biogeography in the eastern Bering Sea and northern Bering Sea, with a particular focus on movement and distribution patterns in warm (2000–2005) and cold (2006–2011) years.

As the Science Director for the North Pacific Research Board, Matthew Baker presented two talks, one on each component of the NPRB Arctic Program. The first was on Arctic Shelf growth advection, respiration and deposition, detailing survey data from June 2017 in the northern Bering and southern Chukchi region. The survey included 26 scientists and covered 2,700 nautical miles, 120 bongo and vertical net tows for zooplankton abundance biomass and distribution, several 10-day onboard incubation, egg production and respiration experiments, results of demersal fish and epibenthic community biomass and abundance through beam trawls and pelagic midwater trawls, and multicore deployments to examine macro and meiofauna, chlorophyll and organic matter deposition, environmental DNA and sediment. Microzooplankton and phytoplankton were identified through FlowCam and flow cytometry analysis and experiments for microzooplankton grazing, total and size fractionated primary productivity were conducted. Samples were also collected for lipid and fatty acid analyses of phytoplankton and zooplankton. Hydrography was surveyed through 172 CTD water column profiles including water samples for nutrients and chlorophyll, 20 days of continuous measurements using a thermosalinograph, multibeam seafloor mapping and the deployment of six moorings. The second component of the NPRB program is the Arctic Integrated Ecosystem Studies project, which conducted a summer survey in the Chukchi and Beaufort seas. Dr. Baker presented a talk developed by Ed Farley and Lisa Eisner on the survey and data collected in the northern Bering Sea in 2007 and in the Chukchi Sea in 2003, 2007, 2012, 2013 and 2017. The 2017 research effort featured extensive collaboration with Russian scientists and included Igor Grigorov (VNIRO, Moscow) and Alexey Somov and Natalia Kuznetsova (TINRO, Vladivostok). Russian collaboration focused primarily on Juday net sample processing for fish diet and fish identification.

Kirill Kivva (Russian Federal Research Institute of Fisheries and Oceanography (VNIRO)) presented a talk on "*Nutrient fields in the Bering Sea: available data and results*". His approach was to apply data collection methods in Ocean Data View [https://odv.awi.de/] and a global geodetic grid creation with package dggridR [https://github.com/r-barnes/dggridR] to arrange data in an Icosahedral Snyder Equal Area Aperture 3 Hexagonal Grid. Spatio-temporal averaging with Gaussian weighting function and truncation radius of 100 km was applied to fill the spatial and temporal gaps in data and results were schematically visualized. As an example, Kirill presented a multiyear mean seasonal cycle of silicate for three grid cells. In general, this approach was highlighted as a synergetic way to combine data and a potential approach for other data analysis.

For further details on the workshop, see A MONITOR/TCODE Workshop on " *The role of the northern Bering Sea in modulating the Arctic II*" (PICES Press, Vol. 26, No. 1, 2018, pp. 15–19).

List of papers

Oral presentations

Flow of pacific water in the Chukchi Sea: Results from RUSALCA expeditions (Invited)
Maria N. Pisareva, Robert S. Pickart, Michael A. Spall, G.W. Kent Moore, Katrin Iken, Elizaveta A. Ershova, Jacqueline M. Grebmeier, Lee W. Cooper, Bodil A. Bluhm, Russell R. Hopcroft, Carin J. Ashjian, Ksenia N. Kosobokova

2017 Arctic Shelf Growth, Advection, Respiration and Deposition (ASGARD) Project
Matthew Baker and Lisa Eisner

2017 Arctic Integrated Ecosystem Studies II (Arctic IES) Project
Matthew Baker, Lisa Eisner and Richard Farley

Visualization of species distribution patterns in warm and cold phases to understand the transition between subarctic and arctic systems
Matthew Baker and Anne Hollowed

Nutrient fields in the Bering Sea: available data and results
Kirill Kivva

HD Workshop (W2)
Coastal ecosystem services in the North Pacific and analytical tools/methodologies for their assessment

Co-Convenors: *Shang Chen (China), Mitsutaku Makino (Japan), Daniel K. Lew (USA), Minling Pan (USA), Sebastian Villasante (Spain)*

Background

Coastal ecosystem services are the benefits people obtain from the coastal ecosystem. These services include seafood, regulation of climate, reduction of storm impacts, waste assimilation, recreation and leisure, and biodiversity maintenance. The identification, quantification, and valuation of ecosystem services and understanding the impacts of human activities and climate change on ecosystem services are key scientific questions. The ecosystem services-based approach to marine ecosystem management is a new approach meant, in part, to enhance human well-being. The goals of this workshop were: (1) to present research that enhances understanding of the interactions between human activities and ecosystem services; (2) to provide a venue for natural scientists and social scientists to exchange results from research on identification, assessment, management and investment of ecosystem services, and (3) to provide Study Group on *Marine Ecosystem Services* (SG-MES) members and scientists around the North Pacific an opportunity to discuss collaboration on scientific projects within the North Pacific Ocean. This workshop made an important contribution to a greater understanding of the status of human dimensions of the North Pacific ecosystem and filled some gaps to achieve the objectives outlined by the FUTURE integrative program.

Summary of presentations

This ½-day workshop arranged 5 high quality presentations and was chaired by Dr. Shang Chen. A total 14 people, including Dr. Hiroaki Saito (Science Board Chair) and Dr. Keith Criddle (HD Chair) attended this workshop. Three oral presentations were presented followed by in-depth discussion.

Professor Jingmei Li made a report on the assessment of ecological damages from land reclamation. She pointed out the increasing amount of land reclamation in China and its negative impact on resources and marine ecosystems. She noted that assessing marginal ecological damage costs incorporated into management will prevent operators from conducting reclamation. There were two methods to choose from to evaluate

environmental costs. Then, based on the choice of experiment method, the loss of ecological benefits caused by wetland reclamation in Jiaozhou Bay was analyzed. Results showed that the change of wetland area is the first most important concern of local residents, followed by improvement in water quality. Based on these concerns, the government should make a proper restoration policy in which enlarging the wetland area should be the key priority.

Dr. Shang Chen presented his study on marine ecological services capital assessments. First, he introduced some basic concepts on marine ecological capital (MEC), such as MEC value and Marine Ecosystem Services (MES). Then he described his assessment methods for evaluating standing stock of marine living resources and marine ecosystem services which have been issued as a national standard in China. The Chinese coastal ecosystem provided 1,034 billion CNY of ecosystem services in 2008, which supported 1,740 billion CNY of marine industrial products. His studies showed that the service value decreased from onshore to offshore, with high value in maricultured and tourism areas, and that service value depended highly on utilization methods. Finally, the MES theory can be used as one of the principles to make functional zoning and marine development planning, as assessment indicators of marine management effectiveness and blue economic policy, as a baseline of eco-compensation or payment for ecosystem service policy.

Kazumi Wakita talked about what influences people's value of marine ecosystem services and their motivation for conservation. Dr. Wakita's study took an interdisciplinary approach that combined environmental economics and social psychology in examining relationships between people's value of marine ecosystem services and factors which influence their value, using responses to a questionnaire from 945 residents in Japan. The analysis reveals that the groups of respondents with a higher willingness to pay (WTP) to conserve marine ecosystem services have higher public spirit and stronger connections with other people and invisible things such as spirits. On the other hand, the groups of free riders who have no WTP to conserve marine ecosystem services have lower public spirit and weaker connections with others, both humans and non-humans. The responents' degree of support for the theory of global warming caused by an increase in carbon dioxide and that for forecasting the increase of carbon dioxide did not seem to influence their WTP. Considering that the scenario provided to the respondents was about the status of marine ecosystem services in the next 100 years, the respondents' WTP can interpreted as representing a kind of altruism.

List of papers

Oral presentations

Valuing the loss of ecological benefits of wetland reclamation in Jiaozhou Bay based on choice experiments
Jingmei Li, Qi Chen

Marine ecosystem services assessment methods
Shang Chen, Wei Liu, Tao Xia and Linghua Hao

What influences people's value of marine ecosystem services: A case study of Japan
Kazumi Wakita, Hisashi Kurokura, Taro Oishi, Zhonghua Shen, and Ken Furuya

FIS Workshop (W3)
Linking oceanographic conditions to the distribution and productivity of highly migratory species and incorporation into fishery stock assessment models

Co-Convenors: *Gerard DiNardo (USA), Carrie Holt (Canada)*

Invited Speaker:
Yong Chen (School of Marine Sciences, the University of Maine, USA)

Background

This workshop was convened by the Joint PICES-ISC Working Group on *Oceanographic Conditions and the Distribution and Productivity of Highly Migratory Fish*, as identified in the Working Group's Terms of Reference. The distribution and productivity of many pelagic fish populations in the North Pacific are determined by largescale oceanographic processes and climate variability. One hypothesis is that highly migratory species, such as albacore tuna (*Thunnus alalungus*) or Pacific sardine (*Sardinops sagax*) have environmental thresholds and preferences that drive their distribution and productivity. The workshop provided an overview of contemporary research on the topic, including the identification of statistical modeling approaches that link spatially explicit environmental data (*e.g.*, satellite derived SST) to distributional fish data (*e.g.*, fishery-dependent and fishery independent), methods to assess impacts of climate variability on fish productivity, and examined methods that explicitly incorporate environmentally driven dynamics into stock assessments for highly migratory species.

List of papers

Oral presentations

Consequences of environmentally driven uncertainty in productivity for management of North Pacific Albacore tuna
Desiree Tommasi, Barbara Muhling, Steven Teo, Gerard Di Nardo

Dynamic ocean management applications for the Drift Gillnet fishery in the California Current
Elliott L. Hazen, Kylie L. Scales, Heather Welch, Dana K. Briscoe, Steven J. Bograd, Heidi Dewar, Suzy Kohin, Scott Benson, Tomo Eguchi, Larry B. Crowder, Rebecca Lewison and Sara Maxwell

Optimal harvest strategies of sandfish based on a stage-structured model in the East Sea
Giphil Cho, Sukgeun Jung, Il Hyo Jung

Differences in biological characteristics of Pacific cod (*Gadus macrocephalus*) between the East and the Yellow Sea, Korea
Kyunghwan Lee, Sukgeun Jung

Individual-based model of chub mackerel (*Scomber japonicus*) covering from larval to adult stages to project climate-driven changes in their spatial distribution in the western North Pacific
Sukgeun Jung

Oceanographic influences on the spawning and recruitment of Pacific bluefin tuna
Barbara A. Muhling, Desiree Tommasi and Gerard DiNardo

Development of methodology for analyses of larval ambient water temperature of Pacific bluefin tuna using SIMS
Yulina V. Hane, Shingo Kimura, Yusuke Yokoyama, Yosuke Miyairi, and Takayuki Ushikubo

MEQ Workshop (W4)

Long-term changes in HAB occurrences in PICES nations; the Eastern vs. Western Pacific

Co-sponsor: *NOWPAP*

Co-Convenors: *Mark Wells (USA), Polina Kameneva (Russia)*

Invited Speakers:
Nicholas Bond (University of Washington, USA)
Keigo Yamamoto (NOWPAP)

Background

The PICES-2016 Workshop on toxic *Pseudo-nitzschia* blooms in the eastern and western Pacific highlighted the stark differences in economic and social impacts of these HABs, and how these effects have been changing over at least the past decade. For example, toxic *Pseudo-nitzschia* blooms have frequent and intense impacts on fisheries and human health in the eastern Pacific, but have not caused any fisheries closures in the western Pacific, despite the widespread presence of toxigenic species in western Pacific waters. Moreover, in some eastern regions these HABs are increasing in frequency, intensity and duration, but it remains unclear whether these changes are linked to climate pressures. There is a strong need to better identify long-term trends in these and other HAB organisms in the context of climate change pressures in PICES nations. This 1-day workshop was used to assemble, present, and analyze long-term datasets on HAB organism abundance and impacts from each nation, along with existing time series data of associated environmental parameters. Trends were then used to identify knowledge gaps, unify methods for data analysis, and propose methods for future data collection to strengthen understanding of climate/HAB linkages. These goals align closely with those of GlobalHAB and NOWPAP, and the International Society for the Study of Harmful Algae (ISSHA), all seeking to strengthen data collection, analysis and communication of findings on climate change and HABs.

Summary of presentations

Keigo Yamamoto (Invited Speaker) set the stage for the discussion of changes in HABs in the east *vs*. west by presenting a long-term series of monitoring of *Alexandrium tamarense* and associated environmental factors in Osaka Bay, in the eastern Seto Inland Sea. From 2002, nearly every year bivalves in Osaka Bay have been contaminated with paralytic shellfish poisoning (PSP). Also, red tides have been observed from March to May, at a temperature of 15 °C or lower and salinity approximately 30. Animals killed by *A. tamarense* include mussels, Japanese mitten crab, goboids. Dr. Yamamoto discussed why these blooms have become more massive in recent years. Factors such as a decline in nutrients (DIN and phosphate) appear to be contributing to the increase in *A. tamarense* which effectively appears to outcompete other species under conditions of declining nutrients.

Nicholas A. Bond (Invited Speaker) presented an overview of the oceanographic conditions and cycles, which can be related to HABs in terms of comparing western and eastern parts of North Pacific. The bathymetry differs with a narrow shelf in the east, and a broad, shallow shelf in the west, and this larger shelf region in the west implies that tidal mixing forces are stronger there, resulting in more significant development of shelf–sea fronts. There is a difference in the net surface heat exchange, with more heat leaving the ocean and going into atmosphere in the west (a lot of heat loss in west) with the opposite occurring in the east. The ENSO can also influence the western North Pacific and there generally is greater river runoff over time in the western Pacific.

The western Pacific is very cold in winter. Summer (August) brings high stratification; in winter (February) there is a very well mixed photic zone, *e.g*., in the Yellow Sea. In the eastern Pacific, waters are less well stratified in August and less well mixed in February.

One intriguing observation is that the Yellow Sea profiles show a very high subsurface chlorophyll maximum at ~20 m depth in summer, with nitrate being almost depleted in surface water, while upwelling winds on the eastern boundary generate high biomass at the surface. The more strongly stratified surface water in the west is in part related to the higher levels of freshwater outflows. Another difference is that the silicate:nitrate ratios are higher in the western North Pacific than in eastern North Pacific during the later spring/early summer. Coastal upwelling in the eastern Pacific is an important source of nutrients in the summer. However, the comparatively narrow shelf means this water has less opportunity to become enriched with Fe from the bottom sediments. The source of deep water in the western Pacific is associated more with bottom Eckman transport where the Kuroshio intrusion happens more in the winter than in the summer. In the western Pacific shelf–sea fronts contribute to offshore flow in the mid depth pycnocline region meaning that the subsurface chlorophyll maximum may be advected offshore, potentially limiting the impact of HAB toxins nearshore.

For the future under climate change, there may be more productivity in the eastern Pacific, with lower Si:N concentrations and pH. Climate change may weaken the shelf–sea fronts in the west.

In summary, there are three major concepts related to HABs, in particular, high toxicity *Pseudo-nitzschia* blooms:

1. *Stress* – Macronutrient, micronutrient and contaminant concentrations have been linked to development of domoic acid.
2. *Retention* – Prolonged periods of particular conditions appear to be instrumental for toxic levels (*e.g*., Juan de Fuca Eddy).
3. *Transport* – Onshore directed flow is necessary to infect coastal locations.

North Pacific: West *vs.* East Shelf Regions

	West	**East**
Shelf width	Mostly broad	Mostly narrow
Tidal mixing	Strong	Moderate
Winter stratification	Well-mixed	Weak
Summer stratification	High	Moderate
Source surface H_2O	Mostly from the south	From the west
Source deep H_2O	Kurioshio (winter)	Coastal upwelling (summer)
Silicate:nitrate ratios	High	Moderate
Iron concentration	High (sediments, dust, rivers)	Low (sediments)
Future stratification	Higher	Higher
Future primary productivity	Probably lower	Maybe higher
Future chemistry	???	Lower pH, O_2

In his presentation, Douding Lu asked whether *Karenia mikimotoi* blooms in China are potentially linked to climate change. Large-scale blooms of *Karenia* appear to be associated with El Niño, in particular with the higher precipitation that occurs during or immediately following El Niño. Flagellates appear to have become a more prominent component of the phytoplankton species in China. Since 1998, over 120 blooms have been recorded in China with only a few recognized prior to this date. Huge damage to fish farms has been caused by *Karenia mikimotoi* blooms resulting in exceptionally large economic losses. Relative cold in winter and a

rapid increase in temperature appears to be associated with the blooms. Jinhui Wang further described the distribution of red tide species in China over the last several decades.

Satsuko Sakamoto described the long-term trends in HABs in Seto Inland Sea, the largest enclosed sea in Japan and a major fishing ground. A special law was enacted in 1973 to control total P by 1979 and total N by 1996. This resulted in the decrease of high biomass ("red tides") in the region since that time. However, *Chattonella* has caused great damage in Harima-Nada in the eastern part of Seto Inland Sea. Yellowtail, red seabream, conger eel, black porgy, gizzard shad, flatfish, rockfish, mullet, and amberjack have been impacted. Higher water temperature in July since 1996 has also led to the shift in the time of *Chatonella* bloom occurrence.

Vera Trainer presented a talk on behalf of Morgaine McKibben about the application of cross-correlation analysis (monthly scale) and linear regression analysis (annual scale) for the analysis of potential linkage of highly toxic *Pseudo-nitzschia* bloom events and climate indices (PDO indicess and El Niño/La Niña years) in the Oregon, USA, using a 25-year data set. Cross-correlation analysis of climatic and local biological (copepod species richness index) and physical variables are significantly related, and a time delay (offset) on the order of months is observed. Conditions leading into the spring/summer upwelling season are a strong predictor of high domoic acid (*Pseudo-nitzschia* toxin) concentrations. Some findings of this research can be used for risk assessment in the future. For example, more toxic events of *Pseudo-nitzschia* are suggested with the warming of surface waters. Only with such dedicated, consistent long-term records will such correlations with climate change factors be possible in other regions around the world.

Tatiana Morozova described the occurrence of dinoflagellate assemblages in Peter the Great Bay, Russia, including epiphytic and benthic dinoflagellates such as *Amphidinium, Amphidiniopsis, Thecadinium, Dinophysis*, and *Ostreopsis*. Two species are the constant components of the summer–autumn community of epiphytic dinoflagellates. Among them, *Ostreopsis* cf. *ovata* reaches a high density and prevails in autumn. The *P. foraminosum* density was significantly lower, but the species was observed in the epiphytic community for a longer period. Significant interannual variations in the density of these species were noted. Both these species have a potential to produce toxins in the natural environment.

Jinhui Wang described the succession, and related potential of alien species in East China Sea (ECS). There has been an increasing trend in red tide occurrence, frequency and coverage area in China since 2001. The species that cause the major red tide events are *Karenia mikimotoi, Prorcentrum donghaiese, Skeletonema costatum* and *Noctiluca scintillans*. For species like *Trichodesmium erthraeum*, the larger distribution along the coastline of China is observed. All observed HABs species can be divided into 4 categories (covering all the coasts; north and south, but not in the east; mainly in the East China Sea; and mainly in the South China Sea). New records of bloom species often are found in regions receiving significant ballast water discharge, such as in the anchoring and harbor areas including Shanghai, Xiamen, Qingdao and Dalian. At least 10 alien species have been identified in China, some of which are known as HAB species

Tatiana Orlova described a general trend of decreasing diatom abundance over time in Far Eastern Russian coastal waters, although in 2017 there was a large bloom of *Skeletonema* to break that apparent trend. In addition, *Heterosigma akashiwo* blooms are becoming more intense. Cyanobacteria are becoming more dominant as cyanobacterial pigments, important UV protectants, are found in high concentrations in Russian waters.

Melissa Peacock described the new concern about freshwater and new algal toxins appearing in coastal marine waters. Although particulate toxins are not always observed, solid-phase adsorption toxin tracking (SPATT)

devices are integrative sampling devices that show the presence of these toxins over time. In particular, microcystins and okadaic acid/diarrhetic shellfish toxin-2 (OA/DTX-2) in marine waters were above the regulatory limit, showing that both marine and freshwater toxins can appear concurrently in shellfish.

Mark Wells argued that pennate diatoms, such as *Pseudo-nitzschia*, are better at nutrient acquisition due to their shape factors so they are more competitive than many centric diatoms at low nutrient concentrations. In fact, pennate diatoms do well in High Nitrate Low Chlorophyll (HNLC) regions. The environmental conditions present weeks before the bloom may condition the water to allow the (later) dominant species to succeed. The STARTING cell population size matters. He described 3 case studies:

1. *Pseudo-nitzschia* success in the "Blob" (a high temperature anomalous water mass off along the eastern boundary region of the Pacific in 2015) – There were low nutrient concentrations within the Blob, conditions under which *Pseudo-nitzschia* can do better than most diatoms.
2. *Pseudo-nitzschia* in the Juan de Fuca eddy – *Pseudo-nitzschia* can be predictively found in this area, unlike most other coastal waters. Here, *Pseudo-nitzschia* can co-occur with high abundances of dinoflagellates—an unusual oceanographic condition.
3. *Pseudo-nitzschia* in the Gulf of Maine – *Pseudo-nitzschia* species have been observed in the Gulf of Maine in the past but with low or no toxicity measured. In the late summer 2016, unusual closures of shellfish harvesting occurred in Maine, Massachusetts and Rhode Island in a retentive area. There was a significant summer drought in the northeastern U.S. in the summer 2016. Lower river runoff and higher SST were also observed.

The unifying parameters associated with these *Pseudo-nitzschia* blooms are: low nutrients, prolonged period of nutrient-deplete conditions, shifting the pre-bloom diatom community toward pennate diatoms. *Pseudo-nitzschia* may be more resilient than other diatoms, perhaps because of the production of DA. In fact, more chlorophyll was produced in an experiment in the Juan de Fuca Eddy where DA was added to deckboard cultures.

William P. Cochlan presented the results of experimental work focused on the influence of ocean acidification and temperature on the growth and domoic acid production of *Pseudo-nitzschia australis* from the California Current upwelling system. Non-axenic strains of *P. australis*, isolated from Monterey Bay, California during the massive West Coast 2015 bloom of this species were exposed to a range of temperatures (5, 7, 9, 11, 13, 15, 17 and 19 °C) using a custom-built incubator, and to four pH levels (8.1, 8.0. 7.9 and 7.8) regulated by direct injection of compressed CO_2/air mixture into culture flasks. Laboratory findings demonstrate that this diatom species reaches maximal growth rates at ~17–18 °C with specific growth rates increasing by ~3-fold from 5 to 17 °C. Stationary cells increased domoic acid production as the partial pressure of CO_2 (pCO_2) increased, and particulate DA was 3-fold greater at pH 7.8 compared to pH 8.1. However, exponential growth rates were not affected until a critical pH of 7.8 was reached when growth rates declined by 30%.

In summary, by understanding the basin-wide differences in oceanography of the eastern *vs*. western Pacific, we can begin to understand the factors that drive the large difference in geographical distribution, species occurrence, and toxicity of HABs in the northern Pacific region.

Future improvements of the methodology/strategies may include: usage of the concentration of nutrients instead of ratios for calculations and models, elaboration of the idea of retention sites (retention models), attempting to find a connection between freshwater inputs (river runoff) and flagellates blooms, and analysis of nutrient sources in the places with a high frequency of HABs

List of papers

Oral presentations

Long-term monitoring of the toxic dinoflagellate *Alexandrium tamarense* and environmental factors in Osaka Bay, eastern Seto Inland Sea, Japan: History of invasion and expansion of toxic blooms (Invited)
Keigo Yamamoto, Ichiro Imai

Observed climatic and oceanographic variations related to harmful algal blooms: Comparisons between the western and eastern North Pacific (Invited)
Nicholas A. Bond

Can large scale of *Karenia* blooms in China coastal waters be linked to climate (weather) signals?
Douding Lu, Xinfeng Dai, Pengbin Wang, Ping Xia and Weibing Guan, Haiyan Huang, Leo Chan

Long-term trend of harmful algal blooms and environmental factors in the Seto Inland Sea of Japan
Setsuko Sakamoto, Tetsuya Nishikawa, Ichiro Imai

Decadal time series tell a story about climate and HABs
S. Morgaine McKibben, Angelique E. White, William P. Cochlan, and Vera L. Trainer

Species composition and long-term dynamics of potentially toxic dinoflagellate species in benthic assemblages of Peter the Great Bay, Sea of Japan
Marina Selina and Tatiana Morozova

The bloom species succession and related potential alien species in East China Sea
Jinhui Wang, Yutao Qin, Hong Cheng

Long-term changes in HAB occurrences in Amursky Bay, Russia
Tatiana Y. Orlova, Inna V. Stonik and Polina A. Kameneva

Oceanographic conditions that lead to large *Pseudo-nitzschia* blooms in coastal waters
Mark Wells, Vera Trainer, William Cochlan, and Charles Trick

Blurred lines: Multiple freshwater and marine algal toxins at the land-sea interface
Melissa B. Peacock, Corinne Gibble, David B. Senn, James E. Cloern, and Raphael M. Kudela

The effects of ocean acidification and temperature on the growth and toxicity of *Pseudo-nitzschia australis* from the California Current upwelling system
William P. Cochlan, Charles J. Wingert, Christopher E. Ikeda and Vera L. Trainer

Poster presentations

Green tide monitoring in the China Sea using Remote Sensing Data
Bin Zou, Lijian Shi, Maohua Guo, Tao Zeng

Outbreak and movement pattern of red tide patches occurred by *Cochlodinium polykrikoides* during last 4 years in the Korean coastal waters
Jaeyeon Park, Eun Young Yoon, Hae Jin Jeong, Kwang Young Kim and Eun Joo Kim

BIO Workshop (W6)
Advantages and limitations of traditional and biochemical methods of measuring zooplankton production

Co-Convenors: *Toru Kobari (Japan), Akash Sastri (Canada)*

Invited Speaker:
Andrew Hirst (School of Environmental Sciences, University of Liverpool, U.K.)

Background

Zooplankton communities occupy a central position in the flow of matter and energy from primary producers to animals at higher trophic levels in marine ecosystems. Over the past two decades, the increasing emphasis on quantitative assessments of marine ecosystem function has been focused on improving our understanding of how marine ecosystems respond to global climate change. Zooplankton (secondary) production represents a quantitative proxy for the functional response of marine ecosystems since it corresponds to the zooplankton biomass accrued through consumption of lower food-web levels. Zooplankton production traditionally has been estimated using methods which either: 1) follow the development of zooplankton populations/ communities over the course of several weeks or months (cohort approaches); or 2) employ *ex situ* fixed-period incubations. Incubation-based techniques with simultaneous sampling of natural communities are the most widely used traditional methods in the field. Recent advances in biochemical methods for measuring zooplankton growth and production, such as quantification of RNA/DNA ratios, chitobiase, or aminoacyl-tRNA synthetases, have been developed and applied to a diverse range of organisms and habitats. The goal of the workshop was to examine and compare traditional and biochemical approaches to estimating zooplankton secondary production.

Summary of presentations

Akash Sastri and Toru Kobari (PICES WG 37 Co-Chair) convened the ½-day workshop in the morning of September 22. Eleven participants joined this workshop and 4 talks and 2 posters were presented.

Invited Speaker, Dr. Andrew Hirst (UK) demonstrated the errors and variations of copepod growth estimates in the molting rate method as an example for disadvantages of the traditional methodologies. He also described a global pattern of the copepod growth estimated with the natural cohort method indicating response of copepod growth to environmental variables. On behalf of Lian E. Kwong, Natalie Mahara described the relevance of 'Biomass Size Spectra' for estimating ecosystem productivity and transfer efficiency and noted that this approach may represent an additional method for estimating zooplankton production. She also demonstrated that zooplankton community structure was associated with oceanographic conditions and emphasized the importance of microscopic analysis. On behalf of Theresa A. Venello, Akash Sastri presented transfer efficiency measurements estimated directly from primary production (dissolved gas ratios and radio isotope incorporation) and zooplankton production by chitobiase activity. He mentioned there is limited information on direct measurements of transfer efficiency but that we are now starting to accumulate such data. For poster presentations, Akash Sastri and Toru Kobari presented the results from collaborative experiments which compared production estimates measured with different methodologies. Our discussions are summarized as follows.

- Specify advantages, disadvantages and limitations of available methodologies to apply natural population or community.
- The taxonomic groups for which the methodologies are not applicable should be specified.

- Errors and deviations of production estimates should be compared among the methodologies using zooplankton population or community in nature or in laboratory.

Active and extensive discussions among the experts were incredibly helpful for promoting the term of reference for our working group and gave some new ideas to the WG members. This report and record of our discussion was shared among the WG members.

List of papers

Oral presentations

Revising our traditions: An overview on method and results of growth and production estimates for zooplankton
Andrew G. Hirst

A comparison of zooplankton secondary production in a high nutrient low chlorophyll (HNLC) and seasonally productive regions in the North Pacific
Natalie Mahara presenting for Lian E. Kwong, Evgeny A. Pakhomov

Zooplankton communities in the coastal northeast Pacific Ocean: A comparison of a highly productive region and a light-limited high nutrient, low chlorophyll region
Natalie Mahara, Brian V.P. Hunt, Evgeny A. Pakhomov

Coupling crustacean zooplankton production and primary production rates to estimate trophic transfer efficiencies in the NE Pacific
Theresa A. Venello, John F. Dower, Akash R. Sastri

Poster presentations

A comparison of protein synthetases activity to standing stock and productivity in a cultured copepod population, *Pseudodiaptomus inopinus*
Toru Kobari, Yuka Matsuura, Akash Sastri, Yuichiro Yamada and Tomonari Kotani

A comparison of chitobiase-based estimates to developing biomass and production rates of a laboratory culture of *Pseudodiaptomus inopinus*
Akash Sastri, John Dower, Alex Clancy, Yuichiro Yamada, Tomonari Kotani, Toru Kobari and Yuka Matsuura