PICES-2014

Toward a better understanding of the North Pacific: Reflecting on the past and steering for the future

North Pacific Marine Science Organization

PICES

October 16-26, 2014
Yeosu, Korea

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Notes for Guidance

The North Pacific Marine Science Organization (PICES) announces its 2014 Annual Meeting to be held October 16-26, 2014, at the Expo Hall in Yeosu, Republic of Korea. The meeting is hosted by the Ministry of Oceans and Fisheries (MOF), in coordination with the PICES Secretariat. Local arrangements are made by Yeosu City, Korea Institute of Ocean Science and Technology (KIOST), and the National Fisheries Research and Development Institute (NFRDI).

Presentations

In order to allow the sessions to run smoothly, and in fairness to other speakers, please note that all presentations are expected to adhere strictly to the time allocated. All authors should designate at least 5 minutes for questions. Authors can download their presentations straight to the computers where the session/workshops will be held.

Important: Please rename your files - time-name.ppt (*e.g.* 0900-Smith.ppt, 1530-Kim.ppt).

If complications occur due to incompatibilities between PCs and Macs, Macintosh owners may use their own computers to make presentations.

Posters

Posters on general interest to the PICES Scientific Committees, including those not necessarily matching the themes of the Topic Sessions, are welcome. Posters will be on display from October 21 (a.m.) until the end of the "Wine and Cheese" Poster Session on the evening of October 23, when poster presenters are expected to be available to answer questions.

Internet access

Internet access via wireless LAN will be available. A few desktop computers will also be available for participants.

Social activities

Monday, October 20 (18:30-21:00)
Welcome Reception
The Welcome Reception for all participants (and registered guests).

Tuesday, October 21 (18:30-21:00)
Sport Event
This year the sport event is Volleyball at Jinnam Gymnasium, Yeosu. Four teams can play at the same time on two indoor courts. About 60 people can play and many cheering attendees are welcome. Bus transportation will be arranged. Participants, please bring clean sports shoes! After the volleyball game, Korean style fried chicken and beer will be served. Please sign up for participation at the Registration Desk.

Thursday , October 23 (18:00-20:30)
Wine & Cheese Poster Session Reception
The wine & cheese Poster Session at the meeting venue will allow participants to roam around the poster displays and chat with presenters while sipping beer or wine and nibbling on hot and cold hor d'oevres.

Meeting Timetable

Wednesday, October 15

Time	
14:00 18:00	PICES- NOWPAP SG Meeting

Thursday, October 16

Time					
09:00 12:30	**W1** Day 1	**WG-30** Meeting Day 1	**MAFF PST** Meeting*	**PICES-NOWPAP SG** Meeting	**WG-27** Meeting
14:00 18:00					

Friday, October 17

Time							
09:00 12:30	**W1** Day 2	**W2**	**W3**	**W4**	**WG-28** Meeting Day 1	**WG-29** Meeting	**AP-MBM** Meeting	**MoE PST** Meeting
14:00 18:00				**W5**				

18:00 20:00	**AP-CPR** Meeting	**WG-30** Meeting, Day 2

Saturday, October 18

Time							
09:00 12:30	**SG-SEES** Meeting	**SG-BC** Meeting	**S-CC** Meeting	**S-HAB** Meeting	**WG-28** Meeting Day 2	**WG-31** Meeting	
14:00 18:00			**S-CCME** Meeting				**AP-CREAMS** Meeting

Sunday, October 19

Time							
09:00 15:30	Joint FUTURE AP Meeting		12:30 14:00	Science Board Meeting			
16:00	AP-AICE		AP-COVE		AP-SOFE		
08:00 20:00	**BIO** Meeting Day 1	**FIS** Meeting Day 1	**MEQ** Meeting Day 1	**MONITOR** Meeting Day 1	**POC** Meeting Day 1	**TCODE** Meeting Day 1	**S-HD** Meeting Day 1

Monday, October 20

Time	
09:00 10:00	**Opening Session**
10:30 18:00	**Science Board Symposium (S1)**
18:30 21:00	**Welcome Reception** for all participants and registered guests

Tuesday, October 21

Time			
09:00 17:30	**S3**	**S9**	**S10**
18:00 21:00	**Sport Event**		

Wednesday, October 22

Time					
09:00 12:30	**S7** Day 1	**S5** Day 1	**S11**	**MEQ-Paper**	**F&A Meeting***
14:00 18:00	**BIO** Meeting Day 2	**FIS** Meeting Day 2	**MEQ** Meeting Day 2	**MONITOR** Meeting Day 2	**POC** Meeting Day 2	**TCODE** Meeting Day 2	**S-HD** Meeting Day 2

Thursday, October 23

Time				
09:00 12:30	**S5** Day 2	**S7** Day 2	**S8**	**BIO-Paper**
14:00 18:00	POC Paper Session Day 1	**S2**		**FIS-Paper**
18:00 20:30	**"Wine and Cheese" Poster Session****			

Meeting Timetable (continued)

Friday, October 24			
09:00	**S6**	**S4**	**POC-Paper Session** Day 2
12:30 14:00	**Closing Session*****		
15:00 18:00	**Science Board Meeting***		
18:30 21:00	**Chairman's Reception*** [by invitation only]		
Saturday, October 25			
09:00 18:00	**Science Board Meeting***		**Governing Council Meeting***
Sunday, October 26			
13:00 18:00	**Governing Council Meeting***		

*   Closed meetings
**   Poster presenters are expected to be available to answer questions.
***   Award-winning scientists (Best Oral/Poster presentations) will be announced during the Closing Session

Sessions/Workshops

S1	Toward a better understanding of the North Pacific: Reflecting on the past and steering for the future
S2	Strengths and limitations of habitat modeling: Techniques, data sources, and predictive capabilities
S3	Tipping points: defining reference points for ecological indicators of multiple stressors in coastal and marine ecosystem
S4	Use of long time series of plankton to inform decisions in management and policy concerning climate, ecosystems and fisheries
S5	Ecosystem considerations in fishery management of cod and other important demersal species
S6	Climate change impacts on spatial distributions of marine fish and shellfish
S7	Recent assessments of climate change impacts on marine ecosystems
S8	Marine debris in the Ocean: Sources, transport, fate and effects of macro- and micro-plastics
S9	Variability in advection and its biological consequences for Subarctic and Arctic ecosystems
S10	Regional climate modeling in the North Pacific
S11	Ecological and human social analyses and issues relating to Integrated Multi Trophic Aquaculture
BIO-P	BIO Contributed Paper Session
FIS-P	FIS Contributed Paper Session
MEQ-P	MEQ Contributed Paper Session
POC-P	POC Contributed Paper Session
W1	Dynamics of pelagic fish in the North Pacific under climate change
W2	Linkages between the winter distribution of Pacific salmon and their marine ecosystems and how this might be altered with climate change
W3	Mitigation of harmful algal blooms: Novel approaches to a decades long problem affecting the viability of natural and aquaculture fisheries
W4	Networking ocean observatories around the North Pacific Ocean
W5	SOLAS into the Future: Designing the next phase of the Surface Ocean-Lower Atmosphere Study within the context of the Future Earth Program
GP	General Poster Session

Meetings

Committees

BIO	Biological Oceanography Committee
FIS	Fishery Science Committee
MEQ	Marine Environmental Quality Committee
MONITOR	Technical Committee on Monitoring
POC	Physical Oceanography and Climate Committee
TCODE	Technical Committee on Data Exchange

Advisory Panels

AP-CPR   Advisory Panel on the Continuous Plankton Recorder Survey in the North Pacific
                    (*reports to MONITOR Committee*)

AP-CREAMS   Advisory Panel for a CREAMS/PICES Program in East Asian Marginal Seas
                    (*reports to MONITOR and POC Committees*)

AP-MBM   Advisory Panel on Marine Birds and Mammals
                    (*reports to BIO Committee*)

FUTURE Science Program Advisory Panels

AP-AICE   Advisory Panel on Anthropogenic Influences on Coastal Ecosystems

AP-COVE   Advisory Panel on Climate, Oceanographic Variability and Ecosystems

AP-SOFE   Advisory Panel on Status, Outlooks, Forecasts, and Engagement

Sections

S-CC   Section on Carbon and Climate
                    (*reports to BIO and POC Committees*)

S-CCME   Section on Climate Change Effects on Marine Ecosystems
                    (*reports to BIO, FIS and POC Committees*)

S-HAB   Section on Ecology of Harmful Algal Blooms in the North Pacific
                    (*reports to MEQ Committee*)

Study Groups

SG-SEES   Study Group on Socio-Ecological-Environmental Systems
                    (*reports to Science Board*)

SG-BC   Study Group on Biodiversity Conservation
                    (*reports to Science Board*)

Working Groups

WG-27   Working Group on North Pacific Climate Variability and Change
                    (*reports to POC Committee*)

WG-28   Working Group on Development of Ecosystem Indicators to Characterize Ecosystem
                    Responses to Multiple Stressors
                    (*reports to BIO and MEQ Committees*)

WG-29   Working Group on Regional Climate Modeling
                    (*reports to BIO and POC Committees*)

WG-30   Working Group on Assessment of Marine Environmental Quality of Radiation around the
                    North Pacific
                    (*reports to MEQ Committee*)

WG-31   Working Group on Emerging Topics in Marine Pollution
                    (*reports to MEQ Committee*)

Keynote Lecture

October 20, 10:30, Keynote

Red tides in North Pacific coastal waters: What have we learned and what else do we need to know?

Hae Jin **Jeong**

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A red tide is defined as discoloration of the sea surface water due to plankton bloom. Red tides can cause large-scale mortalities of fish and shellfish and alter the balance of marine food webs. Thus, understanding and managing red tides are urgent tasks. There have been numerous red tide events in North Pacific coastal waters. Some red tides caused great loss in aquaculture industry. For example, red tides dominated by the mixotrophic dinoflagellate *Cochlodinium polykrikoides* caused losses of USD 60 million in the Korean aquaculture industry in 1995 and USD 20 million in 2013. The Canadian, Chinese, Japanese, Korean, Russian, and USA governments and private industries have spent a large proportion of their budgets to improve prediction, monitoring, and control of red tides. Due to these efforts, our understanding and managing red tides are much improved. Understanding red tide organisms, mechanisms of the outbreak, spread, and decline of red tides, and harmful effects on marine organisms, managing red tides and reducing their economic impacts, and developing effective methods of detecting and monitoring red tide organisms are major topics in red tide research. I reviewed the trends in the outbreak of red tides in North Pacific coastal waters and results of the red tide research in north Pacific countries. Furthermore, I provided an insight on future research for better understanding red tides in North Pacific coastal waters.

Schedules
and
Abstracts

S1

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

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

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

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

Monday, October 20 (10:30-18:00)

10:30   **Red tides in North Pacific coastal waters: What have we learned and what else do we need to know (Keynote)?**
Hae Jin <u>Jeong</u>

11:15   **Pathways of Arctic Ocean acidification (Invited)**
Iris E. <u>Hendriks</u>, Melissa Chierici and Carlos M. Duarte

11:45   **Formation of offshore ecological hotspots and its fluctuation in the western North Pacific**
Shin-ichi <u>Ito</u>, Taku Wagawa, Shigeho Kakehi and Takeshi Okunishi

12:05   **What goes on beneath the waves and when we're not watching**
John A. <u>Barth</u>

12:25   ***Lunch***

14:00   **Looking back to go forward (Invited)**
Jacquelynne <u>King</u>

14:30	**Forecasting North Pacific climate and ecosystem changes: Advances and challenges** Emanuele <u>Di Lorenzo</u>, Nathan Mantua and Mathew Newman
14:50	**Northwestern Pacific subarctic marine ecosystems structure and possible trends of it changing in nearest future** Elena P. <u>Dulepova</u>
15:10	**How much do we know about the 88-91 regime shift in the southwestern East Sea ecosystem?** Sinjae <u>Yoo</u>, Chan Joo Jang, Joo-Eun Yoon and Soonmi Lee
15:30	**The use of physical decomposition to analyze interannual climate variability in the southern Indian Ocean** Yi <u>Cai</u>
15:50	*Coffee/Tea Break*
16:10	**High fishery production supported by complex coastal ecosystems (Invited)** Akihide <u>Kasai</u>
16:40	**Hegemony and shared dominance in marine capture fisheries** Robert <u>Blasiak</u> and Nobuyuki Yagi
17:00	**Projected responses of the central North Pacific pelagic ecosystem to climate-induced changes in micronekton communities** C. Anela <u>Choy</u>, Phoebe Woodworth-Jefcoats and Jeffrey J. Polovina
17:20	**Estimation of the future change of anchovy recruitment in response to global warming off western coast of Kyushu, Japan** Aigo <u>Takeshige</u>, Shingo Kimura, Yoichi Miyake, Hideaki Nakata and Takashi Kitagawa
17:40	**So now people believe that the ocean is changing – And so is the climate. NOW what?** Jake <u>Rice</u>
18:00	*Session Ends*

S1 Posters

S1-P1	**Effects of volcanism on sockeye salmon Oncorhynchus nerka abundance in Kamchstka River** Victor F. <u>Bugaev</u>
S1-P2	**Impact of climate change on the egg and larval transport of Japanese anchovy *Engraulis japonicus* off western coast of Kyushu, Japan** Shingo <u>Kimura</u>, Aigo Takeshige, Yoichi Miyake, Hideaki Nakata and Takashi Kitagawa
S1-P3	**Interannual variability of chlorophyll associated with mixed layer depth changes in the East Sea (Japan Sea)** Chan Joo <u>Jang</u>, Youngji Joh and Sinjae Yoo

S1 Oral Presentations

October 20, 11:15 (S1-9661), Invited

Pathways of Arctic Ocean acidification

Iris E. **Hendriks**[1], Melissa Chierici[2] and Carlos M. Duarte[1,3]

[1]   Global Change Department, IMEDEA (CSIC-UIB), Instituto Mediterráneo de Estudios Avanzados, Esporles (Mallorca), Spain
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[2]   Institute of Marine Research, Tromsø, Norway
[3]   The UWA Oceans Institute, The University of Western Australia, Crawley, Australia

Ocean acidification due to invasion of ocean waters by anthropogenic CO_2 has emerged as a major concern due to the potential impacts on marine calcifiers. The argument that polar oceans are in imminent risk of ocean acidification has found widespread echo among policy makers and is proposed to guide CO_2 emission thresholds. However, many uncertainties about Arctic acidification remain on the multiple possible pathways for Arctic Ocean acidification and the vulnerability of Arctic biota to these changes. We show that (1) the Arctic Ocean shows the lowest fCO_2 levels in the ocean, due to the combined effect of strong biological and ice pumps, (2) current model projections are lacking refinement, (3) future ice loss, freshening and impacts on primary production may either buffer or amplify Arctic acidification, with different mechanisms dominating in different regions of the Arctic Ocean, and (4) experimental evidence on the vulnerability of Arctic calcifiers to ocean acidification is poor or lacking altogether for most species, which may be less vulnerable to low carbonate saturation states than hitherto believed. We conclude that the Arctic Ocean is at a crossroads, where ongoing and future freshening and the strength of biological responses to climate change are likely to play an overriding role in buffering or amplifying ecosystem responses to acidification.

October 20, 11:45 (S1-9604)

Formation of offshore ecological hotspots and its fluctuation in the western North Pacific

Shin-ichi **Ito**, Taku Wagawa, Shigeho Kakehi and Takeshi Okunishi

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Recently autumn bloom of phytoplankton was found in the region 43-45N and 158-166E. This area corresponds to the termination of a quasi-steady warm water jet which separated from the Kuroshio Extension. The quasi-steady jet flows parallel to the subarctic current and horizontally entrains the nutrient rich subarctic water. Additionally, the warm and saline water transported by the quasi-steady jet possibly contribute to deep wintertime mixed layer formation and hence nutrient rich water is supplied from the deep layer to the surface. These horizontal and vertical nutrient supplies resulted in high primary production that possibly create offshore ecological hotspots in the western North Pacific. Indeed, there is a nursery ground of small pelagic fishes in that region. The strength of the quasi-steady jet showed decadal variability accompanied with the meridional shit of the Kuroshio Extension. It is still unclear how the decadal fluctuation of quasi-steady jet influence on the formation of the offshore ecological hotspots and hence on the recruitment of the small pelagic fish. It is a big challenge for us to investigate impacts of fluctuations in limited local key areas to large marine ecosystems.

October 20, 12:05 (S1-9681)

What goes on beneath the waves and when we're not watching

John A. **Barth**

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While predictions of future changes in North Pacific marine ecosytems surely rely on large-scale observational data sets and relatively coarse resolution coupled climate models, important ecosystem dynamics occur at much smaller scales. Mesoscale (10-100 km) currents and eddies, as well as submesocale (100m-10km) fronts, frontal instabilities, current convergences and large-amplitude internal waves are places of intense biophysical interaction. These relatively small features are sometimes captured by high spatial resolution satellite measurements (temperature, color, chlorophyll), but few observations exist of their full three-dimensional structure beneath the sea surface. Progress has been made with focused ship-based surveys in regions of intense biophysical interaction, but much goes on when the ships must return to port. Features at these fine horizontal, temporal and vertical scales are not captured in our models and, because they are poorly observed and understood, are difficult to parameterize in models. New tools are emerging to make measurements at the meso- to submesoscales. Both new sensors and new observational platforms, for example underwater gliders, are opening our eyes to intense, short-scale variability beneath the waves. Examples include upper-ocean fronts, wintertime freshwater-driven currents, mesoscale surface-intensified eddies, subsurface boundary current eddies, and large-amplitude internal waves. While these new views are intriguing, we still lack the measurements necessary to understand ecosystem dynamics at these scales. Concerted field efforts with new tools and informed by high-resolution modeling are needed. PICES is an ideal forum to encourage such efforts, with the goal to improve our understanding and predictive capability for changing North Pacific marine ecosystems.

October 20, 14:00 (S1-9596), Invited

Looking back to go forward

Jacquelynne **King**

Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, BC, Canada. E-mail: Jackie.King@dfo-mpo.gc.ca

The key element of the PICES' Science Program, FUTURE, is understanding the trends and responses of North Pacific marine ecosystems. This is fundamental since it involves the characterization of uncertainty in those trends and responses and is required for forecasting future ecosystem states, the other two elements of FUTURE. FUTURE has inherited a body of research from its predecessor, the CCCC Science Program, which provided momentum to its' key element from the onset. PICES continues to make progress in understanding the mechanisms underlying ecosystem response to natural and anthropogenic forcings and in improving forecasting capabilities. I will review the major accomplishments of the CCCC Science Program that have provided the solid foundation for FUTURE with an overview of what continues to be developed. The next challenge for FUTURE will be to apply the outputs of ocean-climate forecasting activities to answering some of the outstanding questions that are posed in the FUTURE Science Plan, namely those dealing coastal pressures and cumulative impacts.

October 20, 14:30 (S1-9701)

Forecasting North Pacific climate and ecosystem changes: Advances and challenges

Emanuele **Di Lorenzo**[1], Nathan Mantua[2] and Mathew Newman[3]

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[2] NOAA, Southwest Fisheries Science Center, Santa Cruz, CA, USA
[3] CIRES, University of Colorado and NOAA/ESRL/PSD, Boulder, CO, USA

Forecasting changes in marine ecosystem of the North Pacific is a critical goal of the FUTURE program. An important fraction of the observed changes in the structure and function of the marine ecosystem are driven by external pressures such as fishing and climate. Over the last decades important advances have been made in understanding different aspects of Pacific climate variability and change. These include the recognition that (1) the El Niño Southern Oscillation (ENSO) is characterized by different tropical expressions and extra-tropical teleconnections, which have distinct impacts on North Pacific marine ecosystems, (2) new modes of North Pacific decadal variability, such as the North Pacific Gyre Oscillation (NPGO), explain a larger fraction of the observed ecosystem variability over the last two decades, and (3) multiple physical mechanisms connect the North Pacific eastern and western coastal boundaries on decadal timescales, and impact coastal marine ecosystem both through surface (*e.g.* phytoplankton, zooplankton, fish) and subsurface processes (*e.g.* hypoxia and acidification). In this talk we provide a synthesis of the progress made on understanding the impacts of these climate mechanisms on North Pacific marine ecosystems, and discuss the challenges of using these advances in North Pacific climate research to generate marine ecosystem forecasts.

October 20, 14:50 (S1-9504)

Northwestern Pacific subarctic marine ecosystems structure and possible trends of it changing in nearest future

Elena P. **Dulepova**

Pacific Research Fisheries Center (TINRO-center), Vladivostok, Russia
E-mail: dep@tinro.ru

The TINRO-Centre conducts ecosystem studies in the northwestern Pacific for over 30-year period. These studies include an analysis of the status and dynamics of pelagic and benthic communities in the Sea of Okhotsk and the western Bering Sea. The new data obtained during ecosystem studies had changed our point of view about the scale of variability natural phenomena in the seas and revealed greater value of biological productivity. In addition a lot number of trends and great changes were identified in the pelagic and benthic communities and these changes are important for understanding of natural processes and their impact on fishery resources and management. Apart from new information about the total biomass, diet ratio of species which represented the middle and higher trophic levels allowed us to estimate the extent of food consumption by species and calculate approximate energy flow diagrams for the Bering Sea and Sea of Okhotsk. In recent years, the study of chemical and isotopic composition, as well as calculations of the energy value of species allowed to obtain a better real view of their locations in food webs. This data creates the prerequisites for constructing more perfect biological models and develop new ideas about the natural phenomena and processes. The new database which containing extensive information about the composition, quantitative distribution of the pelagic community (nekton) were created in 2000s. Analysis of the spatial dynamics of integral characteristics the pelagic biota of the northwestern Pacific allows to determine variability of impacts for detachment of natural zones for different biological components in the region. The possible versions for biocenological zoning of epipelagic nekton were developed on base of the database.

October 20, 15:10 (S1-9699)

How much do we know about the 88-91 regime shift in the southwestern East Sea ecosystem?

Sinjae **Yoo**, Chan Joo Jang, Joo-Eun Yoon and Soonmi Lee

Korea Institute of Ocean Science & Technology, Ansan, R Korea. E-mail: sjyoo@kiost.ac

We investigated the 88-91 regime shift in the southwestern East Sea ecosystem by reconstructing a long-term chlorophyll *a* time series from Secchi depth data for 1970-2005. The chlorophyll *a* time series showed that a statistically significant shift occurred at 89/90, which is consistent with shifts in a number of climatic, oceanographic, and biological variables with a slight time lag before and after the chlorophyll *a* shift. We put forward a hypothesis that several factors, anthropogenic and climate change-related, worked together to induce the jump in the lower trophic level: continuously increasing atmospheric deposition of anthropogenic nitrogen, continuously increasing nitrate loading of the Changjiang River, and sudden increase of Changjiang discharge around 1989. These effects might have been amplified by an increase in the volume transport of Tsushima Warm Current in 1988 leading to nitrogen enrichment in the south East Sea. If such is the case, the 89-91 regime shift in the East Sea ecosystem presents an interesting case where climate change and anthropogenic forcing interacted and produced synergistic effects leading to a step change. We will also discuss further questions such as linkage to large-scale variability and trophic interactions.

October 20, 15:30 (S1-9729)

The use of physical decomposition to analyze interannual climate variability in the southern Indian Ocean

Yi **Cai**

National Marine Environmental Forecasting Center, State Oceanic Administration, Beijing, PR China. E-mail: caiy@nmefc.gov.cn

This study physically decomposes SODA (Simple Ocean Data Assimilation) SST (sea surface temperature) data for the Indian Ocean from January 1945–December 2003, with each component resulting from the decomposition being analyzed and discussed. On a basin-wide scale, the zonally averaged heat flux in the Indian Ocean can be divided into three latitudinal zones: tropical (6°N–15°S), subtropical-mid-latitude (15°–40°S) and high-latitude (40°–75°S). The heat flux between the mid- to high-latitude zones takes approximately half a year, and is largely positive from the mid- to high-latitude zones (although negative heat fluxes in the same direction may occur); a similar pattern of heat flux occurs between the subtropical to mid-latitude regions within the second zone. Additionally, there exists a dipole-like SST structure in the tropical Indian Ocean, whose relationship with the Pacific ENSO (El Niño/Southern Oscillation) is closer than that between the ENSO and the Indian Ocean dipole. The correlation coefficient between this dipole-like structure and the ENSO is -0.87, and the pattern is entirely the result of the monsoons in the Indian Ocean, with the correlation between the wind fields of a given month and the SST structure of the subsequent month reaching a coefficient of 0.84. It can be seen that the physical decomposition method is superior to the usual method of using the mean monthly climate and decomposing the anomalies. An REOF (rotated empirical orthogonal function) decomposition of the second component arising from a physical decomposition of the surface wind stress data for the Indian Ocean reveal a subtropical tripole structure.

October 20, 16:10 (S1-9485), Invited

High fishery production supported by complex coastal ecosystems

Akihide **Kasai**

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Coastal areas are composed of various habitats such as seagrass beds, rocky shores, and sand beaches, which are some of the most productive areas on the earth. Economic activities concentrated in coastal zones can be a burden on ecosystems, many of which are under stress. Clear policies are required to maintain and/or recover ecosystem functions which are impacted by human activities. Marine organisms are generally transported or migrate over extensive areas, and thus belong to different ecosystem in each life stage. Therefore, it is important to not only understand the roles of each ecosystem, but also to recognize the whole coastal area as a complex system.

As an example, we introduce the survival strategy of temperate seabass *Lateolabrax japonicus*, which distributes in the coastal waters of Japan and Korea. Seabass larvae hatch offshore in winter and are effectively transported to coastal areas by the estuarine circulation. They use the high marine production until early spring. After settlement in coastal areas, some larvae migrate into the estuary, while others remain in the coastal area. The former use the high production in the river and grow faster than those staying in the coastal area in spring, when the marine production declines. 40% of adult seabass are composed of the river migrants, indicating that the stable seabass population is supported by the adaptive use of complex ecosystems. These results represent that not only the coastal areas, but also the river ecosystems need to be conserved for preservation and sustainable use of marine fisheries resources.

October 20, 16:40 (S1-9641)

Hegemony and shared dominance in marine capture fisheries

Robert **Blasiak** and Nobuyuki Yagi

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Strategic decision-making characterizes the cooperative management of marine capture fisheries, which have frequently been assessed using game theory. Existing literature on these issues has suggested that 'grand coalitions' comprised of all nations (players) harvesting a fishery resource grow increasingly unlikely as the number of players increases due to the attractiveness of singleton behavior. Such free-riding can introduce considerable instability into coalitions, potentially leading to a descending spiral of unilateral and retaliatory action. This presentation aims to explore another facet of cooperative management by considering the respective dominance of players. The world's 25 largest marine capture fisheries, many of which are found in the North Pacific, are used as a sample for this analysis and are assessed based on the number of players, their respective dominance, and the existence of absence of cooperative agreements on the management of the fishery. This sample also led to the development of a proposed dominance-based categorization system for shared fisheries into hegemonic, coupled, small group, and non-dominated systems. The analysis suggests strong dominance-based drivers for and against cooperation, which will be introduced during the presentation. Likewise, evidence is presented for shifts in dominance triggering engagement in the development of cooperative management agreements. Finally, the relevance of this research for practical interventions and decision-making will be introduced, namely in regards to early identification of windows for cooperation and potential threats to existing cooperative frameworks.

October 20, 17:00 (S1-9471)

Projected responses of the central North Pacific pelagic ecosystem to climate-induced changes in micronekton communities

C. Anela **Choy**, Phoebe Woodworth-Jefcoats and Jeffrey J. Polovina

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Ecosystem models have been widely used to examine potential food web impacts due to climate induced changes at the base of the marine food web, as well as top down changes induced by fishing removals. Here, we address potential ecosystem changes resulting from direct climate-induced impacts to micronekton food web components (small fishes, crustaceans, and cephalopods ~2-20cm that form the primary forage base for large pelagic fishes). We updated an existing Ecopath with Ecosim (EwE) model for the area of the central North Pacific occupied by the Hawaii-based pelagic longline fishery. Specifically, we focused on representation of the lesser known non-target fish species (*e.g.*, lancetfish, opah, snake mackerel) and mid-trophic micronekton. The model comprises 41 functional groups, organized into approximately five trophic levels where sharks and billfishes occupy the top of the pelagic food web. Detailed diet data argue for specialized niche partitioning amongst large commercially harvested fish species, suggesting that the central North Pacific pelagic ecosystem does not function according to 'wasp-waist' control, as has been previously described from other systems such as the California Current and eastern Australia. The relative impacts between key forage groups and key predators are also presented using EwE. Sensitivity analysis is used to project ecosystem impacts from climate-induced changes to the following micronekton groups: epi-/meso-/bathypelagic fishes, myctophids and gonostomatids epi-/mesopelagic molluscs, decapod crustaceans, and gelatinous zooplankton. Model results can help advance the understanding of overall ecosystem structure of different pelagic systems, particularly how biomass flows through diverse mid-trophic forage groups.

October 20, 17:20 (S1-9602)

Estimation of the future change of anchovy recruitment in response to global warming off western coast of Kyushu, Japan

Aigo **Takeshige**[1], Shingo Kimura[2], Yoichi Miyake[2], Hideaki Nakata[3] and Takashi Kitagawa[1]

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Climate change possibly alters ocean state even in coastal waters, and could induce significant change in fish recruitment. Effect of global warming on the eggs and larval transport of the Japanese anchovy *Engraulis japonicus* in the western Kyushu was investigated using a coupled hydrodynamic and particle tracking model. An atmosphere-ocean coupled model has predicted future environmental change under the Intergovernmental Panel on Climate Change A2 scenario. Using the predicted model result, this study revealed that the eggs and larval transport process would change and affect recruitment of anchovy more than the impact of an increased sea surface temperature of 4°C. Particle tracking experiment showed transport successes in the offshore zone would be lowered compared with those in the 1950–1990s. It was also revealed that the intensified Tsushima Warm Current and shift of spawning ground would decrease retention rate in the offshore zone. Estimated increase in the SST also would change the biological condition such as the growth and survival of larval anchovy. The larval growth rate was estimated to be faster than the present state. Strengthened stratification seems to limit the nutrient supply leading to a low primary production during spring bloom, and it may restrict the food availability. The importance of the understanding of fluctuation mechanism of the anchovy stock in terms of their role of key organism linking the lower and higher trophic levels thought to be large.

October 20, 17:40 (S1-9781)

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

Jake **Rice**

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Over the past two decades there has been a regime shift in public and policy dialogue about the ocean. It is now widely acknowledged that there are important links between ocean and climate, that both are changing, and that the changes are affecting how we can use the ocean sustainably. The science community is now facing important choices with limited resources that must be allocated wisely. I identify three science challenges: solidify our understanding of the processes underlying the linkages; quantify better the rates and trajectories of change (past and expected in future) in the range of ocean and climate properties of scientific interest and societal relevance; clarify the major ecological, economic and social consequences of options to adapt to the changing ocean and climate. Our scientific culture is rooted most deeply in the first challenge; society is awaking to the need for answers to the third challenge; the second challenge is the bridge between the first and third. Building on the IPCC 5th Assessment Report and the other talks in this Symposium, I will share my thoughts with regard to how our science itself has to change, to keep pace with the ocean and climate as they change.

S1 Poster Presentations

S1-P1

Effects of volcanism on sockeye salmon Oncorhynchus nerka abundance in Kamchstka River

Victor F. **Bugaev**

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Azabachye Lake is the most important sockeye salmon spawning and nursery site within the system of the Kamchatka River. There is information that sockeye salmon abundance in the lake visibly increased as a result of fertilizing the lake by volcanic ashes from eruptions of Bezymianny (1956), Plosky Tolbachik (1975) and Klyuchevskoy (1990) volcanoes. Significant effect on fertilizing followed every time in 5-10 years and was 3-years long. Eruption of Shiveluch Volc. on May 9-10, 2004, when the ash layer reached 15-18 mm, caused significant growth of sockeye salmon abundance in Azabachye Lake in 2009-2013, what provided a great contribution to the total harvest and catch of sockeye salmon in Kamchatka River in this period. In 2011-2013 the catches of the Kamchatka River stock sockeye salmon were the highest for more than 80 years (9051 tons in 2011, 11117 tons in 2012 and 14372 tons in 2013). The abundance of sockeye salmon of Azabachye Lake is expected to be high in 2014 also.

S1-P2

Impact of climate change on the egg and larval transport of Japanese anchovy *Engraulis japonicus* off western coast of Kyushu, Japan

Shingo **Kimura**[1], Aigo Takeshige[2], Yoichi Miyake[1], Hideaki Nakata[3] and Takashi Kitagawa[2]

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In the western Kyushu, the annual catch of anchovy in the offshore zone has increased since the mid-1980s, while that in the coastal zone has declined since the mid-1970s. To investigate the impact of climate change on the egg and larval transport of Japanese anchovy *Engraulis japonicus* off western coast of Kyushu, we conducted numerical simulations on the transport success/failure from 1960 to 2007. Particle-tracking experiments showed increased and decreased transport success in the offshore and coastal zones, respectively. We revealed that the northern shift of the spawning ground and the weakened Tsushima Warm Current could contribute to the increase in the transport success in the offshore zone. On the other hand, weakening trend in the onshore current in the Goto-Nada Sea combined with northern shift of the spawning ground resulted in unsuccessful larval transport. These results implied that the recent flourished catch in the offshore zone and decreased catch in the coastal zone would be attributed to the changes in the transport conditions. Our study showed that the changes in transport success induced by environmental change has potential to impact the recruitment of anchovy off western coast of Kyushu.

S1-P3

Interannual variability of chlorophyll associated with mixed layer depth changes in the East Sea (Japan Sea)

Chan Joo **Jang**, Youngji Joh and Sinjae Yoo

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Year-to-year variability of chlorouhyll *a* (Chl-*a*) in the East Sea and its relation with mixed layer depth (MLD) changes are investigated by using Chl-*a* concentration data estimated from satellite (SeaWiFS and MODIS) measurement. MLD was calculated from 1/12° Global HYbrid Coordinate Ocean Model (HYCOM) for the period (2004-2010). In 2008, spring Chl-*a* concentration in the Ulleung basin reaches a maximum during the period of 2004-2010. This Chl-*a* increase can be attributed to relatively deep winter mixed layer that can entrain more deep nutrients into the upper ocean. Comparison of MLD with surface atmospheric forcing (wind and surface heat flux) suggests that the deep MLD was probably caused by a strong wind due to a strengthened Siberian high and Aleutian low, and the associated intensified surface cooling. On the other hand, spring Chl-*a* concentration in 2004 was not intensified although the winter MLD was considerably deep. A deeper spring MLD in 2004 than normal years appears to contribute to an unfavorable light condition for spring bloom, thus resulting in the relatively low Chl-*a* concentration. Our finding suggests that, in addition to winter MLD, spring MLD also plays a crucial role in interannual variability of Chl-*a* in the East Sea. In addition to roles of mixed layer depth, Asian dust effects on spring Chl-*a* concentration variability also will be discussed in the presentation.

S2

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

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

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

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

Thursday, October 23 (14:00-18:05)

14:00   ***Introduction by Session Convenors***

14:05   **Application of habitat models to highly mobile marine animals – Cetaceans in the North Pacific as case studies (Invited)**
Hiroto Murase, Toshihide Kitakado, Yu Kanaji, Hiroko Sasaki, Yoko Mitani, Koji Matsuoka, Makoto Okazaki and Naohisa Kanda

14:30   **Crossvalidating approaches to modeling habitat and distribution of seabirds at-sea (Invited)**
Martin Renner

14:55   **Distribution modeling for deep-sea corals and sponges in Alaska**
Chris Rooper, Mark Zimmermann, Mike Sigler and Jerry Hoff

15:15   **Modeling temporal variation in krill "hotspots": Size, intensity, persistence and coherence with krill predators**
Jarrod A. Santora, Jeffrey Dorman and William J. Sydeman

15:35   ***Coffee / Tea Break***

16:00   **Prediction of zooplankton community Spatial-Temporal patterns in the Chukchi Sea – Case study using habitat modeling approach**
Hiroko Sasaki, Kohei Matsuno, Atsushi Yamaguchi, Yutaka Watanuki and Takashi Kikuchi

16:20   **Comparison of habitat suitability models for neon flying squid (*Ommastrephes bartramii*) in western and central North Pacific**
Irene <u>Alabia</u>, Sei-Ichi Saitoh, Hiromichi Igarashi, Yoichi Ishikawa, Norihisa Usui, Masafumi Kamachi, Awaji Toshiyuki and Masaki Seito

16:40   **GIS-based potential habitat mapping for *Todarodes pacificus* (common squid)**
Yoon-Kyung <u>Lee</u>, Inhye Park, Sang-Woo Kim, Jong-Kuk Choi, Saro Lee and Joo-Hyung Ryu

17:00   **Is seabird bycatch rate affected by the seabird distribution? Estimation of seabird distribution for bycatch risk assessment**
Yukiko <u>Inoue</u>, Makoto Okazaki, Maria P. Dias, Cleo Small and Hiroshi Minami

17:20   **Cassin's Auklet at-sea distribution and exposure to stressors such as ship-source oil pollution and microplastics**
Patrick D. <u>O'Hara</u>, Ken Morgan, Jamie McDevitt-Irwin, Jean-Pierre W. Desforges, Peter S. Ross and Sean Boyd

17:40   **A multi-model ensemble prediction of habitat suitability index (HSI) models for neon flying squid in central North Pacific by using 3-D ocean data assimilation product**
Hiromichi <u>Igarashi</u>, Toshiyuki Awaji, Masafumi Kamachi, Yoichi Ishikawa, Norihisa Usui, Masaaki Iiyama, Yosuke Onoue, Mitsuo Sakai, Yoshiki Kato, Irene Alabia, Sei-ichi Saitoh and Masaki Seitoh

18:00   *Discussion*

18:05   *Session Ends*

S2 Posters

S2-P1   **Developing the suitable operation prediction model of neon flying squid in the central North Pacific using Satellite images and VMS**
Yang <u>Liu</u>, Sei-Ichi Saitoh, Hiroki Takegawa and Toru Hirawake

S2-P2   **Effect of 3-D physical structures on spatial distributions of Japanese common squid in the coastal waters of southwestern Hokkaido, Japan**
Xun <u>Zhang</u>, Sei-Ichi Saitoh, Toru Hirawake, Satoshi Nakada, Koji Koyamada, Toshiyuki Awaji, Yoichi Ishikawa and Hiromichi Igarashi

S2-P3   **Habitat model development of Japanese common squid in Japan Sea using satellite remotely sensed data**
Mariko <u>Dehara</u>, Sei-Ichi Saitoh and Toru Hirawake

S2-P4   **Predicting the potential invasion in Korean waters of the saltmarsh grass *Spartina alterniflora* from China – A joint proposal by KIOST and Nanjing University**
Keun-Hyung <u>Choi</u> and Changyong Wang

S2-P5   **Operational Management of tuna fisheries in Indonesia**
Patrick Lehodey, Inna Senina, Philippe Gaspar and Sylvie <u>Giraud</u>

S2 Oral Presentations

October 23, 14:05 (S2-9489), Invited

Application of habitat models to highly mobile marine animals – Cetaceans in the North Pacific as case studies

Hiroto **Murase**[1], Toshihide Kitakado[2], Yu Kanaji[1], Hiroko Sasaki[3,4], Yoko Mitani[3], Koji Matsuoka[5], Makoto Okazaki[6] and Naohisa Kanda[5]

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[3]   Hokkaido University, Hakodate, Japan
[4]   National Institute of Polar Research, Tokyo, Japan
[5]   The Institute of Cetacean Research, Tokyo, Japan
[6]   National Research Institute of Fisheries Science, Kanagawa, Japan

The habitat model is defined as "a model that describes a spatial distribution of a biological organism as a function of environmental factors". Spatial distributions of animals in unsurveyed areas can be inferred by predicting habitat based on previously fit habitat models. The estimated spatial distribution map can then be used as baseline information for conservation and management of these species. A number of statistical models are now available as habitat models. These can be categorized into three types: regression, profile and machine learning. We applied a total of eight models [two regression models (GLM, and GAM), three profile models (BIOCLIM, DOMAIN and ENFA) and three machine learning models (BRT, RF and MaxEnt)] to sei whales in the western North Pacific. The modelling results were evaluated based on the AUC. However, it was difficult to determine the best estimated spatial distribution maps based thoroughly on such an index because the resultant maps were highly variable even if difference of the AUC was subtle. Conventional habitat models may only estimate spatial distribution of animals given certain environmental conditions at a certain time. Habitat models are snapshot models and at inappropriate scales could overlook dynamics of behavior of animals. Behavior studies using biologging devices revealed that cetaceans were capable to move long distance within a few day and showed complex vertical diurnal behavior. Required environmental conditions to improve models could be different based on different behavioral states. Understanding the limitations of habitat models is important and the development of new modeling techniques is necessary to overcome these limitations.

October 23, 14:30 (S2-9593), Invited

Crossvalidating approaches to modeling habitat and distribution of seabirds at-sea

Martin **Renner**

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At-sea surveys of seabirds sample densities of only a minute sample of the ocean at an instance in time. To generalize beyond these samples, we need a model. Here, I will deal with models of density, not presence-absence or presence-only models. k-fold cross-validation offers a way to evaluate and compare the predictive power of different models. Using data from the North Pacific Pelagic Seabird Database, I will compare the predictive power and bias of several approaches taken in recent publications. These include classical GLMs and simple geographical grids, as well as random Forests, GAMs, kriging, kernel-density smoothing, and ensemble models. Predictive power of random forests has an edge in most cases, but overall differences between the advanced models were small. Residual kriging provided a small but consistent improvement to predictions. Combining several models into an ensemble model provides interesting opportunities, improves some properties of the output, but has considerable computational and programming costs.

October 23, 14:55 (S2-9462)

Distribution modeling for deep-sea corals and sponges in Alaska

Chris **Rooper**[1], Mark Zimmermann[1], Mike Sigler[2] and Jerry Hoff[1]

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[2]   Alaska Fisheries Science Center, Auke Bay Laboratory, Juneau, AK, USA

Deep-sea coral and sponge ecosystems are widespread throughout most of Alaska's marine waters and are associated with many different species of fishes and invertebrates. These ecosystems are potentially vulnerable to the effects of commercial fishing activities and climate change. To better manage fishing activities in these systems we have undertaken a distribution modeling project that predicts the locations of deep-sea coral and sponge ecosystems in all waters of Alaska from 50 to 1000 m. The modeling is based on historical bottom trawl survey data. For the past three years we have also ground-truthed model predictions with underwater camera observations using a randomized survey design. We will present the results of this modeling effort, as well as a comparison of modeling methods (GAM, GLM, BRT) in predicting presence and abundance of corals and sponges. In general, each model type fits the data reasonably well. For most models geographic location, current speed and bathymetric features (such as depth or slope) are the most important factors determining deep-sea coral and sponge distribution. To date, ground-truthing results have supported the models based on trawl survey data. The differences in predicted distribution of deep sea coral and sponge ecosystems using different modeling methods were not large, but they were significant for some areas. The quality of the data for independent variables was an important factor in the accuracy of the resultant distributions. The predictive maps generated from the modeling have already proved useful in the evaluation and discussion of management issues in Alaska.

October 23, 15:15 (S2-9691)

Modeling temporal variation in krill "hotspots": Size, intensity, persistence and coherence with krill predators

Jarrod A. Santora[1,2], Jeffrey Dorman[1] and William J. **Sydeman**[1]

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Identification and prediction of forage "hotspots" in marine ecosystems is important for several reasons, including evaluating factors affecting trophic/energy transfer (food web dynamics), spatial management and conservation (marine spatial planning) and ecosystem-based fisheries management. Currently no framework exists for predicting where forage hotspots are likely to form in pelagic environments, and little is known about their persistence on scales relevant to conservation and management.   Factors influencing the formation and dissolution of forage hotspots include physical attributes of the environment and biological needs of the organism in question (feeding, mating, spawning, *etc.*). Using an established modeling framework that encompasses a coupled oceanographic (ROMS) – ecosystem (NPZ) - IBM approach (parameterized for *Euphausia pacifica*), we tested the hypothesis that the persistence (duration) of krill hotspots and predator spatial coherence is dependent on size and intensity of the hotspot, and habitat characteristics that retain hotspots in particular places. We predicted that hotspots characterized by the highest persistence are large, intense, and dependent on fundamental coastal-shelf processes (upwelling and retention/relaxation). In support of this hypothesis, we found that hotspot persistence and size in spring was dependent on offshore winds (retention) and SST (proxy for upwelling), respectively. Hotspot persistence was positively related to hotspot size and intensity. A new conceptual model for the seasonal evolution and dissolution of krill hotspots and use by place-based (*e.g.* a local seabird colony) and migratory (cetaceans) marine predators is presented.

October 23, 16:00 (S2-9477)

Prediction of zooplankton community Spatial-Temporal patterns in the Chukchi Sea – Case study using habitat modeling approach

Hiroko **Sasaki**[1,2], Kohei Matsuno[1,2], Atsushi Yamaguchi[1], Yutaka Watanuki[1] and Takashi Kikuchi[3]

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Spatial-temporal patterns of zooplankton community are affected by water mass and marine environmental changes. For instance, annual changes in the zooplankton community during summer of 1991, 1992, 2007, 2008 and 2013 were caused by environmental changes in the Chukchi Sea. However, little is known about the environmental factors contributing to changes in their distribution. Moreover, it is important to understand the spatial-temporal patterns of zooplankton community to elucidate and predict their climate-driven distribution response in the future. The objectives of this study are to investigate the oceanographic factors contributed on the spatial-temporal patterns of zooplankton community and predict their spatial-temporal patterns in the Chukchi Sea. We applied two models (generalized liner model (GLM) and generalized additive model (GAM)) to zooplankton samples, which were collected by NORPAC net in Arctic Cruises conducted by T/S Oshoro-Maru of Hokkaido University. Zooplankton abundance data were summarized with taxa (*e.g.* copepods, chaetognaths *etc.*). The collected *in-situ* and satellite-derived oceanographic data were used as model covariates. Based on model results, we will summarize the relationships between zooplankton distribution and marine environment during the 5 year summer periods.

October 23, 16:20 (S2-9478)

Comparison of habitat suitability models for neon flying squid (*Ommastrephes bartramii*) in western and central North Pacific

Irene **Alabia**[1], Sei-Ichi Saitoh[1], Hiromichi Igarashi[2], Yoichi Ishikawa[2], Norihisa Usui[3], Masafumi Kamachi[3], Awaji Toshiyuki[4] and Masaki Seito[5]

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Neon flying squid (*Ommastrephes bartramii*) is a large pelagic squid internationally harvested in the North Pacific. In the present study, we examined its summer potential habitat distribution in western and central North Pacific using suite of statistical models and subsequently assessed their predictive performances. The habitat models were constructed using squid fishing points, selected vertical layers of temperature and salinity, sea surface height and SSH gradient from multi-variate ocean variational estimation system for the western North Pacific (MOVE-WNP) from June-July 1999-2011. These habitat models include maximum entropy (MaxEnt), boosted regression tree (BRT) and generalized additive model (GAM). The predictive performance of models was evaluated based on area under the ROC curve (AUC) computed from independent data projections (June-July 2012). Mean AUCs obtained for independent dataset in June-July 2012, showed that BRT and GAM recorded highest AUCs, respectively. However, a combined mean AUCs for June-July was highest for MaxEnt. Observed differences in performance could stem from inherent algorithm characteristics, highlighting the superior capabilities of machine learning over regression-based models for squid potential habitat prediction. Despite of these differences in the statistical performances, consistent spatial HSI patterns were observed across models. Squid potential habitat were generally found across the Kuroshio-Oyashio transition zone in June and shifted north-ward off the subarctic frontal zone in July. Insights on predictive strengths and preclusions of statistical models could be useful for the development of targeted tools for resource habitat mapping and operational fishery applications.

October 23, 16:40 (S2-9746)

GIS-based potential habitat mapping for *Todarodes pacificus* (common squid)

Yoon-Kyung **Lee**[1], Inhye Park[2], Sang-Woo Kim[3], Jong-Kuk Choi[1], Saro Lee[4] and Joo-Hyung Ryu[1]

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The Japanese common squid, *Todarodes pacificus*, is the one of the most commercially valuable squids in the world (Rosa *et al.*, 2011). It is distributed in northwest pacific between 25 and 50°N, including the East Sea/Japan sea (the East Sea hereafter) (Murata, 1990). The change in distribution of T. pacificus is coincided with periods of climatic regimes shifts in the northwest Pacific and the East Sea, where the main spawning grounds of the T. pacificus shifts from inshore areas off Honshu island to the Tsushima Strait (Kidokoro *et al.*, 2010). To map the potential habitat of the *Todarodes pacificus*, the spatial distribution of ecological variables in the East/Japan Sea were used as inputs to our models. Spatial variables were mapped using remote sensing and a geographic information system (GIS) combined with fisheries catch data. Then a frequency ratio model was employed to map the potential habitat area. Spatial variables affecting its distribution were selected based on *T. pacificus* abundance and used within a spatial database derived from remotely sensed data from various types of sensors. The spatial variables included sea surface temperature (SST), suspended solid (SS), chlorophyll *a* (Chl-*a*), sea surface height anomaly (SSHA), geostrophic surface velocity (GSV), eddy kinetic energy (EKE) and bathymetry. A frequency ratio (FR) was employed in October 2009. The data were randomly divided into a training set (50%) to analyse habitat potential and a test set (50%) to validate the predicted habitat area. The output of the model was overlaid on environmental predictors to produce a map of potential habitat using the T. pacificus potential index value for each pixel. The maps were compared to surveyed habitat locations. The results showed 80.33% accuracy.

October 23, 17:00 (S2-9608)

Is seabird bycatch rate affected by the seabird distribution? Estimation of seabird distribution for bycatch risk assessment

Yukiko **Inoue**[1], Makoto Okazaki[1], Maria P. Dias[3], Cleo Small[3] and Hiroshi Minami[1]

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Bycatch, also known as incidental catch of non-target species, has to be minimized particularly for seabirds as it is one of the cause of declining seabirds. Identifying factors affecting bycatch rate allows us to reveal bycatch mechanisms and then to take proper action to minimize the threat. Our objective is to examine whether bycatch rates are positively related to distribution and probability of seabirds. We analyzed the distribution probability using habitat modeling with GAMs and MaxEnt. We defined Atlantic Ocean, Indian Ocean and a part of Pacific Ocean in southern hemisphere as background. We used satellite-transmitters, GPS loggers and the geolocators data of the black-browed albatross (*Thalassarche melanophris*) and the wandering albatross (*Diomedea exulans*), both species known to be bycaught in pelagic longline fisheries. Kernel densities were calculated quarterly from the tracking data, which were obtained in 1989-2008, and were divided into breeders and non-breeders. For the MaxEnt modeling, 40% of distribution sites were resampled based on the kernel density, while for the objective variable of the GAM, the kernel density of all distribution site were used directly. We defined ten oceanic environmental factors as potential explanatory variables. The areas with high predicted distribution estimated by the models generally agreed with the areas with high utilization distribution calculated from the tracking data. Around colonies in which no tracking data were available, both the black-browed and wandering albatross models predicted foraging distribution but the probability was generally low. As application, we will discuss the factor affecting bycatch rate.

October 23, 17:20 (S2-9682)

Cassin's Auklet at-sea distribution and exposure to stressors such as ship-source oil pollution and microplastics

Patrick D. **O'Hara**[1], Ken Morgan[1], Jamie McDevitt-Irwin[2], Jean-Pierre W. Desforges[3], Peter S. Ross[4] and Sean Boyd[5]

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Cassin's Auklet has one of the most extensive breeding ranges for a Pacific alcid. Although the extent of the breeding range of Cassin's Auklet has not substantially changed since the 19th century, breeding colonies in British Columbia have become increasing more important for the conservation of this species. In particular, it has been estimated that the Triangle Island colony hosts approximately 55 to 65% of the global breeding population of Cassin's Auklet. This concentration of breeding individuals during the summer makes this species seasonally vulnerable to small-scale anthropogenic stressors such as ship-source operational (or chronic) oil pollution and oceanographic accumulations of microplastics. In this talk, we show the estimated at-sea distribution of Cassin's Auklet using a RandomForest model, based on at-sea survey data collected in the Canadian Pacific during the breeding period (May through July, 1990-2011); and, home ranges estimated from radio-telemetry locations of tagged adults breeding on Triangle Island (May through July, 1999-2001). We compared these distributions spatially with vessel traffic information as a proxy for exposure to ship-source operational oil discharges, and with microplastic concentrations derived from the cooling intake of research vessels during late summer 2012. Our results suggest that Cassin's Auklet distributions are exposed to a relatively high risk of encountering ship-source oily discharges, but that they are found in areas with relatively low densities of microplastic. Cassin's Auklet is currently under review for conservation status in Canada, and we believe this approach for estimating spatially explicit risk exposure while foraging at-sea could be useful for informing this review process.

October 23, 17:40 (S2-9648)

A multi-model ensemble prediction of habitat suitability index (HSI) models for neon flying squid in central North Pacific by using 3-D ocean data assimilation product

Hiromichi **Igarashi**[1], Toshiyuki Awaji[1,3], Masafumi Kamachi[1,2], Yoichi Ishikawa[1], Norihisa Usui[2], Masaaki Iiyama[3], Yosuke Onoue[3], Mitsuo Sakai[4], Yoshiki Kato[4], Irene Alabia[5], Sei-ichi Saitoh[5] and Masaki Seitoh[6]

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The neon flying squid (*Ommastrephes bartramii*) has a wide-spread distribution in subtropical and temperate waters in the North Pacific, which plays an important role in the pelagic ecosystem and is one of the major targets in Japanese squid fisheries. Several kinds of habitat suitability index (HSI) models for the neon flying squid have been developed and successfully estimated the potential fishing zone around the date line of the central North Pacific (35-45N) in summer, by using the MOVE (Meteorological Research Institute multivariate ocean variational estimation) ocean reanalysis product, which provides realistic fields of 3-dimensional ocean circulation and environmental structures including meso-scale eddies (Usui *et al.*, 2006). In order to improve the HSI model performance, we applied an empirical weighted multi-model ensemble (superensemble) method to estimating the potential habitat area of neon flying squid by using five different statistical models (HSI, GAM, RandomForest, MaxEnt, Support Vector Machine) as ensemble members. The estimated HSI fields of each member and the observed squid CPUE dataset during the training phase (1999-2012) were utilized to derive model performance statistics, which include the blending coefficients for compiling a single consensus forecast during the forecast phase (2013-2014). The results show better performance of HSI prediction by the superensemble method especially in 2011, the year in which the absolute RMSE value is higher than normal. This suggests that the ensemble technique could be more effective in cases when predictions of individual models have greater variability.

S2 Poster Presentations

S2-P1

Developing the suitable operation prediction model of neon flying squid in the central North Pacific using Satellite images and VMS

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Neon flying squid (*Ommastrephes bartramii*), also named Akaika is one of the most important fisheries sources in the North Pacific. For pelagic fisheries, the search for Neon flying squid is the most time consuming for fisherman and significantly affects fuel and labor costs. The VMS (Vessel Monitoring System) was employed to measure the vessel's position at a constant time interval using GPS satellite without artificial manipulation. Using these data, this study applied generalized adding model (GAM) to create a CPUE (catch per unit effort) model expression by using environment factors (sea surface temperature, sea surface height, geostrophic current u/v and eddy kinetic energy) as explanatory variable, which obtained from the position information by VMS. Finally, the CPUE model integrates the distance of the previous fishing activity from the predicted position, the average time of fishing activities, the market price of squid and the fuel efficiency of fishing vessels to develop squid suitable operation prediction models and management measures. The results show that, the behavioral characteristics of squid fishing boats have a higher probability of moving northeastward. The degree to which the predicted fishing ground matched the actual operated area is 40%. The low prediction accuracy was due to the poor fishing opportunities in 2013, as the operation of fishing vessels depend as much on captain experiences as low accuracy satellite images. For future efforts, we plan to improve the accuracy of this operation prediction model in the future.

S2-P2

Effect of 3-D physical structures on spatial distributions of Japanese common squid in the coastal waters of southwestern Hokkaido, Japan

Xun **Zhang**[1], Sei-Ichi Saitoh[1], Toru Hirawake[1], Satoshi Nakada[2], Koji Koyamada[2], Toshiyuki Awaji[3], Yoichi Ishikawa[4] and Hiromichi Igarashi[4]

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Understanding impacts of seawater physical structures on distribution of marine species will likely improve the predictability of habitat models and will increase fishing efficiency and facilitate fisheries management strategies. In the coastal waters of southwestern Hokkaido, Japan, Japanese common squid (*Todarodes pacificus*) has been regarded as one of the most important commercial species. Fishing locations of this species were recorded according to remote sensed nighttime visible images derived from Meteorological Satellite Program/Operational Linescan System (DMSP/OLS). Distributions of Japanese common squid were found to show seasonal patterns in distribution and distinct spatial variations on daily basis. Daily 3-D (three dimensional) environmental factors (*u*, *v*, *w*, temperature, salinity, density) in series of depth layers between 2008 and 2011 which were derived from the 4D-VAR data assimilation system and were analyzed to explain the distribution of Japanese common squid using boosted regression tree models. After model validation, daily potential fishing zones (PFZ) of this species were predicted. Based on the cross-section views of environmental layers, results revealed that PFZ and real fishing activities were frequently located at areas where coastal upwelling occurs in subsurface water. Japanese common squid in this study area more likely inhabit upper depth of less than 200 meters since the temperature of deeper waters were generally not suitable for their survival. From horizontal current field maps, counter currents and eddies showed close relationships with the occurrences of potential fishing zone. PFZ predictions in the future are expected to be further improved after considering both vertical and horizontal variations of seawater structures.

S2-P3

Habitat model development of Japanese common squid in Japan Sea using satellite remotely sensed data

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Japanese common squid, *Todarodes pacificus*, is an important species in Japan's fishery. They serve an important trophic role between their predators and prey, and therefore common squid is a critical component of the marine ecosystem. Given the importance of squid, it is essential to advance our understanding of squid distribution for conservation efforts. And prediction of squid's habitat may be useful for obtaining knowledge of squid. Therefore, the objective of this study is to fit a common squid HSI (Habitat Suitability Index) and to improve its prediction. Common squid fishery vessels usually can be observed from night-time visible images of DMSP/OLS, so we can estimate positions of fishing vessels in the Japan Sea by using these images. We used sea surface temperature, chlorophyll *a* and other parameters as environmental parameters. We used a GAM (Generalized Additive Model) framework for spatial statistic, and MaxEnt (Maximum entropy) model as machine learning model and compared the resultant HSIs. Histograms of each environment showed near bi-modal patterns. These two peaks could represent habitat in two regions: shallower than 500m and deeper. The depth contour of 500m corresponds to the boundary between the coastal and offshore fishery. In winter and early spring, HSI value of GAM is higher than MaxEnt model results while vessels tend to be distributing at coastal region with low environmental variance. However, in other seasons, HSI value of MaxEnt model is higher while vessels were spreading to offshore. Therefore, it might be necessary to select the optimal HSI model for each season.

S2-P4

Predicting the potential invasion in Korean waters of the saltmarsh grass *Spartina alterniflora* from China – A joint proposal by KIOST and Nanjing University

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Marine biological invasions constitute one of the greatest threats to biological diversity of the coastal and ocean ecosystems. *Spartina alterniflora* was introduced into China in 1979, and now has expanded along the east coast of China due to its strong capability of propagating by seeds and rhizome fragments. It was listed among 16 harmful exotic species in China. Korea has a large tidal mudflat especially on the west coast (Table 1), which could be suitable for the habitat for *S. alterniflora.* The primary objectives of this KIOST-Nanjing University joint research project are to predict potential invasion of *Spartina alterniflora* in Korean waters using habit niche modeling using MaxEnt, and identify potential vectors for such invasion. These exercises will greatly enhance our understanding of the dispersal of the species and therefore assist in managing the species from unwanted invading Korean waters.

S2-P5

Operational Management of tuna fisheries in Indonesia

Patrick Lehodey[1], Inna Senina[1], Philippe Gaspar[1] and Sylvie **Giraud**[2]

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[2]   National Oceanography Directorate/Ministry Of Science, Technology and Innovation, Putrajaya, Malaysia

An ecosystem modelling approach has been developed and implemented for the Ministry of Fisheries in Indonesia as an operational regional model to monitor and predict at high resolution (1/12°x day) the spatial dynamics of three tuna species in a region submitted to the strong pressure of fishing and the impact of climate change. Mechanisms are constrained by relationships based on the bio-physical environment predicted from coupled 3D models of ocean physics and biogeochemistry. The spatial Eulerian ecosystem and population dynamics model (SEAPODYM) is based on advection-diffusion equations simulating random and oriented movements. First the model includes a simplified representation of micronekton at the mid-trophic level of the oceanic food web. Then spatio-temporal dynamics of predators are simulated under the influence of environment and fishing pressure. Surface currents passively transport larvae, while young and adult fish movements are driven using habitat indices. Advection and diffusion are proportional to the size of the fish and the advection term is proportional to the gradient of habitat, while the diffusion decreases when the habitat index increases. For mature fish, the habitat index switches seasonally from the feeding to the spawning habitat definition in order to reproduce changes in migration patterns of mature fish during the spawning season. The spawning habitat index in SEAPODYM also drives the spawning success, and then the subsequent recruitment. Fisheries impacts are included in the model and the comparison between predicted and observed catch used to optimize the model parameterization using the maximum likelihood method.

S3

BIO/MEQ Topic Session
Tipping points: defining reference points for ecological indicators of multiple stressors in coastal and marine ecosystem

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

Co-Convenors:

Rebecca G. Martone (USA)

Ian Perry (Canada)

Jameal Samhouri (USA)

Motomitsu Takahashi (Japan)

Maciej Tomczak (Poland / ICES)

Chang Ik Zhang (Korea)

Invited Speakers:

Phil Levin (NNOAA NW Fisheries Science Center, USA)

Tetsuo Yanagi (Research Institute for Applied Mechanics, Kyushu University, Japan)

Many coastal and marine ecosystems, ranging from reefs to estuaries to pelagic systems, are exposed to multiple stressors, which can lead to rapid changes with significant, long-term consequences that are often difficult to reverse. Changes in ocean climate, the abundance of key species, nutrients, and other factors drive these shifts, which affect ocean food webs, habitats, and ecosystem functions and people's livelihoods and well-being. Determining indicators of ecological changes due to multiple stressors and defining reference points for those indicators are key steps for managers to avoid ecological degradation and loss of keys goods and services. Setting ecological reference points in ecological systems presents a challenge to resource managers because (a) reference points are often difficult to determine due to the complexity of natural systems, including the presence of thresholds, tipping points, and non-linearities; (b) the paucity of theoretical modeling and empirical understanding needed to address these complexities, identify ecological thresholds and develop early warning indicators means that managers must make decisions based on high levels of uncertainty; and, (c) many institutional and governance structures do not allow managers the necessary flexibility to take up this information and react within relevant timeframes. This session will address these pressing challenges, and explore promising approaches to tackling them with the goal of catalyzing new research and management innovation. In particular, we invite presentations that (i) define the conceptual basis for reference points and management objectives surrounding reference points; (ii) use theoretical, modeling and observational approaches to identify potential reference points for indicators of changes in marine ecosystems; (iii) incorporate risk and sources of error (measurement, model, process) in such analyses; (iv) discuss how reference points may be used in helping to manage marine ecosystems, specifically in relation to the decision-making process related to evaluating and deciding on acceptable levels of risk. These discussions will be guided by the FUTURE science themes, with special attention to examining climate and anthropogenic drivers of ecological change, and identifying early warning indicators to enable forecasting to avoid crossing ecological thresholds. The outcomes will contribute to the work of PICES Working Group 28 on *Development of ecosystem indicators to characterize ecosystem responses to multiple stressors*.

Tuesday, October 21 (09:00-17:30)

09:00   *Introduction by Session Convenors*

09:05   **Marine ecosystem regime shifts: Challenges and opportunities for Ecosystem-Based Management (Invited)**
Phil Levin

09:30   **Tipping points and decision-making: Why they matter, why they are hard, and practical things to do**
Jake Rice

09:50　**Embedding the science of tipping points into ocean management**
Rebecca <u>Martone</u>, Carrie Kappel, Courtney Scarborough, Mary Hunsicker, Ben Halpern, Kimberly Selkoe, Phil Levin, Jameal F. Samhouri, Crow White, Ashley Erickson, Ryan Kelly, Lindley Mease, Margaret Caldwell, Larry Crowder and Rod Fujita

10:10　**Ecological network indicators of ecosystem status and change in the Baltic Sea**
Maciej T. <u>Tomczak</u>, Johanna J. Heymans, Johanna Yletyinen, Susa Niiranen, Saskia A. Otto and Thorsten Blenckner

10:30　*Coffee/Tea Break*

10:50　**Regional variations in ecosystem responses to anthropogenic activities and natural stressors in the Seto Inland Sea**
Motomitsu <u>Takahashi</u>, Sachihiko Itoh, Naoki Yoshie and Kazuhiko Mochida

11:10　**Potential early warning indicators of marine ecosystem changes in coastal British Columbia, Canada**
R. Ian <u>Perry</u>

11:30　**Seabird indicators and "tipping points" in North Pacific marine ecosystems**
William J. <u>Sydeman</u>, Sarah Ann Thompson, Julie A. Thayer, Marisol Garcia-Reyes, Heather Renner, John F. Piatt, Stephanie Zador and Yutaka Watanuki

11:50　**The effects of acute gamma irradiation on the survival and the physiological and biochemical indexes of Chinese black sleeper, *Bostrichthys sinensis***
Wen <u>Yu</u>, Tao Yu, Yusheng Zhang and Feng Lin

12:10　**The combined effects of elevated CO_2 and temperature on the physiological condition of the olive flounder larvae *Paralichthys olivaceus***
Kyung-Su <u>Kim</u>, JeongHee Shim and Suam Kim

12:30　*Lunch*

14:00　**Eutrophication and oligotrophication processes in the Seto Inland Sea and their relationships to the Satoumi concept (Invited)**
Tetsuo <u>Yanagi</u>

14:25　**Diversity of perceptions and utility of marine ecosystem services**
Kazumi <u>Wakita</u>, Zhonghua Shen, Taro Oishi, Nobuyuki Yagi, Hisashi Kurokura and Ken Furuya

14:45　**Assessment of the magnitude and interrelationship of seasonal phytoplankton bloom occurrence at the Japanese scallop (*Mizuhopecten yessoensis*) farming area of Okhotsk Sea, Hokkaido, Japan**
Christopher Mulanda <u>Aura</u>, Sei-Ichi Saitoh, Yang Liu and Toru Hirawake

15:05　**Ordered re-assembly of marine ecosystems**
Jameal F. <u>Samhouri</u>, Adrian C. Stier and Phil Levin

15:25　**Potential reference points for mean trophic level of macrofauna in the Sea of Okhotsk**
Konstantin M. Gorbatenko, Vladimir V. <u>Kulik</u> and Artem E. Lazshentsev

15:45　*Coffee/Tea Break*

16:05　**The bioconcentration of artificial radionuclides by marine animals after the Fukushima nuclear accident in the Northwest Pacific**
Wu Men, Jianhua He, Wen Yu, Fenfen Wang, Wuhui Lin and Yusheng <u>Zhang</u>

16:25　**Seasonal and spatial variations in nematode assemblages affected by thermal influence of a nuclear power plant in Korea (East Sea, Pacific Ocean)**
Hyeong-gi <u>Kim</u>, Hyun soo Rho and Chul-woong Oh

| 16:45 | **Characterization of absorbed dose from natural and anthropogenic radionuclides for the purpose of establishing reference points within the marine environment** |
| | Delvan R. **Neville** and Kathryn A. Higley |

| 17:05 | Discussion |

| 17:25 | Summary |

| 17:30 | *Session Ends* |

S3 Posters

| S3-P1 | **DNA damage (Comet Assay) as biomarker of Cd exposure in bivalve mollusks *Modiolus kurilensi* and *Corbicula japonica*** |
| | Valentina V. Slobodskova, Sergey P. Kukla, Viktor P. Chelomin and Elena V. Zhuravel |

| S3-P2 | **Sulfonamide antibiotics in the Northern Yellow Sea are related to resistant bacteria: Implications for antibiotic resistance genes** |
| | Guangshui Na, Hui Gao, Ruijin Li, Jinqiu Du, Ziwei Yao and Chuanlin Huo |

| S3-P3 | **Growth rate comparison of Pacific oyster, Crassostrea gigas, reared *in situ* in a high-CO_2 mesocosm environment** |
| | JeongHee Shim, Hakbin Hwang, Jae-Hyun Lim, Sang-Jun Lee and Jung-no Kwon |

| S3-P4 | **Valuation of ecosystem diversity maintenance service in marine protected areas: Shandong case** |
| | Shang Chen, Shengjie Tu, Tao Xia, Zhengxiang Gao and Tao Zhang |

S3

S3 Oral Presentations

October 21, 09:05 (S3-9791), Invited

Marine ecosystem regime shifts: Challenges and opportunities for Ecosystem-Based Management

Phil **Levin**

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Regime shifts have been observed in marine ecosystems around the globe. These phenomena can result in dramatic changes in the provision of ecosystem services to coastal communities. Accounting for regime shifts in management clearly requires integrative, ecosystem-based management (EBM) approaches. EBM has emerged as an accepted paradigm for ocean management worldwide, yet, despite the rapid and intense development of EBM theory, implementation has languished, and many implemented or proposed EBM schemes largely ignore the special characteristics of regime shifts. Here we first explore key aspects of regime shifts that are of critical importance to EBM, and then suggest how regime shifts can be better incorporated into EBM using the concept of Integrated Ecosystem Assessment (IEA). An IEA uses approaches that determine the likelihood that ecological or socio-economic properties of systems will move beyond or return to acceptable bounds as defined by resource managers and policy makers. We suggest an approach for implementing IEAs for cases of regime shifts where the objectives are either avoiding an undesired state or returning to a desired condition. We discuss the suitability and short-comings of methods summarizing the status of ecosystem components, screening and prioritizing potential risks, and evaluating alternative management strategies. IEAs are evolving as an EBM approach that can address regime shifts; however, advances in statistical, analytical, and simulation modeling are needed before IEAs can robustly inform tactical management in systems characterized by regime shifts.

October 21, 09:30 (S3-9750)

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

Jake **Rice**

Fisheries and Oceans Canada, Ottawa, ON, Canada. E-mail: jake.rice@dfo-mpo.gc.ca

Tipping points are emerging as key aspects of ecosystem and population dynamics, describing the point when a change in productivity regime occurs. However, this just describes what has happened; not the implications of such changes. This talk will first review the implications of having crossed a tipping point, at the scale of the dynamics of a population, a community and an ecosystem. Several levels of implications for dynamics will be considered – implications for persistence, resilience to pressures, and ability to return to previous states. Next the talk will take this catalogue of implications of having crossed tipping points at various scales, and consider their consequences for sustainable use and management. Although passing of a tipping point usually will require some changes to management in order to keep uses sustainable, the *causes* of a change in regime matter greatly to how management should be adjusted. Consequently, science must address difficult challenges when management must deal with risk of passing a tipping point. There must be knowledge of the both location of the tipping points, and of which productivity factors have changed and how. Science has rarely been able to provide this knowledge until after a tipping point has been passed, and management has been unsustainable for some years. The talk will conclude with two causes for some optimism. Rough-and-ready analytical methods will be illustrated to help identify the neighborhood of tipping points, and overlooked aspects of existing management regimes will be revisited, to illustrate how they can contribute to sustainability.

S3

October 21, 09:50 (S3-9557)

Embedding the science of tipping points into ocean management

Rebecca **Martone**[1], Carrie Kappel[2], Courtney Scarborough[2], Mary Hunsicker[2], Ben Halpern[2], Kimberly Selkoe[2], Phil Levin[3], Jameal F. Samhouri[3], Crow White[4], Ashley Erickson[1], Ryan Kelly[1,5], Lindley Mease[1], Margaret Caldwell[1], Larry Crowder[1] and Rod Fujita[1,6]

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In the oceans, diverse ecosystems ranging from estuaries to reefs to pelagic systems have undergone sudden, dramatic shifts. Changes in ocean climate, the abundance of key species, nutrients, and other factors drive these shifts, with resulting effects on ocean food webs, habitats, and ecosystem functions that have direct impacts on people's livelihoods and well-being. The fact that ocean ecosystems have such tipping points may be cause for particular concern because they are often unexpected and can be very difficult, if not impossible, to reverse. The Ocean Tipping Points project seeks to understand and characterize thresholds, or "tipping points," in coastal and ocean systems, in which small changes in human use or environmental conditions result in large, and sometimes abrupt, impacts to marine ecosystems. Our ultimate goal is to help agencies and decision-makers anticipate and manage for these tipping points by identifying early warning indicators of impending shifts, quantifying reference points for drivers of shifts, and establishing safe-operating spaces for management. We will present some foundational results of our project regarding the biophysical nature of ocean tipping points, including a global review of ocean tipping points, and an examination of the prevalence and types of tipping points in pelagic systems, as well as the management of human activities in systems that exhibit tipping points.

October 21, 10:10 (S3-9422)

Ecological network indicators of ecosystem status and change in the Baltic Sea

Maciej T. **Tomczak**[1], Johanna J. Heymans[2], Johanna Yletyinen[3,4], Susa Niiranen[4], Saskia A. Otto[4] and Thorsten Blenckner[4]

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Several marine ecosystems under anthropogenic pressure have experienced shifts from one ecological state to another. In the central Baltic Sea, the regime shift of the 1980s has been associated with food-web reorganization and redirection of energy flow pathways. These long-term dynamics from 1974 to 2006 have been simulated here using a food-web model forced by climate and fishing. Ecological network analysis was performed to calculate indices of ecosystem change. The model replicated the regime shift. The analyses of indicators suggested that the system's resilience was higher prior to 1988 and lower thereafter. The ecosystem topology also changed from a web-like structure to a linearized food-web.

October 21, 10:50 (S3-9634)

Regional variations in ecosystem responses to anthropogenic activities and natural stressors in the Seto Inland Sea

Motomitsu **Takahashi**[1], Sachihiko Itoh[2], Naoki Yoshie[3] and Kazuhiko Mochida[4]

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We examined regional variations in ecosystem responses to anthropogenic and natural stressors in the Seto Inland Sea using an expert-based screening method. The Seto Inland Sea was assigned into 3 waters in the eastern, 4 waters in the central and 3 waters in the western areas based on local bay/straits. Relative risk was scored based on exposure (spatial scale, frequency, functional impact) and sensitivity (resistance, recovery time) using a habitat-stressor matrix. A total of 848 responses from 25 experts were available for the analysis. Responses differed among habitats: 32% in intertidal and 68% in coastal zones. Coastal engineering/development scored highest in 6 of the 10 survey waters. Commercial activities were highest in the eastern area, where population density in the watershed was highest among all survey areas. Harmful algal blooms in the central area were higher than those in the eastern and western areas. This could be due to geographical features of the blooming area, in which the waters are enclosed and not easily replaced by fresh water from the open ocean. Sea level changes ranked one of the five highest scores among the given stressors in the central and western areas and are considered to affect habitat/nursery area of bivalves and flat fishes in tidal flats. Our results demonstrate that stressor-specific risks show regional variability depending on population density or geographical features in the Seto Inland Sea.

October 21, 11:10 (S3-9531)

Potential early warning indicators of marine ecosystem changes in coastal British Columbia, Canada

R. Ian **Perry**

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Effective early warning indicators should provide advance notice that system characteristics are about to change, which will have impacts on valued ecosystem properties. If they can be shown to exist for a marine system, they would be important components of suites of ecosystem indicators and would be especially useful to marine resource managers. Early warning indicators are likely to involve physical or lower trophic level features, as they should respond rapidly to changing forcing conditions and also have important links throughout the ecosystem. Different characteristics of early warning indicators have been proposed, in particular increasing variance. This suggests that an additional feature of early warning indicators should be the ability to measure them frequently (and cheaply). In this presentation, I explore potential early warning indicators of marine ecosystem changes in coastal British Columbia, Canada. Starting with the Strait of Georgia, I show from previous work how six readily-measured variables, termed leading indicators, describe large-scale regime-like changes in this ecosystem. Three of these leading indicators are sea surface temperature, winds measured at Vancouver airport, and the North Pacific Gyre Oscillation Index. I then explore the potential for using each of these as early warning indicators of ecosystem changes, based on their variance properties. Key questions include which of these may serve as effective early indicators, and how early can they give a warning? Preliminary studies indicate that (at least) sea surface temperature has the potential to serve as an early warning indicator; the other variables will also be reported. The potential for using these variables as early warning indicators for other marine ecosystems along the B.C. coast will then be explored.

October 21, 11:30 (S3-9690)

Seabird indicators and "tipping points" in North Pacific marine ecosystems

William J. **Sydeman**[1], Sarah Ann Thompson[1], Julie A. Thayer[1], Marisol Garcia-Reyes[1], Heather Renner[2], John F. Piatt[3], Stephanie Zador[4] and Yutaka Watanuki[4]

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Forage fish are critical to the transfer of energy from primary producers to top consumers in North Pacific marine ecosystems. Changes in forage fish availability (distribution, abundance, and spatial organization) manifest as non-linear responses in seabirds (*e.g.* Cury *et al.* 2011 *Science*). Thus, information on seabird food habits and demographic parameters (breeding success and survival) may provide a valuable complement to traditional forage nekton sampling methods as well as reveal important benchmarks for forage fish fisheries and other human impacts. In this paper, we investigate and compare "tipping points" in seabirds relative to forage fish fisheries and availability in the California Current, Aleutian Island/Bering Sea, and Japan Sea. To establish tipping points, we modeled non-linear functional responses using extensive datasets on breeding success, survival and diet composition. Cury *et al.* (2011) showed that 1/3 of maximum biomass or abundance is a key benchmark below which seabird breeding success consistently declines.   Our models indicate that this benchmark varies by parameter, with survival being less sensitive and diet composition more sensitive than breeding success to variation in forage nekton abundance, but that 1/3 of maximum biomass is not an unreasonable benchmark to use as a target in management. Moreover, multi-species models of functional responses are required to accurately model these parameters. Seabirds provide a unique perspective on North Pacific forage fish "tipping points" which are unlikely to be reproduced in studies of other upper trophic level predators due to a dearth of data on individual-based reproductive success, recruitment and survival.

October 21, 11:50 (S3-9510)

The effects of acute gamma irradiation on the survival and the physiological and biochemical indexes of Chinese black sleeper, *Bostrichthys sinensis*

Wen **Yu**, Tao Yu, Yusheng Zhang and Feng Lin

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The survival and the physiological and biochemical indexes of Chinese black sleeper, *Bostrichthys sinensis* were observed and analyzed after single exposure to gamma radiation. The animals were given doses of 3, 6, 12, 24 or 48 Gy in the experiment. The $LD_{50(30)}$ value for Chinese black sleeper was estimated. Behavioral changes following irradiation appeared in the fishes, and changes in the physiological and biochemical indexes were also present after irradiation.

October 21, 12:10 (S3-9465)

The combined effects of elevated CO$_2$ and temperature on the physiological condition of the olive flounder larvae *Paralichthys olivaceus*

Kyung-Su **Kim**[1], JeongHee Shim[2] and Suam Kim[1]

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Little is known about how marine fishes respond to the reduced pH condition caused by the increased CO$_2$ in the atmosphere. We investigated the effects of CO$_2$ concentration and temperature on the growth of olive flounder (*Paralichthys olivaceus*) larvae. Newly hatched larvae were reared in three different concentrations of CO$_2$ (574, 988 and 1297 ppm CO$_2$) and two different temperature (18 and 22°C) water tanks for four weeks until metamorphosis. Body lengths and weights were measured at the completion of each experiment, and the experiment was repeated three times in June, July and August 2013. Results indicated that body length and weight of flounder larvae significantly increased with increasing CO$_2$ concentration (P<0.05). The higher daily growth rate during the early larval stage (hatching to 14 days) was found from the larvae reared in low pCO$_2$, while significantly lower growth rate occurred in the higher pCO$_2$ water. On the other hand, in the late larval stage (18 days after hatching to metamorphosis), the daily growth rate of larvae was much higher in high CO$_2$ water. Bone density was decreased with increasing CO$_2$ concentration of rearing water.

October 21, 14:00 (S3-9713), Invited

Eutrophication and oligotrophication processes in the Seto Inland Sea and their relationships to the Satoumi concept

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In the 1960s, when rapid economic growth began in Japan, nutrient concentrations were low but biodiversity was high and fish production was not so low in the Seto Inland Sea. Due to the increase of nutrient loads from land during this period of rapid economic growth, marine nutrient concentrations increased and fish production also increased. The maximum fish catch was attained in 1985. The total nutrient loads control was begun in 1979 under the framework of Special Law but the TP and TN concentrations in the Seto Inland Sea did not change until the 1990s due to the large supply of nutrients from the Pacific Ocean compared to the nutrient supply from land. Biodiversity and fish production in the Seto Inland Sea continued to decrease due to hypoxia, destruction of shallow area environments, especially the decreasing area of tidal flats and seagrass beds. From the late 1990s, DIN began to decrease mainly due to the change of material cycling of nitrogen, itself related to the change of biochemical processes in a changed Seto Inland Sea marine ecosystem. Our main target is to clarify the way to return the biodiversity and production of the Seto Inland Sea from the present state (2010) to the past state (1960). It is thought that the pathway of changing nutrient concentrations and biodiversity or production during eutrophication is different from that during oligotrophication, that is, the multi-phase steady state may exist under the same nutrient concentration. The biodiversity and production during eutrophication are thought to be higher than those during oligotrophication at the same nutrient concentration due to the hysteresis of the effects of hypoxia. In order to change the path of oligotrophication to that of eutrophication, the Satoumi concept (Yanagi, 2007, 2012) is very useful.

October 21, 14:25 (S3-9649)

Diversity of perceptions and utility of marine ecosystem services

Kazumi **Wakita**[1], Zhonghua Shen[2], Taro Oishi[3], Nobuyuki Yagi[2], Hisashi Kurokura[2] and Ken Furuya[2]

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Utility – the satisfaction experienced by a consumer of a good or service – forms a basis for decision-making that usually involves choosing among alternatives. Thus, the utility of marine ecosystem services is crucial in marine and coastal management. A number of notable studies on the valuation of ecosystem services have accumulated, exploring, among other things, how to take people's values into account. However, the causes of differences in people's perceptions and the utility of marine ecosystem services has been the subject of limited study. Focusing on this gap in knowledge, this study explores the background of diverse perceptions and the utility of marine ecosystem services, using a case study of Japanese residents from five different prefectures. Over the course of this study, we use "indispensability" as a key concept. Building on the presumption that the higher the perceived indispensability, the greater the utility, a corresponding hypothesis has been proposed, namely that the higher the indispensability, the greater its influence on enhancing behavioral intentions for marine conservation. We conducted a factor analysis and tested a structural equation model to correlate perceived indispensability and behavioral intentions for each respective prefecture, based on responses to questionnaires from 814 residents in Japan. Diverse perceptions of marine ecosystem services and causal relationships between perceived indispensability and behavioral intentions were identified. The possible influence of a "scarcity principle" in regards to marine ecosystem services on people's perception is also discussed. Findings from this study will contribute to tailoring marine conservation policies more effectively to suit each locality.

October 21, 14:45 (S3-9480)

Assessment of the magnitude and interrelationship of seasonal phytoplankton bloom occurrence at the Japanese scallop (*Mizuhopecten yessoensis*) farming area of Okhotsk Sea, Hokkaido, Japan

Christopher Mulanda **Aura**[1,2], Sei-Ichi Saitoh[1], Yang Liu[1] and Toru Hirawake[1]

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Some marine productivity-determining processes of phytoplankton bloom occurrences are important for developing appropriate management actions. They also help in understanding how the water column structure affects marine habitat quality. In order to assess these seasonal phytoplankton bloom occurrence dynamics, we examined trends and mechanism of sea ice and chlorophyll *a* changes as marine indicators using satellite data for an 8-year study (2005-2012) from the Special Sensor Microwave/Imager (SSM/I), Moderate Resolution Imaging Spectroradiometer (MODIS). Also data on Japanese scallop (*Mizuhopecten yessoensis*) landings as well as wind stress in the same period from the coastal region of Okhotsk Sea, Hokkaido, Japan were used. Spatial and inter-annual variability in the timing of sea ice retreat and the development of phytoplankton blooms were observed alongside distinct and considerably weaker spring and autumn blooms. The strong positive relationship between open water bloom and ice edge bloom showed that both variables are interlinked and the magnitude of their proportions depended on each other. In most areas, ice edge bloom occurrence was followed by subsequent open water bloom. Scallop landings showed distinct increases from the onset of sea ice retreat and decreases towards the arrival of sea ice cover which could be associated to the inability of scallop harvesters to access ice-covered waters. Scallop landings, residence time of sea ice and bloom occurrences showed unstable interrelationship that are inherent in the complexity of the water column structure and the coastal system.

October 21, 15:05 (S3-9751)

Ordered re-assembly of marine ecosystems

Jameal F. **Samhouri**[1], Adrian C. Stier and Phil Levin

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The "fishing down the food web" paradigm posits that ordered extinction of species is a commonly observed pattern of community dis-assembly in the ocean. This theory holds that marine ecosystems have seen a sequential loss of higher-trophic-level species, and are now disproportionately represented by lower-trophic-level species. Increasingly, these changes and others are provoking the development of ecosystem-level recovery plans in the ocean. However, little consideration has been given to how the sequence of recovery actions, or the order of community re-assembly, can influence the rate and extent of recovery for individual species, entire communities, and ecosystem-level functioning. This knowledge gap is surprising given the extensive attention that has thus far been devoted to the reverse process of community dis-assembly. Here we review examples, in a variety of geographies, of alternative community re-assembly scenarios that have been implemented in depleted marine ecosystems. We highlight 3 major categories of community re-assembly, including recovery of lower trophic level (LTL) species first, recovery of higher trophic level (HTL) species first, and recovery of all species simultaneously irrespective of trophic level. With this backdrop, we use a simple generalist predator-prey model to explore the predicted transient and equilibrium dynamics implied by community re-assembly scenarios that do versus do not proceed predictably with respect to the trophic level of the species. We find that for all community re-assembly scenarios the dynamics of LTL species are more reactive and prone to transient population booms than those of HTL species. Similarly, the return time to equilibrium is greater for LTL species than for HTL species under all community re-assembly scenarios. However, transient spikes in LTL population density are smallest, and their return times are shortest, when the HTL species are allowed to recover first. We argue that just as we have gleaned insights into how ecosystem functions have been lost through ordered dis-assembly of communities, so too we can learn about the potential benefits (and costs) of alternative recovery strategies by considering the consequences of different types of ordered community re-assembly.

October 21, 15:25 (S3-9518)

Potential reference points for mean trophic level of macrofauna in the Sea of Okhotsk

Konstantin M. Gorbatenko, Vladimir V. **Kulik** and Artem E. Lazshentsev

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Stable isotope ratio of nitrogen (^{15}N/^{14}N) was used to determine mean trophic level (muTL) of 67 fish, 6 squid and 5 Decapod species. Seasonally different were muTL of *Clupea pallasii* and *Leuroglossus schmidti.* Differentiation of muTL by weight was made for 10 fish and 2 squid species. Mean trophic level of *Theragra chalcogramma* was estimated according to season and its weight. We also included 147 species using estimates of muTL from www. fishbase.org. All the other species of macrofauna were occasional and thus we excluded them. We also excluded jellyfish species, because the proportion of bio-Carbon in gelatinous body composition is 40 times lower than that of fish. This fact could influence greatly our results; therefore, we used statistical weighting of each muTL by wet kg per square km. Finally we estimated muTL from 9926 trawls (with 1 cm mesh) in the pelagic waters (in 1984-2013) and from 6321 bottom trawls (in 1977-2010). We analyzed spatial and temporal variation of muTL using Generalized Additive Models with splines on coordinates, horizon of trawling, years and months. Thus we got estimates of intercepts and spline components over years. Based on these annual estimates, we conclude that muTL over the last 10 years increased significantly (the rate was about 0.007 per year on the linear scale) in the pelagic waters and it crossed the intercept (3.95) in 2008. The muTL of the demersal component of the observed community stopped declining below the intercept (4.35) in 2005 and since then there has been no significant trend.

S3

October 21, 16:05 (S3-9687)

The bioconcentration of artificial radionuclides by marine animals after the Fukushima nuclear accident in the Northwest Pacific

Wu Men, Jianhua He, Wen Yu, Fenfen Wang, Wuhui Lin and Yusheng **Zhang**

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A huge amount of artificial radionuclides was released into the seawater of the northwest Pacific from the Fukushima nuclear accident. Not only the seawater but also the marine organism have been impacted by the released artificial radionuclides because marine organisms have high enrichment ability with certain artificial radionuclides. In order to study the transport and the bioconcentration of artificial radionuclides by marine animals after the Fukushima nuclear accident in the northwest Pacific, six cruises were executed by the State Oceanic Administration of China during 2011-2013. This paper reports the bioconcentration of ^{137}Cs, ^{134}Cs, ^{90}Sr, ^{58}Co, ^{60}Co and ^{110m}Ag by some species of marine animals, such as squid (*Ommastraphes bartrami*), blue shark (*Prionace glauca*), snake mackerel (*Gempylus serpens*) and dolphinfish (*Coryphaena hippurus*) in the studied waters. Four of these radionuclides, all but ^{58}Co and ^{60}Co, could be detected in almost all collected species of marine animals. For the squid the highest activities of ^{137}Cs and ^{90}Sr were 21 and 12 times higher than that before the Fukushima accident, respectively. ^{134}Cs and ^{110m}Ag, which were not detectable before the accident, could be detected in the all cruises. Based on a comparison of the artificial nuclide activities in different tissues, it appeared that the squid muscles preferred enriching ^{137}Cs and ^{134}Cs, rather than concentrating ^{110m}Ag and ^{90}Sr, while the reverse was true for the viscera of squid. The blue shark muscles preferred enriching ^{137}Cs and ^{134}Cs while the bones preferred concentrating ^{90}Sr.

October 21, 16:25 (S3-9318)

Seasonal and spatial variations in nematode assemblages affected by thermal influence of a nuclear power plant in Korea (East Sea, Pacific Ocean)

Hyeong-gi **Kim**[1], Hyun soo Rho[2] and Chul-woong Oh[1]

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[2]   Korea Institute of Ocean Science and Technology, Gyeongbuk, R Korea

The effects of thermal discharge from a coastal nuclear power plant on the spatial and seasonal variability of nematode assemblages were investigated in the Gori coastal waters of the southern East Sea. Taxonomic and functional approaches were taken to describe the assemblage structure and relate it to the abiotic environment based on a sampling scheme involving three stations and four seasons. The analysis of the nematode communities suggested that heated effluent influenced the assemblage structure or the spatial distribution of the taxa studied. The abundance of the nematodes differed significantly among seasons and stations and the numbers of species also differed significantly between stations. The seasonal variation was greater in winter and summer than in spring and autumn. The numbers of species and their abundances were highest at station 3 (impact station), attributable to the increased bottom temperature. However, the functional diversity of the assemblages did not change notably between stations or seasons. Species such as *Sabatieria* sp. (34%), *Linhystera* sp. (18%) and *Parodontophora* sp. (11%) were usually dominant in all seasons and at all stations. *Parodontophora* sp. displayed a significant negative correlation with bottom temperature ($p<0.05$). These results indicate that nematode species composition was significantly affected by bottom temperature.

October 21, 16:45 (S3-9452)

Characterization of absorbed dose from natural and anthropogenic radionuclides for the purpose of establishing reference points within the marine environment

Delvan R. **Neville** and Kathryn A. Higley

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There are only limited studies of deterministic effects of radiation in non-humans, the majority of which focused on terrestrial mammals used as proxies for humans. Ethical treatment of laboratory animals necessitates that these animals not face multiple stressors during the course of these experiments. Lacking a direct threshold for deterministic effects from absorbed dose in marine life, an alternative reference level that is available is the absorbed dose from natural and anthropogenic radionuclides that these ecosystems already endure without ill effect. Methodology and challenges in quantifying these doses is presented, in addition to absorbed dose estimates for several member organisms in the Northern California Current.

S3 Poster Presentations

S3-P1

DNA damage (Comet Assay) as biomarker of Cd exposure in bivalve mollusks *Modiolus kurilensi* and *Corbicula japonica*

Valentina V. **Slobodskova**[1,2], Sergey P. Kukla[1,2], Viktor P. Chelomin[1,2] and Elena V. Zhuravel[2]

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Cadmium (Cd) is one of the most toxic heavy metals because it can induce the production of toxic hydroxyl radicals that cause various oxidative processes including DNA damage. The assessment of DNA damage by the single cell gel electrophoresis (Comet assay) has been described as a useful nonspecific general stress biomarker in marine organisms. The aim of the present study was to estimate the influence of cadmium accumulation on the level of DNA damage expressed as DNA strand breaks in isolated gill cells from the mollusks *Modiolus kurilensis* and *Corbicula japonica*. The level of DNA damage was assessed using the Comet assay, and results were expressed as % DNA in comet tail. The bivalves *M. kurilensis* and *C. japonica* are widespread species in Peter the Great Bay and able to accumulate the toxic cadmium in tissues. Significant increases in DNA damage were observed after exposure to Cd in comparison with control marine scallops. The results of these experiments thus show that cadmium accumulation can contribute to the DNA damage effects. The data from the present study indicate that the maximum rate of cadmium accumulation and formation of DNA damage was observed in the gills of *C. japonica*, making it the most efficient accumulator of cadmium and indicator of environmental pollution with cadmium. DNA molecules are one of the main targets of cadmium accumulation and toxic effect development.

S3-P2

Sulfonamide antibiotics in the Northern Yellow Sea are related to resistant bacteria: Implications for antibiotic resistance genes

Guangshui **Na**[1], Hui Gao[1], Ruijin Li[1,2], Jinqiu Du[1], Ziwei Yao[1] and Chuanlin Huo[1]

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[2]   Dalian Ocean University, Dalian, PR China

Antibiotic resistance gene (ARG) residues and the mode of transmission in marine environments remain unclear. The sulfonamide (SAs) concentrations, different genes and total bacterial abundance in seawater and sediment of the Northern Yellow Sea were analyzed. Results showed the genes *sul I* and *sul II* were presented at relatively high concentrations in all samples, whereas the detected gene *sul III* was fewer. The ARGs concentrations in the sediments were 10^3 times higher than those in water, which indicated sediment was an essential ARG reservoir. Statistical analysis revealed the total antibiotic concentration was positively correlated with the relative abundance of the gene *sul I* and *sul II*. The relative abundances of the gene *sul I* and the gene *sul II* were also correlated positively with those of the gene *int1*. This correlation demonstrated that SAs exerted selective pressure on these ARGs, whereas the gene *int1* could be implicated in the propagation of the genes *sul I* and *sul II* in marine environments.

S3-P3

Growth rate comparison of Pacific oyster, Crassostrea gigas, reared *in situ* in a high-CO$_2$ mesocosm environment

JeongHee **Shim**[1], Hakbin Hwang[2], Jae-Hyun Lim[1], Sang-Jun Lee[1] and Jung-no Kwon[1]

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[2]   Seodaemun Museum of Natural History, Seoul, R Korea

To discover effects of ocean acidification on marine invertebrates, we compared growth of Pacific oyster *Crassostrea gigas* reared in different pH conditions. We set up artificial mesocosm facilities that were made with frames and polypropylene film at the most important oyster spawning area of Korea on Nulcha Island, located at Nakdong River estuary, from April to May 2013 (about 50 days). During this mesocosm experiment, mean pH_{NBS} values ($\pm$SD) of controlled environments (M1, M2) were 7.71$\pm$0.28 and 7.72$\pm$0.28, respectively, while that of reference was 8.20$\pm$0.12. Juvenile oysters, with mean ($\pm$SD) shell length and weight of 29.21$\pm$6.30 mm and 4.08$\pm$2.36 g (n=90), respectively, were detached from shells of scallop (a device for settling spat), and exposed to three mesocosm treatments. The mean growth rates of oyster weight and shell length were significantly different (ANOVA, p=0.01). The weight and length growth rate of reference (19.5$\pm$17.6 mg day^{-1} and 0.143$\pm$0.121 mm day^{-1}) were higher than those of low pH controlled (M1: 13.5$\pm$14.3 mg day^{-1} and 0.100$\pm$0.076 mm day^{-1}, M2: 14.9$\pm$14.6 mg day^{-1} and 0.124$\pm$0.133 mm day^{-1}). These results indicate that ocean acidification can seriously affect shell and weight growth of juvenile oysters.

S3-P4

Valuation of ecosystem diversity maintenance service in marine protected areas: Shandong case

Shang **Chen**[1], Shengjie Tu[2], Tao Xia[1], Zhengxiang Gao[2] and Tao Zhang[1]

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Marine ecosystem provides a lot of benefits to people, including provisioning, regulating, cultural and supporting services. As one of supporting services, biodiversity maintenance service includes not only the diverse living organisms living in the sea, but also key habitats such as spawning, overwintering and feeding grounds, shelter field and so on, the former is called as the species diversity maintenance service while the later as ecosystem diversity maintenance service. The ecosystem diversity maintenance service is valuated through the total willingness to pay of local residents in coastal regions based on the theory of Contingent Valuation Method. In order to examine the willingness to pay of local residents for the maintenance of 56 marine protected areas in Shandong coastal waters, a questionnaire survey was conducted in two typical cities, Qingdao and Jinan during April 2 to 21 in 2012. A WTP-Annual per capita income regression models based on the survey data was developed to estimate total WTP of all Shandong residents. The value of ecosystem biodiversity maintenance service in Shandong coastal ecosystem is 7.14 billion RMB, average WTP is 206 RMB per person. The total value of 12 marine natural reserves is 2.997 billion RMB, average 0.25 billion per reserve; The total value of 23 Special Marine Protected Areas is 2.28billion RMB, average 99 million per one. The total value of 21 Marine Aquatic Germplasm Resources Protected Areas is 1.86 billion RMB, average 88 million per one. The results show that the cultural level and annual income and marine awareness of local residents increase their' WTP. The valuation of biodiversity maintenance service help clearly describe the scientific significance of rare living organisms and key habitats, it provides a simple and practical tool to assess marine management effectiveness.

S3

S4

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

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

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

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

Friday, October 24 (09:00-12:35)

09:00   ***Introduction by Session Convenors***

09:05   **Climate variability and Interacting Trophic Control in the Southern California Current (Invited)**
Martin <u>Lindegren</u>, David M. Checkley, Jr., Mark D. Ohman, J. Anthony Koslow and Ralf Goericke

09:30   **Big YES to sustainable ecosystem management and why NO to sustainable monitoring efforts? – Gap between demand and supply in Japanese case**
Sanae <u>Chiba</u>

09:50   **Design of ocean observation systems: Sampling requirements to monitor fish population and community trends as Essential Ocean Variables**
J. Anthony <u>Koslow</u> and Melaina Wright

10:10   **Understanding the mechanisms of the interannual variability of phytoplankton in the Ulleung Basin, East Sea: A modeling study**
Soonmi <u>Lee</u>, Sinjae Yoo, Chanjoo Jang and Momme Butenschon

10:30   ***Coffee/Tea Break***

10:50   **The role of plankton time-series in managing our seas in a climate of macroecological change (Invited)**
Abigail <u>McQuatters-Gollop</u>

11:15   **The North Pacific Continuous Plankton Recorder survey**
Sonia <u>Batten</u>

S4

11:35   **How the 20 year Newport Line zooplankton time series is used to inform fisheries management**
William Peterson, Jay Peterson, Jennifer Fisher and Cheryl Morgan
(*Harold Batchelder on behalf of William Peterson*)

11:55   **Long term zooplankton monitoring and database programs in British Columbia – Understanding the dynamics of a changing ocean**
Moira Galbraith, David Mackas and R. Ian **Perry**

12:15   **Taking stock**
David M. Checkley, Jr.

12:35   *Session Ends*

S4 Oral Presentations

October 24, 09:05 (S4-9552), Invited

Climate variability and Interacting Trophic Control in the Southern California Current

Martin **Lindegren**[1], David M. Checkley, Jr., Mark D. Ohman, J. Anthony Koslow and Ralf Goericke

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The degree to which ecosystems are regulated through bottom-up (resource-driven) or top-down (consumer-driven) processes represents a long-standing issue in ecology, with important consequences for resource management and conservation. In marine ecosystems, the role of bottom-up and top-down forcing has been shown to vary over spatio-temporal scales, often linked to highly variable and heterogeneously distributed environmental conditions. Ecosystem dynamics in the Northeast Pacific have been suggested to be predominately bottom-up regulated. However, it remains unknown to what extent top-down regulation occurs, or whether the relative importance of bottom-up and top-down forcing may change in response to climate variability. In this study, we investigate the effects and relative importance of bottom-up and top-down forcing during changing climate conditions on the food-web dynamics of the Southern California Current System (SCCS) using a generalized food-web model. This statistical approach is based on non-linear threshold models and a unique long-term data set (~60 year) covering multiple trophic levels from plankton to predatory fish. We show evidence of strong bottom-up regulation throughout the food-web, interacting with moderate top-down forcing, but only during periods of low nutrient availability and productivity, such as occurring during El Niño events. Furthermore, we highlight potential concerns for marine and fisheries management by demonstrating increased sensitivity of pelagic fish to exploitation during unfavorable climate and feeding conditions.

October 24, 09:30 (S4-9562)

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

Sanae **Chiba**

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The world oceans and ecosystem today are exposed to multiple environmental stressors, such as global warming, ocean acidification, hypoxia and direct human activities. As a better understanding of responses of ocean biogeochemistry and the ecosystem to these threats is crucial for sustaining ecosystem services for human society, there is an increasing demand in establishing regional to global ocean observing systems and research networks. In reality, however, it is not easy to sustain such observing efforts, in many cases due to the limitation of resources, and Japan is not an exception. In June 2014, we had the workshop "Toward the Better Collaboration between Scientists and Policy Makers" in Tokyo, funded by the University of Tokyo through its research project, "New Ocean Paradigm on Its Biochemistry, Ecosystem and Sustainable Use (NEOPS)" (http://ocean.fs.a.u-tokyo.ac.jp/index-e.html) and the "Science, Technology, and Innovation Governance" program at the Graduate School of Public Policy (http://stig.pp.u-tokyo.ac.jp/). The goal of the workshop was to define the major obstacles in their communication and seek a better strategy to facilite collaboration between scientists and policy makers in Japan, particularly to promote future ocean research. Talks and discussion occurred with invited experts from various areas in the natural and social sciences, science policy, public relations, and NGOs. This presentation is to report on the summary and outcome of the workshop.

S4

October 24, 09:50 (S4-9671)

Design of ocean observation systems: Sampling requirements to monitor fish population and community trends as Essential Ocean Variables

J. Anthony **Koslow** and Melaina Wright

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Essential ocean variables for observing ocean ecology must be selected on the basis of their maturity, societal benefit, relevance to ocean health, and ease/cost of observations. Fish communities are a highly-valued component of marine ecosystems and are sensitive to natural environmental variability and a range of human stressors: overfishing, habitat loss, pollution and eutrophication, and potentially ocean acidification and deoxygenation. Fishery statistics are collected widely but are limited to commercial species and are subject to bias. Ichthyoplankton surveys serve to monitor regional fish communities by sampling when most species are vulnerable to capture by simple gears (plankton nets), including commercial and non-commercial taxa, and taxa inhabiting coastal and oceanic, epi- and mesopelagic, demersal, and reef habitats. However, fish eggs and larvae are patchily distributed and do not dominate plankton samples, so it is unclear whether limited sampling programs would adequately capture trends in larval fish abundance.

To test this, we sub-sampled the CalCOFI data set to assess whether sampling a single transect or fraction of a transect would capture the trends exhibited by key species or multivariate patterns observed in the full data set. Time series of abundance for common fish species based on a single onshore-offshore transect were generally significantly correlated with those from the full data set, with the variance explained related to the number of sampling stations. Similar multivariate patterns of community change were observed between the full and reduced data sets, with the correlation again related to sample size.

October 24, 10:10 (S4-9577)

Understanding the mechanisms of the interannual variability of phytoplankton in the Ulleung Basin, East Sea: A modeling study

Soonmi **Lee**[1,2], Sinjae Yoo[1,2], Chanjoo Jang[1,2] and Momme Butenschon[3]

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We investigated the seasonal dynamics of phytoplankton responding to the changes in the mixed layer depth and atmospheric deposition in the Ulleung Basin for the years 2001-2012. To address the effect of vertical mixing and atmospheric deposition on interannual variability of phytoplankton communities, we used a zero-dimensional European Regional Seas Ecosystem Model (ERSEM). We compared the years of deep winter mixing with the years of shallow winter mixing during the period. The model results showed that the deep winter mixing increased the nutrient supply to the upper layer. It led to a better growth of diatoms. On the other hands, the shallow winter mixing advanced the initiation of spring blooms of diatoms because of enhanced light availability but reduced the production in spring by poor nutrient supply. Also the model indicated that the nutrient supply by atmospheric deposition controls the phytoplankton community in warm season. but it had little effect on regulating the phytoplankton blooms. These results suggest that in the Ulleung Basin, the balance between the vertical mixing and the atmospheric deposition process can induce a shift in phytoplankton communities. We discuss the implication of this results in light of climate change and anthropogenic N production.

October 24, 10:50 (S4-9423), Invited

The role of plankton time-series in managing our seas in a climate of macroecological change

Abigail **McQuatters-Gollop**

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Unprecedented basin-scale ecological changes are occurring in our seas. As temperatures warm ocean pH is lowering, sea ice is decreasing, and marine stratification and nutrient regimes are changing. We are only just beginning to understand the ecological manifestations of these climate alterations and their consequences for marine management. The management of our seas towards a healthy state will therefore take place against a background of large-scale climate-driven macroecological change, which must be considered when developing indicators and setting environmental targets. Much of our knowledge of macroecological change in the North Atlantic is a result of research using data gathered by the Continuous Plankton Recorder (CPR) survey, a near-surface plankton monitoring program which has been sampling in the North Atlantic since 1931. CPR data indicate that North Atlantic and North Sea plankton dynamics are responding to both climate and human-induced changes, presenting challenges to the development of pelagic indicators and targets for achievement of good environmental status in European Seas. Long-term ecological time-series, such as the CPR, further our understanding of ecological response to climate and anthropogenic drivers, providing evidence to inform and support the sustainable management of marine waters through policy mechanisms.

October 24, 11:15 (S4-9721)

The North Pacific Continuous Plankton Recorder survey

Sonia **Batten**

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The North Pacific CPR survey was a PICES initiative, developed from the 1998 MONITOR Technical Committee Meeting's desire to address the lack of open ocean plankton sampling in the North Pacific. While much shorter than the North Atlantic CPR survey the North Pacific survey is now in its 15th year of sampling. During this time-span the north-east Pacific has seen unusually high-frequency variability in ocean climate with the warmest and coldest years of the last several decades occurring only 3 years apart, offering a challenge to marine resource managers. This presentation explores some of the strengths of this monitoring program, for example; 1.That the ocean-climate variability is readily detected in the plankton data both in terms of timing and composition changes. 2 That the survey provides a link between the regionally-focused national sampling programs, an aspect that could be further exploited. 3 That the data are already included in regional assessments of use to resource managers. The presentation will also include a discussion of some of the added-value components of the survey, such as the instrumentation fitted to the CPR and the sample archive now being exploited for molecular analyses. These have the potential to generate new insights and greater applicability of the program in the future.

S4

October 24, 11:35 (S4-9666)

How the 20 year Newport Line zooplankton time series is used to inform fisheries management

William **Peterson**[1], Jay Peterson[2], Jennifer Fisher[2] and Cheryl Morgan[2]

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Through fair weather and foul, the Peterson lab has gone to sea fortnightly since 1996, mostly on small research vessels (length 12-17m), to study seasonal and interannual variations in the physical drivers of pelagic ecosystem change in the coastal upwelling zone in the northern California Current (NCC). Seven stations are sampled along a transect (44.6°N) that spans continental shelf and slope waters off Newport Oregon. Standard parameters measured include water column profiles of temperature, salinity, fluorescence and oxygen, water samplings for nutrients, chlorophyll and phytoplankton species composition, and plankton net tows for zooplankton, krill and fish eggs and larvae. Several ecological indicators have been produced from these time series data which characterize the bioenergetics of the food web: biomass of northern and southern copepods which are indicators of 'lipid-rich' and 'lipid-depleted' food chains, respectively. Significant correlations are found between the copepods and salmon returns (coho and Chinook salmon), rockfish, sablefish, and lamprey as well as recruitment of mole crabs (*Emerita*) and the invasive European green crab. These findings are of interest to managers because the information reveal mechanisms on how basin-scale climate drivers such as the PDO and ENSO affect many fisheries in the NCC, by providing early warning of future recruitment variability and by providing a unique view of how variable ocean conditions affect the pelagic marine ecosystems. However the data are not yet used directly in management because our work is a "research time series" and not an "operational time series", and thus one that could end at any time.

October 24, 11:55 (S4-9752)

Long term zooplankton monitoring and database programs in British Columbia – Understanding the dynamics of a changing ocean

Moira Galbraith[1], David Mackas[1] and R. Ian **Perry**[2]

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Zooplankton monitoring is very important in providing early indications of changing ocean conditions because of short time lags and closer connections with physical processes, compared with fish populations. The Department of Fisheries and Oceans (DFO) has been collecting biological oceanographic samples as part of various historical and ongoing monitoring programs off the west coast of British Columbia, Canada since the late 1970's. The majority of zooplankton data were held in numerous archives, computer tables, tech reports and raw count sheets in filing cabinets. In recognition of the difficulty in using or even accessing the data the Zooplankton Database was developed at the Institute of Ocean Sciences in 1997. We describe how this database has grown to include over 22178 samples and 1228 species representing 5643 taxonomic categories, back to 1956 (Stn. P. weather ship). It contains useful features that are sometimes not incorporated in other zooplankton archives, such as separate life stages and/or size classes within species, the ability to multiply abundance by body size to estimate biomass within taxa and the capability to roll-up abundance or biomass across life stages or species into broader taxonomic groups. This "low-level" (*e.g.* life stage) information is much more important for models of predator-prey interactions that use size-based approaches, compared with species-based feeding relationships. We also discuss the difficulties and limitations in comparing time series across temporal and spatial changes plus shifting priorities in analyses and taxonomic resolution. The development of this database has enabled analyses and summaries of these data to contribute regularly to DFO activities, including the State of the Ocean reviews, salmon survival dynamics, and indicators of ecosystem conditions.

October 24, 12:15 (S4-9734)

Taking stock

David M. **Checkley**, Jr.

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Time series of observations are necessary to understand the past dynamics of systems and predict their future states. Disciplines as disparate as finance and fisheries rely on predictions, hence time series, as the basis for decisions on management and policy affecting their respective stocks. Why, then, are plankton time series so difficult to maintain funding for? I will draw on plankton time series from major fisheries oceanography programs in the world to illustrate their value for making decisions in management and policy. Their value scales with their duration, such that they become increasingly relevant to large-scale phenomenon such as ecosystem degradation and climate change, and thus their value transcends their intended use for fisheries management to use in environmental policy. I argue that this increased value should justify continued, if not greater, investment in such observing programs while acknowledging the limits of our ability to understand and predict stock dynamics.

S4

S5

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

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

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

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

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

Day 1, Wednesday, October 22 (09:00-12:30)

09:00   ***Introduction by Session Convenors***

09:05   **Population dynamics of Atlantic cod (*Gadus morhua*) and the roles of climate and fishing (Invited)**
Kenneth F. <u>Drinkwater</u>

09:30   **Overview of reproductive characteristics and strategies among the Pacific gadid fishes (Invited)**
Yasunori <u>Sakurai</u>

S5

| 09:55 | **Searching for robust management procedures for Hecate Strait Pacific cod (*Gadus macrocephalus*): A data-limited stock with highly uncertain dynamics (Invited)**
Robyn Forrest, Kendra Holt, Sean Cox and A. Rob Kronlund |

| 10:20 | **Comparison of short-term and long-term climate changes on catch fluctuations of Pacific cod, *Gadus macrocephalus*, in the Yellow Sea**
Heeyong Kim and Daehyun Kim |

| 10:40 | *Coffee/Tea Break* |

| 11:00 | **Observations of seasonal movement of a single tag release group of Pacific cod in the eastern Bering Sea**
Kimberly M. Rand, Elizabeth A. Logerwell, Peter Munro, Sandra K. Neidetcher and Daniel G. Nichol |

| 11:20 | **Effects of water temperatures on the size and GSI variations of walleye pollock (*Gadus chalcogrammus*) in the East Sea**
Minkyoung Bang, S. Kang, J.-H. Park and S. Kim |

| 11:40 | **Spawning phenology and geography of Aleutian Islands and eastern Bering Sea Pacific cod (*Gadus macrocephalus*)**
Sandra K. Neidetcher, Thomas P. Hurst, Lorenzo Ciannelli and Elizabeth A. Logerwell |

| 12:00 | **Effects of temperature and ontogeny on vertical movement ability of newly hatched larvae of the Pacific cod *Gadus macrocephalus***
Zhe Li, Jun Yamamoto and Yasunori Sakurai |

| 12:20 | Discussion |

| 12:30 | *Session Ends* |

Day 2, Thursday, October 23 (09:00-12:30)

| 09:00 | *Introduction by Session Convenors* |

| 09:05 | **Review of the saffron cod *Eleginus gracilis* (Tilesius) fishery in the seas on Russian Far East**
Olga V. Novikova |

| 09:25 | **Asynchronous responses of fish assemblages to climate-driven ocean regime shifts between the upper and deep layer in the Ulleung Basin of the East Sea from 1986 to 2010**
Sukgeun Jung |

| 09:45 | **Exploration of ecosystem factors responsible for coherent recruitment patterns of Pacific cod and walleye pollock in the eastern Bering Sea**
Patricia A. Livingston, Kerim Aydin, James Ianelli and Grant Thompson |

| 10:05 | **Molecular genetic study of the population structure as a basis for Pacific cod fishery management in the Russian Far East**
Maria A. Rabchun, Svetlana Y. Orlova, Alexey M. Orlov and Nikolay S. Mugue |

| 10:25 | *Coffee/Tea Break* |

| 10:45 | **An ecosystem-based assessment of the Bering Sea pollock recruitment and spatial distribution**
Mikhail A. Stepanenko and Elena V. Gritsay |

11:05   **Spatial match-mismatch between juvenile walleye pollock (*Gadus chalcogrammus*) and zooplankton prey in the eastern Bering Sea may contribute to recruitment variability**
Elizabeth Calvert Siddon, Trond Kristiansen, Franz J. <u>Mueter</u>, Kirstin Holsman, Ron Heintz and Edward Farley

11:25   **Carbon flows through *Gadidae* species in the ecosystem of the Northeastern part of the Sea of Okhotsk estimated in a carbon flow mass balance model**
Konstantin M. Gorbatenko, Vladimir V. <u>Kulik</u>, Artem E. Lazshentsev, Alexander V. Zavolokin and Victor A. Nadtochy

11:45   **Development of multispecies models to investigate predator-prey interactions and temperature-mediated predation rates of Pacific cod and other groundfish in the eastern Bering Sea**
Tadayasu Uchiyama, Gordon H. <u>Kruse</u> and Franz J. Mueter

12:05   **Parasitology of Pacific cod**
Nadezhda L. <u>Aseeva</u>

12:25   Discussion

12:30   *Session Ends*

S5

S5 Oral Presentations, Day 1

October 22, 09:05 (S5-9580), Invited

Population dynamics of Atlantic cod (*Gadus morhua*) and the roles of climate and fishing

Kenneth F. **Drinkwater**

Institute of Marine Research, Bergen, Norway. E-mail: ken.drinkwater@imr.no

Atlantic cod *(Gadus morhua)* have traditionally supported some of the most valuable commercial fisheries in the North Atlantic Ocean. In this presentation I will review the variability in the abundance and recruitment of several of the major cod stocks around the North Atlantic. In recent years, many cod stocks have exhibited very low abundances especially in the southern regions of its geographic distribution. The possible causes of the low numbers of cod for these stocks will be reviewed including responses to climate, fishing, and predation. As well, particular attention is paid to the Northeast Arctic cod stock that inhabits the Barents Sea as it is defying the common trend with its abundance at or near historic highs. Reasons for this will also be examined. In addition, mention will be made of changes in distribution and their possible causes. Finally, a brief overview of how ecosystem considerations are presently taken into account in Atlantic cod fishery management will be presented.

October 22, 09:30 (S5-9714), Invited

Overview of reproductive characteristics and strategies among the Pacific gadid fishes

Yasunori **Sakurai**

Faculty of Fisheries Sciences, Hokkaido Univ., Hakodate, Japan. E-mail: sakurai@fish.hokudai.ac.jp

Since the 1980s, we have examined reproductive characteristics and strategies of Pacific gadid fishes, including Pacific cod, walleye pollock, saffron cod and Arctic cod mainly by captive experiments of spawning behavior, optimal temperature and salinity conditions for eggs and larval survival, and others. Recent phylogenetic studies of gadid fishes show that walleye pollock is more closely related to Atlantic cod, but Pacific cod is a sister species of Greenland cod. Based on reproductive characteristics, these fishes can be grouped into two types. The first type, which include Atlantic cod and walleye pollock, produce separate pelagic eggs at intervals of a few days. For this first type of species, spawning is characterized by ventral mounting behavior between a male and female pair, but we recently observed a "sneaky behavior" by other males of walleye pollock in captivity. In addition, these fishes produce courtship and aggressive sounds using a drumming muscle attached to the swim bladder. These reproductive characteristics of Atlantic cod and walleye pollock coincide with their status as sister species by the phylogenetic analysis. The second type includes Pacific cod and saffron cod, which lay slightly adhesive demersal eggs in a single spawning event within a minute. They do not produce sound and do not demonstrate ventral mounting behavior during spawning. In this review, I discuss the importance of experimental studies on reproductive characteristics and strategies of Pacific gadid fishes, including their early life stages at different environmental conditions such as those experienced during climate regime shifts and global warming.

S5

October 22, 09:55 (S5-9688), Invited

Searching for robust management procedures for Hecate Strait Pacific cod (*Gadus macrocephalus*): A data-limited stock with highly uncertain dynamics

Robyn **Forrest**[1], Kendra Holt[1], Sean Cox[2] and A. Rob Kronlund[1]

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[2] School of Resource and Environmental Management, Simon Fraser University, Burnaby, BC Canada

While stock assessment models often identify persistent poor recruitment as a cause of low fish stock abundance, it is difficult to disentangle process-based hypotheses about causes of low recruitment from the effects of management in the absence of large-scale experiments. Studies have demonstrated linkages between recruitment and environmental indices for many fish populations around the world. Predator-prey dynamics and density-dependent survival may also contribute to cycles in productivity. In this study, we use long-term historical data to investigate whether predictive, process-based relationships can explain observed variation in productivity of Pacific cod (*Gadus macrocephalus*) in the Hecate Strait, British Columbia. Between the 1950s and 1990s, catches varied in a strong cyclic pattern, leading to a number of studies investigating alternative hypotheses for the cyclic behaviour. Hypotheses included environmental drivers, predator-prey cycles, and density-dependent survival. Our analysis of these predictive relationships using updated datasets shows that these hypotheses are difficult to distinguish because of large changes in historical fishery management practices, difficulties in ageing and assessing this short-lived, fast-growing species, and uncertainty about total abundance. We therefore incorporate a set of process-based hypotheses into a closed-loop simulation model of the Pacific cod fishery management system to search for fishery management procedures that are robust to uncertainties in underlying drivers of productivity. We show that closed-loop simulation can be used to illustrate trade-offs in setting fishery management objectives in the presence of large uncertainty.

October 22, 10:20 (S5-9680)

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

Heeyong **Kim**[1] and Daehyun Kim[2]

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[2] Oceantech Co., Seoul, R Korea

The catch fluctuation of Pacific cod in the Yellow Sea is influenced by changes in hydrographic conditions due to the Siberian High (SH). Cold surface waters associated with the SH in winter form the Yellow Sea Bottom Cold Water (YSBCW) that lies on the bottom of the Yellow Sea throughout the year. The cooling period of surface waters corresponds to the main spawning season of Pacific cod in Korean waters. The water temperature changes impact the early survival of Pacific cod in the Korean waters. Water temperature ranged from 6 to 10°C in the area where Pacific cod are caught. In the early 1990s, when Pacific cod catches were lowest, YSBCW was restricted to the center of the Yellow Sea, but in 2007 when the catches were at highest level, YSBCW ranged over the entire Yellow Sea. However, the SH variation could not explain influences by global warming. An increase of the water temperature associated with global warming will affect the spawning area and spawning period of Pacific cod in the Yellow Sea. Therefore, the effects of SH will be coupled with those of global warming using an IPCC model to predict Pacific cod catch fluctuations.

October 22, 11:00 (S5-9664)

Observations of seasonal movement of a single tag release group of Pacific cod in the eastern Bering Sea

Kimberly M. Rand[1], Elizabeth A. **Logerwell**[1], Peter Munro[2], Sandra K. Neidetcher[1] and Daniel G. Nichol[2]

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The eastern Bering Sea stock of Pacific cod (*Gadus macrocephalus*) is the target of one of the most lucrative fisheries in Alaska, however, relatively little is known about movement of cod and how this interacts with intense fishing on local spawning aggregations of cod every spring (January – April). This study aims to draw inferences on cod movement using a single tag release group of fish and the fishery as a proxy for movement by qualitatively examining both temporal and spatial patterns of tag recoveries. This study supports historical research on cod movement in this region and new insights into Pacific cod movement patterns are hypothesized. The results from this study also support genetic evidence that Pacific cod show both homing tendencies and site fidelity during the spring when large aggregations of cod form to spawn. During the summer and fall months, cod are widely distributed across the Bering Sea. Understanding the movement of cod and the interactions with the fishery is essential to the successful management of the Pacific cod stock.

October 22, 11:20 (S5-9654)

Effects of water temperatures on the size and GSI variations of walleye pollock (*Gadus chalcogrammus*) in the East Sea

Minkyoung **Bang**[1], S. Kang[2], J.-H. Park[2] and S. Kim[1]

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[2] National Fisheries Research and Development Institute, R Korea

Walleye pollock (*Gadus chalcogrammus*) used to be the most dominant fished species in the East Sea until the 1980s. However, its catch has decreased rapidly through the 1990s, and the stock collapsed completely in the 2000s. No comprehensive explanation on this collapse has been proposed, but we believe that overfishing on juveniles in the 1970s and 1980s, as well as climate change effects on the ocean system, might be responsible for such catastrophic decline of the walleye pollock population and fisheries in the East Sea. The National Fisheries Research and Development Institute (NFRDI) scientists collected fisheries and ecological information on walleye pollock since the 1960s. We investigated the relationship between changes in water properties and biological characteristics of walleye pollock. Water temperature at depth (100, 150, and 200 m) showed an alternating pattern of warm and cool phases off coastal areas where the walleye pollock fishery operated: warm phase in 1971-1980, cool phase in 1981-1987, warm in 1988-1993, and cool in 1994-2003. Fish size and gonad-somatic index (GSI) at each regime period corresponded to water temperature: fish size was relatively small but GSI was high during warm period, and vice versa. Also, due to density-dependent effects on gonad maturation, higher GSI appeared in 2000s compared to high abundance periods of 1970s and 1980s.

S5

October 22, 11:40 (S5-9668)

Spawning phenology and geography of Aleutian Islands and eastern Bering Sea Pacific cod (*Gadus macrocephalus*)

Sandra K. Neidetcher[1], Thomas P. Hurst[2], Lorenzo Ciannelli[3] and Elizabeth A. **Logerwell**[1]

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Pacific cod (*Gadus macrocephalus*) is an economically and ecologically important species in the southeastern Bering Sea and Aleutian Islands, yet little is known about the spawning dynamics of Pacific cod in these regions. To address this knowledge gap, we applied a gross anatomical maturity key for Pacific cod to describe temporal and spatial patterns of reproductive status over three winter spawning seasons: 2005, 2006, and 2007. Maturity status of female Pacific cod was used to construct maps showing spawning activity in the Bering Sea and Aleutian Islands. Most spawning activity was observed on the Bering Sea shelf and Aleutian Island plateaus between 100 and 200 m depth. Data for those days when a high percentage of spawning stage fish were observed were used to identify areas with concentrations of spawning fish. Spawning concentrations were identified north of Unimak Island, in the vicinity of the Pribilof Islands, at the shelf break near Zhemchug Canyon, and adjacent to islands in the central and western Aleutian Islands along the continental shelf. The spawning season was found to begin in the last days of February or early March and extend through early to mid-April. Variation in spawning time (averaging ~10 days between years) may have been associated with a change from warm (2005) to cold (2007) climate conditions during the study period. Our information on Pacific cod spawning patterns will help inform fishery management decisions, models of spawning and larval dispersal and the spatial structure of the stock.

October 22, 12:00 (S5-9589)

Effects of temperature and ontogeny on vertical movement ability of newly hatched larvae of the Pacific cod *Gadus macrocephalus*

Zhe **Li**, Jun Yamamoto and Yasunori Sakurai

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The vertical position and specific gravity of larval Pacific cod *Gadus macrocephalus* reared at various temperatures (3, 5, 7 and 9°C) were measured in experimental columns during the initial 3 d post hatch (dph). The vertical velocities of the larvae were also measured at 5°C. Larvae swam upward and stayed in the upper section in the experimental column. The specific gravities of the larvae generally did not change for all the temperatures over the initial 3 dph, but decreased as ontogenetic development. The vertical velocities of the larvae reared at the warmer temperatures were slower than those at the colder temperatures during 0-2 dph, but it tended to be similar at 3 dph. The vertical velocity (V) of the larvae correlated positively with body size (standard length, SL; $V=8.073SL-21.679$, $r^2=0.49$) and negatively with yolk-sac size (yolk-sac volume, YSV; $V=-0.063YSV+17.273$, $r^2=0.37$), respectively. Results suggest that Pacific cod larvae maintain vertical position by upward swimming during 0-2 dph and by near-neutral buoyancy at 3 dph. Therefore, the demersal-pelagic habitat transition of larval Pacific cod seems to be achieved through the combination of upward swimming behavior and change in buoyancy, and finally the migration speed is proposed to become partly temperature dependent.

S5 Oral Presentations, Day 2

October 23, 09:05 (S5-9717)

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

Olga V. **Novikova**

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Saffron cod, a representative of cod family (*Gadidae*), is an important target of coastal fishing. In 2003-2013 catch of saffron cod varied between 16.7-38.2 thousand tons and averaged 27.0 thousand tons. The main fishing grounds of saffron cod are located in the Sea of Okhotsk and western Bering Sea, which account for 68.8% and 21.2% of total catch, respectively. The catch of cod in the Sea of Japan (6.25%) and in the region of Kuril ridge (3.7%) are much smaller. During the study period the maximum average yield of 10,545 thousand tons was taken off West Kamchatka. On the other hand, the Eastern Sakhalin catch averaged 7,491 thousand tons. The fishery targets cod during feeding and spawning. The fishery is prosecuted by low- to mid-tonnage vessels using active fishing gears – Danish seine and trawls. Cod is also fished by passive gears, such as nets and sweep-nets. The main fishing gear is the Danish seine, which accounts for the majority of the yield (78%). The size structure of saffron cod in commercial catches varies by region depending on environmental conditions and type of fishing gear. The smallest average fish length occurred in bays of Eastern Kamchatka – 23.1 cm (nets), whereas the maximum average length occurs in Pacific waters of the north Kuril Islands and near Western Kamchatka – 42.7 cm (trawl) and 36.3 cm (Danish seine), respectively.

October 23, 09:25 (S5-9482)

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

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Past studies suggested that a basin-wide regime shift occurred in 1988-1989, impacting the marine ecosystem including fish assemblages in the western North Pacific. However, detailed mechanisms involved in this phenomenon are still yet unclear. In the Ulleung basin of the East Sea, filefish, anchovy and sardine dominated the commercial fish catches in 1986-1992, but thereafter common squid comprised >60% of the total catch in 1993-2010. To illuminate the mechanisms causing this dramatic shift in dominant fisheries species, I related changes in depth-specific oceanographic conditions from 0 to 500 m to interannual changes in the fish assemblage structure from 1986 to 2010. In upper layer depths of 50-100 m, water temperature suddenly increased in 1987-1989. Consequently, warm-water epipelagic species (anchovy, chub mackerel, and common squid) became dominant, while sardine, a relatively cold-water epipelagic species, nearly disappeared. An annual index of the volume transport by the Korea Strait Bottom Cold Water, originating from the deep water of the Ulleung Basin, displayed a sudden intensification in 1992-1993. This shift was accompanied by decreased water temperature and increased water density in the deep water and replacement of dominant benthopelagic species from filefish, warm-water species, to herring and cod, cold-water species. The results suggest that climate-driven oceanic changes and the subsequent ecological impacts can occur asynchronously, often with time lags of several years, between the upper and the deep layer, and between epipelagic and deep-water fish assemblages.

S5

October 23, 09:45 (S5-9677)

Exploration of ecosystem factors responsible for coherent recruitment patterns of Pacific cod and walleye pollock in the eastern Bering Sea

Patricia A. **Livingston**, Kerim Aydin, James Ianelli and Grant Thompson

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Pacific cod, *Gadus macrocephalus*, is categorized as a demersal fish species primarily based on its near-bottom occurrence and dominance of benthic prey in its diet as adults. However, walleye pollock, *Gadus chalcogrammus*, is considered semi-demersal because of its occurrence in the water column and reliance on zooplankton prey as adults. Nonetheless, historical recruitment patterns of the two species based on number of age-1 recruits from stock assessment models during the period of 1977-2013 are remarkably coherent. This suggests common ecological factors influencing survival during the early life history phase. This study will outline the similarities in life history characteristics of each species in terms of timing and location of spawning, larval characteristics, and location and diet of fish in the first year of life. Potential mechanisms responsible for the similar recruitment patterns will be outlined using recent research results to provide supporting evidence.

October 23, 10:05 (S5-9468)

Molecular genetic study of the population structure as a basis for Pacific cod fishery management in the Russian Far East

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Pacific cod *Gadus macrocephalus* is one of the most important harvested species for many countries in the North Pacific. Existing fishery management is based mostly on TAC setting on administrative and geographical principles rather than in compliance with the population structure of this species. Currently, the number and stock boundaries of Pacific cod is poorly studied, which makes long-term and sustainable fisheries impossible. Results of a molecular genetic study of Pacific cod population structure are presented. Samples were collected from six different areas of the Okhotsk and Bering Seas. A control region of mtDNA and gene of Cyt b were used as genetic markers. Analysis with Cyt b showed that proportion of unique haplotypes increases from south to north, which probably indicates that distribution of Pacific cod also went in that direction. In addition, two haplotypes, specific only to samples collected in Tauiskaya Bay (northern Sea of Okhotsk) and off the northern Kurils respectively, were revealed. Analysis with the control region of mtDNA also revealed a haplotype, specific only to samples from Tauiskaya Bay. Another haplotype was identified only in South Kuril and northern Bering Sea samples. This might be evidence of migration of Pacific cod in this direction. Haplotype nets (for both markers) visualize several main haplotypes distributed in Pacific cod population and characterize it as polymorphic and steady for a long period of time. Knowledge of the population structure and patterns of discrete stocks will serve to develop adequate and efficient measures for sustainable Pacific cod fisheries.

October 23, 10:45 (S5-9420)

An ecosystem-based assessment of the Bering Sea pollock recruitment and spatial distribution

Mikhail A. **Stepanenko** and Elena V. Gritsay

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Bering Sea pollock recruitment displays high annual variability. Annual surveys do not indicate a direct dependence of pollock recruitment on temperature, ice distribution, nor parental spawning biomass. On the contrary, annual variability in physical oceanography and zooplankton abundance and species composition are associated with large differences in pollock seasonal migrations, distribution, reproduction, early life survival and subsequent year class size and total biomass. Large variability in young-of-the-year pollock survival during winter supports the hypothesis that fluctuations in Bering Sea pollock year class strength depend on overwinter survival of this early life stage.

Annual surveys in the Bering Sea demonstrated that the strong pollock year classes generally do not appear during cold (*e.g.*, 1985-1988) or warm periods (*e.g.*, 1997-1999, 2002-2005), but rather during short transition periods from cold to warm or vice versa. Likewise, the very abundant 1978 year class appeared during a short climate shift from warm to cold. Moderate to strong pollock year classes occurred in 1977-1979, 1982-1984, 1989-1992, 1995-1996, 1999-2001, 2006-2008, 2009-2010; corresponding climate shifts from warm to cold were observed in 1978-1979, 1986-1988, 1994-1995, 1999-2000, 2006-2008 and from cold to warm in 1982-1984, 1989-1992, 1996-1998, 2009-2012. Reasons behind relationships between strong year classes and periods significant temperature gradients and anomalies during the early stage of pollock development in the Bering Sea remain unknown. It is not likely that annual variability in year class strength is attributable to changes in egg and larvae survival, because large temperature gradients are expected to have negative consequences on survival of most fish eggs and larvae. However, there is a possible relationship between zooplankton abundance and the survival of pollock young-of-the-year in winter and subsequent year class size in the Bering Sea. For instance, the strong 2006 and 2008 year classes appeared during a period of climate shift to cold conditions with higher zooplankton abundance in the Bering Sea. Quite possibly better food supply for young-of-the-year pollock is associated with rapid changes in zooplankton community composition, thus increasing the diversity of plankton size groups. During climate shifts, abundance of some plankton species, which predominated during the outgoing thermal conditions, temporarily remain at high levels while at the same time the abundance of other plankton species, which will predominate during incoming thermal condition, start increasing.

The abundance and biomass of eastern Bering Sea pollock have increased and stabilized at average levels during 2010-2013 as result of a strong 2008 year class and some average year classes during 2006 and 2009-2012.

October 23, 11:05 (S5-9564)

Spatial match-mismatch between juvenile walleye pollock (*Gadus chalcogrammus*) and zooplankton prey in the eastern Bering Sea may contribute to recruitment variability

Elizabeth Calvert Siddon[1], Trond Kristiansen[2], Franz J. **Mueter**[1], Kirstin Holsman[3], Ron Heintz[4] and Edward Farley[4]

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Variability in walleye pollock (*Gadus chalcogrammus*) growth and survival is structured in part by climate-driven bottom-up control of zooplankton composition. We used two modeling approaches to understand the roles of prey quality, prey composition, and water temperature on juvenile walleye pollock growth: (1) a bioenergetics model that included local predator and prey energy densities, and (2) an individual-based model that included a mechanistic feeding component, local prey densities and size, and physical oceanographic conditions. Prey composition in late-summer shifted from predominantly smaller copepod species in the warmer 2005 season to larger species in the cooler 2010 season, reflecting differences in zooplankton composition between years. Spatial patterns in prey composition and water temperature lead to areas of enhanced growth, or growth 'hot spots', for juvenile walleye pollock and survival may be enhanced when fish overlap with these areas. This study provides evidence that a spatial mismatch between juvenile walleye pollock and growth 'hot spots' in 2005 contributed to poor recruitment while a higher degree of overlap in 2010 resulted in improved recruitment. Our results indicate that climate-driven changes in prey quality and composition can impact growth of juvenile walleye pollock, potentially severely affecting recruitment variability.

October 23, 11:25 (S5-9626)

Carbon flows through *Gadidae* species in the ecosystem of the Northeastern part of the Sea of Okhotsk estimated in a carbon flow mass balance model

Konstantin M. Gorbatenko, Vladimir V. **Kulik**, Artem E. Lazshentsev, Alexander V. Zavolokin and Victor A. Nadtochy

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A food web model for the Northeastern part of the Sea of Okhotsk was developed for all major species. It was constrained by measured stable isotope ratios of nitrogen ($^{15}N/^{14}N$) as markers in mass balance equations and by approximate diet ranges for every 20 cm size class of fish length. We also used respiration, assimilation and production constraints, which resulted in 3994 inequalities for 166 equations with 2034 flows. Biomasses were averaged in mmol C•m^{-2} for the last decade. We tried to account for seasonal changes at the levels of plankton and highly migratory species. Obviously we could not find the exact solution for such a big complex, but we obtained the least squares solution for further investigation. Some flows were inversed to satisfy the equilibrium. Those flows can give us a clue about possible corrections of the given parameters and constraints in the near future. Our uncorrected food web model shows that the sum of flows to Pacific cod and walleye pollock is about 1.6% of primary production.

October 23, 11:45 (S5-9450)

Development of multispecies models to investigate predator-prey interactions and temperature-mediated predation rates of Pacific cod and other groundfish in the eastern Bering Sea

Tadayasu Uchiyama, Gordon H. **Kruse** and Franz J. Mueter

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We constructed multispecies models for the eastern Bering Sea involving Pacific cod *(Gadus macrocephalus)*, walleye pollock *(Gadus chalcogrammus)*, arrowtooth flounder *(Atheresthes stomias)*, yellowfin sole *(Limanda aspera)*, northern rock sole *(Lepidopsetta polyxystra)*, and flathead sole *(Hippoglossoides elassodon)*. Our objectives were to: (1) estimate the magnitude of predator-prey relationships, (2) reconstruct observed survey trends in biomass based on trophic interactions, (3) estimate multispecies biological reference points, and (4) estimate the effects of temperature on predation intensity. We developed and contrasted two alternative model formulations: a multispecies biomass dynamics (MBD) model and a multispecies delay difference (MDD) model. Both MBD and MDD models were able to reconstruct observed trends in survey biomass over 1982-2009. Although the MDD model fit the survey biomass estimates better than the MBD model, the MDD model and its maximum likelihood parameters produced biologically unrealistic biomass projections at values of instantaneous fishing mortality, $F > 0.14$. Both multispecies models predicted reference points B_0, MSY, and F_{MSY} to be lower than the sum of estimates from single-species assessment models. Using the MBD model, we found temperature effects were largest for arrowtooth flounder predation on age-1 pollock, with predation increasing at warmer temperatures. Warmer temperatures increased Pacific cod predation on age-0 pollock and decreased cod predation on age-2 pollock. Conversely, cannibalism increased on age-1 pollock and decreased on age-0 pollock with increasing temperatures. We are now extending our MBD model to examine effects of climate change on inter-specific interactions within the groundfish community and their implications on ecosystem structure and productivity.

October 23, 12:05 (S5-9561)

Parasitology of Pacific cod

Nadezhda L. **Aseeva**

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Parasitic fauna of Pacific cod *Gadus macrocephalus* Tilesius is still poorly known, though infestation by parasites is an important factor in the commercial value of this species. After review of published and other information on cod parasites, 65 species were defined: 21 species of Trematoda, 15–Cestoda, 10–Nematoda, 6–Copepoda, 6–Protozoa, 5–Acanthocephala, 1–Monogenea, and 1–Hirudinea. Both intensity of infestation and species diversity of cod parasites increase at lower latitudes: 28 species are registered in the Bering Sea, 30 in the Okhotsk Sea, 36 in the North-West Pacific, and 40 in the Japan Sea. Cestodes *Nybelinia sp.*, trematode *Hemiurus levinseni*, and acanthocephalas *Echinorhynchus gadi* are the most usual parasites that infect 100% of cod; nematodes *Anisakis simplex* are also rather frequent and infect up to 75% of cod. However, another species is the most numerous: *Pseudoterranova decipiens* (Nematoda); other numerous species are Anisakis simplex 1, and *Nybelinia sp.* (Cestoda), but their abundance is considerably lower. The most dangerous group of parasites is Nematoda that usually infects the liver and muscles of cod; it is significantly less frequent in the Far-Eastern Seas in comparison with the North Pacific. Muscles of young cod (length <35cm) are virtually uninfected.

S5

S6

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

Co-Convenors:

Anne Hollowed (USA)
Sukyung Kang (Korea)

Invited Speaker:

Elvira Poloczanska (CSIRO, Australia)

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

Friday, October 24 (09:00-12:30)

09:00   ***Introduction by Session Convenors***

09:05   **Analyses of observed and projected shifts in marine life (Invited)**
Elvira <u>Poloczanska</u>, Jorge García Molinos, Michael Burrows and the NCEAS marine biological impacts of climate change working group

09:30   **Incorporating North Pacific climate signals in long-term fishery management**
Romeo <u>Saldívar-Lucio</u>, Aida Martínez-López, Emanuele Di Lorenzo, Germán Ponce-Díaz, Jacquelynne King, Gordon McFarlane, Christian Salvadeo, Daniel Lluch-Cota and José Alberto Zepeda-Domínguez

09:50   **Projected climate impacts on the distribution and volume of marine ecoregions and implications for species interactions**
Anne B. Hollowed, Matthew R. <u>Baker</u>, Albert Hermann and Kirstin Holsman

10:10   **Global Change effects on Pacific saury distribution and its effects on fisheries**
Shin-ichi <u>Ito</u>, Kosei Komatsu, Takeshi Okunishi, Akinori Takasuka, Naoki Yoshie, Takahiko Kameda, Sohsuke Ohno, Kazuyoshi Watanabe, Takashi Setou and Hiroshi Kuroda

10:30   ***Coffee/Tea Break***

10:50   **Expansion of albacore tuna habitat in the northeast Pacific Ocean under anthropogenic warming**
James <u>Christian</u> and John Holmes

11:10   **Predicting present and future distributions of yellowtail in the Japan Sea**
Xiaozhe <u>Pan</u>, Sei-Ichi Saitoh and Yongjun Tian

11:30   **Fluctuations of the greenland halibut stocks in the Okhotsk Sea under influence of circulation patterns change**
Nadezhda L. <u>Aseeva</u>

11:50   **Temporal changes in spatial distribution of Bristol Bay red king crab in the eastern Bering Sea and their implications for fisheries management**
Jie Zheng, M.S.M. Siddeek and Gordon H. <u>Kruse</u>

12:10   **Latitudinal shifts in the distribution of commercially important fish species in Korean waters during the last 30 years: A consequence of climate change**
Sukgeun <u>Jung</u>, Ig-Chan Pang, Joon-ho Lee and Ilsu Choi

12:30   *Session Ends*

S6 Posters

S6-P1   **Climate-change driven range shifts of anchovy biomass projected by bio-physical coupling individual based model in the marginal seas of East Asia**
Sukgeun <u>Jung</u>, Ig-Chan Pang and Joon-ho Lee

S6-P2   **The impacts of marine environment change on sustainable aquaculture model for Japanese scallop in southern Hokkaido and Aomori prefecture, Japan using RS/GIS and OGCM**
Yang <u>Liu</u>, Sei-Ichi Saitoh, Christopher Mulanda Aura and Toru Hirawake

S6-P3   **Effect of global warming on the life history and population dynamics of Japanese chum salmon**
Masahide Kaeriyama, Hyunju <u>Seo</u>, Yu-xue Qin and HyeSeon Kim

S6-P4   **Changes in distribution and composition of major fish species in alternating pattern of warm and cool years in Korean waters**
Sukyung <u>Kang</u>,·Kwangho Choi,·Jisuk Ahn,·Jae Dong Hwang, Dong Woo Lee and Suam Kim

S6 Oral Presentations

October 24, 09:05 (S6-9503), Invited

Analyses of observed and projected shifts in marine life

Elvira **Poloczanska**[1], Jorge García Molinos[2], Michael Burrows[2] and the NCEAS marine biological impacts of climate change working group

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In recent decades, the impacts of climate change have been detected across all oceans, even in the presence of strong confounding factors such as exploitation. Observations of impacts, ascribed at least partly to climate change, include changes in distributions, abundance, phenology, demography and calcification. We undertook a meta-analysis of 1735 marine biological responses from 208 studies to provide an attribution to recent climate change. 83% were in the direction expected under climate change. Leading edges extended by 72 km dec^{-1}, and trailing edges contracted 15 km dec^{-1}. The fastest distribution shifts were observed in plankton and fish although considerable variability was observed within and among species groups, these differences suggest species' interactions and marine ecosystem functions may be substantially reorganized at the regional scale. The speed and direction of isotherm shifts, the *velocity of climate change*, can explain observed distribution shifts and differences in rates of movement at leading and trailing edges. Considerable geographical heterogeneity exists in rates of velocity of climate change and directions often deviate from simple expectation of polewards shifts. The velocity of climate change can be used to derive spatial trajectories for climatic niches, and the properties of these trajectories to infer changes in species distributions. For example, climate sink areas, where isotherms converge, are areas where climate conditions locally disappear, potentially blocking the movement of climate migrants. The velocity trajectory approach gives global and regional maps of the expected direction and rate of shifts of climate migrants, and suggests areas of potential loss of species richness.

October 24, 09:30 (S6-9669)

Incorporating North Pacific climate signals in long-term fishery management

Romeo **Saldívar-Lucio**[1], Aida Martínez-López[1], Emanuele Di Lorenzo[2], Germán Ponce-Díaz[1], Jacquelynne King[3], Gordon McFarlane[3], Christian Salvadeo[1], Daniel Lluch-Cota[4] and José Alberto Zepeda-Domínguez[1]

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The climate of the North Pacific exhibits variability at different temporal scales that determines the extent and frequency of suitable environmental conditions for the Pacific sardine (*Sardinops sagax*) lifecycle, thus modulating its abundance and distribution range (~23-59°N). The impacts of low frequency climatic forcing on Pacific sardine population also provoke long term behavior of the fishery´s economic activities, increasing the need for forecasting capacity in support of adaptive management. In this context, we developed climate-fisheries catch models based on analysis of the most persistent patterns in North Pacific climate variability, emphasizing the climatic forcing induced to the eastern boundary of the basin (Alaska and California Currents). We employed statistical downscaling to evaluate the predictive power of climatic patterns for sardine fishery catches in: British Columbia (~48°N), Washington-Oregon (~45°N), California (~38°N), Ensenada (~32°N) and Bahía Magdalena (~24°N). The macro scale atmospheric circulation, sea surface temperature and upwelling/downwelling presented particular and reproducible patterns that underlie to the physical environment that sardines occupy. While understanding the physical mechanisms underlying these connections are still to be elucidated, the North Pacific climate signals showed promising predictive capacity of sardine fishery catches ($R^2 > 0.75$; Exp. Dev. > 78%) from Bahía Magdalena through British Columbia. The pertinence and predictive performance of climatic signals to sardine catch forecasting is discussed. Additionally, climate-fishery catch analysis of the Pacific sardine could be used to identify suitable fishery reference points for resilient management strategies that could deal with natural Pacific sardine collapse/expansion phases.

S6

October 24, 09:50 (S6-9723)

Projected climate impacts on the distribution and volume of marine ecoregions and implications for species interactions

Anne B. Hollowed[1], Matthew R. **Baker**[2], Albert Hermann[3] and Kirstin Holsman[3]

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This paper presents a novel approach to estimating climate change impacts on the spatial distribution and volume of marine ecoregions in the southeast Bering Sea Shelf. The approach extends the habitat envelope approach to include multiple factors influencing the spatial distribution of selected fish species. Species distribution and abundance patterns are driven by many factors, including threshold environmental tolerances and resource preferences and species interactions. To visualize how individual species were distributed relative to dominant physical drivers (temperature and depth) in the ecosystem, we developed contour plots of mean weighted biomass for all species consistently sampled via bottom trawl methods and compared trends between function guilds within the eastern Bering Sea. A combination of random forest and gradient forest methods were used to identify key relationships that allowed for the prediction of the past and present distribution patterns for individual species and species guilds. These relationships were projected forward based on predicted ocean conditions through 2040 derived from a coupled bio-physical model forced with three different climate change scenarios. Results of this exercise and the implications for future fisheries will be discussed.

October 24, 10:10 (S6-9736)

Global Change effects on Pacific saury distribution and its effects on fisheries

Shin-ichi **Ito**[1], Kosei Komatsu[1], Takeshi Okunishi[2], Akinori Takasuka[3], Naoki Yoshie[4], Takahiko Kameda[5], Sohsuke Ohno[2], Kazuyoshi Watanabe[6], Takashi Setou[3] and Hiroshi Kuroda[7]

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To evaluate global warming effects on Pacific saury, three-box ocean domain model which includes Kuroshio, mixed water and Oyashio regions had been used with an ecosystem-based bioenergetics model NEMURO.FISH. The model was forced by the sea surface temperature (SST) of global warming conditions generated by IPCC-AR4 climate models with three emission scenarios. The results showed a decrease of wet weight of Pacific saury in 73% cases. The egg production was enhanced in 33% cases. However, the model did not include east–west migration of Pacific saury. We conducted numerical simulations including two dimensional horizontal migration of Pacific saury. Sea surface temperature, velocity and prey plankton fields were obtained by simulations with CHOPE-eNEMURO using current and future climate forcings. A NEMURO.FISH type fish growth and migration model was forced with the current and future conditions. As a result, southward migration of saury was restricted by higher temperature, the number of saury advected by the Kuroshio Extension increased and hence the distribution center moved offshore under the future condition. Uniform offshore condition stabilized the saury growth but diminished large size saury. The price of large Pacific saury is highly valued. In addition, saury is traditionally fished in fall in Japan and the fishing season is closely related to Japanese culinary culture. Saury caught early in the fishing season sell at high prices. If it becomes difficult to catch these higher-priced early saury in the Japanese economic waters, that will be a serious problem for Japanese fisheries.

October 24, 10:50 (S6-9469)

Expansion of albacore tuna habitat in the northeast Pacific Ocean under anthropogenic warming

James **Christian**[1] and John Holmes[2]

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Albacore tuna (*Thunnus alalunga*) are found in the northeast Pacific Ocean, predominately in waters where sea surface temperature is between 14 and 19°C. These fish are therefore found in mid-latitude waters only in summer, and rarely north of 52°N. However, anthropogenic warming of the Earth's oceans could cause an expansion of suitable habitat for this fish in regions of the Northeast Pacific not presently within the fish's thermal range. The 5th Coupled Model Intercomparison Project established a large archive of climate model output that includes historical simulations and future projections following a variety of emission scenarios. We evaluated the ability of these models to accurately simulate observed SST in the northeast Pacific Ocean, and examined projections of future climate with the subset of models that are deemed to have sufficient skill in simulating present climate. We used these projections to estimate the potential expansion of albacore habitat in the Northeast Pacific under anthropogenic warming, and conclude that there will be a significant expansion into subarctic regions currently outside the fish's thermal range. There may also be some loss of habitat in currently viable areas (summer temperatures in excess of 19°C) under the highest emission scenario considered.

October 24, 11:10 (S6-9572)

Predicting present and future distributions of yellowtail in the Japan Sea

Xiaozhe **Pan**[1], Sei-Ichi Saitoh[1,2] and Yongjun Tian[3]

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Recognizing the link between fish and other components of the marine ecosystem is an essential step for ecosystem-based fisheries management. Yellowtail (*Seriola quinqueradiata*) is an important pelagic and highly migratory fish in the Japanese waters and its distribution and migration support set net fishery along the coastal areas of Japan. However, the relationship between the distribution of yellowtail and environment remains unclear. In this study, tagging geo-data of 26 yellowtail collected during 2006-2009 and 9 environmental factors (sea surface temperature, chlorophyll *a* concentration, kd490, u, v, eddy kinetic energy, sea surface height, sea surface height anomaly and depth) were used to develop generalized additive model (GAM), generalized linear model (GLM) and Maximum entropy model (MaxEnt) to determine present distributions of yellowtail. Then future distributions of yellowtail were predicted using projected monthly SST for 2090-2099 under the IPCC-SRES B1 scenario. The MaxEnt model showed highest model performance, followed by GAM and GLM. These results suggested that the temperature and water depth in spring and winter played more important roles in determining yellowtail's distribution rather than other factors, whereas current vectors (u, v) were the dominant environmental variables to yellowtail's habitats in summer and fall. The projected habitat suitability maps show that the present habitats of yellowtail exhibit spatial decrease and the overall distribution show a future pole-ward movement with the increasing temperature. This study provides some clues on the mechanisms of yellowtail's distribution and effects of global warming on fishes along the Japan Sea coast.

S6

October 24, 11:30 (S6-9640)

Fluctuations of the greenland halibut stocks in the Okhotsk Sea under influence of circulation patterns change

Nadezhda L. **Aseeva**

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Stocks of greenland halibut in the Okhotsk Sea and their biological parameters fluctuate considerably in recent times, in particular that one at East Sakhalin. The local stock in this area exceeded 27 thousand tons in the early 1990s but fell to 5 thousand in the last decade, age-size structure changed, and sex ratio was distorted. These changes could not be reasoned by overfishing, so far as the fishery was stopped a decade ago. Similar fluctuations were observed in other local populations of greenland halibut in the Okhotsk Sea, because all of them are based on the same spawning area located over the continental slope of West Kamchatka. However, the local stocks at West Kamchatka and in the northern Okhotsk Sea began to grow after 2008, in spite of continuous fishery, but the stock at East Sakhalin is still very low. The misalignment between the stocks in the northern Okhotsk Sea (exploited but growing) and at East Sakhalin (unexploited but constantly low) is supposedly caused by changes in water circulation patterns, so far as the halibut larvae is transported from the spawning area to both areas by surface currents over the shelf edge. Possible trajectories of the larvae transport are discussed.

October 24, 11:50 (S6-9532)

Temporal changes in spatial distribution of Bristol Bay red king crab in the eastern Bering Sea and their implications for fisheries management

Jie Zheng[1], M.S.M. Siddeek[1] and Gordon H. **Kruse**[2]

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Annual summer trawl survey data show that spatial distributions of Bristol Bay red king crab, *Paralithodes camtschaticus*, changed greatly over time. Large mature female red king crab (≥105 mm carapace length) primarily occurred in southwestern Bristol Bay before 1977, and their distributions shifted to central and northeastern Bristol Bay in the late 1970s and early 1980s. Mature female red king crab has been found primarily in central Bristol Bay since the early 1980s. The distribution centers of large mature females moved south slightly during 1988–1990, 1999-2000, 2009 and 2012-2013, but did not reach the southern locations previously occupied in the 1970s. Temporal changes in spatial distribution appear to be associated with changes in bottom water temperature; northward movements occurred during a warm period. Shifts in spatial distribution may be confounded somewhat with a sharp decline in abundance during the early 1980s, but the distribution shifts occurred before the large decline. Northward shifts of mature females may partly explain recruitment variation. Ocean currents likely favor delivery of larvae to prime nearshore nursery areas from hatching sites in southern Bristol Bay. Northward shifts in spatial distributions of mature females make it difficult to supply larvae to the southern portions of their range, and a proportion of the larvae hatched in central Bristol Bay may be carried beyond the northern boundary of the juvenile nursery areas. The northward spatial shifts resulted in a decline in productivity associated with lower recruitments, low spawning biomasses, and reduced total allowable catches.

October 24, 12:10 (S6-9483)

Latitudinal shifts in the distribution of commercially important fish species in Korean waters during the last 30 years: A consequence of climate change

Sukgeun **Jung**[1], Ig-Chan Pang[1], Joon-ho Lee[1] and Ilsu Choi[2]

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Sea surface temperatures in Korean waters have increased by approximately 1°C during the past 40 years, implying possible range shifts of marine fishes and invertebrates. We analyzed spatially explicit, commercial catch data for 12 major fish species collected from 1984 to 2010 in Korean waters to evaluate and project their range shifts based on climate-driven hydrographic changes simulated by a general circulation model under a climate change scenario. There were significant relationships between the mean latitude of the catch distribution and water temperature for seven of the 12 species examined. Our circulation model projected that temperature stratification in the Korea Strait will disappear by 2030, and our empirical relationships predicted that the ranges of five of the fish species examined will shift poleward by 19–71 km from the 2000s to the 2030s. Compared with studies of demersal fishes in the western North Atlantic and the North Sea, our estimated speeds of shift in mean latitude of fishes were, on average, slower by factors of 2.3 and 5.7, respectively. This suggests that the pattern of range shift of marine species can vary regionally, depending on oceanographic and geomorphologic conditions. International cooperative research among fisheries scientists from countries throughout the region, especially Japan and China, is required to more reliably and comprehensively assess and project the range shifts of fish species. This will provide a scientific basis for the development of fishery policies and their adaptation to climate change in the western North Pacific.

S6 Poster Presentations

S6-P1

Climate-change driven range shifts of anchovy biomass projected by bio-physical coupling individual based model in the marginal seas of East Asia

Sukgeun **Jung**, Ig-Chan Pang and Joon-ho Lee

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Recent studies in the western North Pacific reported a declining standing stock biomass anchovy (*Engraulis japonicus*) in the Yellow Sea and a climate-driven southward shift of anchovy catch in the Korean waters. We investigated the effects of warming ocean on the latitudinal shift of anchovy catch by developing and applying individual-based models (IBMs) based on a regional ocean circulation model and an IPCC climate change scenario. Despite the greater uncertainty, our two IBMs projected that, by the 2030s, the strengthened Tsushima warm current in the Korea Strait and the East Sea, driven by global warming, and the subsequent confinement of the relatively cold water masses within the Yellow Sea will decrease larval anchovy biomass in the Yellow Sea, but will increase in the Korea Strait and the East Sea. The decreasing trend of anchovy biomass in the Yellow Sea was reproduced by our models, but it requires a further enhancement of the models together with extended ichthyoplankton surveys to understand and reliably project range shifts of anchovy and its impacts on the marine ecosystems and fisheries in the region.

S6-P2

The impacts of marine environment change on sustainable aquaculture model for Japanese scallop in southern Hokkaido and Aomori prefecture, Japan using RS/GIS and OGCM

Yang **Liu**[1], Sei-Ichi Saitoh[1], Christopher Mulanda Aura[2] and Toru Hirawake[1]

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The Japanese scallop (*Mizuhopecten yessoensis*) is the most valuable cultured marine shellfish in Japan. The previous study used integrated satellite remote sensing (RS) data and geographic information systems (GIS) based model to develop the suitable aquaculture site-selection model (SASSM) for hanging cultures of Japanese scallop in southern Hokkaido and Aomori prefecture, Japan. The pattern of the results in both regions reflected the different phases of suitability levels. However, SASSM was initially developed for the surface of the aquaculture area, which is limited in representing the actual depth of scallop farming (5 - 30m). Therefore, our work applied a four-dimensional variational (4-D VAR) data assimilation model and RS data to develop the three-dimensional (3-D) growth prediction model for Japanese scallop in both two regions. And we analyzed the spatial and temporal variations of environment factors (water temperature, salinity, velocity) in cross-sections by full depths, which could be explored the potential impact of marine environment changes on scallop growth in 3-D structure of ocean features and marine habitats. The results revealed that GAM (generalized adding model) is an effective model to predict the vertical growth of Japanese scallop, the predict results were well verified by *in-situ* data. From the 3-D growth distribution maps, we could see that scallop growth varies in southern Hokkaido and Aomori prefecture region. The marine environment of these two regions affected by Oyashio current and Tsugaru warm current was shown great changes in different year. These changes are perhaps due to climate change.

S6-P3

Effect of global warming on the life history and population dynamics of Japanese chum salmon

Masahide Kaeriyama[1], Hyunju **Seo**[2], Yu-xue Qin[1] and HyeSeon Kim[3]

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We have reviewed the effects of long-term climatic/oceanic conditions on the growth, survival, production dynamics, and distribution of Hokkaido chum salmon *Oncorhynchus keta* in Japan during the period 1945–2005 using path analysis, back-calculation, and scale analyses, and applied a prediction method based on the SRES-A1B scenario of the intergovernmental panel on climate change. The populations of Hokkaido chum salmon were found to have had high growth rates at age 1 year since the late 1980s. Path analysis indicated that the growth at age 1 year in the Okhotsk Sea was directly affected by warm sea surface temperature associated with global warming, with the increased growth at age 1 year resulting in higher rates of survival and large population sizes. Predictions on the global warming effects on the chum salmon were (1) decreased carrying capacity and distribution area, (2) occurrence of a strong density-dependent effect, and (3) loss of migration route to the Sea of Okhotsk, especially for Hokkaido chum salmon. We have also outlined the future challenges of establishing a sustainable conservation management scheme for salmon that include adaptive management and precautionary principles, as well as conservation of natural spawning populations and recovery of natural river ecosystems in Japan despite the warming climate.

S6-P4

Changes in distribution and composition of major fish species in alternating pattern of warm and cool years in Korean waters

Sukyung **Kang**[1], ·Kwangho Choi[1], ·Jisuk Ahn[2], ·Jae Dong Hwang[2], Dong Woo Lee[1] and Suam Kim[3]

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Together with food availability and suitable spawning grounds, temperature is one of the main factors for determining the large-scale distribution pattern of marine fish, and for regulating the timing of seasonal migration. Purse seine fishery is currently the largest fishery in Korea, and we examined potential impact of climate variability on the distribution and composition of major fish species caught by purse seine fishery during warm and cool years in Korean waters. We hypothesize that the changes in distribution and species composition might be related to changing ocean conditions such as continuous warming as well as interannual variability in water column structure. Variability in habitat-use by major fish species and the link between variability in spatial distributions and temperature will be described. And we will forecast the impact of climate variability on major fish stocks by stock projection model which will provide early warnings message for the purse seine fishery management in Korean waters.

S6

S7

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

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

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

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

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

Day 1, Wednesday, October 22 (09:00-12:30)

09:00   ***Introduction by Session Convenors***

09:10   **Ocean acidification: Trouble for ocean ecosystems (Invited)**
Richard A. <u>Feely</u>, Simone Alin and Nina Bednarsek

09:40   **Climate change impacts on the world's oceans: A sectoral analysis by IPCC AR5 (Invited)**
Hans-O. <u>Pörtner</u>

10:10   **Fisheries of the North Pacific: Pathways to Food Security and Nutrition (Invited)**
Meryl J. <u>Williams</u>

10:40   ***Coffee/Tea Break***

11:00   **The linkage between the Yellow Sea algae bloom burst in 2008 and regional climate change**
Hongjun <u>Song</u> on behalf of Fangli <u>Qiao</u>

11:20   **North Pacific climate change impacts as projected by a suite of CMIP5 model output**
Phoebe <u>Woodworth-Jefcoats</u> and Jeffrey J. Polovina

11:40   **Top predators as indicators of climate change: Statistical techniques, challenges and opportunities**
Elliott L. <u>Hazen</u>, Rob Suryan, Steven J. Bograd, Takashi Yamamoto, Emanuele Di Lorenzo, Jeff Polovina, William J. Sydeman, Kevin Weng, Rolf Ream and Yutaka Watanuki

12:00   **Decadal scale variation in phosphate concentration in the Oyashio and Kuroshi-Oayashio Transition waters, western North Pacific from 1955 to 2010**
Kazuaki <u>Tadokoro</u>, Hiroshi Kuroda and Tsuneo Ono

12:20   Discussion

12:30   *Session Ends*

Day 2, Thursday, October 23 (09:00-12:30)

09:00   *Introduction by Session Convenors*

09:10   **IPCC 5ᵗʰ Assessment Report WG 3 – Drivers, Trends, and Mitigation: Where is the ocean?**
Jake Rice

09:30   **Effects of climate change on marine ecosystems in Polar Regions**
Anne B. Hollowed and Andrew Constable

09:50   **Effects of Climate Change on Marine ecosystems and fishery resources in the Northwestern Pacific**
Suam Kim

10:10   **Plankton in a changing climate: Coastal and polar cases study**
Hongjun Song and Rubao Ji

10:30   *Coffee/Tea Break*

10:50   **Chapter 30 the Ocean, Working Group II, IPCC fifth assessment report**
Ove Hoegh-Guldberg, Rongshuo Cai, Elvira Poloczanska, Peter G. Brewer, Svein Sundby, Karim Hilmi, Victoria J. Fabry and Sukgeun Jung

11:10   **Assessment of climate trends and projections and their associated impacts on the Pacific coast of Canada**
James Christian, Robin M. Brown, Michael Foreman, Karen Hunter and Kim Hyatt

11:30   **Impacts of climate change on U.S. oceans and marine resources: Technical input to the third U.S. National Climate Assessment**
Roger B. Griffis, Jennifer Howard and Anne B. Hollowed

11:50   **Vulnerability and adaptation strategies of pteropods due to ocean acidification and hypoxia**
Nina Bednarsek, Richard A. Feely, J.C.P. Reum, B. Peterson, J. Menkel, S.R. Alin and B. Hales

12:10   Discussion

12:30   *Session Ends*

S7 Posters

S7-P1 **Distribution patterns of polychaete assemblage and benthic quality status estimated by AMBI in Jindo-Jejudo subtidal areas**
Kwang-Bae <u>Kim</u>, Jae-Hoon Cha, Dong-Yeong Kim, Ji-Na Song, Doo-Chan Um and Chu-Hwui Kwoun

S7-P2 **Marine climate change impacts and adaptation report card for Australia**
Elvira <u>Poloczanska</u>, Anthony J. Richardson and Alistair J. Hobday

S7-P3 **Projecting impacts of rising water temperature on the distribution of seaweeds around Japan under warming scenarios**
Shintaro <u>Takao</u>, Naoki Kumagai, Hiroya Yamano, Masahiko Fujii and Yasuhiro Yamanaka

S7-P4 **North Pacific upper-ocean changes projected by CMIP5 models**
Chan Joo <u>Jang</u>, Dongwon Yi, Jihyeon Lee, Ho-Jeong Shin and Yong Sun Kim

S7-P5 **Changes of distributions and composition of nutrients in the Changjiang Estuary after the normal storage of Three Gorges Reservoir**
Baodong <u>Wang</u>, Zicheng Wang, Ming Xin, Xia Sun, Qinsheng Wei and Bo Yang

S7 Oral Presentations, Day 1

October 22, 09:10 (S7-9748), Invited

Ocean acidification: Trouble for ocean ecosystems

Richard A. **Feely**[1], Simone Alin and Nina Bednarsek

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Carbon dioxide (CO_2) is one of the most important "green-house" gases in the atmosphere affecting the radiative heat balance of the earth. As a direct result of the industrial and agricultural activities of humans over the past two centuries, atmospheric CO_2 concentrations have increased more than 100 ppm. The atmospheric concentration of CO_2 is now higher than experienced on Earth for at least the last 800,000 years, and is expected to continue to rise, leading to significant temperature increases in the atmosphere and oceans by the end of this century. The global oceans are the largest natural long-term reservoir for this excess CO_2, absorbing approximately 30% of the anthropogenic carbon released into the atmosphere since the beginning of the industrial era. Recent studies have demonstrated that both the temperature increases and the increased concentrations of CO_2 in the oceans are causing significant changes in marine ecosystems. Many marine organisms are already affected by these anthropogenic stresses, including impacts due to ocean acidification. Dr. Feely will discuss the present and future implications of ocean acidification on the health of our ocean ecosystems and related ocean-based economies.

October 22, 09:40 (S7-9509), Invited

Climate change impacts on the world's oceans: A sectoral analysis by IPCC AR5

Hans-O. **Pörtner**

Integrative Ecophysiology, Alfred-Wegener-Institut, Bremerhaven, Germany
IPCC Coordinating Lead Author, WGII, Chapter 6, Ocean Systems. E-mail: hans.poertner@awi.de

Oceans cover 70% of the planet and create half the oxygen (O_2) humankind uses to breathe and burn fossil fuels. They provide 20% of the animal protein consumed by more than 1.5 billion people. Oceans are home to diverse species and ecosystems valued in tourism, they offer rich biodiversity and resources for innovative drugs or biomechanics, and sustain coral reefs and mangroves protecting coastlines from tsunamis and storms. They also sustain shipping of 90% of all goods the world uses. Oceans play a major role in climate regulation globally, they absorb >90% of the heat accumulating in the atmosphere and absorb 25% of man-made CO_2. As a consequence, oceans warm and stratify, thereby losing oxygen overall and during an expansion of hypoxic zones. The accumulation of CO_2 in ocean surface waters disturbs water chemistry and causes acidification. Last not least, oceans accumulate the water from melting icesheets leading to sea level rise. Ocean ecosystems have responded and will continue to respond to climate changes of different rates, magnitudes, and durations. Human societies and especially small island states depend on marine ecosystem services, which are sensitive to climate change, in particular the provisioning of food (fisheries and aquaculture) and other natural resources; the recycling of nutrients; the regulation of global climate (including production of oxygen and removal of atmospheric CO_2); the protection from extreme weather and climate events; and aesthetic, cultural, and supporting services. The present paper will summarize the findings of IPCC Working Group II, chapter 6 author team, for ocean systems, their natural components and the associated human and economic interests.

October 22, 10:10 (S7-9757), Invited

Fisheries of the North Pacific: Pathways to Food Security and Nutrition

Meryl J. **Williams**

AsiaPacific-FishWatch. E-mail: MerylJWilliams@gmail.com

The North Pacific is vital to world fisheries, yielding about one third of world marine capture fisheries production. The impacts of this rich fish yield on national economies and fishing enterprises are well recognized; so too are the issues concerned with sustaining the yields in a changing environment and climate. Much less, however, is known about the contributions the fish and fisheries make to food security and nutrition (FSN) for the people in the PICES countries, the North Pacific region and beyond. To examine FSN, this presentation will apply the concepts developed in the recent report by the United Nations High Level Panel on Food Security and Nutrition. It will focus on value chain case studies of walleye pollock (*Theragra chalcogramma*) and sardines (*Sardinops* spp) in addressing the contributions made through direct and indirect FSN pathways. Critical elements of food security and nutrition will be examined, including sustainability, trade and markets, labour throughout the value chains, gender relations and inequalities, and access to benefits from use of the fisheries resources.

The case studies will also provide insights that may assist the PICES Section on Human Dimensions in its current task of developing a system for time series observations for human dimensions.

October 22, 11:00 (S7-9772)

The linkage between the Yellow Sea algae bloom burst in 2008 and regional climate change

Fangli **Qiao**

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The reason why the serious algae bloom of the Yellow Sea occurred in 2008 has attracted much scientific interests. Higher surface sediment concentration (SSC) in the ocean is unfavorable for algae blooms. The origin area of the algae bloom in 2008 was believed to have been located in a region off Jiangsu coast where the SSC is quite high all year round. Previous studies suggested that strong tidal current and shallow water depth cause the high SSC. Our result reveals that the surface wave-induced vertical mixing accounts for 3/4 of the SSC. Due to regional climate change, the wind and then surface wave is weak in April and May, 2008 compared with several previous years. We conclude that the weak surface wave in 2008 resulted in low SSC off the Jiangsu coast which was favorable for the algae bloom. The low SSC is confirmed by satellite observation and model results.

October 22, 11:20 (S7-9470)

North Pacific climate change impacts as projected by a suite of CMIP5 model output

Phoebe **Woodworth-Jefcoats**[1,2] and Jeffrey J. Polovina[1]

[1]   Pacific Islands Fisheries Science Center, Honolulu, HI, USA. E-mail: Phoebe.Woodworth-Jefcoats@noaa.gov
[2]   University of Hawaii at Manoa, Honolulu, HI, USA

We examine biophysical output from a suite of models included in the fifth phase of the Climate Model Intercomparison Project (CMIP5). Our analysis focuses on those models that include two trophic levels of biological output, phytoplankton and zooplankton. Many of these models provide data for several functional groups and size classes of phytoplankton and a few provide size structured zooplankton data. We use these output data to examine projected trends in plankton size structure through measures such as the slope of the plankton community, mean plankton size, and changes in community composition. Because each model represents the North Pacific slightly differently, we examine these trends in relation to oceanographic features such as the subtropical gyre, the Transition Zone Chlorophyll Front (TZCF), the California Current, and the equatorial upwelling region. This approach allows us to link projected biological impacts to their appropriate biome rather than to static geographic areas. Our approach also allows for the phenology associated with these features to be investigated. In addition to examining changes in the plankton community, we also examine projected changes in variables including sea surface temperature, surface chlorophyll, and depth-integrated primary productivity.

October 22, 11:40 (S7-9683)

Top predators as indicators of climate change: Statistical techniques, challenges and opportunities

Elliott L. **Hazen**[1], Rob Suryan[2], Steven J. Bograd[1], Takashi Yamamoto[3], Emanuele Di Lorenzo[4], Jeff Polovina[5], William J. Sydeman[6], Kevin Weng[7], Rolf Ream[8] and Yutaka Watanuki[4]

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[7]   University of Hawaii, Honolulu, HI, USA
[8]   NMML, Alaska Fisheries Science Center, NOAA, Seattle, WA, USA

On April 14th, 2014 we convened a workshop at the PICES FUTURE meeting in Kona, Hawaii. The primary goal of this workshop was to review existing examples of observed and predicted top predator responses to and to differentiate top predator response from climate variability and change in the North Pacific. This session had numerous submitted and invited talks on turtles, sharks, seabirds, and marine mammals reviewing techniques that can be used to differentiate top predator response from climate variability & change. Ultimately, the session helped identify sentinel species and life history characteristics that may best reveal responses to physical and biological changes. Our workshop discussion highlighted the need to move to more interdisciplinary, multi-datatype and multi-species projects to understand how climate variability and change are integrated by top predators, *e.g.* into adjustments in behavior, distribution, abundance, and demography. We also plan to write a review paper on a framework for assessing top predator response to climate variability (*e.g.* the potential 2014 El Niño) and a N. Pacific-wide proposal to synthesize and contrast top predator datasets relative to potential climate change effects. We plan to continue collaborations with other organizations such as IMBER and CLIOTOP at future meetings, as the diversity in top predator data provides more information than single type or species alone.

October 22, 12:00 (S7-9573)

Decadal scale variation in phosphate concentration in the Oyashio and Kuroshi-Oayashio Transition waters, western North Pacific from 1955 to 2010

Kazuaki **Tadokoro**[1], Hiroshi Kuroda[2] and Tsuneo Ono[3]

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We investigated the decadal scale variation of phosphate concentration in the surface and mid-layer in the Oyashio and Kuroshio-Oyashio Transition waters from 1955 to 2010. The data of WOD2009, JODC and A-line were used for study. Phosphate concentration represented linear decrease trend in the surface layer in the both waters from 1955 to 2010. On the other hand, the concentration represented linear increasing trend in the mid-layer. The same trends were observed from 1955 to 2000 by previous study (Tadokoro *et al.*, 2009). This study confirmed that the trends had continued from 2000 to 2010. The decreasing trend in salinity and increasing trend in temperature were reported in the broad area of the North Pacific Ocean during recent half century (AR5, IPCC 2013). The changes in water properties would intensify the stratification in the surface layer. The trends might be caused by diminishing of water exchange between mid to surface layer. We also confirmed the bidecadal scale oscillation of phosphate concentration which is considered to be related 18.6-year cycle of tidal strength continued from 2000 to 2010.

S7 Oral Presentations, Day 2

October 23, 09:10 (S7-9745)

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

Jake **Rice**

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The ocean has become increasingly prominent in the succession of IPCC Assessment Reports. It has been a major component of WG 1, on dynamics and possible trajectories of global climate and ocean-atmosphere interactions. In AR 5 the ocean also emerged as an important theme in WG 2 - adaptation. New pressures potentially altering marine ecosystems were discussed as were options for human cultures and economies to adapt to those alterations. However, the ocean is hard to find in WG 3 – the drivers and trends in greenhouse gas [GHG] emissions and options to mitigate them. The talk will consider if the ocean really is irrelevant to mitigation. It will first review the types of questions that must be addressed in providing science support for policies on mitigation of GHG emissions. These are complex social issues about equity, burden sharing and risk, and equally complex issues about science-policy interfaces - technology and behaviour, global vs local actions, *etc*. Considering the IPCC conclusions about drivers and recent trends of emissions will provide context for considering roles the ocean can play in mitigation, and a few openings for greater consideration of the ocean in climate change mitigation may exist. However, the nature of the dialogue necessary to address the questions about mitigation policy confronts issues central to decisions about conservation and sustainable use of the oceans more broadly. That change in dialogue on ocean policy may be the major way that WG 3 of IPCC AR 5 impacts oceans and their uses.

October 23, 09:30 (S7-9722)

Effects of climate change on marine ecosystems in Polar Regions

Anne B. **Hollowed**[1] and Andrew Constable[2]

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[2]   Australian Antarctic Division, Kingston, Tasmania, Australia

This paper reviews the key findings of the Polar Region chapter of Working Group II of the recently released Intergovernmental Panel on Climate Change fifth assessment report (AR5). The paper traces the impacts of projected physical and chemical changes in the Polar Regions through the plankton, to fish and crabs to fish dependent communities. Results suggest that the exposure to climate change will exhibit spatial heterogeneity in the Polar Regions because of the high diversity bio-physical regions and associated drivers of change. Shifts in the timing and magnitude of seasonal biomass production could disrupt matched phenologies in the food webs, leading to decreased survival of dependent species. Some marine species will shift their ranges in response to changing ocean and sea ice conditions in the Polar Regions. Case studies illustrating these impacts will be discussed.

October 23, 09:50 (S7-9740)

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

Suam **Kim**

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The status and prospect of marine ecosystems and fisheries in the northwestern Pacific Ocean was reviewed in conjunction with climate change. The northwestern Pacific area occupies only 6.1% of world's ocean, but its production from capture fisheries and aquaculture production shows the biggest yield. Also, due to the high human population and its fast increasing rate of the region, the consumption and international trade of fisheries products are the largest in the world. Therefore people are heavily dependent upon marine products for their leisure and dietary needs. The global warming over the continent as well as the sea indicates one of the fastest areas in the world. For example, the warming rate of sea surface temperature (SST) of the regional seas was about 0.67-1.35°C during the 1982-2006 period. Furthermore, main fishery products from the northwestern Pacific are composed of small pelagic fish (SPF) which biomasses are fluctuated very sensitively for climate change. Also, based on comparative studies on fishing area distribution during cool and warm phases of the climate, it is expected that fishing area for current SPF species would be moved toward the north due to the increase in SST in the 21st century. The current economic development and status of China, Japan, and Korea is very fast or relatively stable compare to other regions of the world, so that more demand and preference on seafood is required in diet habits. Therefore it is recommended that management plan in fishery be considered in conjunction with changes in climate and social systems.

October 23, 10:10 (S7-9770)

Plankton in a changing climate: Coastal and polar cases study

Hongjun **Song**[1] and Rubao Ji[2]

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[2]   Woods Hole Oceanographic Institution, Woods Hole, MA, USA

To better understand the impact of climate change on marine ecosystem, plankton groups are always selected as the preferred indicators. The increasing availability and spatial and temporal extent of biological ocean time series (from both *in situ* and satellite data) have helped reveal significant phenological variability in marine plankton. This talk will begin with an overview of results from a phenology study of both phytoplankton and zooplankton. Then, the effects of freshening and warming on plankton will be explained from several coastal and polar case studies. Freshening can affect the dynamics of phytoplankton blooms, and cause the change of zooplankton structure in the Gulf of Maine. The remote sensing and modeling analysis show that salinity is the main factor influencing the phytoplankton bloom dynamics in this region. In the Arctic case, climate warming causes shrinking ice coverage and earlier ice retreat, which has strong impact the timing of primary production and is likely to have consequences for higher trophic levels. Furthermore, to improve the quality of the gappy satellite data, a new method combining generalized additive model (GAM) and spatio-temporal kriging is introduced to the interpolation of the satellite-derived chlorophyll data in the Arctic Ocean, which will be useful in capturing the phenological variability of phytoplankton.

October 23, 10:50 (S7-9506)

Chapter 30 the Ocean, Working Group II, IPCC fifth assessment report

Ove Hoegh-Guldberg[1], Rongshuo Cai[2], Elvira **Poloczanska**[3], Peter G. Brewer[4], Svein Sundby[5], Karim Hilmi[6], Victoria J. Fabry[7] and Sukgeun Jung[8]

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Chapter 30 of Working Group II synthesized information across the global ocean, excluding polar oceans. Regional responses were addressed by dividing the ocean into seven sub-regions: High Latitude Spring Bloom (including the North Pacific), Eastern Boundary Upwelling, Coastal Boundary, and Equatorial Upwelling Systems, Sub-Tropical Gyres, Semi-Enclosed Seas, and the Deep Sea. Knowledge of climate change impacts on marine systems has increased considerably since the Fourth Assessment Report. Rapid changes in physical and chemical conditions within ocean sub-regions have already affected the distribution and abundance of organisms and ecosystems although there are imbalances in knowledge among regions and taxonomic groups. The rapid changes in the physical, chemical, and biological state of the Ocean pose a number of key risks and vulnerabilities for ecosystems, communities, and nations worldwide such as the sustainability of capture fisheries and aquaculture development. Non-climate related stressors as well as natural climate variability confound the detection and attribution of the impacts of climate change and ocean acidification on ecosystems, yet may also represent opportunities for reducing risks through management strategies aimed at reducing their influence. Emerging issues and key knowledge gaps include understanding of how modes of natural climate variability will change their form or behavior in the future and their interaction with anthropogenic climate change, the role and temperature sensitivity of microbial systems in determining O_2 concentrations, ocean acidification, changes in primary production, potential for reorganization of food webs and ecosystems, and how to reinforce socio-ecological resilience in human communities affected by the changes of marine ecosystems.

October 23, 11:10 (S7-9754)

Assessment of climate trends and projections and their associated impacts on the Pacific coast of Canada

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Over the last four years Fisheries and Oceans Canada has carried out the Aquatic Climate Change Adaptation Services Program (ACCASP), which consists of both funding of new research and assessment of existing knowledge. A systematic analysis of available information on climate trends and projections was conducted for four separate regions of Canada, including the Pacific and Atlantic coasts, the Arctic and a freshwater domain centred on the Great Lakes. This information was in turn used to evaluate potential impacts, vulnerabilities and opportunities arising from climate change effects on ecosystems, fisheries and infrastructure. For the Pacific region, a workshop was held where scientists from a wide variety of disciplines and other participants responsible for *e.g.*, management of coastal infrastructure assets were asked to evaluate the risks associated with a range of different processes that might arise as a result of changing climate. The consensus of participants was that the risk of serious impacts from ecological changes (*e.g.*, ecosystem reorganizations that can serve as nonlinear amplifiers of changes to the physical environment) is high even over relatively short time scales (*e.g.*, 10-20 years). In the Pacific region the most serious threats to marine ecosystems and commercial fisheries include ocean deoxygenation and increasing temperature in rivers where salmon spawn.

October 23, 11:30 (S7-9767)

Impacts of climate change on U.S. oceans and marine resources: Technical input to the third U.S. National Climate Assessment

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In 2014 the United States completed the Third National Climate Assessment (NCA) to assess U.S. vulnerability to climate change, help government entities prioritize science investments and management actions, and assist public and private decision-makers more effectively plan for and respond to a changing world. The NCA includes a number of new features including the first chapter specifically assessing the effects of climate change on US oceans and marine resources. The Ocean and Marine Resources Chapter was based largely on a Technical Report designed to synthesize the state of the science regarding 1) the physical and chemical changes currently being observed in the marine environment; 2) how those changes affect marine organisms and ecosystems; 3) the effect of climate change on ocean services and the socioeconomic consequences; 4) potential international implications; and 5) management challenges, adaptation approaches, and opportunities.   This presentation will discuss development of the Technical Report by a team of experts from government, academia and other organizations, and the role it played in shaping the final NCA Oceans and Marine Resources Chapter. The Report documents the growing evidence of climate-related changes in the physical, chemical and biological conditions of US ocean ecosystems and the impacts these changes are having on fisheries and other ocean users.   It also highlights key needs to better prepare for and respond to these changes including improved monitoring, research and modeling of climate impacts on these valuable marine ecosystems.

October 23, 11:50 (S7-9678)

Vulnerability and adaptation strategies of pteropods due to ocean acidification and hypoxia

Nina **Bednarsek**[1], Richard A. Feely, J.C.P. Reum, B. Peterson, J. Menkel, S.R. Alin and B. Hales

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The ocean uptake of anthropogenic CO_2 has shoaled the aragonite saturation horizon in the California Current Ecosystem, but only a few studies to date have demonstrated widespread biological impacts of ocean acidification under present-day conditions. Pteropods are especially important for their role in carbon flux and energy transfer in pelagic ecosystems. In the California Current Ecosystem, conditions are becoming increasing unfavorable for sustaining shell maintenance because of enhanced dissolution. Our results show a strong positive correlation between the proportion of pteropods with severe dissolution and the percentage of the water column that is undersaturated with respect to aragonite. From this relationship, we are able to determine the extent of dissolution for the pre-industrial era, 2011, and 2050. Our calculations show that dissolution has increased by 30% since the beginning of the industrial era, and could increase to 70% by 2050. Although dissolution is occurring in most of the investigated pteropod species, some species have changed their daily vertical distribution pattern by migrating to upper supersaturated waters to avoid corrosive waters, a potential indication of an adaptation strategy to ocean acidification. Preliminary analyses of calcification and respiration rates demonstrate that part of the coastal pteropod population is already under increased effect of ocean acidification and hypoxia.

S7 Poster Presentations

S7-P1

Distribution patterns of polychaete assemblage and benthic quality status estimated by AMBI in Jindo-Jejudo subtidal areas

Kwang-Bae **Kim**, Jae-Hoon Cha, Dong-Yeong Kim, Ji-Na Song, Doo-Chan Um and Chu-Hwui Kwoun

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This study was carried out at 7 Jindo and 7 Jejudo stations (a total of 14 stations) in subtidal areas in order to understand the faunal structure of polychaete assemblage and ecological quality of benthic environment. The results of sediment analysis showed a mud/sand sedimentary facies in the Jindo areas while the Jejudo had higher sand content. There were 68 species of polychaete in a total of 14 stations, with 231 inds./m^2 and 61 species, 167 inds./m^2 in Jindo areas while 62 species, 295 inds./m^2 in Jejudo areas. The dominant species in Jindo areas were *Heteromastus filiformis, Ampharete arctica, Prionospio* sp., *Sigambra tentaculata, Thelepus* sp.. In Jejudo areas, *Amphicteis gunneri, Ampharete arctica, Prionospio* sp., *Telepsavus costarum, Heteromastus filiformis* were represented the dominant species. The result of cluster analysis showed that the stations were clearly clustered with Jindo and Jejudo subtidal areas except ST 5 and 6. AMBI values indicated that no V grade in all stations and there were relatively many II grade species in Jindo and Jejudo subtidal zones. So two locations showed different geographical location, sedimentary facies and the distributions of polychaete assemblage.

S7-P2

Marine climate change impacts and adaptation report card for Australia

Elvira **Poloczanska**[1], Anthony J. Richardson[1,2] and Alistair J. Hobday[2]

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The Marine Climate Change Report Cards for Australia (2009 and 2012) provide information about the observed and projected impacts of climate change on marine ecosystems and taxonomic groups and present potential or implemented adaptation actions. Knowledge of observed and projected changes in ocean physics and chemistry as well as climate variability were also synthesized. Over 80 authors from 35 universities and institutions contributed to the syntheses. Key findings of the 2012 Report Card include warming temperatures are influencing the distribution of marine plants and animals, with species currently found in tropical and temperate waters moving polewards; winds over the Southern Ocean and ocean current dynamics strongly influence foraging for seabirds that breed in southeast Australia and feed close to the Antarctic each summer; some tropical fish species have a greater ability to acclimatize to rising water temperatures than previously thought; the impacts of two years of extreme events, including floods and heatwaves, are widely evident in the marine environment; the Australian Science community is widely engaged in research, monitoring and observing programs to increase our understanding of climate change impacts and inform management; adaptation planning is underway, from seasonal forecasting for fisheries and aquaculture, to climate-proofing of breeding sites for turtles and seabirds. Plans for the third version of the Marine Report Card include inclusion of indicators to monitor adaptation progress.

S7-P3

Projecting impacts of rising water temperature on the distribution of seaweeds around Japan under warming scenarios

Shintaro **Takao**[1], Naoki Kumagai[2], Hiroya Yamano[2], Masahiko Fujii[1] and Yasuhiro Yamanaka[1]

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[2]   National Institute for Environmental Studies, Tsukuba, Japan

Seaweed beds play a key role in providing essential habitat and energy to coastal areas, with enhancements of productivity, biodiversity, and human societies. However, seaweed beds around Japan have decreased due to coastal reclamation, water quality change, and barren ground. Using monthly mean sea surface temperature (SST) from 1960 to 2099 obtained by multiple climate projection models and SST-based indices for barren ground of temperate seaweed *Ecklonia cava*, which predominates in the south part of Japan, we quantitatively evaluated the effects of SST rises on habitats of *E. cava* in Japanese coastal areas. In addition, grazing effects of herbivorous fish on *E. cava* were evaluated under future emission scenarios. Our results suggested that ongoing warming might drive potentially poleward shift of *E. cava* with large differences depending on the scenarios. For a lowest emission scenario, most of existing *E. cava* populations would survive from warming-induced barren ground by the end of the 21st century, while at the same time they were exposed to high grazing pressure by herbivorous fish. For a highest emission scenario, climate models projected that the extent of barren ground of *E. cava* can spread all over the coasts in Japan by the 2090s. Our projections highlighted the importance of not only mitigating global warming but also protecting *E. cava* from herbivores to conserve habitats of *E. cava* around Japan.

S7-P4

North Pacific upper-ocean changes projected by CMIP5 models

Chan Joo **Jang**, Dongwon Yi, Jihyeon Lee, Ho-Jeong Shin and Yong Sun Kim

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IPCC (Intergovernmental Panel on Climate Change) have recently released its fifth assessment report (AR5) which provides up-to-date scientific knowledge and socio-economic aspects of climate change, largely based on observational data and CMIP5 (Coupled Model Intercomparison Project Phase 5) global models. In this study, we aim to evaluate performance of global climate models (CMIP5 models) by comparing their historical run simulation with observed climatology, and to analyze their future climate change projection, focusing on North Pacific upper ocean changes that are associated with ecosystem response to global warming. Statistical analyses including Taylor diagram show that CMIP5 models have improved spatial patterns of PDO (Pacific Decadal Oscillation) compared with those of CMIP3 models, mainly through better teleconnection representation between the tropics and mid-latitudes. Furthermore, the improvement is not only by decrease in number of models with poor performance, but also by better simulation of PDO spatial patterns. Sea surface temperature and mixed layer depth in the North Pacific Ocean, however, still appear to have significant biases, thus contributing to simulation biases in ecosystem including estimates of chlorophyll concentration. CMIP5 models project that upper ocean processes including mixed layer depth tend to change considerably in the North Pacific, as projected by CMIP3 models. Possible causes of such changes and inter-model spreads in future projection will be also presented.

S7-P5

Changes of distributions and composition of nutrients in the Changjiang Estuary after the normal storage of Three Gorges Reservoir

Baodong **Wang**, Zicheng Wang, Ming Xin, Xia Sun, Qinsheng Wei and Bo Yang

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Based on field observations in the Changjiang Estuary and its adjacent sea areas in 2010-2011, changes of distributions and composition of nutrients in the Changjiang Estuary was studied after the normal storage of Three Gorges Reservoir. By comparison with the field data before closure of Three Gorges Dam in 2002, it was found that concentrations of dissolved inorganic nitrogen and phosphate increased by 27% and 60%, respectively, while dissolved silicate decreased by 20% in the Changjiang Estuary and its adjacent sea areas after the normal storage of Three Gorges Reservoir. The changes in nutrient concentrations resulted in significant decrease of N/P ratio as well as substantial decrease of Si/N ratio in the Changjiang Estuary, which relieving, to some extent, the extent of phosphate limitation but strenthening the potential advantage of non-diatom competition in the Changjiang Estuary and its adjacent sea areas. Besides, the reduction of freshwater discharge from the Changjiang in autumn, which was resulted by the water storation of Three Goeges Reservoir, led to significant reduction in the range of extension of the Changjiang Diluted Water and concentrations of nutrients and their affecting area in the Changjiang Estuary and its adjacent sea areas.

S8

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

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

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

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

Marine debris is increasingly recognized as a threat to biota in the ocean, which can have a range of socio-economic impacts from coastal areas to the open ocean. The majority of marine debris consists of synthetic polymers, or 'plastics', which readily float on the ocean surface or are suspended in the water column. Microplastics may be attributed to the intentional manufacture of commercial products or the fragmentation of plastic products. They can increase the bioavailable fraction of marine litter and act as a vector for the delivery of intrinsic or adsorbed toxic chemicals to exposed biota. Floating, submerged and beached debris have been documented in marginal seas and the adjacent coastal zone of the North Pacific Ocean. In addition, the North Pacific Ocean Gyre is known to accumulate floating debris in what has become known as the "Great Pacific Garbage Patch". Marine debris represents trans-boundary pollution which can also deliver associated chemicals and invasive organisms to regions far removed from source. The objective of this session is to present status and trend information for marine plastic debris pollution and its environmental consequences in the PICES region. Papers are invited that assess macro- or micro-plastic debris 1) hotspots in the PICES region, 2) source and input pathways, 3) long-range transport, 4) role as sink or source of associated toxic chemicals, and 5) biological and ecological effects. Recommendations on how to address growing problems associated with marine debris will be also considered.

Thursday, October 23 (09:00-17:45)

09:00　　***Introduction by Session Convenors***

09:05　　**Patterns of microplastic distribution in the global ocean and inland environments (Invited)**
Marcus Eriksen

09:35　　**Litter in the Mediterranean Sea within the European Marine Strategy Framework Directive (MSFD): Indicators for descriptor 10, GES and monitoring (Invited)**
Francois Galgani

10:05　　**Microlitter: Recommendations for monitoring from the MSFD**
Jesus Gago, Richard C. Thompson, Francois Galgani and T. Maes

10:25　　***Coffee/Tea Break***

10:45   **Results and lessons learned from joint beach debris surveys by Asian NGOs (Invited)**
Yong Chang Jang, Sunwook <u>Hong</u>, Jongmyoung Lee, Jong Su Lee, Sang Hee Hong, Won Joon Shim, Martin Thiel, Fujieda Shigeru, Tai-di Chang, Kanyarat Kosavisutte and Trieu Thuy Ha

11:15   **Hazardous chemicals in plastics in marine environments and their potential effects on marine organisms (Invited)**
Hideshige <u>Takada</u>, Kosuke Tanaka, Rei Yamashita and Yutaka Watanuki

11:45   **Marine litter problem at the Russian Far East and approaches for solution**
Iana <u>Blinovskaia</u>

12:05   **Distribution, sources and abundance of Marine debris in the coastal area of southern part of Primorsky Krai (Russia)**
Nikolai <u>Kozlovskii</u>

12:25   *Lunch*

14:00   **Sequential monitoring of beach litter at multiple sites using webcams**
Tomoya <u>Kataoka</u>, Hirofumi Hinata and Shin'ichiro Kako

14:20   **Inverse estimation of marine-debris outflows using webcam observation data**
Shin'ichiro <u>Kako</u>, Atsuhiko Isobe, Tomoya Kataoka and Hirofumi Hinata

14:40   **Distribution and impacts of micro- and macro-plastics in coastal British Columbia, Canada**
Peter S. <u>Ross</u>, Jean-Pierre W. Desforges, Jean Fong, Moira Galbraith and Wendy Szanizlo

15:00   **Producing fragmented micro- and nano-plastics from expanded polystyrene with an accelerated mechanical abrasion experiment**
Won Joon <u>Shim</u>, Young Kyoung Song, Sang Hee Hong, Mi Jang, Gi Myung Han and Seung Won Jung

15:20   **Analysis of a beach as a time-invariant linear input/output system of marine litter**
Tomoya Kataoka, Hirofumi <u>Hinata</u> and Shigeru Kato

15:40   *Coffee/Tea Break*

16:00   **Chemicals of concern in plastic marine debris: Hexabromocyclododecanes in expanded polystyrene products**
Sang Hee <u>Hong</u>, Won Joon Shim, Manviri Rani, Mi Jang, Najat Ahmed Al-Odaini, Gi Myung Han and Young Kyoung Song

16:20   **Leaching characteristics of Hexabromocyclododecane from expanded polystyrene buoy fragments in marine water**
Manviri <u>Rani</u>, Won Joon Shim, Mi Jang, Gi Myung Han, Young Kyoung Song and Sang Hee Hong

16:40   **Persistent organic pollutants adsorbed on microplastic from two beaches in China**
Weiwei <u>Zhang</u>, Zhifeng Zhang, Xindong Ma, Yan Wang and Ling Qu

17:00   **Transport of marine debris from the 2011 tsunami in Japan: Model simulations and observational evidence**
Jan <u>Hafner</u>, Nikolai Maximenko and Gisela Speidel

17:20   **Selective transport of microplastics and mesoplastics by drifting in coastal waters**
Atsuhiko <u>Isobe</u>, Kenta Kubo, Yuka Tamura, Shin'ichio Kako, Etsuko Nakashima and Naoki Fujii

17:40   Discussion

17:45   *Session Ends*

S8 Posters

S8-P1   **Monitoring of traditional and emerging BFRs in expanded polystyrene (EPS) from various countries**
Manviri <u>Rani</u>, Sang Hee Hong, Mi Jang, Gi Myung Han and Won Joon Shim

S8-P2   **Expanded polystyrene buoy as a moving source of toxic chemicals to marine life: Enrichment of hexabromocyclododecanes in mussel**
Mi <u>Jang</u>, Sang Hee Hong, Manviri Rani, Gi Myung Han, Young Kyoung Song and Won Joon Shim

S8-P3   **Compositions and distributions of microplastic in Korean beaches**
Young Kyoung <u>Song</u>, Mi Jang, Gi Myung Han, Sang Hee Hong, and Won Joon Shim

S8-P4   **A Nile Red staining method for microplastic identification and quantification**
Young Kyoung <u>Song</u>, Sang Hee Hong, Mi Jang, Gi Myung Han and Won Joon Shim

S8-P5   **Potential threat of microplastics to neustonic zooplankton in surface waters of the Southern Sea of Korea**
Jung-Hoon <u>Kang</u>, Oh-Youn Kwon, Bu-Gyeong Choi and Won Joon Shim

S8-P6   **Estimation of used buoy debris outflow from oyster aquaculture with Material Flow Analysis**
Su Yeon <u>Hong</u>, Yong Chang Jang, Jongmyoung Lee, Sunwook Hong and Chan Won Lee

S8-P7   **Conceptual difference of flow and stock of marine debris and its implications to setting of policy goals and indicators**
Yong Chang <u>Jang</u>, Sunwook Hong, Jongmyoung Lee, Hyun Woo Choi and Won Joon Shim

S8-P8   **Abundance of packaging debris on beaches increases as non-recycled amount increases: A case in Korea**
Yong Chang <u>Jang</u>, Jongmyoung Lee, Sunwook Hong, Jong Su Lee, Su Yeon Hong and Won Joon Shim

S8-P9   **The distribution of floating macro- and micro-plastics in the Open Ocean and Large Marine Ecosystems**
Peter J. <u>Kershaw</u>, Courtney Arthur, Marcus Eriksen, Jésus M. Gago Piñeiro, Kara Lavender Law and Laurent Lebreton

S8-P10   **Sources, fate and effects of micro-plastics in the marine environment – A global assessment**
Peter J. <u>Kershaw</u>, A. Andrady, C. Arthur, J. Baker, H. Boumann, S. Gall, V. Hidalgo-Ruz, A. Koehler, K.L. Law, H. Leslie, J. Potemra, P. Ryan, W.J. Shim, H. Takada, R. Thompson, A. Turra, D. Verthaak and K. Whyles

S8 Oral Presentations

October 23, 09:05 (S8-9426), Invited

Patterns of microplastic distribution in the global ocean and inland environments

Marcus **Eriksen**

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The global distribution and density of microplastic pollution is a dynamic system dependent on source and sink mechanisms and local and large scale currents. Surface abundance is typically not consistent within the same area, or static in the same place over time. Over six years, 26 expeditions explored the five subtropical gyres, coastal environments, and inland lakes. Though microplastic concentrations were highest in the subtropical gyres, higher weight densities were found in "hotspots" of plastic generation related to proximity to densely populated watersheds and near river outfalls. Inland lakes exhibited no current-driven accumulation zones, but rather directly reflect coastal inputs. Our expedition to the Great Lakes of North America produced recognizable microplastics in the form of microbeads, unlike any other ocean sample, which are too degraded to identify the source. Using the ocean data to populate an oceanographic model, we estimate there are .269 million tons of plastic in the global ocean from 5.25 trillion particles. Simultaneously, we separate microplastic into two size classes (0.33-0.99mm, 1.0-4.75mm) and mesoplastic (4.76-200mm) and macroplastic (>200mm). Using expected rates of particle fragmentation, we find that the two smaller size classes are less abundant than expected, suggesting that there are mechanisms that remove microplastics from the sea surface.

October 23, 09:35 (S8-9428), Invited

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

Francois **Galgani**

Ifremer, Immeuble Agostini, ZI Furiani, Bastia, Corsica. E-mail: francois.galgani@ifremer.fr

Within the context of the European Marine Strategy Framework Directive (MSFD, 2008/56/EC), the European Commission decided (2010/477/EU) that Good Environmental Status will be achieved, when, as a priority for descriptor 10, litter and its degradation products present in, and entering into EU waters, do not cause harm to marine life and damage to marine habitats. To support the process, the commission retained the following indicators to be included in monitoring programs:

(i) 10.1.1: Trends in the amount, source and composition of litter washed ashore and/or deposited on coastlines;

(ii) 10.1.2: Trends in the amount and composition of litter in the water column and accumulation on the sea floor;

(iii) 10.1.3: Trends in the amount, distribution and composition of micro-particles (mainly micro-plastics),

(iv) 10.2.1: Trends in the amount and composition of litter ingested by marine animals.

In this work, we present the situation of marine litter in Europe and how research and institutional programs may support an efficient monitoring program. Implications for the Mediterranean Sea are discussed in terms of monitoring, definition of targets and acceptable levels of harm.

October 23, 10:05 (S8-9758)

Microlitter: Recommendations for monitoring from the MSFD

Jesus **Gago**[1], Richard C. Thompson[2], Francois Galgani[3] and T. Maes[4]

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Microplastic litter is a pervasive pollutant present in marine systems across the globe. The legacy of microplastics pollution in the marine environment today may remain there for centuries to come due to the persistence of these materials. In the EU, the Marine Strategy Framework Directive (MSFD) adopted in 2008, aims to establish a good environmental status (GES) of the European seas by 2020. The amount, distribution and, composition of microparticles (specifically microplastics) are variables in the assessment whether a GES for marine litter has been achieved.

The abundance and distribution of microplastics (maximum size of 5 mm) in the marine environment is challenging owing to the lack of standardization in the sampling and analytical methodologies. Sampling of microplastics in the different marine compartments (sea water, sediment and biota) requires different approaches: samples can be selective, bulk, or volume-reduced. In this presentation is explained the approach that was decided by a group of European experts working in the implementation of the MSFD.

A key step for the MSFD is to re-evaluate the state of art in 2016 in terms of the knowledge base on spatial distributions of microplastics, rates of accumulation and the potential for harm. It is important to note that the comparable quantification of microplastics across Europe and also worlwide, by the use of common methodologies is not only relevant for identification of the microplastics, is important for identification of the sources, planning of measures against marine litter and for checking the efficiency of the counter-measures.

October 23, 10:45 (S8-9519), Invited

Results and lessons learned from joint beach debris surveys by Asian NGOs

Yong Chang Jang[1], Sunwook **Hong**[1], Jongmyoung Lee[1], Jong Su Lee[1], Sang Hee Hong[2], Won Joon Shim[2], Martin Thiel[3], Fujieda Shigeru[4], Tai-di Chang[5], Kanyarat Kosavisutte[6] and Trieu Thuy Ha[7]

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[7]   Centre for Marinelife Conservation and Community Development, Ha Noi, Vietnam

Joint beach debris surveys were conducted by Asian NGOs in four countries (Korea, Taiwan, Thailand, and Vietnam). At a training workshop held in June 2013, we reviewed a monitoring protocol suggested by United Nations Environmental Programme and Intergovernmental Oceanographic Commission in 2009. Eighteen NGOs and researchers from 11 Asian countries and Chile improved the protocol together on the basis of discussion and a pilot survey. The protocol was improved so that (i) debris can be clearly classified by material types, (ii) fragments and whole items of debris can be separately counted, and (iii) the proportion of debris with attached organisms can be determined. Then we conducted a debris survey in the home regions in September 2013. The results showed that plastic debris was dominant and its majority was fragments. There was little debris with attached organisms, which suggests that most of debris were of local origin.

October 23, 11:15 (S8-9657), Invited

Hazardous chemicals in plastics in marine environments and their potential effects on marine organisms

Hideshige **Takada**[1], Kosuke Tanaka[1], Rei Yamashita[1] and Yutaka Watanuki[2]

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Plastics carry two categories of chemicals in marine environments. One is additives including antioxidant agents such as nonylphenol and flame retardants such as polybrominated diphenyl ethers (PBDEs). Another is hydrophobic compounds including persistent organic pollutants (POPs) sorbed from surrounding seawater. Concentration factor of POPs to marine plastics is up to one million. International Pellet Watch demonstrated that the accumulation, *i.e.*, amplification of toxicity of plastics, occur globally. We studied transfer of the chemicals from plastics to internal system of organism which ingest plastics through the analyses of short-tailed shearwater collected from Bering Sea (Tanaka *et al.*, 2013). BDE209 and BDE183 were detected from abdominal adipose of several birds. Same congeners were detected also in the plastics in the digestive tracts of the same individuals, though they were not detected in their prey fish. These data suggested the transfer of chemicals from plastic to the organisms. We further examined the process of the transfer and demonstrated that stomach oil in the digestive tracts of seabirds facilitate the dissolution of BDE209 from plastics. There have been some other studies which indicated the transfer of chemicals from plastics to organism based on laboratory experiments (Rochman *et al.*, 2013; Browne *et al.*, 2013; Chua *et al.*, in press) and field observation (Yamashita *et al.*, 2011; Rochman *et al.*, 2014). Furthermore, contribution of plastic ingestion to the decrease in the population of a species of seabird was suggested (Lavers *et al.*, 2014).

October 23, 11:45 (S8-9431)

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

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Marine litter issue tackling is in continuation at the Russian Far East. Results of earlier research have shown that the sources of introducing the polluting matter into the sea coastal environment in Japan, Korea, China and Russia are quite different. The fact that marine litter is no longer an aesthetic problem alone but has acquired the significance of economic and environmental problems bringing harm to a man's health and safety of life is well-known. But Russian communities most often do not perceive that marine litter has grown into a problem of international significance. In contrast to neighboring countries coastal, the main course of pollution in Russia is recreation activity. With due regard to all of above, Maritime State University conducts the assessment of coastal zone pollution and development of marine litter monitoring techniques.

The analysis of the data obtained through the 1999-2013 research made it possible to arrive at the following conclusions:

•   It's the supra-littoral zone which is the most heavily polluted part of the coastal zone;
•   The coast closer to the developed lands is more polluted;
•   Near-estuary areas are subjected to extensive pollution;
•   Small sized litter has predominated;

As marine litter has a broad impact and these are only public environmental organizations that can first draw society attention to the problem. One of the most illustrative decisions in the solving of marine litter problem is organization of coastal cleanup campaigns. The coastal cleanup actions carrying out by public ecological organizations has become the tradition too.

October 23, 12:05 (S8-9493)

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

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A comparative analysis of marine litter distribution in the Amur Bay of the East Sea/Sea of Japan was carried out. Coastal area of the Amur Bay is partly occupied by the most populated part of the Primorsky Krai (Russia) - the Vladivostok city agglomeration, being the home of approximately 623 thousand people, and the main contributor to the pollution. Consequently, the environment of the Amur Bay faces considerable recreational and economic press. Despite relatively scarce but still increasing development of the coastal territories, as compared to the closest areas of neighbor countries in the Pacific (China, Japan, and Korea), the southern coast of the Primorsky Krai experiences several types of pollution, including pollution of the marine water areas with potentially hazardous materials such as plastics. The pattern of currents near the coast of Primorsky Krai provides a considerable reduction of transboundary transfer of pollutants from the neighboring countries. The lack of efficient sewage system and municipal waste treatment system is still one of the major drawbacks resulting in littering of inner water areas and coastal wetlands in the Uglovoy Bay (a part of the Amur Bay).The monitoring data was collected by the Maritime State University named after Nevelskoy and by the author (since 2011). It was used to assess the exposure of various coastal sites to the solid waste pollution. A map showing the sites exposed to the marine debris pollution was composed. The study of of marine debris composition in the area revealed that the number of recreational litter items surpasses the number of items from activities such as construction and fishing where the latter categories include the most bulky and heavy pieces. A table showing the quantities of around 50 most frequent marine litter items in the area was composed.

October 23, 14:00 (S8-9505)

Sequential monitoring of beach litter at multiple sites using webcams

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We have established a system for sequential monitoring of beach litter using webcams at four sites around the East China and Japan Seas (*i.e.*, Wakkanai, Tobishima, Wajima and Tsushima) since November 2010, and developed a new technique for calculating the area covered by beach litter based on the webcam images. First, color references are generated by converting RGB values in the original images into color values in uniform color space (*i.e.*, CIELUV color space). The pixels corresponding to beach litter are detected using the color references. The covered area is calculated by applying a projective transformation to webcam images in which litter pixels have been detected.

We successfully monitored the temporal variability of the covered areas for 14 months with 18% calculation error. The calculation error depends strongly on the illumination angle of sunlight because the color of beach litter changes by the shade of neighboring objects such as other litter and coastal hinterland. Thus, it is important to consider the illumination angle in sequential webcam monitoring of the quantity of beach litter. Our webcam monitoring system enables us to monitor the temporal variability of the quantity of beach litter with a high time resolution at multiple sites. Such webcam monitoring can assist the evaluation of the potential risks of beach litter in the marine environment and development of a systematic plan for removing beach litter.

October 23, 14:20 (S8-9466)

Inverse estimation of marine-debris outflows using webcam observation data

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The present study has attempted to establish a scientifically reliable method capable for computing the marine debris sources and its outflows using webcam monitoring in conjunction with numerical modeling. First, temporal variability of quantities of marine debris washed ashore on the beaches was sequentially monitored using webcams which could continuously transmit photos of beaches with marine debris every 120 minutes via the Internet. In total, we used 1-year data to obtain the time series of marine-debris quantity using four webcams placed on beaches around the East China and Japan Seas. Second, we conducted two-way particle tracking model (PTM) experiments for identifying source locations of marine debris by combining a "backward-in-time" PTM with a "forward-in-time" PTM. In these experiments, we used reanalysis of ocean surface currents and leeway drifts derived from satellite-observed wind speed data. Last, an inverse method with a Lagrange multiplier was applied to estimate marine-debris outflows at each source on the basis of the results of two-way PTM and sequential monitoring by using four webcams. To validate the accuracy of the outflows derived from the inverse method, the quantities of marine debris monitored by webcams were hindcasted using a forward in-time PTM with reanalysis surface currents and satellite-derived leeway drifts, in conjunction with the results of inverse method. The time series of the hindcasted quantities of marine debris were consistent with that of quantities of marine-debris determined from sequential webcam images on actual beaches.

October 23, 14:40 (S8-9494)

Distribution and impacts of micro- and macro-plastics in coastal British Columbia, Canada

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Microplastics represent an emerging concern in the marine environment, but little is known about their sources. We are carrying out research to characterize the source, transport, fate and effects of microplastics in coastal British Columbia (BC), Canada, consisting of studies of i) microplastics in sea water and ii) debris along the BC shoreline. We recently observed subsurface seawater microplastics (62 μm to 5000 μm) in the NE Pacific Ocean at concentrations reaching 9200 particles/m3. Fibres accounted for approximately 75% of enumerated microplastic particles, but were higher nearshore than offshore ($p < 0.05$). Lowest concentrations were in offshore Pacific waters, increasing up to 27-fold in nearshore waters adjacent to urban centers. This is consistent with land-based origins for the majority of the microplastics. Some may originate from the breakdown of larger products. For example, data from the 2013 Great Canadian Shoreline Cleanup reveal the extent of macroplastic litter along 1,250 km of coastal BC to be 43 kg of debris per km. Top ranked items included cigarette filters, food containers, plastic bags, container lids, glass bottles, paper bags, cutlery, cans, building materials, straws, plastic bottles, and cigar tips. While the impacts to ocean life from microplastics are unclear, entanglement by packing straps, fishing nets, and lines, continues to represent a serious problem for marine mammals in BC. As many as 300 California sea lions and Steller sea lions along southwest Vancouver Island were entangled in marine debris between 2005 and 2012. These results highlight the need for additional information on sources of all types and sizes of plastic debris in the oceans.

October 23, 15:00 (S8-9600)

Producing fragmented micro- and nano-plastics from expanded polystyrene with an accelerated mechanical abrasion experiment

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Fragmented secondary microplastic particles account for the majority of microplastics and have various origins, which makes proper control difficult. Photo-oxidation and mechanical abrasion on beaches and (or) sea surface are thought to be major weathering and fragmentation process for generating secondary microplastic particles. None of scientific information is, however, available where and how secondary microplastics are produced. Fragmentation of expanded polystyrene (EPS), one of top three polymer types in marine debris monitoring study was done with an accelerated mechanical abrasion experiment in a laboratory. Forty EPS spherules detached from a EPS float were placed in an amber bottle with glass bead (3 mm in diameter) or natural sand (pre-combusted at 450°C), respectively. The bottles were rotated with a tumbler for a month at 113 rpm. Fragmented EPS particles were extracted by density separation with deionized water and identified with microscopic FT-IR, SEM and fluorescence microscope after Nile Red staining. After mechanical abrasion, apparent surface damage of EPS spherules was observed by SEM analysis. The hundreds of micron scale EPS particles were identified with FT-IR. The EPS particles were selectively stained with Nile Red and subsequently identified and quantified under a fluorescent microscope. EPS particles obviously outnumbered the control and were quantifiable. Number of EPS particles was 5.15×10^5/bottle. About 85% of the EPS particles were within size range of 1-25 mm in maximum length. SEM with energy dispersive spectroscopy revealed that a number of nano-sized EPS particles were also produced during the mechanical abrasion experiment.

October 23, 15:20 (S8-9476)

Analysis of a beach as a time-invariant linear input/output system of marine litter

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We have been investigating the residence time of beached plastic floats and their movements on the beach by conducting mark-recapture experiments at Wadahama Beach on Niijima Island, Japan every two- to three-months since September 2011. The beach is located on the west side of the island, runs in the north-south direction, and is approximately 1 km long. We selected three kinds of fishery float as a target item because the floats could be found on many Japanese beaches and two of them has been reported to contain a toxic lead material. In the experiments, all the target items were collected, numbered with a permanent marker and replaced where they were found. We also measured their positions by a handheld GPS receiver. The experiments provide us a time series of the residual ratio (*i.e.* residual number of buoys divided by the initial number newly found in each survey), and the tracks of the items on the beach. The residual ratio, that is, the unit impulse response function, decreased exponentially. From the function, the average residence time of the items was calculated as seven to eight months. Additionally, from the Fourier transformation of the function, we could obtain the characteristics of the beach as a linear system of the float input, which are fully determined by the residence time. The tracks of the items will help us develop the physical model of the residence time in the future with the aid of wind wave statistics and beach geomorphology.

October 23, 16:00 (S8-9592)

Chemicals of concern in plastic marine debris: Hexabromocyclododecanes in expanded polystyrene products

Sang Hee **Hong**[1,2], Won Joon Shim[1,2], Manviri Rani[1], Mi Jang[1,2], Najat Ahmed Al-Odaini[1], Gi Myung Han[1] and Young Kyoung Song[1,2]

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Plastic marine debris contains numerous organic chemicals such as adsorbed hydrophobic chemicals and additives. Adsorbed chemicals are adsorbed from surrounding water due to their high affinity towards hydrophobic surface of plastic, and additives are added during manufacture in order to enhance the performance of plastics. However, our understanding about what are the chemicals of high concern along with their ecological impact is very poor. We have detected large amounts of hexabromocyclododecane (HBCD) in expanded polystyrene (EPS) buoys stranded along the coasts of South Korea. HBCD is currently the most widely used brominated flame retardants. Due to its potential toxicity, environmental persistence, bioaccumulative tendencies and long-range transportability, HBCD has been added to the list of global elimination compounds under the Stockholm Convention on Persistent Organic Pollutants in 2013. The concentration of HBCD in the outside layer was lower than that of inside the buoys, which indicates leaching of HBCD from the surface of the buoys throughout their lifetime. HBCD was also measured in small sized EPS spherules spreading over the coasts. Through laboratory and field experiment, it is observed that HBCD can easily and quickly leach out from the surface of EPS buoy to surrounding water and enriched in nearby environment and aquatic species. The occurrence of HBCD in EPS buoys and its fragments implies that EPS debris can be a moving source of HBCD in the marine environment, and its influence can be extensively extended through gradual fragmentation.

October 23, 16:20 (S8-9433)

Leaching characteristics of Hexabromocyclododecane from expanded polystyrene buoy fragments in marine water

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Polystyrene (PS) is a very important plastic material for building insulation. To prevent it's burning, HBCD (globally eliminated in May 2013) is frequently added as flame retardant. Expanded polystyrene buoys (EPS) are extensively used as floating device (2 million buoy/year) in aquaculture farming of oyster and mussel in Korea and end up in the environment as marine debris. Due to irregular addition of HBCD in EPS buoy (~70-85 µg/g of EPS), it may be considered as a cause of HBCD contamination through leaching by sea water. Therefore, leaching characteristics of HBCD from EPS buoy fragments in water under laboratory and field conditions were clarified. First-order reaction reflecting fast-leaching initially followed by slow-desorption over time was observed. Gamma-HBCD was the most abundant isomer followed by αHBCD and βHBCD of the total HBCD concentration (4.7-10.9 µg/L, ~20%) leached in deionized water at room temperature after 96h. Significantly enhancement in leaching with increase in temperature was attributed to fact of solubility especially αHBCD indicated high α/γ ratio. Agitation effect was more or less on similar line but not statistically different because of desorption-cum-absorption of HBCD. Lower salinity was favoured for leaching of HBCD. Field studies follow the order: dark exposure<sunlight exposure<sea surface with an approximately loss of 46.64, 57.39 and 66.73 µg/g, respectively. Releasing of HBCD was greater in field (54-83%) than laboratory (20%) favoring weathering due to several environmental factors. Data will be helpful to predict potential risk of HBCD that could leach into environment from EPS buoy or other PS products.

October 23, 16:40 (S8-9598)

Persistent organic pollutants adsorbed on microplastic from two beaches in China

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Microplastics provide a mechanism for transport of hydrophobic chemical contaminants to remote locations and marine organism. In this study, plastic resin pellets were collected from Dalian beach and Qinhuangdao beach. Concentration of 16 polycyclic aromatic hydrocarbons (PAHs), 20 polychlorinated biphenyls (PCB$_S$), Hexachlorocyclohexane (HCHs), DDTs, chlordane, heptachlor, endosulfan, aldrin, dieldrin and endrin in the microplastic were analyzed. The total concentration of PCBs ranged from 34.7~213.7 ng g^{-1} and 21.5~323.2 ng g^{-1} for Dalian beach samples and Qinghuangdao beach samples respectively. Higher concentrations of PCBs were observed in congeners 44, 110, 138, 155 and 200. DDTs concentration was 1.2~101.5 ng g^{-1} and 1.5~127.0 ng g^{-1} for the two beaches. PAHs concentration ranged from 136.3~1586.9 ng g^{-1} and 397.6~2384.2 ng g^{-1} respectively. For all the detected pollutants, except PAHs and heptachlor, concentrations of other pollutants for Dalian beach samples are higher than Qinhuangdao beach samples. The difference was possibly due to regional industrial development level, agricultural characteristics and the coal burned.

October 23, 17:00 (S8-9606)

Transport of marine debris from the 2011 tsunami in Japan: Model simulations and observational evidence

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Marine debris represents an increasing threat to marine environment and marine life. Still the detection and monitoring of marine debris is problematic. The tragic 2011 tsunami in Japan generated a vast amount of marine debris. This provided us with a unique opportunity to study and understand the dynamics of marine debris transport across the North Pacific. The IPRC's SCUD model of surface ocean currents is utilized in this study. The model is forced by satellite-observed sea level and winds, and it is employed to simulate trajectories of the 2011 tsunami debris. In addition, a direct effect of wind is considered to capture movement of object with various geometry and buoyancy. The visualization of the model solution provides the advection, dispersion, and the sorting of model virtual tracers due to the effects of surface currents and winds. The direct quantitative verification of the model results is not possible due to lack of marine debris observing system. However, the model results were consistent with limited reports from sea and, mainly, from coastline with respect to timing of arrival and composition of verified and potential tsunami debris. The presentation gives an overview of the modeling results and discusses the utility of modeling studies for monitoring long-range marine debris transport.

October 23, 17:20 (S8-9459)

Selective transport of microplastics and mesoplastics by drifting in coastal waters

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To investigate the quantity and size distributions of small plastic fragments, field surveys were conducted at 15 stations from 2010 to 2012. We chose coastal stations at the Hiji River mouth, in the Iyo Sea, the Uwa Sea, and the Hyuga Sea, which are all located in the western part of the Seto Inland Sea, Japan, to investigate how sizes of plastic fragments vary spatially. Microplastics and mesoplastics collected on board were brought back to our laboratory to count the number of pieces (defined as "quantity" in the present study), and to measure their sizes. The quantities within each size range were divided by the water volumes measured by the flow meter at each sampling station to convert them to the number of pieces per unit seawater volume (hereinafter, "drift density" in the unit of pieces/m^3). Of note, the size and quantity of mesoplastics (approximately > 5 mm) gradually increased close to the coast irrespective of the existence of river mouths. Additionally, microplastics were more dominant as we moved further offshore. A particle-tracking numerical model reproduced the near-shore trapping of mesoplastics, suggesting that mesoplastics are selectively conveyed onshore by a combination of Stokes drift and terminal velocity, dependent on fragment sizes. It is suggested that mesoplastics washed ashore on beaches degrade into microplastics, and that the microplastics, which are free from near-shore trapping, are thereafter spread offshore in coastal waters.

S8 Poster Presentations

S8-P1

Monitoring of traditional and emerging BFRs in expanded polystyrene (EPS) from various countries

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Strict bans have been imposed on the worldwide use of pentabromodiphenyl ether (PBDE) and hexabromocyclododecane (HBCD) due to their persistence and adverse biochemical effects. Consequently, alternative flame retardants are being used increasingly in commercial applications. Therefore, to evaluate the extent of exposure of HBCD and other NBFRs from EPS, we analysed various (n=37) types of EPS (in-land and marine debris, product used for food category, packing, aquaculture *etc.*) collected from in-land and coastal beaches of various countries (S. Korea, USA, Canada, Japan, India, Thailand, Singapore, Australia, Switzerland, England and Malaysia) and determined the concentration of HBCD and other additives such as BTBPE, TBBPA, DBDPE, ATE, BATE, TBP, DPTE, HCDBCO, BEHTBP, EHTBB, TBBPA-DBPE and PBCD. HBCD, PBCD, TBP and ATE were the most frequently detected. Overall, HBCD was highest with a mean (n=37) of 578±2008 µg/g (Median: 36 µg/g, Range: 0.01-4291 µg/g) followed by PBCD (Mean: 43±112 µg/g, Median: 4.8 µg/g, Range: n.d-52 µg/g) and others. S. Korea is found to be highest user for HBCD in Asian countries investigated but lower than Canada and comparable to USA. Moreover, EPS debris (Mainly comes from EPS buoy used in aquaculture) collected from Korean beach have 221±54-2974±172 µg/g of HBCD. Good correlation was obtained for HBCD and its metabolite PBCD formed by thermal degradation of EPS products during processing in industry. Concentrations of other BFRs were lower than HBCD indicating their recent use in EPS that cannot be ignored. ATE and HCDBCO were enriched in USA and Canada EPS debris indicating the region specific use.

S8-P2

Expanded polystyrene buoy as a moving source of toxic chemicals to marine life: Enrichment of hexabromocyclododecanes in mussel

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A large amount of expanded polystyrene (EPS) buoys have been used in aquaculture of oyster and mussels in South Korea. After their use, a lots of EPS buoys may be lost or disposed as waste. Floating EPS buoy as marine debris has become a habitat for marine organisms. In our previous study, we detected a considerable amount of hexabromocyclododecanes (HBCDs) in EPS buoy with a median concentration 40 µg/g. To find an evidence of its impact on marine organism via release from floating marine debris, EPS buoy along with attached mussels were collected from Jinhae Bay, Korea. Collected samples were categorized as follows; EPS buoy, mussel attached to its EPS buoy, mussels attached to high density polyethylene (HDPE) and metal buoys, mussel attached to natural rock. The HBCD concentration analyzed among EPS buoys showed a large variation in the range of 0.15-1,580 µg/g dw (median; 16.7). The median concentrations of HBCD in mussels attached onto EPS buoy, HDPE buoy, metal buoy and natural rock were 111, 61, 62 and 16 ng/g lipid weight, respectively. Mussel inhabiting EPS buoy had significantly higher concentration of HBCDs than those from other substrates. These results revealed that EPS buoy has a direct effect to mussel attached to it. There were clear changes observed in α/γ ratios of HBCDs in mussels according to the type of their substrates. These results strongly imply that plastic marine debris can be a moving source of toxic chemicals to marine life and those can be biomagnified via marine food chain.

S8-P3

Compositions and distributions of microplastic in Korean beaches

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The composition and distribution of microplastics in six beaches along Korean coast and six beaches of Geoje Island affected by riverine discharge from nearby Nakdong River were determined in April-May, 2013 and May, 2012 respectively. On the beaches, ten quadrats (0.5 m x 0.5 m) were randomly placed along the high-stranded line and 1L sand passed through a 1 mm sieve was collected. In the laboratory, 50 mL sand from each 1L of ten quadrats was sub-sampled to make a composite sample (500 ml) representing each beach. The microplastics were separated with sediment using saturated NaCl solution. Supernatant was filtered through a 0.2 µm filter paper and plastic like particles on the filter papers were identified with a FT-IR microscope. The abundance of microplastics from twelve beaches was in the range of 32-9,280 particle/L-sediment. The mean abundance of microplastics from six beaches of Geoje (2,689 particles/L-sediment) was 17 times higher than those in others beaches (157 particles/L-sediment). The beaches in the East coast of Geoje Island were severely contaminated by microplastics. Among the five categories of microplastics (fragment, fiber, spherule, sheet and expanded polystyrene (EPS)), fragment type accounted for the highest portion (69-100%) in the 9 beaches, while in Gangneung, the highest portion was fiber (50%) and in Guyoung and Wahyun was EPS (63% and 90%). In composition, polypropylene, polyethylene and styrofoam accounted for 33%, 26%, and 19%, respectively.

S8-P4

A Nile Red staining method for microplastic identification and quantification

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Microplastics are classically visually identified with a microscope. Microscopic identification has low reliability especially in small (*e.g.* <200μm) transparent or white particles. FT-IR equipped with a microscope has been frequently applied to spectroscopic identification of micro-scale polymers including qualitative confirmation of polymer types. It is a little hard to detect microplastics less than 50μm in size. We aim to develop a subsidiary method to facilitate identification of synthetic polymers using a fluorescent dye.

Nile Red (NR), a fluorescent dye, which was well known to dye neutral lipid in cell and tissue sample is used in this study. It is strongly fluorescent only in the presence of a hydrophobic environment. Applicability of NR for identification and quantification of microplastics was tested and staining condition was optimized in this study. Micro-sized polyethylene (PE), polypropylene (PP) and expanded polystyrene (EPS) were used as model plastics. Stained polymer particles were recognized better in green fluorescence (Ex.; 534-558 and Em.; 515-565) than red (Ex.; 534-558 and Em.; >590). The 50mg/L solution showed higher fluorescence than 5 mg/L solution. Fluorescence intensity was in the order of EPS > PP > PE. The developed NR staining method was successfully applied to identify and quantify the fragmented polymer particles in a laboratory accelerated mechanical abrasion study. Other polymer types are being tested with the NR staining method. The further application of NR staining to field samples accompanying with removal of biogenic materials are currently undergone.

S8-P5

Potential threat of microplastics to neustonic zooplankton in surface waters of the Southern Sea of Korea

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The potential for the bioavailability and physical impacts of floating debris by neustonic zooplankton was assessed by measuring the relative abundance of microplastic (<2mm) and zooplankton in surface water of the southern sea of Korea. Surveys using a Manta-trawl net with 330μm mesh were carried out at western and eastern parts of Geoje bay before and after rainy season in 2012 and 2013. Abundances of total zooplankton and microplastic ranged from 0 to 126 inds.m^{-3} and 0.56-8.87 particles m^{-3} in May, from 43 to 644 inds.m^{-3} and 0.64-52.1 particles m^{-3} in July 2012, respectively. Abundances of total zooplankton and microplastic ranged from 9 to 315 inds.m^{-3} and 0.60-3.08 particles m^{-3} in June, from 13 to 763 inds.m^{-3} and 0.57-1.81 particles m^{-3} in July 2013, respectively. The average ratio of microplastic to zooplankton was 0.37 (May) and 0.03 (July) in 2012, 0.06 (June) and 0.02 (July) in 2013. Among observed microplastics, encounter rate of paint chips to zooplankton was relatively high before rainy season at eastern part of Geoje Bay. All the values are relatively low compared to previous studies conducted in North pacific Central Gyre, Mediterranean Sea and California shore. The reduced ratios after rainy season stemmed mainly from highly increased abundance of zooplankton compared to microplastic. This can imply that neustonic zooplankton was less susceptible to microplastic after rainy season around the Geoje Bay during the study.

S8-P6

Estimation of used buoy debris outflow from oyster aquaculture with Material Flow Analysis

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Styrofoam buoys for aquaculture have been known as one of the major sources of marine debris in Korea. In oyster aquaculture of Tong Yeong City, where lots of styrofoam buoys are used, amount of buoys entering the ocean was estimated with Material Flow Analysis (MFA). MFA is a systematic assessment of the flows and stocks of materials within a system defined in space and time. We defined the oyster aquaculture area as the main target space for the analysis and the world ocean and the recycling center as the supplementary space. After specifically estimating the flows and stocks of the year 2012, we expanded the result into 10 years period from 2003 to 2012. To get information on the amount of use and recycle, we reviewed documents on the aquaculture area size, subsidy on styrofoam buoys, and recycling outcomes, and to get information on used and retrieved amount of buoys we interviewed buoy sellers and fishermen. This is one of the scarce studies on marine debris input and shall contribute to establishing proper policy to prevent debris from entering the ocean.

S8-P7

Conceptual difference of flow and stock of marine debris and its implications to setting of policy goals and indicators

Yong Chang **Jang**[1], Sunwook Hong[1], Jongmyoung Lee[1], Hyun Woo Choi[2] and Won Joon Shim[3]

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Assessing effectiveness of policy instruments to reduce marine debris amount needs proper indicators with which marine debris amount can be measured. In this paper, it is discussed that conceptual difference of flow and stock of marine debris is important in setting the goals and indicators of marine debris policy. The stock of plastic marine debris in the ocean is the accumulation of the annual flow. If we suppose that 10% of plastics produced worldwide since 1950 have entered the ocean as marine debris, the stock of plastic marine debris at the end of 2010 shall be 528 million ton and its annual flow of 2010 shall be 26 million ton, only 5% size compared to the stock. If we reduce 100% of the annual flow of marine debris in 2011, then the stock of marine debris shall be the same as 528 million ton at the end of 2011. From the monitoring of marine debris on beaches, only the change of stock, not the flow, is measured. So, the effectiveness of this policy intervention (preventing 26 million ton of marine debris flow) shall be hardly measured from the beach monitoring. Better indicators to measure the policy effectiveness are needed.

S8-P8

Abundance of packaging debris on beaches increases as non-recycled amount increases: A case in Korea

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The relationship between abundance of packaging materials debris on 16 beaches of Korea and their non-recycled amount was statistically tested. In the spring of 2014, beached debris of nine kinds packaging materials recycled with the Extended Producers Responsibility (EPR) was collected and weighed: glass bottles, PET (polyethylene terephthalate) bottles, packaging plastic film, plastic bowls, paper packs, iron cans, aluminium cans, packaging foamed plastic, and PVC (polyvinyl chloride) bags. With the glass bottles being both biggest in debris and non-recycled amount, the linear regression analysis showed coefficient of determination of 0.595 ($p<0.05$), meaning the debris weight increases as non-recycled amount increases. This result can be interpreted that required recycle ratio under EPR should be increased in order to reduce marine debris on beaches.

S8-P9

The distribution of floating macro- and micro-plastics in the Open Ocean and Large Marine Ecosystems

Peter J. **Kershaw**[1], Courtney Arthur, Marcus Eriksen, Jésus M. Gago Piñeiro, Kara Lavender Law and Laurent Lebreton

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The abundance of floating macro- and micro-plastics has been used as an indictor of overall pollution in the Transboundary Waters Assessment Programme (TWAP). This global initiative (2012-2014), organised through the Global Environmental Facility (http://geftwap.org), will be used to target efforts to reduce the impact of human activities on land and at sea. Most observational data of floating plastic has been collected from the open ocean, often using vessels of opportunity or on multi-purpose scientific cruises. Data from visual observation and by towed nets are both subject to significant sampling uncertainty. In addition, abundance may vary up to several orders of magnitude due to meso-scale processes. This hinders establishing time-trends, even from long time-series studies. A relative lack of comprehensive observational data for LMEs led to the decision to produce a map of relative abundance by combining an ocean circulation model with estimates of floating plastic inputs. The inputs were based on proxies of human activity: shipping density, coastal population density and area of impervious catchment (equivalent to enhanced run-off in urban areas). The model results suggested that litter abundance varies considerably between LMEs, with 'hot spots', such as the Japan Sea and Mediterranean, corresponding to observed higher plastic abundance.

S8-P10

Sources, fate and effects of micro-plastics in the marine environment – A global assessment

Peter J. **Kershaw**[1], A. Andrady, C. Arthur, J. Baker, H. Boumann, S. Gall, V. Hidalgo-Ruz, A. Koehler, K.L. Law, H. Leslie, J. Potemra, P. Ryan, W.J. Shim, H. Takada, R. Thompson, A. Turra, D. Verthaak and K. Whyles

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A global assessment of the sources, fate and effects of microplastics has been completed by a Working Group of GESAMP (the Joint Group of Experts on Scientific Aspects of Marine Protection), on behalf of UNESCO-IOC, UNEP and IMO. The Group combined expertise on a wide range of scientific disciplines and geographic experience, critically reviewing and assessing published information. The outcomes included a compilation of what is known, recommendations for further scientific research, recommendations to guide future assessments, and recommendations of more immediate use for decision-makers and funding bodies.

The Assessment Report will be published at the 2nd International Ocean Science Conference in November 2014 (Barcelona).

S9

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

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

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

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

The advection of water masses and their associated nutrients and plankton is critical to biological processes within the subarctic gyres and on the productive shelf regions bordering the gyre. Cross-shelf and along-shelf advection regulate the supply of nutrients and plankton to these shelves, thereby affecting the productivity and species composition of the prey organisms that support higher trophic levels. Moreover, the advection of larvae to suitable nursery areas affects the spatial and temporal overlap between larvae and their prey and predators (match-mismatch dynamics). Advective processes have been linked to the recruitment success of walleye pollock off Japan and in the Gulf of Alaska, which benefit from increased retention within certain near-shore regions, and to recruitment patterns of flatfishes and crab in the eastern Bering Sea, which benefit from increased advection towards suitable nursery areas. Interannual variability in advection has long been understood as an important source of biological variability, while variability at shorter time scales (days to weeks) has only recently received more attention due to the increased availability of high-frequency observations and the development of high-resolution models. The main goal of this session is to explore how variability in the advection of nutrients, zooplankton prey, and early life stages at all scales affects the recruitment, abundance and distribution of subarctic fish and invertebrate species, including the potential to extend their range into Arctic waters. We invite papers that explore past variability and potential future trends based on field observations, analyses of long-term data series, and biophysical models. Contributions from both the Pacific and Atlantic Subarctic are welcome.

Tuesday, October 21 (09:00-17:00)

09:00   ***Introduction by Session Convenors***

09:05   **The relative importance of advective *vs.* in-situ processes to mesozooplankton biomass on the Eastern Bering Sea shelf (Invited)**
Georgina A. Gibson, Albert Hermann, Kenneth Coyle, Katherine Hedstrom and Enrique Curchitser

09:30   **Catastrophic reduction of sea-ice in the Arctic Ocean -its impact on the marine ecosystems in the polar region**
Naomi Harada, Katsunori Kimoto, Jonaotaro Onodera, Eiji Watanabe, Makio C. Honda, Michio J. Kishi, Takashi Kikuchi and Yuichiro Tanaka

09:50   **Seasonal cycle of phytoplankton community structure and photophysiological state in the western subarctic gyre of the North Pacific**
Tetsuichi Fujiki, Kazuhiko Matsumoto, Yoshihisa Mino, Kosei Sasaoka, Masahide Wakita, Hajime Kawakami, Makio C. Honda, Shuichi Watanabe and Toshiro Saino

10:10   **Siliceous phytoplankton flux reflecting oceanographic variation in the southern Northwind Abyssal Plain**
Jonaotaro Onodera, Eiji Watanabe and Naomi Harada

10:30   *Coffee/Tea Break*

10:50   **A biological contribution to partial pressure of CO_2 in the western Arctic Ocean and Bering Sea**
Ryosuke Futsuki, Toru Hirawake, Amane Fujiwara, Takashi Kikuchi, Shigeto Nishino, Daisuke Sasano, Masao Ishii, Hiroshi Uchida and Sei-Ichi Saitoh

11:10   **Current status of primary production in the western Arctic Ocean**
Mi Sun Yun, Bo Kyung Kim, Eun Jin Yang, Sung-Ho Kang,Terry E. Whitledge, Mike Gong and Sang H. Lee

11:30   **Distribution of viable diatom resting stage cells in bottom sediments and water columns in the Chukchi Sea: Importance as seed populations of spring bloom**
Chiko Tsukazaki, Ken-Ichiro Ishii, Kohei Matsuno, Atsushi Yamaguchi and Ichiro Imai

11:50   **Assessment of the relationship between timing of sea-ice retreat and phytoplankton community size structure derived from remote sensing in the Bering and Chukchi Sea shelf region**
Amane Fujiwara, Toru Hirawake, Koji Suzuki, Ichiro Imai and Sei-Ichi Saitoh

12:10   **Spatial and temporal changes of zooplankton community in the Chukchi Sea**
Hiroko Sasaki, Kohei Matsuno, Atsushi Yamaguchi, Yutaka Watanuki and Takashi Kikuchi

12:30   *Lunch*

14:20   **Cross-shelf advection as a mechanism of regional climate change influence on plankton community in the coastal waters**
Yury Zuenko and Victoria Nadtochy

14:40   **Pacific and Atlantic gateways to the Arctic for plankton and fish**
Franz J. Mueter, Seth Danielson, Harald Gjøsæter and Kenneth F. Drinkwater

15:00   **Reproduction of walleye pollock (*Theragra chalcogramma*) and some oceanographic parameters of their habitat off eastern Sakhalin Island, Sea of Okhotsk**
Sen Tok Kim, I.N. Mukhametov, G.V. Shevchenko and V.N. Chastikov

15:20   **Distribution, transport pathway and modification of the Coastal Oyashio water, off the Hokkaido coast, in the Northwestern Pacific**
Hiroshi Kuroda, Yuko Toya, Taku Wagawa, Akira Kuwata, Shin-ichi Ito and Shigeho Kakehi

15:40   *Coffee/Tea Break*

16:00   **Hydrography of an Aleutian eddy in the developing phase and the potential influence to lower trophic level ecosystems**
Rui Saito, Ichiro Yasuda, Kosei Komatsu, Hiromu Ishiyama, Hiromichi Ueno, Hiroji Onishi, Atsushi Yamaguchi, Takeshi Setou and Manabu Shimizu

16:20   **Some effects of advection between the Arctic and Subarctic**
Kenneth F. Drinkwater

16:40   Summary and Discussion

17:00   *Session Ends*

Cancellations

14:40
(cancelled)   **Understanding annual variability in distribution and transport processes for the early life stages of *Todarodes pacificus* using behavioral-hydrodynamic modeling approaches**
Jung Jin Kim, William Stockhausen, Suam Kim, Yang-Ki Cho, Gwang-Ho Seo and Joon-Soo Lee

S9 Oral Presentations

October 21, 09:05 (S9-9755), Invited

The relative importance of advective *vs.* in-situ processes to mesozooplankton biomass on the Eastern Bering Sea shelf.

Georgina A. **Gibson**[1], Albert Hermann[2], Kenneth Coyle[3], Katherine Hedstrom[3] and Enrique Curchitser[4]

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[2]   Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, Seattle, USA
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[4]   Institute of Marine and Coastal Sciences, Rutgers University, New Brunswick, NJ, USA

Biomass of large crustacean zooplankton on the eastern Bering Sea has been found to vary quite substantially inter-annually and appears negatively correlated with temperature. The mechanisms giving rise to these changes are not yet well understood, including whether changes are due to bottom up processes driven by physical processes, or by top down effects due changes in predation pressure. Using model estimates from both a eularian lower trophic level ecosystem model and a lagrangian particle tracking model I will discuss the mechanisms, timing, and location of the transport of zooplankton onto the eastern Bering Sea shelf. The relationships between biomass, production and the physical environment and the importance of advective *vs.* in-situ processes and how the relative importance of these processes changes in 'warm' and 'cold' years will be presented. Results indicate that the timing of on-shelf transport and the distribution of oceanic zooplankton on the shelf can vary substantially between one year and another. The Bering, Pribilof, and Zhemchug Canyons and Cape Navarin appear to be regions of elevated on-shelf float transport and wind direction is the primary factor controlling inter-annual variability in the timing, amount, and location of the on-shelf zooplankton transport. The response of both zooplankton production and on-shelf advection to environmental changes in the Bering Sea will likely not be uniform as the north and south appear to respond in opposite directions to environmental variability. In-situ production by zooplankton appears to be generally more important to biomass accumulation than the transport of zooplankton biomass by advective processes. However, advection of zooplankton biomass may be an important contributor to standing stock biomass in some regions at certain times of year – notably the northern and southern middle shelf regions.

October 21, 09:30 (S9-9738)

Catastrophic reduction of sea-ice in the Arctic Ocean -its impact on the marine ecosystems in the polar region

Naomi **Harada**[1], Katsunori Kimoto[1], Jonaotaro Onodera[1], Eiji Watanabe[1], Makio C. Honda[1], Michio J. Kishi[2], Takashi Kikuchi[1] and Yuichiro Tanaka[3]

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The sea-ice in the Arctic Ocean has dramatically reduced during the past decade. The drastic sea-ice reduction would cause a complicated and difficulty to understand the perspective on marine ecosystem surrounding the Arctic Ocean, because "disadvantage" phenomena such as ocean acidification and "advantage" phenomena such as improving light condition for primary producers, respectively, are simultaneously progressing. We have investigated the response of marine organisms caused by catastrophic sea ice reduction in the Chukchi Sea and Northwind abyssal plain at where the sea ice reduction has progressed most seriously in the Arctic Ocean. The aims of our study are 1) to understand temporal changes in primary production, 2) to understand the physiological response of marine phyto- and zooplanktons having carbonate tests on warming or freshening associated with sea-ice melting, 3) to develop a new model for marine ecosystems in the Arctic Ocean, to reproduce the primary production by using the model and to understand the response of marine ecosystems on the environmental changes caused by rapid sea-ice reduction.

In this presentation, we will adress an overview of this project composed of three sub-themes (Observation, Culturing, and Modeling). Specifically, we will show a seasonal change in biogenic components flux obtained at the Northwind abyssal plain by a year round time series sediment trap system and the potential mechanism of high biogenic fluxes found in the beginning of the sea-ice season using the original Arctic Ocean ecosystem model.

October 21, 09:50 (S9-9739)

Seasonal cycle of phytoplankton community structure and photophysiological state in the western subarctic gyre of the North Pacific

Tetsuichi **Fujiki**[1], Kazuhiko Matsumoto[1], Yoshihisa Mino[2], Kosei Sasaoka[1], Masahide Wakita[3], Hajime Kawakami[1], Makio C. Honda[1], Shuichi Watanabe[3] and Toshiro Saino[1]

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We investigated the seasonal variability of the phytoplankton community in the western subarctic gyre (WSG) of the northwestern North Pacific with respect to structure (abundance, size, and taxonomic composition) and photophysiological state from 2006 to 2012 by using the chemotaxonomy program CHEMTAX, microscopy, and fast-repetition-rate fluorometry. Chlorophyll a standing stock (ʃChl a) varied seasonally from 20 to 52 mg m^{-2} and increased frequently to > 40 mg m^{-2} in June and July. Diatoms (20–35%) and prymnesiophytes (13–23%) comprised major portions of the ʃChl a during the bloom period. Diatoms decreased to < 23% during the postbloom period, and prymnesiophytes became the most abundant group (24–35%). Mean Fv:Fm ratios (potential photochemical efficiency of photosystem II) in the mixed layer were relatively high (0.41–0.47) in winter and early spring, decreased rapidly to 0.32–0.39 concomitant with bloom development, and remained at low levels in the summer and autumn, although macronutrients [NO_3^-, PO_4^{3-}, and $Si(OH)_4$] in the mixed layer were not depleted at any time. In June 2012, onboard-ship iron (Fe)-enrichment experiments stimulated increases of Chl-a concentrations (from 0.64 to 7.15 mg m^{-3}) and Fv:Fm (from 0.33 to 0.44). Seasonal variability of the phytoplankton community in the WSG is controlled mainly by Fe, with light and temperature limitation occurring in winter and early spring. Our study also suggests that the magnitude and duration of blooms in the WSG are strongly affected by Fe availability.

October 21, 10:10 (S9-9741)

Siliceous phytoplankton flux reflecting oceanographic variation in the southern Northwind Abyssal Plain

Jonaotaro **Onodera**, Eiji Watanabe and Naomi Harada

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In order to study the relationship between siliceous microplankton and sea-surface water masses, settling particle flux of siliceous phytoplankton were observed in the western Arctic Ocean. The studied particle samples were taken by bottom-tethered sediment trap at Station NAP (75°N 162°W, 1970 m water depth, nominal trap depth 180 m) in the southern Northwind Abyssal Plain during October 2010-September 2012. Total mass flux showed the annual flux maximum with abundant silt-clay minerals in November-December 2010 and 2011. The diatoms in November-December were mainly composed of *Chaetoceros* (subgenus *Hyalochaete*) and their resting spores. Coastal flagellate *Ebria tripartita* was observed in the early winter only. These results suggest the significant input of shelf materials to the study area. The shelf material transportation by cold eddy to basin side were figured by the sea ice-ocean general circulation model COCO 4.9. Maximum diatom flux in summer 2011 was clearly observed with dominance of sea-ice species *Fossula arctica*, whereas phytoplankton and lithogenic fluxes in summer 2012 were quite low. According to the physical oceanographic model, the suppressed particle fluxes in 2012 were probably due to limited nutrient supply for upper 100m water column by extent of oligotrophic Beaufort Gyre water to Station NAP.

October 21, 10:50 (S9-9744)

A biological contribution to partial pressure of CO$_2$ in the western Arctic Ocean and Bering Sea

Ryosuke **Futsuki**[1], Toru Hirawake[2], Amane Fujiwara[2,3], Takashi Kikuchi[4], Shigeto Nishino[4], Daisuke Sasano[5,6], Masao Ishii[5,6], Hiroshi Uchida[4] and Sei-Ichi Saitoh[2]

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Arctic Ocean contributes 5-14% to the global balance of CO$_2$ sink and source. Major controlling factor of air-sea CO$_2$ flux in seasonal ice zone is physical processes, such as temperature, salinity, fraction of sea ice melt water, and wind-driven mixing. On the other hand, contribution of biological processes is also significant, such as blooming season after ice retreat. However few studies focused on the relationship between the biological process and surface water partial pressure of CO$_2$ (pCO$_2$), therefore little is known about the contribution of primary production. Objective in this study is to clarify biological contribution to pCO$_2$ in the western Arctic Ocean and Bering Sea by using in-situ and satellite data. We conducted cluster analysis to infer the controlling factor of pCO$_2$ variability using in-situ sampled pCO$_2$, sea surface temperature and sea surface salinity, and satellite derived wind velocity and primary productivity as the input variable. The northern Bering Sea and the northern shelf of Chukchi Sea were classified into relatively low pCO$_2$ with high primary productivity, weak wind and less stratified region. Our result suggests that biological contribution to pCO$_2$ in the two regions is greater than other regions.

October 21, 11:10 (S9-9728)

Current status of primary production in the western Arctic Ocean

Mi Sun **Yun**[1], Bo Kyung Kim[1], Eun Jin Yang[2], Sung-Ho Kang[2], Terry E. Whitledge[3], Mike Gong[3] and Sang H. Lee[1]

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Phytoplankton production measurements were conducted in the Chukchi Sea and the western Canada Basin during the summers in 2009 and 2010, using a ^{13}C–^{15}N dual tracer technique. In the Chukchi Sea shelf, the daily carbon production rate in 2009 was remarkably low with a mean of 0.3 g C m^{-2} d^{-1} (SD = ± 0.2 g C m^{-2} d^{-1}). These lower rates of phytoplankton production were induced by high amount of fresh water accumulated from the Siberian Coastal Current and the Alaskan Coastal Water which is negatively affected phytoplankton production rates. Under the low nutrient and freshening conditions during this study, small phytoplankton were more abundant than those reported previously in the Chukchi Sea shelf. In 2010, the regionally high nitrate production rates compared to ammonium production rates were found in the western Canada Basin, caused by warm-core eddies which supply high levels of nitrate to the euphotic zone. The warm-core eddies substantially enhanced local phytoplankton production and the contribution of large phytoplankton in the Canada Basin. The effects of physical forcing events (such as eddy) under ongoing environmental changes on the primary production need to be more examined to better understand future changes of primary production in the Arctic Ocean.

October 21, 11:30 (S9-9743)

Distribution of viable diatom resting stage cells in bottom sediments and water columns in the Chukchi Sea: Importance as seed populations of spring bloom

Chiko Tsukazaki[1], Ken-Ichiro Ishii[2], Kohei Matsuno[3], Atsushi Yamaguchi[1] and Ichiro **Imai**[1]

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Arctic region has the long dark winter period covered with sea ice and hence photosynthetic organisms are incapable of growth during winter. Formation of resting stage cells presumably helps autochthonous arctic diatoms to survive the long arctic night and in sea ice. In Chukchi Sea, resting stage cells of arctic diatoms were densely accumulated ($3.5 \times 10^5 - 6.8 \times 10^6$ g^{-1} wet sediment) in the bottom sediments especially at the north of Bering Straits where nutrients rich water inflow from the Bering Sea. High densities of resting stage cells of ice algae and arctic plankton species in bottom sediments reflect occurrences of ice algae blooms in the past and followed phytoplankton blooms. Resting stage cells found *in situ* water columns during the sampling period were 1.6×10^4 MPM L^{-1} in average and probably supplied with inflow of the Alaska Coastal Current and/or resuspension of bottom populations, and probably have more chances to initiate occasional blooms. In arctic marginal ice edge zone, the following sequential processes are proposed on ice algae blooms and spring blooms: 1) diatom resting stage cells in sediments are carried into the water columns by meteorological and oceanographic processes such as vertical mixing, 2) suspended resting stage cells are incorporated into ice during ice formation, 3) these resting stage cells in ice function as seed-populations of blooms of ice algae such as *Fragilariopsis* and following phytoplankton blooms in water columns after the improved light conditions.

October 21, 11:50 (S9-9737)

Assessment of the relationship between timing of sea-ice retreat and phytoplankton community size structure derived from remote sensing in the Bering and Chukchi Sea shelf region

Amane Fujiwara[1], Toru Hirawake[2], Koji Suzuki[3], Ichiro Imai[2] and Sei-Ichi **Saitoh**[2]

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Extremely high primary production in the shelf region of the Bering and Chukchi Seas supports large biomass of higher trophic level organisms. Not only phytoplankton biomass during spring bloom but also its size structure can affect energy use of higher trophic levels through pray-predator body size relationship. The timing of sea ice retreat should also take into account because it is tightly coupled with timing of spring bloom. In order to assess the influence of sea ice melt timing on phytoplankton community size structure, we investigated inter-annual and spatial variability of phytoplankton community size structure during spring and timing of sea ice retreat using satellite remote sensing (1998–2013).

Significant negative relationship between proportion of larger phytoplankton ($\%Chla_{>5\mu m}$) and onset date of sea ice retreat was found for the most part of the shelf region. That is to say, earlier sea-ice retreat causes larger $\%Chla_{>5\mu m}$ in spring. It can be suggested that nutrients were utilized before sea ice retreat by sub-ice algae and/or under-ice phytoplankton bloom in the late retreat years. On the other hand, we found not only length of ice-free season but also annual mean $\%Chla_{>5\mu m}$ positively correlated with annual net primary production. Thus, both phytoplankton community composition and growing season are important for annual primary production at least in the study area. Our findings would contribute to comprehend the mechanism of recent changings of ecosystem structure in the shelf region.

October 21, 12:10 (S9-9742)

Spatial and temporal changes of zooplankton community in the Chukchi Sea

Hiroko **Sasaki**[1,2], Kohei Matsuno[1,2], Atsushi Yamaguchi[1], Yutaka Watanuki[1] and Takashi Kikuchi[3]

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Annual variation in the spatial-temporal patterns of zooplankton community in the Chukchi Sea in summer between 1991 – 1992 and 2007 - 2008 have been reported to be caused by environmental changes. However, little is known about their recent changes and the environmental factors contributing to changes in their distribution. Moreover, it is important to understand the spatial and temporal patterns of zooplankton community to elucidate and predict their climate-driven distribution response in the future. The objectives of this study is to investigate the changes in the spatial and temporal patterns of the zooplankton community between summer of 2013 and previous study periods (1991 – 1992; 2007 - 2008) in the Chukchi Sea. We analyzed the spatial-temporal patterns of zooplankton samples, which were collected by NORPAC net in Arctic Cruises conducted by T/S Oshoro-Maru of Hokkaido University. Zooplankton abundance data were then summarized by taxa (*e.g.* copepods, chaetognaths *etc.*). We further investigated the collected *in-situ* and satellite-derived oceanographic data to understand the environmental factor contribute to their distribution. We will summarize the spatial-temporal patterns of zooplankton community during the 5-year summer periods.

October 21, 14:20 (S9-9567)

Cross-shelf advection as a mechanism of regional climate change influence on plankton community in the coastal waters

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Plankton community in the coastal waters of Peter the Great Bay (Japan/East Sea) includes a number of mass species reproduced in the deep-water sea (*Neocalanus plumchrus, Calanus glacialis, Metridia pacifica, Sagitta elegans*) or even in subtropical waters (*Calanus pacificus, Mesocalanus tenuicornis, Paracalanus parvus, Labidocera japonica*) which are transported to the coastal zone by cross-shelf wind-driven currents. The deep-water species appear in the coastal waters after monsoon change in spring, when dominant southeastern winds induce the cross-shelf circulation with on-shore flow in the upper layer and compensatory off-shore flow in the bottom layer. This circulation intensifies in times of the Hawaiian High strengthening, when thickness of the surface layer and portion of the deep-water plankton species increase in the coastal zone, as happened in the 1990s. Recently the summer monsoon becomes weaker because of smoothing of atmospheric pressure difference between the Hawaiian High and Far-Eastern Low, therefore the thermocline becomes shallower, the bottom layer becomes colder, and the portion of allochtonous deep-water plankton species becomes lower in the coastal waters, including the mass predator: *Sagitta elegans*. As the result of these changes, species composition of the coastal planktonic community becomes poorer but its abundance becomes higher.

October 21, 14:40 (S9-9563)

Pacific and Atlantic gateways to the Arctic for plankton and fish

Franz J. **Mueter**[1], Seth Danielson[1], Harald Gjøsæter[2] and Kenneth F. Drinkwater[2]

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Warmer waters, reduced ice cover and changes in circulation affect the distribution of fish in subarctic seas. Strong gradients in species composition from the subarctic to the Arctic imply a high potential for populations expanding into arctic waters, but the rate of expansion and mechanisms are likely to differ between the Pacific and Atlantic Arctic Gateways. We review the main pathways connecting subarctic seas to the Arctic Ocean along these gateways, the main drivers affecting fluxes, and evidence for changes in these fluxes and in the distribution and abundance of subarctic and arctic fish species. In the Pacific, we find little evidence for changes in the demersal fish community north of Bering Strait since the early 1990s. We argue that such changes are unlikely to occur in the foreseeable future because bottom temperatures on the shallow shelf are "reset" each winter, severely limiting the distribution of boreal fishes. Moreover, there is no evidence that the inflow of Pacific waters and associated fauna into the Chukchi Sea has increased to date. However, pelagic species may exploit the longer ice-free season by expanding their summer feeding range into the Arctic, but evidence for either range expansions or increased abundances in the Pacific Arctic is limited. In contrast, increased inflows of warm Atlantic water into the Barents Sea and reductions in sea ice cover have resulted in the expansion of both demersal and pelagic species along the Atlantic Arctic Gateway and several commercially exploited stocks have recently increased to record high biomass levels.

October 21, 14:40 (S9-9630) -CANCELLED

Understanding annual variability in distribution and transport processes for the early life stages of *Todarodes pacificus* using behavioral-hydrodynamic modeling approaches

Jung Jin **Kim**[1], William Stockhausen[2], Suam Kim[3], Yang-Ki Cho[4], Gwang-Ho Seo[4] and Joon-Soo Lee[1]

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To understand annual variability in distribution and transport process for the early life stages of *Todarodes pacificus* summer spawning population, we used a coupled bio-physical model that combines an individual-based model (IBM) incorporating ontogenetic vertical migration for paralarval behavior and temperature-dependent survival process with a ROMS oceanographic model. From the backward experiment using distribution of paralarvae collected in northern East China Sea (ECS), the spawning ground for the summer-spawning population is estimated from southeast Jeju Island to central ECS near the 29°N. Also, the forward experiment from the potential spawning ground satisfactorily reproduced the inter-annual variability of paralarval distribution obtained by the field survey; the survival individuals in northern ECS were substantially more abundant in late July 2006 than in 2007, corresponding to the paralarval density distribution from the observation. Total number of survival individuals at 60 days after release based on simulation throughout summer spawning period (June to August) was 20,329 and 13,816 individuals in 2006 and 2007, respectively. The survival individuals are mainly distributed in EJS corresponding to pathway of nearshore branch of the Tsushima Warm Current flowing along the Japanese coast during both years. However, in the Pacific side of Japan, the abundance of survival individuals was extremely low in 2007 compared to 2006. Inter-annual variability in transport and survival processes made a substantial impact not only the abundance of surviving parlarvae, but also on the flux of paralarvae to adjacent waters, as well.

October 21, 15:00 (S9-9585)

Reproduction of walleye pollock (*Theragra chalcogramma*) and some oceanographic parameters of their habitat off eastern Sakhalin Island, Sea of Okhotsk

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Vertical and horizontal distribution of walleye pollock eggs in the Sea of Okhotsk along eastern Sakhalin Island and the factors determining their survival have been almost unknown. Studies carried out in June 2012 allow us to distinguish some relationships between eggs aggregations and water's dynamics. Walleye pollock spawning in the area coincides with the period of intensive sea ice melting and deceleration of currents over shelf. The East Sakhalin Current has determined the situation all over the region in the cold period of the year. Its spring weakness is appeared to be necessary for fish spawning and subsequent developing on eggs and larvae life stages. The eggs hatching is taking place in near-bottom layer at comparatively small depths being entirely under effect of the cold intermediate layer of the sea. When floating the eggs are distributed in subsurface layer over thermocline where conditions are more favorable for their development. The great bulk of eggs have been retaining around spawning area by local eddies and upwelling. Featured spring dynamics of waters having considerable likeness over all studying area of Northern Pacific could form the mechanisms of increased survival of eggs. Despite of severe conditions of the subarctic sea the periodicity of waters dynamics near northeastern Sakhalin in great extent determines the timing of species spawning whereas in spring the features of water circulations promote vertical and horizontal transfer of eggs to the sea areas more favorable for their development.

October 21, 15:20 (S9-9735)

Distribution, transport pathway and modification of the Coastal Oyashio water, off the Hokkaido coast, in the Northwestern Pacific

Hiroshi **Kuroda**[1,2], Yuko Toya[1], Taku Wagawa[3], Akira Kuwata[3], Shin-ichi Ito[4] and Shigeho Kakehi[3]

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The Coastal Oyashio (CO) water has been known to be distributed in winter to spring on the shelf-slope region off the Hokkaido coast in the Northwestern Pacific. This water is characterized by cold (<2°C) and low salinity (<33.0psu) and originates from the East Sakhalin Current water in the Okhotsk Sea, which is affected by freshwater discharge from the Amur River. Previous studies pointed out that the CO water includes not only high nutrients but also high dissolved-iron concentration, which is 5-10 times as large as that of the Oyashio surface water. Satellite chlorophyll images in March-May also demonstrate that particularly high concentration associated with phytoplankton spring bloom lasts for three months on the shelf-slope region off of Hokkaido coast where the CO water is expected to be certainly distributed. Additionally, the high chlorophyll concentration seems not to spread extensively over the Oyashio region in these months but to be restricted to the west of 150°E. Our hypothesis is that the CO and its modified water spreading in the Northwestern Pacific can contribute to occurrence/maintenance of spring bloom, which basically follows an idea of Kono and Sato (2010). To validate this hypothesis, spatio-temporal distribution of the CO water was examined by compiling historical temperature-salinity records. Observed features were then reproduced by a triply-nested 1/50-degree realistic ocean model. Our results indicated a typical transport pathway of this water along the shelf-slope region and an intermittent seaward transport due to several-scale eddies. The details will be shown in our presentation.

October 21, 16:00 (S9-9574)

Hydrography of an Aleutian eddy in the developing phase and the potential influence to lower trophic level ecosystems

Rui **Saito**[1], Ichiro Yasuda[1], Kosei Komatsu[1,2], Hiromu Ishiyama[3], Hiromichi Ueno[4], Hiroji Onishi[4], Atsushi Yamaguchi[4], Takeshi Setou[5] and Manabu Shimizu[5]

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Mesoscale anticylonic eddies formed in the western Alaskan Stream region south of the Aleutian Islands between the 180° meridian and about 170°E are called Aleutian eddies. Many of the Aleutian eddies move southwestward, and reach the western subarctic gyre. Comparing with mesoscale eddies in the Gulf of Alaska, the hydrography of Aleutian eddies and the impacts to lower trophic level ecosystems are not fully understood. In the present study, we observed a vertical profile of developing Aleutian eddy in July 2010 and examined changes from the early development phase in February to July in 2010 using a 1/10° eddy resolving ocean model called Fisheries Research Agency Regional Ocean Modeling System (FRA-ROMS). Inside the eddy, a subsurface cold water (3.0−4.0°C) and a somewhat warmer water (4.0−4.5°C) were observed at 70−200 m and 200−500 m depth, respectively. In the subsurface cold layer, temperature was relatively colder than the outside of eddy. The particle tracking experiments using the FRA-ROMS suggested that the water in the eddy was mainly originated from Alaskan Stream region in the early spring of 2010. The subsurface water inside the eddy was colder than that outside the eddy throughout the experiment. These hydrographic structures of the eddy potentially yield higher phytoplankton concentration and zooplankton abundance observed in our previous study within the eddy.

October 21, 16:20 (S9-9581)

Some effects of advection between the Arctic and Subarctic

Kenneth F. **Drinkwater**

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Significant water mass and sea-ice exchange occurs between the North Atlantic and the Arctic through Fram Strait, the Barents Sea and the Canadian Arctic Archipelago. These exchanges have ecosystem consequences in terms of heat and freshwater in the downstream directions, and in turn on their associated flora and fauna. They are far reaching with Atlantic Waters extending throughout the Arctic Basin while Arctic-influenced waters affect Subarctic regions well to the south including off both sides of Greenland, Iceland, eastern Canada and onto the US eastern seaboard. In terms of biology effects, the variability in exchanges and advection has a direct influence on most trophic levels through changes in species distribution and indirectly on metabolism, phenology and production. A review of some of these exchanges, including of sea ice, and their impacts on the Subarctic and Arctic ecosystems will be given. This will include how they change under climate variability, including the present warming and sea-ice loss, and how they may vary under future climate change. The latter is particularly important given that these regions are likely to undergo the some of the largest temperature increase in the world's oceans. Particular attention will be paid to the effects of advection on fish entering the Arctic under climate change.

S10 POC/TCODE/FUTURE Topic Session
Regional climate modeling in the North Pacific

Co-Convenors:

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

Invited Speakers:

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

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

Tuesday, October 21 (09:00-17:00)

09:00   ***Introduction by Session Convenors***

09:05   **Climate—Boundary current interactions: Stories from East and West (Invited)**
         Enrique <u>Curchitser</u>, Justin Small, William Large, Raphael Dussin, Katherine Hedstrom and Brian
         Kaufman

09:30   **Regional coupled modeling of the eddy-wind interactions in the California Current System
         (Invited)**
         Hyodae <u>Seo</u>

09:55   **Climate change projection for the western North Pacific Ocean by dynamical downscaling**
         Chul Min Ko, Chan Joo <u>Jang</u>, Ho-Jeong Shin and Yong Sun Kim

10:15   **Regional climate change projection for the northwest Pacific marginal seas**
         Gwang-Ho <u>Seo</u>, Yang-Ki Cho, Byoung-Ju Choi and Kwang-Yul Kim

10:30   ***Coffee/Tea Break***

10:55   **CORDEX and its recent progress for East Asia (Invited)**
         Hyun-Suk <u>Kang</u>, S. Hong, J.-Y. Jung, M.-S. Suh, S.-K. Oh, D.-H. Cha and S.-K. Min

11:20   **Introducing the MIT Regional Climate Model (MRCM) and its application to climate studies worldwide (Invited)**
Eun-Soon <u>Im</u> and Elfatih A.B. Eltahir

11:45   **Projected change in the East Asian summer monsoon from dynamical downscaling: Moisture budget analysis**
Chun-Yong <u>Jung</u>, Chan Joo Jang, Hyung-Jin Kim and Ho-Jeong Shin

12:05   **An assessment of ocean climate reanalysis by the Data Assimilation System of KIOST**
Young Ho <u>Kim</u>, Chorong Hwang and Byoung-Ju Choi

12:25   *Lunch*

14:00   **Application of a regional marine system model on the northwestern Pacific and the variability of the Yellow and the East China Seas (Invited)**
Hyoun-Woo <u>Kang</u>, Hanna Kim, Jae Kwi So, Momme Butenschon and Icarus Allen

14:25   **Development of a Seto-Inland-Sea model toward operational monitoring and forecasting (Invited)**
Kei <u>Sakamoto</u>, Goro Yamanaka, Hiroyuki Tsujino, Hideyuki Nakano, Norihisa Usui and Shogo Urakawa

14:50   **A biogeochemical model for the British Columbia continental shelf**
Angelica <u>Peña</u>, Diane Masson and Michael Foreman

15:10   **Transport of *Todarodes pacificus* winter cohort into the Yellow Sea in the early life states**
Ji-Young <u>Song</u>, Joon-Soo Lee, Jung-Jin Kim and Ho-Jin Lee

15:30   *Coffee/Tea Break*

15:50   **Impact of horizontal model resolution on air-sea CO_2 exchange in the California Current**
Jerome Fiechter, Enrique <u>Curchitser</u>, Christopher Edwards, Fei Chai, Nicole Goebel and Francisco Chavez

16:10   **Seasonality and linear trend of circulation around Korea derived from multi-platform observations**
Sung Yong <u>Kim</u>

16:30   **Regime-dependent nonstationary relationship between the East Asian winter monsoon and North Pacific Oscillation**
Gyundo <u>Pak</u>, Young-Hyang Park, Frederic Vivier, Young-Oh Kwon and Kyung-Il Chang

16:50   Summary and Discussion

17:00   *Session Ends*

Cancellations

16:10
(cancelled)   **The three-dimensional dynamic characteristics in the southern Subei radiation shoal waters**
Panjun <u>Du</u> and Bei Zhang

17:10
(cancelled)   **Features of the low-frequency variability of circulation in the northern Japan/East Sea based on numerical simulations**
Dmitry V. <u>Stepanov</u>, Victoriia I. Stepanova and Nikolay A. Diansky

Posters S10

S10-P1   **Characteristics of physical elements during a typical algae bloom in the Yellow Sea**
Xu <u>Shanshan</u>, Dong Mingmei, Yu Ting and Miao Qingsheng

S10-P2   **Regional efficacy of ocean heat uptake under a CO_2 quadrupling**
Ho-Jeong <u>Shin</u>, Ken Caldeira, Chan Joo Jang and Yong Sun Kim

S10-P3   **Analysis of HadGEM2-AO historical and climate forecasting experiments**
Haejin <u>Kim</u>, Cheol-Ho Kim and Hong-Ryeol Shin

S10

S10 Oral Presentations

October 21, 09:05 (S10-9747), Invited

Climate—Boundary current interactions: Stories from East and West

Enrique **Curchitser**[1], Justin Small[2], William Large[2], Raphael Dussin[1], Katherine Hedstrom[3] and Brian Kaufman[2]

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[2]   National Center for Atmospheric Research, USA
[3]   U. Alaska Fairbanks, USA

There is growing evidence that the large-scale climate affects character of oceanic boundary currents and by extension their ecosystems. In this talk, we present results from a climate model integration with a multi-scale ocean component capable of locally enhancing resolution. The model is the NCAR Community Earth System Model (CESM), in which the ocean component contains a high-resolution ROMS nest. We will show results from implementations in both eastern and western boundary currents. In this presentation we will show the latest results from a century-long integration showing that the better representation of coastal currents has both regional and global ramifications to the climate system. We will present a prototype two-way boundary condition between the global and regional ocean models and distinguish between the role of atmospheric tele-connections and oceanic advection in propagating oceanic signals.

October 21, 09:30 (S10-9491), Invited

Regional coupled modeling of the eddy-wind interactions in the California Current System

Hyodae **Seo**

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The California Current System (CCS) is characterized by energetic mesoscale and filamentary eddy variability, which is important for ecosystem response in this region. Recent high-resolution satellite observations show that these mesoscale eddies significantly modify the Ekman pumping velocity through the effect of SST and surface currents on the wind stress, suggesting that the eddy-wind interaction is an important mechanism for eddy dynamics. The relative importance of the eddy-wind interactions via SST and currents, however, remains poorly understood. Here, we use the high-resolution fully-coupled Scripps Coupled Ocean-Atmosphere Regional (SCOAR) model to address this question by implementing a novel coupling technique that selectively filters the coupling effect due to SST and currents. The result shows that eddy kinetic energy (EKE) is reduced by 20% when the eddy-wind coupling is allowed, and this reduction is almost entirely due to the effect of currents on the wind stress. This surface current effect leads to an Ekman pumping velocity that is twice as strong (30 cm/day) as that by SST effect. The significant damping of EKE and increase in Ekman pumping by the current-wind coupling suggests that the ocean modeling studies of regions of strong mesoscale currents will need to parameterize the effects of air-sea velocity differences in the calculation of surface stress to more accurately simulate eddy dynamics and their impact on the mean state.

October 21, 09:55 (S10-9685)

Climate change projection for the western North Pacific Ocean by dynamical downscaling

Chul Min Ko, Chan Joo **Jang**, Ho-Jeong Shin and Yong Sun Kim

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Global climate models (GCMs) provide future climate projections on a global scale. However, assessments of climate change (CC) impacts, adaptation to CC, and mitigation of CC require detailed regional-scale information which can be obtained by regional climate models (RCMs) mainly through their ability to accommodate much higher spatial resolution. This study aims to develop a RCM for the western North Pacific Ocean, where considerable climate change has occurred, and to apply it to future climate change projections. The RCM consists of the Regional Ocean Modeling System (ROMS) as an oceanic component and the Weather Research Forecast (WRF) as an atmospheric component. The ocean model has a horizontal resolution of 1/12 degrees, while the atmospheric model, covering the East Asia region, has a horizontal resolution of 50km. As a first step for future climate change projections with the RCM, we used future climate changes by CanESM2 that accurately reproduce the East Asian monsoon. Both ocean and atmospheric RCM projections with a pseudo global warming method show some prominent features including considerable surface warming in the East/Japan Sea, Yellow Sea, and Okhotsk Sea, an overall freshening concentrated near the Kuroshio-Oyashio, and an opposite trend in precipitation change between the southern and northern regions over the Korean Peninsula. Detailed regional patterns in future changes will be presented and compared with global model projections.

October 21, 10:15 (S10-9511)

Regional climate change projection for the northwest Pacific marginal seas

Gwang-Ho **Seo**[1], Yang-Ki Cho[1], Byoung-Ju Choi[2] and Kwang-Yul Kim[1]

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The relatively coarse resolution of global climate models results in either the isolation of marginal seas from large open ocean basins or unreasonably large or small transport in the straits. Exchanges of water between the semi-enclosed marginal seas and the open ocean are important to simulate regional climate change and what in nature involves the straits. This study presents details of future climate change projections in the Northwest Pacific (NWP) marginal seas using a dynamic downscaling method from global climate model (GCM) output. A regional climate model (RCM) for the Northwest Pacific was set up and integrated over the period from 2001 to 2100. The model used forcing fields from three different GCM simulations to downscale the effects of global climate change. The climate change signals were calculated from the GCMs using Cyclostationary Empirical Orthogonal Function analysis and added to the present lateral open boundary and the surface forcing. The RCM was validated by comparing hindcast results with the observations. Relatively large increases in water temperature were found in the marginal seas. However, only a tiny change was found along the Kuroshio path. Volume transports through major straits, except the Taiwan Strait, into the marginal seas are projected to increase slightly in future. Increased northeasterly wind stress in the East China Sea may also result in transport changes. Although the projection from the NWP is generally in agreement with that of GCMs, the former provides substantially improved regional features, volume transports, and the mean seasonal variations in water temperature.

October 21, 10:55 (S10-9650), Invited

CORDEX and its recent progress for East Asia

Hyun-Suk **Kang**[1], S. Hong[1], J.-Y. Jung[1], M.-S. Suh[2], S.-K. Oh[2], D.-H. Cha[3] and S.-K. Min[4]

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This talk will introduce the Coordinated Regional Downscaling Experiment (CORDEX) and its achievements for the East Asia domain. CORDEX is a WCRP-sponsored research program that aims for improvements in regional climate downscaling methods, production of downscaled climate projections, and facilitation of communication between the modeling and IAV communities. CORDEX recommends a common framework (*e.g.*, domain, resolution, forcing) in model configurations for 16 worldwide regions. For East Asia, the model domain covers the whole Tibetan Plateau, central Asia, and India to the west and reaches the northern part of Australia to the south with a 50 km resolution. Five regional climate models were driven by ERA-interim reanalysis forcing for evaluation, and driven by a CMIP5 GCM (HadGEM2-AO) forcing to reproduce current climate and future projections in accordance with 4 RCP emission scenarios. The talk will show the results by focusing on the overall performance in representation of the current climate, the evolution of the East Asia summer monsoon, and some extremes including tropical cyclone activities. Since CORDEX-East Asia has been successfully completed, the regional climate modeling community is now moving toward the second phase in which the model resolution will be twice as high, which will be also briefly introduced in the talk.

October 21, 11:20 (S10-9528), Invited

Introducing the MIT Regional Climate Model (MRCM) and its application to climate studies worldwide

Eun-Soon **Im**[1] and Elfatih A.B. Eltahir[2]

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[2]   Ralph M. Parsons Laboratory, Massachusetts Institute of Technology, USA

During the last decade researchers at the Massachusetts Institute of Technology (MIT) have worked on improving the skill of Regional Climate Model version 3 (RegCM3) in simulating climate over different regions through the incorporation of new physical schemes or the modification of original schemes. The MIT Regional Climate Model (MRCM) features several modifications over RegCM3 including coupling of the Integrated Biosphere Simulator (IBIS), a new surface albedo assignment method, a new convective cloud and rainfall auto-conversion scheme, and a modified boundary layer height and cloud scheme. In this talk, we introduce the MRCM and describe the major model modifications relative to RegCM3 and their impact on the model performance in simulating the fine-scale climate information worldwide. For example, the MRCM is capable of reproducing the main features of the West African Monsoon in terms of rainfall, clouds, surface energy balance, and large-scale circulation. In particular, the spatial distribution and seasonal variation of rainfall exhibit reasonable performance, which is comparable to various state-of-the-art regional climate models participating in the Coordinated Regional Downscaling Experiment (CORDEX) in Africa. In addition, the modification of the convection scheme brings more physical realism into an important component of the model, and succeeds in simulating convective-radiative feedback improving model performance across several radiation fields and rainfall characteristics over the Maritime Continent.

October 21, 11:45 (S10-9646)

Projected change in the East Asian summer monsoon from dynamical downscaling: Moisture budget analysis

Chun-Yong **Jung**[1], Chan Joo Jang[1], Hyung-Jin Kim[2] and Ho-Jeong Shin[1]

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[2]   APEC Climate Center, Busan, R Korea

Changes in summer precipitation over East Asia due to global warming are assessed by a dynamical downscaling method, a so-called "pseudo global warming (PGW) method". The Weather Research and Forecast model is forced by a projected climate change simulated with a global climate model superimposed on the present climate state obtained from a reanalysis dataset. The projected future climate by the PGW method shows an increase in precipitation along the Meiyu-Baiu front and southern part of the Korean Peninsula, whereas a decrease in precipitation is shown over the Changma front stretching from central China to the central Korean Peninsula. A column-integrated moisture budget analysis indicates that the precipitation increase in the southern China region is attributed primarily to the increase in moisture convergence due to local surface evaporation rather than by the horizontal advection of moisture. Meanwhile, the precipitation decrease in central China can be explained mostly by the weakening of horizontal moisture advection. This regional contrast, especially over the mainland of China, appears to originate from changes in the wind around the Yangtze River which plays a role as a moisture source, suggesting the importance of regional effects on climate change.

October 21, 12:05 (S10-9625)

An assessment of ocean climate reanalysis by the Data Assimilation System of KIOST

Young Ho **Kim**[1], Chorong Hwang[1] and Byoung-Ju Choi[2]

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A data assimilation system has been developed to apply to a fully coupled climate model, CM2.1, at the Korea Institute of Ocean Science and Technology (KIOST). While the ocean observation data are assimilated into the ocean component model through the Data Assimilation System of the KIOST (DASK), the other component models are freely integrated. Here, we evaluated the variability of the ocean climate in the climate re-analysis by the DASK from 1947 to 2012. To assess oceanic processes and ocean climate variability as modeled by the DASK, we examined the North Pacific Intermediate Water, El Niño Southern Oscillation (ENSO), Pacific Decadal Oscillation (PDO), Indian Ocean Dipole (IOD), upper 300 m heat content (HC300), meridional heat transport, and mean global temperature and salinity. Furthermore, we compared these modeled features with various in-situ observations and with various other global re-analyses, such as the Simple Ocean Data Assimilation (SODA) and the GFDL Ensemble Coupled Data Assimilation (ECDA) systems. The DASK represents global temperature and salinity well, not only at the surface but also at intermediate depths in the ocean. In addition, the DASK closely models the features of North Pacific Intermediate Water, a typical water mass in the North Pacific characterized by the salinity minimum layer. The DASK's ocean climate variability also matches well with observations of the ENSO, PDO and IOD. The HC300 of the DASK shows as good or better correlations with real-world observations compared to other re-analysis systems. It is noteworthy that the DASK performs better, particularly in the North Pacific and North Atlantic, even though the DASK applies the Ensemble Optimal Interpolation, which is numerically simpler than the Ensemble Kalman Filter applied by the ECDA, and a lower horizontal model resolution than that of the SODA. The high performance of the DASK in terms of ocean climate estimation and variability suggests that the DASK could produce accurate initial conditions for climate prediction models at a lower computational cost than the other two re-analysis systems we studied. In this study, the ENSO prediction system of KIOST will be also introduced as an example of applications using the DASK.

October 21, 14:00 (S10-9730), Invited

Application of a regional marine system model on the northwestern Pacific and the variability of the Yellow and the East China Seas

Hyoun-Woo **Kang**[1,2], Hanna Kim[2], Jae Kwi So[2], Momme Butenschon[3] and Icarus Allen[3]

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A high resolution marine system model coupling the POLCOMS and the ERSEM models has been applied to the East Asian Marginal Seas including the Yellow Sea, the East China Sea, the East (Japan) Sea, and the Okhotsk Sea as well as the Kuroshio and the Oyashio currents regions. The POLCOMS (Proudman Ocean Laboratory Coastal Ocean Modelling System) is a three-dimensional baroclinic hydrodynamic model with s-coordinate in the vertical and the ERSEM (European Regional Seas Ecosystem Model) is one of the most complicated lower trophic marine ecosystem model with the capability of benthic coupling and marine carbonate cycle. In this talk, emphasis is put on the seasonal cycle of various biogeochemical variables extracted from a 10-year (1992-2001) coupled simulation, especially for the Yellow Sea and the East China Sea (YES). The influence of the tide and the Changjiang River discharge, which are crucial factors in the study area, on the phytoplankton phenology and the dominant functional group changes are presented as well. The 10-year interannual variability of the marine ecosystem in the YES region also has been interpreted in the context of physically driven changes such as temperature, light availability and nutrient supply. An additional development plan and strategies for using the regional marine system model as a climate impact assessment tool under anthropogenic and climate change driven stresses will be discussed further.

October 21, 14:25 (S10-9486), Invited

Development of a Seto-Inland-Sea model toward operational monitoring and forecasting

Kei **Sakamoto**, Goro Yamanaka, Hiroyuki Tsujino, Hideyuki Nakano, Norihisa Usui and Shogo Urakawa

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We have developed a coastal ocean model of the Seto Inland Sea for the next-generation monitoring and forecasting system, which is operated by the Japan Meteorological Agency (JMA), to provide information about disaster prevention and oceanic conditions. With a horizontal resolution of approximately 2 km, the new model can represent explicitly coastal topographies and phenomena at a scale of 10 km, while they are almost ignored in the current ocean model of JMA with a horizontal resolution of 10 km. Especially, the new model realistically reproduces the warm Kuroshio water that intrudes into the Pacific coast of Japan in the shape of eddies and tongues, which leads to good representation of short-term variation in sea surface temperature observed at coastal stations (over 2 degree in a few days). In addition to the horizontal resolution, some features are improved to upgrade model representation of coastal seas. One is the incorporation of a tidal mixing parameterization. Though sea surface temperature tends to be relatively high near the coasts in the model, the parameterization reduces the high bias by increasing vertical mixing, and contributes to formation of the coastal front in the Bungo Channel (a western channel of the Seto Inland Sea). Another improvement is use of an accurate river-runoff dataset, which has a strong impact on sea surface salinity in the Seto Inland Sea. In addition, we are developing an ocean model covering the whole coastal region of Japan toward the next version of the JMA system, and this will be also shown in the presentation.

October 21, 14:50 (S10-9715)

A biogeochemical model for the British Columbia continental shelf

Angelica **Peña**, Diane Masson and Michael Foreman

Fisheries and Oceans Canada, Institute of Ocean Sciences, Sidney, BC, Canada.   E-mail: Angelica.Pena@dfo-mpo.gc.ca

The British Columbia shelf is at the northern end of the California Current System and is influenced by summer coastal upwelling, mesoscale eddies, and freshwater inputs. A regional circulation-biogeochemical model of this region is being developed to gain a better understanding of the potential impact of climate variability and change on lower trophic levels and the biogeochemistry of the region. A first step to address the impacts of climate variability on the marine ecosystem is to develop biophysical models that simulate the present ecosystem state in relation to the climate record and can be used to examine the influence of different forces acting, at different scales, on ecological processes. This allows us to evaluate the role of specific mechanisms in governing the observed and future variability of the physical-biological environment, and biogeochemical fluxes in a region. This talk will present results from a coupled plankton /circulation (ROMS) model of the British Columbia continental shelf. In particular, we will focus on the capability of the model to reproduce observations and to respond to main episodic events (*e.g.*, seasonal cycle and El Niño events).

October 21, 15:10 (S10-9655)

Transport of *Todarodes pacificus* winter cohort into the Yellow Sea in the early life states

Ji-Young **Song**[1], Joon-Soo Lee[1], Jung-Jin Kim[1] and Ho-Jin Lee[2]

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To understand the effects of hydrographic conditions on the migration, distribution and survival processes of eggs and larvae of the *Todarodes pacificus* winter cohort into the Yellow Sea during 2005 - 2010, a Lagragian – particle – tracking experiment was conducted using the Regional Ocean Modelling System (ROMS). The inferred winter cohort spawning area , as the initial position, was calculated using geographic limits, depth and monthly SST range from data acquired from NOAA AVHRR monthly SSTs(Rosa *et al*., 2011).

Numerical experiments were performed for four case in the Lagrangian – particle – tracking experiment incorporating a temperature-dependent survival process. (1) no random walk. (2) horizontal random walk. (3) verical random walk. (4) horizontal and vertical random walk. Based on these four cases, the influences of the random walks and the difference in spatial and temporal variations of *Todarodes pacificus* – simulating particles (TSP) were analyzed. In addition, the inital spawning area of the entrained TSP in the Yellow Sea is presumed .

October 21, 15:50 (S10-9763)

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

Jerome Fiechter[1], Enrique **Curchitser**[2], Christopher Edwards[3], Fei Chai[4], Nicole Goebel[3] and Francisco Chavez[5]

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[4]   School of Marine Sciences, University of Maine, ME, USA
[5]   Monterey Bay Aquarium Research Institute, Moss Landing, CA, USA

We use a suite of coupled physical-biogeochemical model simulations at 1/3°, 1/10°, and 1/30° to assess the impact of horizontal resolution on air-sea CO_2 fluxes in the California Current System (CCS), a relevant issue for downscaling between coarser resolution global climate models and higher resolution regional models. The results demonstrate that horizontal resolution is important to (1) reproduce the sharp transition between near-shore outgassing and offshore absorption, and (2) resolve the regions of enhanced near-shore outgassing in the lee of capes. The width of the outgassing region is overestimated when horizontal resolution is not eddy-resolving, but becomes more dependent on shelf topography for eddy-resolving simulations. Because enhanced near-shore

outgassing is associated with local increases in wind-driven upwelling in the lee of capes, sufficient horizontal resolution is needed both in the ocean circulation model and surface forcing. The sensitivity to the wind field is illustrated by running the coupled model with different resolution atmospheric products (COAMPS, CCMPS, MERRA, CORE2, NCEP) and comparing air-sea CO_2 fluxes. From a global carbon budget perspective, the model indicates that biological production generates sufficient absorption within a few hundred kilometers of the coast to offset near-shore outgassing, which is consistent with the notion that mid-latitude eastern boundary current upwelling systems act both as a sink and source for atmospheric CO_2.

October 21, 16:10 (S10-9733) - CANCELLED

The three-dimensional dynamic characteristics in the southern Subei radiation shoal waters

Panjun **Du** and Bei Zhang

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Based on high precision terrain data, a high resolution FVCOM (Finite-Volume Coastal Ocean Model) numerical model was used to simulate tidal currents and study three-dimensional dynamic characteristics in the southern Subei radiation shoal waters, Yellow Sea. Results show that transverse circulation was easy to produce in the channels and grooves. The vorticity and helicity computation method was applied to the area for the first time. Transverse circulation and helical flow characteristics of typical sections were studied, and results show quantitative evidence for the existence of the Spiral flow. Deep grooves do not always appear in double reverse spiral flow structures; they change with the main flow velocity. Shoal grooves appear, according to a main spiral flow structure, and show great adaptability to the terrain, which is the reflection of the spiral flow to the terrain mechanism.

October 21, 16:10 (S10-9456)

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

Sung Yong **Kim**

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The surface and subsurface circulation around Korea (East/Japan Sea, Yellow Sea, and southern coast) are investigated with conductivity-temperature-depth (CTD) profiles collected from historical hydrographic surveys, along-track altimeter-derived sea surface height anomalies (SSHA), and satellite sea surface temperature (SST) for the last 10 years (2001 to 2010). The seasonal circulation is enhanced in the surface mixed layer, and its subsurface phase in the East/Japan Sea increases onshore, which may indicate a westward propagating seasonal Rossby wave. The timing that both temperature and SSHA at the seasonal frequency reaches their maximum characterizes the complexity of regional circulation in the southern coast of Korea as a part of the interactions of the Tsushima Current and outflow from the Yellow Sea. The cooling tendency of East/Japan Sea and the warming trend of the Yellow Sea are consistent with the linear trend of satellite products, which allows us to infer the subsurface variability at the climate time scale.

October 21, 16:30 (S10-9731)

Regime-dependent nonstationary relationship between the East Asian winter monsoon and North Pacific Oscillation

Gyundo **Pak**[1,3], Young-Hyang Park[2], Frederic Vivier[3], Young-Oh Kwon[4] and Kyung-Il Chang[1]

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The East Asian winter monsoon (EAWM) and the North Pacific Oscillation (NPO) constitute two outstanding surface atmospheric circulation patterns affecting the winter sea surface temperature (SST) variability in the northwest Pacific. Our analyses show that the relationship between the EAWM and NPO and their impact on the SST are nonstationary and regime-dependent with a sudden change around 1988. These surface circulation patterns are tightly linked to the upper-level blocking events, Ural and Kamchatka blockings, respectively. During the strong winter monsoon regime, especially in the 1973-1987 period, the EAWM and NPO were significantly correlated to each other. On the other hand, during the weak winter monsoon regime, especially in the 1988-2002 period, the correlation between the EAWM and NPO practically vanishes. This nonstationary relationship is related to the pronounced decadal weakening of the Siberian high system over the Eurasian continent after the 1988 regime shift as well as to the concomitant, positive NPO-like dipole change in surface and upper-level circulation patterns over the North Pacific.

October 21, 17:10 (S10-9609) -CANCELLED

Features of the low-frequency variability of circulation in the northern Japan/East Sea based on numerical simulations

Dmitry V. **Stepanov**[1], Victoriia I. Stepanova[1] and Nikolay A. Diansky[2]

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[2]   Institute of Numerical Mathematics of the RAS, Moscow, Russia

Using the Institute of Numerical Mathematics Ocean Model (INMOM) and atmospheric forcing from 1958 to 2006 (CORE database), we reconstructed the large-scale circulation in the Japan/East Sea (JES) on a 1/10° mesh with 15 sigma levels. The straits of the JES are closed with a nudging condition for temperature and salinity. To represent the coastline and topography ETOPO2 is used.

The climatological circulation and its low-frequency variability were analysed in the Japan Basin (JB). In the intermediate and abyssal layers we found that the circulation is cyclonic, which increases in spring and decreases in autumn. Spatial-mean relative vorticity (MRV) analysis revealed that the MRV variability spectrum has peaks at the frequencies: ~1/2.3, ~ 1/3.7, and ~ 1/4.7 (1/year) as well as in the decadal frequency range: ~1/9.5 and 1/14.3 (1/year). The MRV variability spectrum does not vary with depth. However, we found a weakening in the decadal variability of the MRV in contrast to the interannual variability of the MRV. There is a similarity between the circulation variability and temperature variability spectra in the intermediate layer of the JB. Analysing the wind stress curl (WSC) and sensible heat flux (SHF), we found that the interannual variability of the MRV is caused by the WSC, whereas the decadal variability of the MRV is caused by the combined effects of the WSC and the SHF.

S10 Poster Presentations

S10-P1

Characteristics of physical elements during a typical algae bloom in the Yellow Sea

Xu **Shanshan**, Dong Mingmei, Yu Ting and Miao Qingsheng

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The sea water temperature in the Yellow Sea was very favorable for the reproduction of *Enteromorpha prolifera* during early May to the end of June 2008. Temperature contours can show the range and moving direction of the algae. The densely distributed area of algae is consistent with the wind convergence and the drift of the area is related to the downwind direction. Using five days of the sea surface temperature and wind fields during the algae bloom period in 2008 as forcing, the Yellow Sea circulation was simulated using the Princeton Ocean Model (POM). We found that the surface flow field is mainly influenced by the wind direction. In summer, the simulated Yellow Sea Coastal Current (YSCC) presents a northward flow along Jiangsu Province offshore with a relatively large velocity, while northeastward along the southern coast of Shandong Peninsula at a low velocity. This flow pattern of YSCC forms a clockwise circulation. Together with the eddies distributed in the north and south offshore of Qingdao, the location where the current changes direction forms a 'virtual barrier', which helps the algae to converge at the center of circulation and drift from the middle of the Yellow Sea to the Qingdao coast. The consistency between the simulated northward Yellow Sea coastal surface current and the in-situ observation is due to the introduction of accurate bottom topography and summer wind in the model.

S10-P2

Regional efficacy of ocean heat uptake under a CO_2 quadrupling

Ho-Jeong **Shin**[1], Ken Caldeira[2], Chan Joo Jang[1] and Yong Sun Kim[3]

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[3]   Korea Maritime and Ocean University, Busan, R Korea

As a great heat reservoir, the ocean plays an important role in climate change and variation. While the atmospheric concentration of greenhouse gases increases, the ocean absorbs heat from the atmosphere and stores it into the abyssal zone, leading to a reduced atmospheric warming. This study aims to investigate the regional efficacy of ocean heat uptake and the relative contribution of the ocean basins simulated by the global climate models submitted to the Coupled Model Intercomparison Project-phase 5 for an idealized experiment with a quadrupling of atmospheric carbon dioxide. A preliminary result shows that the efficacy of ocean heat uptake differs with depth and ocean basin depending on the activity of deep convection within the basin. The model results normalized by each model's total heat content change will be presented with more details and the inter-model differences will be discussed.

S10-P3

Analysis of HadGEM2-AO historical and climate forecasting experiments

Haejin **Kim**[1], Cheol-Ho Kim[1] and Hong-Ryeol Shin[2]

[1] Korea Institute of Ocean Science & Technology, Ansan, R Korea. E-mail: hjkim127@kiost.ac
[2] Kongju National University, Gongju, R Korea

In this study we analyzed sea surface temperature (SST) of the historical and climate change experiments in the Northwestern Pacific using HadGEM2-AO (Hadley Centre Global Environmental Model version2 – Atmosphere and Ocean) which is the climate system model developed by the Hadley Centre for Climate Prediction and Research. In the historical experiment, the difference in the annual mean SST between model and observation in the Northwestern Pacific Ocean is about 0.035°C, in which the model values are a little higher than the observations during 1950 to 2000. After 1960, the model accurately simulates the long-term variations in the observations. In particular, SSTs in the model show an increasing trend after 1985, similar to the observations. In the future climate change scenarios of the IPCC, both RCP4.5 and RCP8.5 experiments of HadGEM2-AO show an increasing trend in SST in the Northwestern Pacific and Northeast Asian Seas with a higher rate in the latter. The SST increases in the Northwestern Pacific in 2100 compared to 2006 at RCP4.5 and RCP8.5 are 2.23°C and 3.7°C, respectively.

S11

MarWeb Topic Session
Ecological and human social analyses and issues relating to Integrated Multi-Trophic Aquaculture

Co-Convenors:

Masahito Hirota (Japan)
Jianguang Fang (China)
Mitsutaku Makino (Japan)
Grant Murray (Canada)
Naesun Park (Korea)
Mark Wells (USA)

Invited Speakers:

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

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

Wednesday, October 22 (09:00-12:30)

09:00   ***Introduction by Session Convenors***

09:05   **Integrated Multi-Trophic Aquaculture (IMTA): An environmentally, economically and societally responsible aquanomic approach to farming the sea with many variations (Invited)**
Thierry Chopin

09:35   **Obtaining a social license for IMTA: Challenges and opportunities in British Columbia, Canada (Invited)**
Mark Flaherty

10:05   **The effect of multi-trophic aquaculture on nutrient loading in fish and shrimp ponds, Karawang Indonesia**
Mark L. Wells, Mitsutaku Makino, Suhendar I. Sachoemar and Masahito Hirota

10:25   ***Coffee/Tea Break***

10:45   **Dissemination of SATO UMI for sustainable aquaculture development in Indonesia (Invited)**
Suhendar I. Sachoemar, Tetsuo Yanagi, Mitsutaku Makino, Mark L. Wells, Masahito Hirota and Ratu Siti Aliah

11:15   **Implementation of SATO UMI concept at pond aquaculture in Karawang, Indonesia (Invited)**
Susanna Nurdjaman, Tetsuo Yanagi and Suhendar I. Sachoemar

11:45   **Social-ecological studies towards the integrated management of local fisheries in North-Eastern Hokkaido, Japan**
Emmanuel A. Sweke, Rotaro Okazaki, Yumi Kobayashi, Mitsutaku Makino and Yasunori Sakurai

12:05   Discussion

12:10   *Session Ends*

Posters S11

S11-P1   **Parasites of marine fishes and climate change: Implications for Korean aquaculture**
B.A. Venmathi Maran and Jung-Goo Myoung

S11-P2   **Accumulation of lactate in the coelomic fluid of sea urchins under stress suggests the switching-on of anaerobic glycolysis**
Konstantin A. Drozdov, Anatoliy L. Drozdov and Lidia T. Kovekovdova

S11 Oral Presentations

October 22, 09:05 (S11-9571), Invited

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

Thierry **Chopin**

Canadian Integrated Multi-Trophic Aquaculture Network (CIMTAN), University of New Brunswick, Saint John, NB, Canada
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In tomorrow's food production systems, aquaculture will have an increasing share. However, the Blue Revolution needs to become the greener Turquoise Revolution by developing innovative technologies and practices with increased environmental sustainability, economic stability and societal acceptability, such as Integrated Multi-Trophic Aquaculture (IMTA). With IMTA, farmers cultivate species from different trophic levels with complementary ecosystem functions in proximity. They combine fed species (*e.g.* fish and shrimps) with extractive species (*e.g.* seaweeds, aquatic plants, shellfish and other invertebrates) to take advantage of synergistic interactions among them while biomitigation operates. The IMTA concept has many variations adaptable to open-water and land-based systems, marine and freshwater environments, and temperate and tropical climates. The ecosystem services provided by extractive species (*e.g.* nutrient biomitigation, oxygen provision, carbon sequestration and reduction of ocean acidification) should be valued as nutrient trading credits used as financial incentive tools. Business models will have to embrace the emerging Integrated Sequential BioRefineries (ISBR) concept to manufacture diverse products for a wide variety of applications. Moreover, if aquaculture is to make a major contribution to the efficient and responsible food production systems of the future, far more production and applications of inorganic extractive seaweeds and aquatic plants, and organic extractive animals, must be developed in a more evenly distributed manner throughout the world. Humans will soon not be able to continue thinking of mostly land-based agronomic solutions for securing their food, nor for providing many other derived products, but will have to turn increasingly to responsible aquanomy to manage their "aquatic fields".

October 22, 09:35 (S11-9517), Invited

Obtaining a social license for IMTA: Challenges and opportunities in British Columbia, Canada

Mark **Flaherty**

University of Victoria, Victoria, BC, Canada. E-mail: flaherty@mail.geog.uvic.ca

The development of aquaculture in British Columbia's coastal areas has been the subject of longstanding heated, and increasingly polarized debate. A wide range of stakeholders - government agencies, First Nations, industry representatives, community groups, and environmental NGOs - have all sought to advance their positions by issuing scientific and media reports – many of which are conflicting. Public confidence in the industry has waned in the face of uncertainty surrounding many issues including, but not limited to, the environmental impacts of the industry and food safety.

Integrated Multi-Trophic Aquaculture (IMTA) has been identified as a means of promoting greater environmental stewardship while increasing economic benefits for growers and communities. It combines the cultivation of fed aquaculture species (*e.g.* finfish) with organic extractive aquaculture species (*e.g.* shellfish) and inorganic extractive aquaculture species (*e.g.* seaweed) to create balanced systems for environmental sustainability. While the majority of research has focused on the design of IMTA production systems, the broader social and governance contexts within which IMTA would operate also requires attention. This paper briefly reviews the aquaculture controversy in BC, and then considers some of the key factors that could inhibit the adoption of IMTA, as well as the drivers for its adoption.

S11

October 22, 10:05 (S11-9670)

The effect of multi-trophic aquaculture on nutrient loading in fish and shrimp ponds, Karawang Indonesia

Mark L. **Wells**[1], Mitsutaku Makino[2], Suhendar I. Sachoemar[3] and Masahito Hirota[2]

[1] University of Maine, Orono, USA. E-mail: mlwells@maine.edu
[2] Fisheries Research Agency, Yokohama, Japan
[3] Agency for The Assessment and Application of Technology (BPPT), Jakarta, Indonesia

The increasing need for large-scale pond aquaculture to supply shrimp and fish food products has resulted in significant to overwhelming eutrophication impacts in most adjacent coastal waters, particularly in developing nations. The result is additional pressure on wild fisheries already stressed by intensive fishing activities. In many cases pond aquaculture products are targeted for more lucrative export markets, muting benefits from the environmental degradation for local communities. One major step towards limiting coastal impacts from pond aquaculture would be to reduce excess nutrient (N, P) inflows. Co-production of macroalgae and bivalves in shrimp or fish ponds, a strategy known as multitrophic aquaculture, should help to reduce dissolved nutrient loading within ponds as well as to increase the economic output from pond operations, but there are few examples where this approach has been tested in tropical environments. We report here on a pond experiment conducted in Karawang, Indonesia designed to test whether co-aquaculture of macroalgae and oysters successfully diminishes nutrient loading in shrimp and Tilapia pond operations. The goal of these experiments is to foster the design and optimization of practical multitrophic aquaculture operations that maximize the economic benefits and food supply to local communities, while diminishing the negative impacts of pond operations on coastal environments.

October 22, 10:45 (S11-9435), Invited

Dissemination of SATO UMI for sustainable aquaculture development in Indonesia

Suhendar I. **Sachoemar**[1], Tetsuo Yanagi[2], Mitsutaku Makino[3], Mark L. Wells[4], Masahito Hirota[3] and Ratu Siti Aliah[1]

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[3] Fisheries Research Agency (FRA), Yokohama, Japan
[4] Maine System University, Orono, USA

SATO UMI, a new concept for sustainable management of fishery resources where human intervention seeks to improve the productivity and diversity of fishery resources in coastal areas has been introduced, socialized and disseminated in Indonesia. In aquaculture, the concept has been applied in the development of Integrated Multi Tropic Aquaculture (IMTA), a sustainable aquaculture model that is based on a bio-recycle system. This model was developed to improve the productivity and ecosystem stability with minimizing organic waste coming from the aquaculture activities. The preliminary results show that the IMTA model with aquatic cultivation of shrimp, tilapia, seaweed and oyster has provided the highest productivity with the best water quality stability compare to the monoculture and poly culture without the benthic organism such the oyster. Our current activities have focused on establishing a larger experimental pond system for sustainable aquaculture, discussed elsewhere in this session. We also have organized dissemination activities in the form of workshops and training for stakeholders to inspire and give new spirit to manage and utilize fishery, coastal and marine resources optimally, harmonious and productive to ensure the sustainability of food supply from fisheries resources as well as improving the community welfare and local income. The results indicate that the IMTA model and SATO UMI concept will improve the sustainable productivity of aquaculture fisheries and lessen their impacts on wild fisheries in coastal areas of Indonesia.

October 22, 11:15 (S11-9515), Invited

Implementation of SATO UMI concept at pond aquaculture in Karawang, Indonesia

Susanna **Nurdjaman**[1], Tetsuo Yanagi[2] and Suhendar I. Sachoemar[3]

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[2]   Research Institute for Applied Mechanics, Kyushu University, Japan
[3]   Agency for the Assessment and Application of Technology (BPPT)

SATO-UMI, the concept of management and use of natural resources while maintaining the balance and stability of the natural resources and the environment, has been implemented in a coastal area Karawang, West Java. Karawang is an area of shrimp aquaculture and has been designated as an area for shrimp industrialization program. A polyculture experiment was designed with multiple species in one pond such as only shrimp; shrimp and tilapia; shrimp – tilapia – seaweed; and shrimp – tilapia – seaweed – green mussel. The aim of this concept is to obtain a high biodiversity without excess nutrient concentrations in order to maximize the quality of the biota and to determine which combination and biomass composition generates the optimal production and good water quality. Good management of water resources in terms of environmental, economic and socio-cultural in accordance with local communities is needed to gain sustainable cultivation and high production.

October 22, 11:45 (S11-9490)

Social-ecological studies towards the integrated management of local fisheries in North-Eastern Hokkaido, Japan

Emmanuel A. **Sweke**[1,2], Rotaro Okazaki[1], Yumi Kobayashi[1], Mitsutaku Makino[3] and Yasunori Sakurai[1]

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Fisheries in Akkeshi and Erimo in North-eastern Japan face a number of challenges including changes in catch species composition, reduced catch that affect income, declining fishing manpower due to a large aging riparian population and decreases in the number of fishers, and destruction of fisheries from seals. Fishers are engaged in a variety of fisheries and target a wide range of species. Akkeshi is famous for oyster aquaculture while Erimo's main fishery species are seaweed, *Laminaria angustata* and salmon, *Oncorhynchus keta*. Herein, a 45 year (1965-2010) time series of fisheries data from city halls and fisheries authorities in the towns was assessed, including catch, income, number of fishing vessels and gears, seals population, and number of fishers. Anomalous sea surface temperature (SST) data (1915-2010) in Erimo was also used to assess fish catch dynamics due to sea warming. Survey questionnaires evaluated fishers' perception on inputs and outputs. Fishers indicated that good leadership in fisheries cooperative associations (FCAs) is required to attain sustainable fisheries management in the region. There were noticeable temperature increases in the last decade. Catches of some species such as Pacific herring, *Clupea pallasii* and salmon have declined remarkably. Recently, whelk spp. and prawn spp. are recovering in Akkeshi. Sound management strategies and adaptation of suggested changes would assist decision makers and other stakeholders towards an integrated ecosystem approach to fisheries and aquaculture management.

S11 Poster Presentations

S11-P1

Parasites of marine fishes and climate change: Implications for Korean aquaculture

B.A. **Venmathi Maran** and Jung-Goo Myoung

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Climate change has resulted in rising sea temperatures and exposed the world's aquatic systems to increasing levels of ultraviolet radiation. As sea surface temperatures are predicted to increase in Korea (and elsewhere) due to climate change, the distribution of tropical and subtropical fishes, including their associated parasite fauna, would expand to Korean Peninsula. This is particularly alarming as the arrival of exotic/alien fish parasites could have cause negative consequences for Korea's lucrative sea-cage aquaculture industry. At present (2013), Korea produces fish protein per annum: 60% by capture and 40% by aquaculture. Korea's sea-cage aquaculture industry is indeed anticipated to intensify in the foreseeable future, as commercially important marine fish stocks are increasingly being overexploited in Korea and neighboring countries. Parasitic crustaceans belonging to the Subclass Copepoda, most notably members of the genera *Caligus* and *Lepeophtheirus* commonly known as "sea lice", are of particular concern for the sea-cage aquaculture industry in addition the 'worms' monogeneans, as they can: a) cause mortality, reduce growth rates and reduce the marketability of cultured hosts; and b) be transmitted easily from infected wild fish to non-infected fish farmed in sea-cages. In the neighboring country, the parasitic copepod and monogenean fauna of marine fishes is relatively well documented. In marked contrast, nothing is known about the parasitic copepods infecting marine fishes in the Korean Peninsula. This is rather unfortunate as this information can underpin parasite management and prevent disease outbreaks from occurring on fish farmed in sea-cages on Korean Peninsula.

S11-P2

Accumulation of lactate in the coelomic fluid of sea urchins under stress suggests the switching-on of anaerobic glycolysis

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Anaerobic glycolysis was, apparently, the oldest type of metabolism, and all modern organisms retain enzymatic systems that ensure it. Lactate in animal tissues occurs due to anaerobic oxidation of glucose. Modern sophisticated methods of biochemical analysis, in particular nuclear magnetic spectroscopy, demonstrated that lactate is an active metabolite migrating between cells and organs. Intensification of anaerobic metabolism is an important mechanism of adaptation to changing conditions.

Using of ^1H-NMR spectroscopy we investigated the coelomic fluid in sea urchins *Mesocentrotus nudus* kept under different environmental conditions, with the method. There was a significant increase in the lactate content in the coelomic fluid of sea urchins under hypoxic conditions. This indicates an increase in the intensity of anaerobic digestion of glucose. Thus, our data suggest that sea urchins have a special mechanism that allows them, if necessary, to switch over from aerobic to anaerobic metabolism.

BIO Paper Session

Co-Convenors:

Angelica Peña (Canada)

Atsushi Tsuda (Japan)

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, we welcome all papers on biological aspects of marine science in the PICES region. Contributions from early career scientists are especially encouraged.

Thursday, October 23 (09:00-12:35)

09:00   ***Introduction by Session Convenors***

09:10   ***Pseudo-nitzschia* diversity in the North Pacific from Continuous Plankton Recorder surveys**
Rowena Stern, Vera Trainer, Stephanie Moore and Sonia Batten

09:30   **Determination of nanomolar concentration phosphate in seawater using a long-path liquid waveguide capillary cell (LWCC)**
Eun-Ju Park, Dong-Jin Kang, Sung-Rok Cho, Tae-Keun Rho and Eun-Soo Kim

09:50   **New approach for primary productivity assessment in the Bering Sea**
Kirill Kivva

10:10   **Age determination and growth rate of *Mactra chinensis* (Bivalvia, Mactridae) by external rings and chondrophore growth bands**
Jung-Yeon Kim, Ho Jin Bae and Chul-Woong Oh

10:30   *Coffee/Tea Break*

10:50   **Responses in macrozooplankton population to water mass exchange and the spring phytoplankton bloom in the Oyashio region**
Yoshiyuki Abe, Atsushi Yamaguchi, Yuichiro Yamada, Kohei Matsuno, Rui Saito, Hiromichi Ueno, Kosei Komatsu, Takashi Setou, Manabu Shimizu and Ichiro Imai

11:10   **Comprehensive transcriptome study to develop the molecular resources of the copepod (*Calanus sinicus*) for their potential ecological applications**
Hongjun Li and Qing Yang

11:30   **Effects of water temperature on distribution and life cycle of northern shrimp at the southwest coast of Kamchatka**
Oksana G. Mikhailova

11:50   **Population structure and life history of *Neomysis awatschensis* (Crustacea:Mysidae) in Jeju Island, Korea**
Jaeyong Bae and Wongyu Park

12:10   **Estimation of prey consumption by sei, Bryde's, common minke and sperm whales in the western North Pacific taking into account uncertainties**
Tsutomu Tamura, Kenji Konishi, Koji Matsuoka and Takashi Hakamada

12:30   Discussion

12:35   *Session Ends*

Posters BIO-Paper

BIO-P1 **Comparison of benthic community structure and installed area on two artificial reef types**
Ji-Hyun <u>Lee</u>, Wan Ki Kim, Yong Soo Son and Chae-Sung Lee

BIO-P2 **A method for simultaneous determination of chlorophyll and pheopigments using a spectrofluorometer**
Cho-Rong <u>Moon</u>, Dong-Jin Kang, Sung-Hyun Kahng and Eun-Soo Kim

BIO-P3 **Decadal change of spatial distribution of Steller sea lions around Ishikari-Bay, Sea of Japan**
Kaoru <u>Hattori</u>, Akihiko Wada and Orio Yamamura

BIO-P4 **Persistent organic contaminants in tissue and organs of fulmar *Fulmarus Glacialis* from the coast of Eastern Kamchatka and the Kuril Islands**
Vasiliy <u>Tsygankov</u>, Margarita Boyarova and Olga Lukyanova

BIO-P5 **Detecting the phytoplankton non-uniform distribution around the warm core rings**
Haruka <u>Nishikawa</u>, Yumi Yamashita, Yoshikazu Sasai and Hideharu Sasaki

BIO-P6 **Evaluation of incubation volume effect on *in-situ Euphausia pacifica* grazing rates on natural food assemblages**
Ah-Ra <u>Ko</u>, Se-Jong Ju, Eun-Jin Yang and C. Tracy Shaw

BIO-P7 **Tracking seasonal dietary shift of *Euphausia pacifica* in the Yellow Sea using stomach contents and lipid biomarkers**
Ah-Ra <u>Ko</u>, Se-Jong Ju and Hye Seon Kim

BIO-P8 **Diet of chaetognaths *Sagitta nagae*, *S. crassa* in Yellow sea inferred from gut content and signature fatty acid analyses**
Hyun Jin <u>Yoon</u>, Ah-Ra Ko, Joong Ki Choi and Se-Jong Ju

BIO-P9 **Monsoon-driven hydrographic features affect thaliacean distribution in the Taiwanese waters, western North Pacific Ocean**
Wen-tseng <u>Lo</u>, Zhen-heng Liao and Hung-yen Hsieh

BIO-P10 **Exploring the variability and role of functional diversity on copepod communities of the western subarctic North Pacific**
Carmen García-Comas, Sanae <u>Chiba</u>, Hiroya Sugisaki, Taketo Hashioka and S. Lan Smith

BIO-P11 **How water resources management can impact on coastal ecosystem: Implications from watersheds connected to coastal bays**
Nam-Il <u>Won</u>

BIO-P12 **Phenology of calanoid copepod: *Calanus pacificus* associated with sea surface temperature in the western subarctic North Pacific**
Tomoko M. <u>Yoshiki</u>, Sanae Chiba, Tadafumi Ichikawa, Hiroya Sugisaki and Sonia Batten

BIO-P13 **Abrupt change in phytoplankton community in the Kuroshio region of the East China Sea associated with the Kuroshio frontal eddy**
Naoki <u>Yoshie</u>, Kohei Sakamoto, Miwa Nakagawa, Eisuke Tsutsumi and Xinyu Guo

BIO-P14 **Top predators partition the Bering Sea**
Andrew W. <u>Trites</u>, B. Battaile, K.J. Benoit-Bird, A. Harding, S. Heppell, B. Hoover, D. Irons, N. Jones, K. Kuletz, C. Nordstrom, R. Paredes and D. Roby

BIO-P15 **Grazing pressure of the size-fractionated copepod community on phytoplankton and protozoan preys at a fixed station, southeastern coast of Korea**
Bome <u>Song</u>, Hyung-Ku Kang, Woo Yul Yi and Joong Ki Choi

BIO Paper Session Oral Presentations

October 23, 09:10 (BIO-9449)

Pseudo-nitzschia **diversity in the North Pacific from Continuous Plankton Recorder surveys**

Rowena Stern[1], Vera Trainer[2], Stephanie Moore[2] and Sonia **Batten**[3]

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A common genus of harmful algae is *Pseudo-nitzschia*, a diatom that can produce the toxin domoic acid. This toxin can be biomagnified up the food chain to cause illness and death to marine wildlife and humans as well as economic damage to fisheries. *Pseudo-nitzschia* blooms are an increasing threat to the west coast of North America, in particular through harvest closures of the commercial, recreational and subsistence fisheries off the Washington, Oregon, and California coasts and the deaths of marine mammals and seabirds in California. A novel approach to monitor the diversity and abundance of *Pseudo-nitzschia* is with the Continuous Plankton Recorder (CPR), used to survey the Pacific Ocean from Vancouver, Canada to Hokkaido, Japan since 2000. Conventionally derived taxonomic CPR data were studied to evaluate community composition variability but this study also used Next Generation Sequencing (NGS) methods. These were applied to the CPR survey samples to determine phytoplankton diversity and abundance of samples from the northwest American coast and an offshore Pacific region, using a *Pseudo-nitzschia* specific D1-D2 region of LSU over three climatically different years (2002, 2005 and 2008). Weighted abundance results revealed spatially distinct communities in the open ocean, dominated by assemblages containing *P. multiseries*, versus coastal assemblages dominated by *P. fraudulenta*. In the exceptionally cold year of 2008, from a negative-PDO phase/La Nina, *P. hasleana* was also found in high abundance. To our knowledge, this is the first molecular identification of *P. hasleana* in the open Pacific Ocean.

October 23, 09:30 (BIO-9586)

Determination of nanomolar concentration phosphate in seawater using a long-path liquid waveguide capillary cell (LWCC)

Eun-Ju **Park**[1,2], Dong-Jin Kang[1], Sung-Rok Cho[1], Tae-Keun Rho[1] and Eun-Soo Kim[1]

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Phosphate, together with nitrogen, is an essential nutrient for the plant growth and living organisms as well as a limiting factor on primary productivity in the ocean. In oligotrophic surface waters which cover about 40% of the world ocean, the concentration of nitrate and phosphate are typically in nanomolar (nM) scale. Generally, nitrogen has been known as the limiting factor for primary production in marine waters. Recent studies, however, reported that some nitrogen-fixing organisms could make the ocean a phosphate-limited system. Hence, accurate determination of phosphate in lower concentration has become more important. As the conventional method for phosphate measurement in seawater has higher detection limit, development of new method is required. The most suitable way to improve the detection limit is to increase the optical length of the measurement cell according to Lambert-Beer's law, to apply a long-path length cell. In this study, a flow injection analytical system with a long-path liquid waveguide capillary cell (LWCC; path-length 1m) was instructed based on previous studies. Some difficulties such as micro-bubbles and baseline stability in previous studies were overcome by controlling temperature in the cell of the system. Comparing the results with conventional method, it came to a good agreement. As we applied this system to real seawater samples, we found a structure of phosphate concentration gradient in the surface layer, where previous studies detected depleted phosphate concentration.

BIO PAPER

October 23, 09:50 (BIO-9663)

New approach for primary productivity assessment in the Bering Sea

Kirill **Kivva**[1,2]

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Oceanographic surveys of high spatial resolution were carried out in the western Bering Sea during past few years, which allow estimates of net community production in the region based on drawdowns of nutrients. Present work suggests a new method of net ($\approx$ to new) and gross ($\approx$ to total) primary production assessment based on summer or autumn profiles of nutrients and dissolved oxygen (DO). The method requires high resolution vertical profiles of nutrients and DO, which could be obtained with sampling after preparatory CTD casts. It is based on spring nutrient concentration evaluation through DO deficit and observed nutrient concentration at bottom of cold intermediate layer. Assuming continuous nutrient consumption during vegetation season and taking into consideration near zero concentrations of total inorganic nitrogen (TIN), one may conclude that the assimilated amount of silica reflects gross production, while the assimilated TIN have to be responsive to the new production. For 2012, gross (or total) primary production in the region was in range of 50-250 g C m^{-2} a^{-1}, while net community (or new) primary production reached 30-80 g C m^{-2} a^{-1}. New to total production ratio was in a range of 0.2-0.8. The presented new method revealed good agreement with previous studies and supposed for use in the future investigations.

October 23, 10:10 (BIO-9636)

Age determination and growth rate of *Mactra chinensis* (Bivalvia, Mactridae) by external rings and chondrophore growth bands

Jung-Yeon **Kim**, Ho Jin Bae and Chul-Woong Oh

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Age, growth and mortality of *Mactra chinensis* were investigated during the period from October 2012 to September 2013 in ocean waters near Busan, South Korea. The relationship between shell length (SL) and height (SH) was related by the equation SL= 1.3249SH+0.0162 (r^2=0.9250, *n*=2463, *P*<0.001). The relationship between shell length (SL) and total weight (TW) was expressed by the equation TW=0.0005SL$^{2.6415}$ (r^2=0.8063, *n*=2472, *P*<0.001). The monthly variation of the marginal index (MI) of the shell and chondrophore showed that the ring of this species was formed once a year during July. We estimated the age of *M. chinensis* by reading the external rings on the shell and the growth bands of chondrophore to compare growth parameters between the two growth characters. The age of this species ranged from 0 to 8 years (shell-based age reading) and from 0 to 10 years (chondrophore-based age reading). Based on external rings and growth bands of chondrophore for the same period, the von Bertalanffy growth functions were expressed by the equation L_t = 101.53[1-exp{-0.16(t+0.75)}] and L_t = 90.03[1-exp{-0.20(t+0.50)}], respectively. The likelihood test showed that there was a significant difference in growth parameters between the two methods for L_∞ (*P*<0.001), K (*P*<0.001), t_o (*P*<0.001). Total mortality (Z) and survival rate (S) estimated from chondrophore were 0.692 yr^{-1}, 0.501 yr^{-1}, respectively

October 23, 10:50 (BIO-9545)

Responses in macrozooplankton population to water mass exchange and the spring phytoplankton bloom in the Oyashio region

Yoshiyuki **Abe**[1], Atsushi Yamaguchi[1], Yuichiro Yamada[2], Kohei Matsuno[3], Rui Saito[4], Hiromichi Ueno[5], Kosei Komatsu[4], Takashi Setou[6], Manabu Shimizu[6] and Ichiro Imai[1]

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In the Oyashio region, dominant water masses are switched at the surface layer within a short period during spring. Simultaneously, a large phytoplankton bloom is known to occur at the surface layer, and nearly half of the annual primary production is concentrated during spring. These drastic changes in water mass and food condition are expected to strongly affect macrozooplankton population dynamics. However, their effects on macrozooplankton population remain unknown. To evaluate the effects of water mass exchanges and the spring phytoplankton bloom, we analyzed short-term changes in the population structure of the macrozooplankton (dominant hydromedusa *Aglantha digitale* and amphipods) in the Oyashio region during March–April 2007. Samples were collected with Bongo nets at night via oblique towing from depth of 200 m to the surface on eight times from March 9 and April 30. The abundance and biomass of macrozooplankton rapidly increased from April. During April, the rapid reproduction and growth of macrozooplankton is achieved due to the initiation of the spring phytoplankton bloom and the increase in the abundances of small copepods. The rapid exchange of the dominant water masses was also observed during spring in the Oyashio region. Effects of water mass exchange were significant for *A. digitale*, while moderate for amphipods. These taxa-specific differences in responses to water mass exchange may be related with their vertical distribution: *i.e.* shallower for *A. digitale*. Analyses on chaetognaths and water mass using FRA-ROMS (Regional Ocean Modeling System) are now in progress, and additional results will be presented at the conference.

October 23, 11:10 (BIO-9487)

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

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Calanus sinicus Brodsky (Copepoda, Crustacea) is a dominant planktonic species widely distributed in the margin seas of the Northwest Pacific Ocean. Genomic tools have not yet been exploited to study the ecological processes in *C. sinicus*. There are significant gaps in our understanding of the physical response of *C. sinicus* to environmental cues and geographical differentiation especially among wild populations. To close these gaps, we utilized an RNA-seq-based approach to develop molecular resources for *C. sinicus*. *C. sinicus* adult samples were sequenced using the Illumina HiSeq 2000 platform. The sequencing data generated 69,751 contigs from 58.9 million filtered reads. The assembled contigs had an average length of 928.8 bp. Gene annotation allowed the identification of 43,417 unigene hits against the NCBI database. Gene ontology (GO) and KEGG pathway mapping analysis revealed various functional genes related to diverse biological functions and processes. Transcripts that were potentially involved in stress response and lipid metabolism were identified among these genes. Furthermore, 4,871 microsatellites and 110,137 single nucleotide polymorphisms (SNPs) were identified in the *C. sinicus* transcriptome. SNP validation by the melting temperature (T_m)-shift method suggested that 16 primer pairs amplified the target products and showed bi-allelic polymorphism among 30 individuals. The present work demonstrates the power of Illumina-based RNA-Seq for the rapid development of molecular resources in non-model species. The validated SNP set from our study is currently being utilized in an ongoing ecological analysis to support a future study of *C. sinicus* population genetics.

October 23, 11:30 (BIO-9444)

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

Oksana G. **Mikhailova**

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Temperature for northern shrimp is one of the major abiotic factors having essential impact on its distribution and life cycle. Although shrimp is typically a widespread circumpolar species, its distribution in the Okhotsk Sea is limited to a certain temperature range. We have collected a huge data pool on the southwest coast of Kamchatka, including hydrological observations. Analyzing the information has revealed interesting results. It is found that the optimal temperature range of shrimp distribution at the southwest coast of Kamchatka is from 0 to 2°C, where catches were maxima. For the period of research, shrimp were not observed at a temperature over 2.4°C. Shrimp movement was connected tightly to temperature dynamics. When the temperature rose to between 2.5 and 2.8°C at depths more than 400m, shrimp moved to shallower depths (where temperature is low). Analysis of temperatures and depths of distribution provided maps of the spawning area of northern shrimp at the southwest coast of Kamchatka. The temperature surely cannot be reckoned as the only or the most principle factor of regulation. However, the correlation revealed insight on further studies predicting possible changes in distribution and life cycle.

October 23, 11:50 (BIO-9639)

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

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Population structure and life history of a mysid *Neomysis awatschensis* were studied in ocean waters near Jeju Island, Korea. *N. awatschensis* was collected monthly from a semi-enclosed embayment of Jeju Island from May 2013 to May 2014. Temperature and salinity were measured during the sampling. Total length, carapace length and statolith diameter of samples were measured. Samples were classified by six demographic categories, and embryos in the marsupium were classified by developmental stage. Water temperatures ranged from 7 to 32°C during the study period. Body length of females was larger than males. The mean size of *N. awatschensis* had a significant negative correlation with seasonal temperature variations. The body lengths of *N. awatschensis* in winter and spring were larger than those in summer and autumn. Statolith diameter was significantly correlated with body lengths. Brooding females and juveniles appeared all year round. Juvenile's abundance increased in May, July, December and February. The number of embryos in marsupium increased with female size, but decreased with increasing development stage. In conclusion, the present study suggests that *N. awatschensis* produce more than 4 generations in a year and reproduces all year around. We also suggests that statolith diameter of mysids can be an indicator of body lengths in mysids.

October 23, 12:10 (BIO-9560)

Estimation of prey consumption by sei, Bryde's, common minke and sperm whales in the western North Pacific taking into account uncertainties

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Prey consumption of baleen and sperm whales distributed in spring/summer in the western North Pacific has been studied previously. However, those studies did not address appropriately the uncertainty in the different steps involved in the estimation of prey consumption. The purpose of this study was to estimate the seasonal prey consumption in common minke, Bryde's, sei and sperm whales in the western North Pacific, accounting for some uncertainties. For this aim a Monte Carlo simulation approach was used. Uncertainties in the whale abundance estimates, body weight of whales, daily prey consumption, energetic content of prey species, assimilation efficiency and the ratio of low/high feeding intake of whales were taken into account. Whales were collected under the Second Phase of the Japanese Whale Research Program under Special Permit in the western North Pacific (JARPN II) from May to September during 2000-2007. The total prey consumption during May-September (152 days) by the three baleen whale species was estimated to be 1,142,500 metric tons (95% CI: 770,600-1,602,000 metric tons), and that for sperm whales 965,100 metric tons (95% CI: 621,90-2,196,800 metric tons). This estimate applied to the area comprised in the longitudinal sector between the Pacific coast of Japan and 170°E, and the latitudinal sector between 35ºN and 50ºN. The updated estimates of prey consumption, including confidence intervals, will be useful as input data in ecosystem models.

BIO Paper Session Poster Presentations

BIO-P1

Comparison of benthic community structure and installed area on two artificial reef types

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Two types (double box type steel and dice) of artificial reefs deployed in 2003 and 2008 along the Uljin and Pohang coast were investigated in December 2013. The studies of double box type steel were six in number in 23m of water and the two groups of dice type were in 24m of water. These quadrat (25×25cm) samples were collected at the surface on each artificial reef module using destructive methods. Each sample was analyzed by wet biomass and species identification. Of the two types of reefs deployed in 2003 in Uljin, the dice samples consisted of dominant species belonging to the phylum chordata (82.9%) and porifera (9.1%). The dominant benthic species present were *Chelyosoma dofieini*. The double box type steel reefs were dominated by chordata (77.4%) and mollusks (14.2%). In 2008, double box type steel were deployed in Uljin and Pohang. The Uljin were chordata (41.0%) and Echinodermata (22.5%), dominated by *Chelyosoma dofieini*. From the Pohang, mollusks (61.0%) and chordata (14.9%) were observed and the dominant were *Mytilus coruscus*. According to the results, the benthic community structures are affected more by deployed area than by artificial reef types. However, this study cannot be sure of the effect of deployed area on the benthic communities because those artificial reefs were not monitored from first deployment time. Based on this study, the artificial reefs are not only increasing some organisms but increasing marine ecosystems it needed.

BIO PAPER

BIO-P2

A method for simultaneous determination of chlorophyll and pheopigments using a spectrofluorometer

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Concentrations of phytoplankton pigments in seawater provide information on primary productivity, phytoplankton biomass and so on. Chlorophyll *a* (Chl-*a*), a major photosynthesis pigment, has been measured by spectrophotometry and fluorometry. Despite the convenience of these optical methods such as rapid and simple operation, they have limitation of accurate measuring due to the interference. Even though HPLC is complicated and slow, it has been used because of the advantages in reducing interference effects by separation and detection of various individual pigments. 3D-EEMS (3 Dimensional-Excitation Emission Matric Spectroscopy) was suggested as a rapid assay method to distinguish and to determine chlorophyll and phaeopigments using their fluorometric properties. This study has been carried out in order to validate previous studies using 3D-EEMS and to improve them. For qualitative analysis, we determine fluorescence spectral peak positions (specific Excitation/Emission wavelength point) using pigment standards of chorophylls (Chl-*a*, Chl-*b*, Chl-c_2, Chl-c_3) and phaeopigments (Chlorophyllide *a*, Pheophytin *a* etc.). Calibration curves with several different concentrations of these standards were obtained using rapid spectrofluorometer (HORIBA Aqualog®) for quantitative analysis. In the results of mixed standard experiment, the peaks of each pigment are distinguishable and peak heights have linear relation with the pigment concentration. To calculate each pigment concentration, an empirical equation was set up using the calibration curves for each phytoplankton pigment. This method is rapid, simple, and accurate compared with previous methods. Hence, this method can be applied easily to for *in vivo* and *in situ* analysis of phytoplankton pigments in seawater.

BIO-P3

Decadal change of spatial distribution of Steller sea lions around Ishikari-Bay, Sea of Japan

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Spatial distribution and abundance of marine predators are affected by prey availability and oceanographic conditions. Seasonal movements of Steller sea lions (SSLs, *Eumetopias jubatus*) are often discussed in relation to the spring-spawning of forage fishes including eulachon (*Thaleichthys pacificus*) and Pacific herring (*Clupea pallasii*) around their distribution. The western coast of Hokkaido Island is one of major wintering grounds of SSLs originated from the Okhotsk Sea. Their haul-out sites moved substantially over the years. Such movements reflected both of 1) dynamics of natal population, and 2) biotic condition (*i.e.* prey availability) of each haul-out site. Along the eastern coast of Ishikari-Bay, an important spawning ground of herring, high concentration of SSLs has been observed repeatedly in recent years. However, a former major haul-out site on the western edge of the bay has been scarcely used since 2006. SSLs probably shifted their haul-out sites and foraging habitats in response to the change in prey availability including herring, walleye pollock (*Theragra chalcogramma*) and Pacific cod (*Gadus macrocepahlus*).

BIO-P4

Persistent organic contaminants in tissue and organs of fulmar *Fulmarus Glacialis* from the coast of Eastern Kamchatka and the Kuril Islands

Vasiliy **Tsygankov**[1], Margarita Boyarova[1] and Olga Lukyanova[1,2]

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Persistent organochlorine pesticides (POPs) are persistent toxic substances of anthropogenic origin with effects on biota. All POPs are highly lipophilic, and fat reserves of marine organisms serve as a depository for these substances. The POPs group includes such organochlorine compounds as DDTs and HCHs pesticides that were widely used as pesticides in different countries in the past but are of limited use these days. HCH isomers (α-, β-, γ-), DDT and its metabolites (DDD and DDE) were detected in five individuals of fulmars *Fulmarus glacialis* Linnaeus, 1761 from the coast of Eastern Kamchatka and the Kuril Islands. The levels of pesticides were determined by gas chromatography. The average amount of HCH isomers in organs of fulmars ranged from 608 ± 177 ng/g lipids in total homogenate of organs to 2093 ± 264 ng/g lipid in feathers with skin. Average range of amounts of DDT and its metabolites ranged from 3606 ± 333 ng/g lipid in feathers with skin to 4076 ± 1624 ng/g lipid in the feathers. The total concentrations of pesticides in organs of fulmars were less than in organs of the seabirds from the different urbanized areas in World Ocean.

BIO-P5

Detecting the phytoplankton non-uniform distribution around the warm core rings

Haruka **Nishikawa**, Yumi Yamashita, Yoshikazu Sasai and Hideharu Sasaki

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Phytoplankton density is known to be higher near the edge of the warm core rings (WCR) in the Kuroshio-Oyashio transition region, so regions near the WCR are good fishing grounds for the Japanese sardine, the Pacific saury, the Skipjack tuna and the Neon flying squid. One of the factors that cause high productivity is the intrusion of the surrounding high productive water from the Kuroshio into the WCR. Since the high productive waters intrude intermittently, the high productive spots show the temporally and spatially non-uniform distribution around the WCR. The chlorophyll *a* distribution can be detected by satellite data, but there are often data deficits due to clouds in the Kuroshio-Oyashio transition region. On the other hand, we can simulate the realistic velocity field by using the ocean general circulation model with data assimilation system. In this study, we examined an easy method to detect the water intrusion around the WCR by using velocity data. The finite-size Lyapunov exponents (FSLE) represent the time-dependent separation of the two nearby particles in the flow field. Around the eddy, FSLE is an index of the horizontal water exchange activity. We calculated FSLE on the basis of the velocity data of the ecosystem model and compared it with the phytoplankton distribution of the model. Distribution of the high FSLE corresponds well to the distribution of the high phytoplankton density. This result suggests that calculating FSLE is an effective way to detect the high productive spots for the real ocean.

BIO PAPER

BIO-P6

Evaluation of incubation volume effect on *in-situ Euphausia pacifica* grazing rates on natural food assemblages

Ah-Ra **Ko**[1], Se-Jong Ju[1,2], Eun-Jin Yang[3] and C. Tracy Shaw[4]

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Euphausia pacifica is a key player to link between low and high trophic levels in the Yellow Sea. Their feeding ecology can be used as the basic information for understanding the food-web dynamics. *In-situ* feeding experiment as traditional approach to study the feeding ecology provides the direct feeding rate. However, experimental conditions (incubation volume, number of individual, diet concentration, *etc.*) must be cautiously designed to get more realistic values. Therefore, we conducted the *in-situ* feeding experiment for *E. pacifica* under the three different incubation volumes to determine the optimal incubation volume. Live adult krill were sampled in spring and summer 2013-2014 from the Yellow Sea. They were maintained in filtered seawater (GF/F filter) for 6 hours to empty their gut. The 2, 4, and 10 krill individuals were set into bottles with three different volumes (2, 4, and 10L), respectively, filled with pre-screened seawater (200μm) from the depth where the krill were sampled. Then they were incubated with natural food assemblages under dark and *in-situ* water temperature for 10 hours. Food assemblages and biochemical components (nutrient, POC/N, Chl-*a*) were examined at the end of incubation. No incubation volume effects on grazing rate and food selectivity were observed. However, the small volume (2L) experiment with a few individuals has a risk due to their mortality. Furthermore, a large volume (10L) experiment needs a large space and volume of *in-situ* seawater. Therefore, we choose the incubation volume (4L) with 4 individuals as the optimal condition for *in situ* feeding experiment.

BIO-P7

Tracking seasonal dietary shift of *Euphausia pacifica* in the Yellow Sea using stomach contents and lipid biomarkers

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Krill *Euphausia pacifica*, known as one of major preys to various predators, is important species to understand their role for the energy transfer in the Yellow Sea ecosystem. Therefore, to determine the nutritional condition and seasonal diet shift of *E. pacifica*, they were collected by conical type net during spring and summer 2010 in the Yellow Sea. Lipid and fatty acid (FA) were analyzed for adults, whereas stomach contents were examined in selected adults to provide a visual snapshot of eaten material and to compare with trophic FA markers. Total lipid contents in *E. pacifica* were higher in spring (7.4±1.5% of dry mass) than those in summer (5.2±2.3% of dry mass), with the major component of phospholipid (over half of total lipid). Overall major FAs composition showed seasonal differences (spring *vs.* summer). *E. pacifica* from spring contained higher concentration of polyunsaturated FAs (PUFAs) originating from algae than those from summer, whereas the relative abundance of branched FAs known to be of bacterial origin were significantly higher in *E. pacifica* from summer than those from spring. Actually, these results were also revealed through stomach contents, which consisted of more diatoms in spring and diverse prey items (algae, protozoa, detritus, *etc.*) in summer. Thus, it suggests that *E. pacifica* mainly feeds on diatoms and flagellates in spring, but their diets can be resorted to protozoa, small flagellates, and bacteria as well as diatom in summer.

BIO-P8

Diet of chaetognaths *Sagitta nagae, S. crassa* in Yellow sea inferred from gut content and signature fatty acid analyses

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Chaetognaths are known to be an important primary predator of zooplankton but are also prey organisms for planktivorous species (*i.e.* fish larvae, small fish, and other carnivores) in the Yellow Sea. Nevertheless, few studies have been conducted to understand their feeding ecology. Therefore, to identify the diet of the most predominant chaetognath species, *Sagitta nagae* and *S. crass*, in Yellow Sea, we analyzed the gut content and whole body fatty acids (FAs) of specimens sampled in April and August 2013 from Yellow Sea. About 20% of specimens (*S. nagae* (n=969) and *S. crassa* (n=838)) contained foods in their guts without detecting any significant differences between species. Most of gut contents (>70%) consisted with small copepods. For fatty acid composition, relatively high amounts of carnivorous FA (especially, copepod FA marker 20:1 and 22:1) were appeared in both species. Based on the results, chaetognaths are carnivores and mainly feed on the small copepod as their major food source in Yellow Sea. Therefore, chaetognaths could play ecologically important roles to transfer energy from copepods to planktivorous fishes and govern the abundance of small copepods, known as top-down forcing, in Yellow Sea.

BIO-P9

Monsoon-driven hydrographic features affect thaliacean distribution in the Taiwanese waters, western North Pacific Ocean

Wen-tseng **Lo**[1], Zhen-heng Liao[1] and Hung-yen Hsieh[2,3]

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The mesoscale distribution of thaliaceans associated with hydrographic conditions in the waters around Taiwan was investigated during two different monsoon seasons in 2004 to elucidate possible influences of hydrological conditions driven by seasonal monsoons on distribution patterns of thaliaceans. In total, 18 thaliacean species, belonging to 12 genera and 3 families, were identified. *Thalia rhomboides, Doliolum denticulatum, Doliolum nationalis, Thalia orientalis, Pyrosoma verticillatum,* and *Thalia democratica* were the six predominant species and contributed 93% to the total thaliacean count. Thaliacean assemblages were similar in composition between the two seasons, but abundances and species numbers were higher in summer than in winter. Spatial distribution patterns of doliolids and salps clearly differed and were closely associated with hydrographic characteristics. Doliolids were mainly found in lower-salinity and nutrient-rich shelf and neritic waters; among them, *D. denticulatum* could be used as an indicator species of the China Coastal Current. Most salp species showed higher abundances in warm oceanic waters, such as the Kuroshio Current, Kuroshio Branch Current, and South China Sea Surface Current. This study showed that the succession of water masses driven by monsoons affects seasonal and particularly spatial distributions of abundances of the thaliacean assemblage in the area studied.

BIO-P10

Exploring the variability and role of functional diversity on copepod communities of the western subarctic North Pacific

Carmen García-Comas[1], Sanae **Chiba**[1], Hiroya Sugisaki[2], Taketo Hashioka[1] and S. Lan Smith[1,3]

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Understanding how species can coexist in rich communities, the relationship of biodiversity with environment and the role of biodiversity on ecosystem functioning is a long-standing major challenge in ecology. Regarding diversity-functioning, multiple studies on terrestrial plants have identified a positive relationship between species richness and functioning. Nevertheless, mechanisms are not yet well understood, particularly in planktonic communities. Recently there has been increasing interest in relating functional-trait diversity to functioning, out of concern that species richness may hide high functional redundancy. Functional-trait based studies are revealing new patterns that will contribute to understanding community structure and ecosystem functioning. In order to deepen our knowledge of the role of diversity on functioning and susceptibility to environmental forcing, we analyze copepod species data from the historical ODATE dataset, which consists of 3142 samples covering the period 1960-2002 and ~10x10° area of the western subartic North Pacific. The sampled area corresponds to the Oyashio-Kuroshio Transition System, east of Japan, which hosts a total of 332 species constituting distinctive communities. Copepod species have been classified in terms of five functional traits (*i.e.*, size, food, reproduction, thermal affinity and coastal-offshore habitat), following an online database and local taxonomic keys. Beyond the familiar pattern of functional richness increasing towards saturation with species richness, we observe a general opposite hump-shaped relationship of species evenness (lower at mid-point) and functional diversity (higher at mid-point) with species richness. Despite sub-tropical Kuroshio communities being richer and with higher species evenness, transition waters host communities of higher functional diversity.

BIO-P11

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

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Climate change effects have been crucial concerns for important water resources such as fishery resources. Increasing extreme droughts and floods have caused severe impacts on human society as well as ecological community. Rising water security concerns induced many actions to manage water resources efficiently. Those management actions could change the natural water cycle in terms of both quality and quantity of incoming freshwater, which leads to adverse impacts on coastal ecosystems. However, coastal ecosystems are less frequently considered in water management plans. This paper describes water management efforts done in watersheds of Juam multi-purpose Dam (main Dam). These watersheds have been providing water supply for citizens downstream of the Dam and produced a lot of electricity by the hydroelectric power plant located at Juam Controlled Dam (sub Dam). These water management efforts lead to two different types of impacts on coastal ecosystem: the sub Dam has been criticized by giving a lot of deep and cold water to Suncheon Bay during its power-generating water release, while the main Dam has discharged decreased quantity of water to Kwangyang Bay due to the increased water use for power generation. Subsequently, the Juam watershed gave two different stressors to adjacent coastal bays, continuous cold water and decreased water inputs for Suncheon and Kwangyang Bays, respectively. With further discussion with other cases of water management actions, this paper suggests that recent water resources management should give more attention to coastal ecosystems changed by water inputs after water management actions.

BIO-P12

Phenology of calanoid copepod: *Calanus pacificus* associated with sea surface temperature in the western subarctic North Pacific

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Northerly shift of warm-water copepod distribution has been observed with SST increment in western North Pacific after 2007 in our previous result. In the present study, interannual variation of average developmental stage of *Calanus pacificus*, which is the main component of the warm-water species, was examined in order to elucidate seasonal timing of them, based on Continuous Plankton Recorder (CPR) sampling during 2001-2010. Abundance of *C. pacificus* increased seasonally in summer and/or autumn, and was significantly higher in high sea surface temperature (SST) area (>7.5°C). Stage composition in higher abundance areas was dominated by young copepodite stages, while significant negative relationship between abundance and average developmental stage was observed. Interannual variations of abundance and average developmental stage were positively and negatively correlated to sea surface temperature variation (SST) respectively. This suggested that *C. pacificus* is sensitive to SST variation and the recruitment rate increased in the high SST environment. The young stages were dominant in summer and autumn before 2008, whereas they were observed in spring-summer on and after 2008. SST was higher during 2008-2010, which was associated with PDO index. The warm SST in 2008-2010 was considered to have caused not only the northerly shift of distribution but also the phenological shift of warm-water copepods.

BIO-P13

Abrupt change in phytoplankton community in the Kuroshio region of the East China Sea associated with the Kuroshio frontal eddy

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Lower-trophic level ecosystem in the Kuroshio region of the East China Sea (ECS) during the summer generally shows the typical subtropical features, *i.e.*, small size pico-phytoplankton such as cyanobacteria dominates in the euphotic layer under the oligotrophic condition due to the stable stratification. It is also known that such stable physical and chemical conditions are often disturbed by the Kuroshio frontal eddy. In this study, we investigated the short-term dynamics of lower-trophic level ecosystem associated with the passing of a Kuroshio frontal eddy. We conducted an intensive observation over 72hrs around the Kuroshio region in the ECS in the mid-June, 2012. We observed a drastic change of phytoplankton community in the subsurface water where the dominant groups of phytoplankton abruptly changed from small size prochlococcus to large size diatom. This drastic change from the oligotrophic ecosystem to the eutrophic ecosystem was caused by the upwelling of nutrient-rich subsurface water associated with the passing of a frontal eddy. Therefore, the lower-trophic level ecosystem in the Kuroshio region of the ECS can quickly adopt the short-term disturbance by the frontal eddy.

BIO PAPER

BIO-P14

Top predators partition the Bering Sea

Andrew W. **Trites**[1], B. Battaile[1], K.J. Benoit-Bird[2], A. Harding[3], S. Heppell[2], B. Hoover[4], D. Irons[5], N. Jones[4], K. Kuletz[5], C. Nordstrom[1], R. Paredes[2] and D. Roby[2]

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We tracked the movements of seals and seabirds breeding on the Pribilof Islands (central Bering Sea) and Bogoslof Island (southern Bering Sea) to determine where these central place foragers feed relative to the constraints of distance from land, environmental conditions, and availability of food. A total of 115 northern fur seals, 128 thick-billed murres and 106 black-legged kittiwakes were equipped with GPS and activity tags in 2008 and 2009. At-sea locations showed no overlap in foraging areas for kittiwakes or murres breeding on the two Pribilof Islands despite the islands being within foraging distance of each other. Nor was there any overlap between the foraging areas for seabirds from Bogoslof Island compared to those from the Pribilofs. Foraging ranges of northern fur seals also showed segregation of feeding areas by breeding sites between and within islands. The distinct segregation of feeding areas by breeding colonies and the similarities in segregation between both groups of central place foragers implies a common set of selective mechanisms related to compass orientation of breeding colonies, competition within and between species, predation risk, and energetic constraints associated with distance, prey size and energy content. Our data suggest that immediate environmental conditions may have less effect on broad-scale habitat selection compared to colony orientation and the longer-term selective forces related to foraging costs and predictability of annual environmental conditions. This implies that existing breeding colonies in the Bering Sea may be poorly adapted and unable to respond favourably to global warming and environmental change.

BIO-P15

Grazing pressure of the size-fractionated copepod community on phytoplankton and protozoan preys at a fixed station, southeastern coast of Korea

Bome **Song**[1,2], Hyung-Ku Kang[1], Woo Yul Yi[1,2] and Joong Ki Choi[2]

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Copepods are important component of marine zooplankton, grazing on phytoplankton and protozoan preys and affecting energy flow in marine food webs. Species-level grazing rates have known useful information in feeding ecology of copepods. Considering the high species diversity of copepods, however, measuring the feeding rates of various kinds of copepod species is not practical. So, measurement of feeding rates in copepod community is a good alternative approach to understand the effect of copepod community on phytoplankton and protozoan preys. We measured feeding rates of the size-fractionated copepods on phytoplankton and protozoan preys at a fixed station off Tong-young city, southeastern coast of Korea, from February to December 2013 bimonthly. Copepods were size-fractionated into the three groups (*i.e.* 200-500μm, 500-1000μm, and 1000-2000μm) using sieve, and incubated in surface water for 24hrs. Prey concentrations were measured before and after incubation. The feeding rates were calculated by Frost equation (1972). We will discuss the seasonal variation of grazing pressure of the size-fractionated copepods on phytoplankton and protozoan preys, and evaluate the importance of both diets for the size-fractionated copepod community in the marine ecosystem.

FIS Paper Session

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

This session invites 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).

Thursday, October 23 (14:00-17:50)

14:00   *Introduction by Session Convenors*

14:05   **Shelf Habitat and EcoLogy of Fish and Zooplankton (SHELFZ) of the Chukchi Sea 2013**
Elizabeth A. Logerwell, Kimberly M. Rand, Leandra de Sousa, Alexi Pinchuk, Sandra Parker-Stetter, John Horne, Johanna Vollenweider and Ron Heintz

14:25   **Spatiotemporal variation of benthic communities associated with weathervane scallop (*Patinopecten caurinus*) beds off Alaska**
Jessica R. Glass and Gordon H. Kruse

14:45   **Toothed whale interactions with longline fisheries in Alaska and economic implications**
Megan J. Peterson, Franz J. Mueter, Courtney Carothers, Keith R. Criddle and Alan C. Haynie

15:05   **Spatial-temporal variation in feeding pattern and trophic position of Pacific salmon in the North Pacific Ocean**
Yuxue Qin and Masahide Kaeriyama

15:25   *Coffee / Tea Break*

15:45   **Comparison of anchovy biomass estimates measured by trawls, egg production methods and hydro-acoustics in the Chesapeake Bay and the Korea Strait**
Sukgeun Jung and Edward D. Houde

16:05   **Interannual variations in abundance and distribution of Japanese jack mackerel *Trachurus japonicus* larvae in the shelf-break region of the East China Sea during late winter and spring**
Chiyuki Sassa, Motomitsu Takahashi, Yoshinobu Konishi and Youichi Tsukamoto

16:25   **Vertical distribution of common squid (*Todarodes pacificus*) paralarvae in the northern East China Sea**
Hwa Hyun Lee, Suam Kim and Chul Park

16:45   **Short term exposure of migratory coho salmon *Oncorhynchus kisutch* to increased CO_2 concentrations impairs olfactory sensitivity to homing cues**
Junho Eom, Nolan Bett, Wes Didier, David Close and Sang-Seon Yun

17:05   **A spatially explicit account of California fisheries as ecosystem services**
John C. Field, Rebecca R. Miller, Jarrod A. Santora, Rosemary Kosaka and Cindy Thomson

17:25   **Pollock fishery and stock assessment**
Oleg Bulatov

17:45   Summary

17:50   *Session Ends*

FIS PAPER

FIS Paper Session Poster

FIS-P1   **Pelagic ecosystem monitoring in British Columbia, Canada**
Jennifer L. Boldt, Stéphane Gauthier, Henrik Kreiberg, Doug Bertram, Jaclyn Cleary, George Cronkite, Linnea Flostrand, Jackie Detering, Vanessa Hodes, John Holmes, Moira Galbraith, Kyle Garver, Chris Grandin, John Holmes, Stewart Johnson, Jacquelynne King, Sean MacConnachie, Bruce McCarter, Chrys Neville, Linda Nichol, R. Ian Perry, Dennis Rutherford, Nathan Taylor, Mary Thiess, Matt Thompson, Marc Trudel and Greg Workman

FIS Paper Session Oral Presentations

October 23, 14:05 (FIS-9584)

Shelf Habitat and EcoLogy of Fish and Zooplankton (SHELFZ) of the Chukchi Sea 2013

Elizabeth A. **Logerwell**[1], Kimberly M. Rand[1], Leandra de Sousa[2], Alexi Pinchuk[3], Sandra Parker-Stetter[4], John Horne[1,5], Johanna Vollenweider[6] and Ron Heintz[6]

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A group of scientists from NOAA Alaska Fisheries Science Center, University of Washington, University of Alaska Fairbanks and the North Slope Borough Department of Wildlife surveyed the fish and invertebrate community from the beach to the shelf during August-September 2013. The objectives of this project, "SHELFZ", are to 1): collect baseline information needed to detect and predict impacts of changing environment and increased human activities on arctic ecosystems, and 2): identify similarities and differences between nearshore (<20m water depth) and offshore (>20m water depth) communities. The work was conducted on two chartered vessels. The *F/V Alaska Knight* surveyed the offshore area, deeper than 20m depth, while the *Ukpik* surveyed the nearshore area, shallower than 20m. Both vessels sampled with bottom trawls, midwater trawls, fishery acoustics, zooplankton nets and oceanographic instruments. Scientists on the nearshore boat, *Ukpik*, also deployed beach seines. This talk will explore species composition of fish and invertebrate communities in the benthic and pelagic habitats. Similarities and differences between the offshore and nearshore will be examined. Spatial distribution will also be investigated, with particular attention to the role of Barrow Canyon in determining distribution and species diversity.

October 23, 14:25 (FIS-9451)

Spatiotemporal variation of benthic communities associated with weathervane scallop (*Patinopecten caurinus*) beds off Alaska

Jessica R. Glass and Gordon H. **Kruse**

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We conducted an analysis of benthic communities in areas targeted by a commercial weathervane scallop (*Patinopecten caurinus*) fishery on the continental shelf off Alaska, USA. Some bycatch species taken in this fishery are commercially valuable, including Tanner crab (*Chionoecetes bairdi*). Using bycatch data collected by onboard observers during 1996-2012, we analyzed spatial patterns in community composition on weathervane scallop beds, as well as changes in community composition over time. We also explored whether spatiotemporal differences in benthic communities could be related to environmental variables (sediment type, depth, bottom temperature, and freshwater discharge) and anthropogenic variables (trawling and dredging effort). Using non-parametric statistics, statistically significant ($P<0.05$) differences in community structure were observed at the scale of state fishery registration districts, as well as among individual scallop beds. Certain species displayed a latitudinal gradient across the continental shelf. Spatial differences were most strongly correlated with sediment, depth and dredging effort. Changes over time were also detected, with significant differences between 1996-1999 and 2000-2012. However, these changes could be due to changes in the observer program after start-up years or altered fishing behavior associated with the formation of a fishery cooperative. Subtle changes during 2000-2012 were also present. Temporal changes were weakly yet significantly correlated with freshwater discharge, depth and dredging effort. Results from this study provide a quantitative baseline of benthic community composition on weathervane scallop beds against which future changes can be assessed. Findings also contribute to our understanding of essential fish habitat for weathervane scallops and associated species.

FIS PAPER

October 23, 14:45 (FIS-9565)

Toothed whale interactions with longline fisheries in Alaska and economic implications

Megan J. Peterson[1], Franz J. **Mueter**[1], Courtney Carothers[1], Keith R. Criddle[1] and Alan C. Haynie[2]

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Killer whale (*Orcinus orca*) depredation (whales removing or damaging fish caught on fishing gear) adversely impacts demersal longline fisheries for sablefish (*Anoplopoma fimbria*), Pacific halibut (*Hippoglossus stenolepis*) and Greenland turbot (*Reinhardtius hippoglossoides*) in the Bering Sea, Aleutian Islands and Western Gulf of Alaska. We examined how depredation rates varied in space and time, their effect on groundfish catch rates, and the socio-economic implications of depredation avoidance. The percentage of commercial fishery sets affected by killer whales was highest in Bering Sea fisheries for sablefish (*Anoploploma fimbria*; 21.4%), Greenland turbot (*Reinhardtius hippoglossoides*; 9.9%), and Pacific halibut (*Hippogolosus stenolepis*; 6.9%). Killer whale depredation was more common on the standardized longline survey (9.2-34.6% sets impacted) than in the commercial sablefish fishery (1.0-21.4% sets impacted) in all three management areas. Average catch reductions on depredated sets ranged from 35-69% in the commercial fishery and from 51-73% in the survey. To compensate for depredation, fishermen set additional gear to catch the same amount of fish, which increased fuel costs by an additional 82% per depredated set (average $433 additional fuel per depredated set). Reported avoidance measures resulted in an average additional cost of $494 per depredated vessel-day for fuel and crew food. Opportunity costs of time lost by fishermen averaged $522 per additional vessel-day on the grounds. This assessment of killer whale depredation costs is the most extensive economic evaluation of this issue in Alaska and will help longline fishermen and managers consider the costs and benefits of depredation avoidance and alternative policy solutions.

October 23, 15:05 (FIS-9534)

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

Yuxue Qin and Masahide **Kaeriyama**

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Pacific salmon, *Oncorhynchus* spp, have flexible feeding habits. In general, sockeye, chum, and pink salmon are zooplanktivores, and coho, chinook salmon and steelhead trout are piscivores. In this study, we surveyed the feeding habits, and quantified the trophic position of Pacific salmon using carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) stable isotope designations of trophic position in North Pacific Ocean ecosystems. Chum and pink salmon showed feeding habits typical of zooplanktivores and they had the lowest trophic position (3.5). Chinook salmon and steelhead trout feeding habits indicated that they were piscivores and they had higher trophic positions (4.1 and 4.3, respectively). Sockeye and coho salmon feeding habits demonstrated that they were opportunistic feeders depending on environmental conditions, and intra- and inter-specific interactions. They had a middle trophic position (3.9). In conclusion, Pacific salmon have both species-specific and plastic feeding patterns.

October 23, 15:45 (FIS-9481)

Comparison of anchovy biomass estimates measured by trawls, egg production methods and hydro-acoustics in the Chesapeake Bay and the Korea Strait

Sukgeun **Jung**[1] and Edward D. Houde[2]

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We compared estimates of anchovy biomass derived from trawl surveys, egg production method (EPM) and acoustic surveys, conducted in two remote regions. Biomass density of bay anchovy *Anchoa mitchilli* was estimated in Chesapeake Bay, USA, by trawls, EPM and acoustics from 1990 to 2000. Biomass density of Pacific anchovy *Engraulis japonicus* was estimated in the Korea Strait using EPM, simulation-based daily cohort analysis and acoustics from 1984 to 2006. Most of the existing estimates already had considered body-size-dependent gear selectivity, highly-variable instantaneous natural mortality of anchovy eggs, and avoidance of trawl nets by adult anchovy. Despite great variability in the ratio of trawl to acoustic biomass estimates (0.034-8.35), annually-averaged biomass density of young-of-the-year individuals derived by the two methods were similar for bay anchovy in Chesapeake Bay and Pacific anchovy in the Korea Strait (0.83 and 0.70 g m^{-3}, respectively). Results suggested that, despite substantial uncertainty, anchovy biomass estimates are generally compatible between EPM and acoustics. However, reported estimates of biomass density derived from the two acoustic surveys in the Korea Strait differed by a factor of 28, suggesting that further improvements in calibrations are required to reliably estimate anchovy biomass. The comparisons suggested that all biomass estimates could be biased and will require comparison and validation by other, independent sampling methods.

October 23, 16:05 (FIS-9508)

Interannual variations in abundance and distribution of Japanese jack mackerel *Trachurus japonicus* larvae in the shelf-break region of the East China Sea during late winter and spring

Chiyuki **Sassa**[1], Motomitsu Takahashi[1], Yoshinobu Konishi[1] and Youichi Tsukamoto[2]

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Abundance and distribution of Japanese jack mackerel *Trachurus japonicus* larvae <5 mm standard length (SL) were examined in relation to hydrographic conditions in the shelf-break region of the East China Sea (ECS) during later winter and spring for twelve years from 2001 to 2012. Larval abundances in late winter were higher than those in spring. In late winter, ratios (expressed as %) of larval abundance in the southern ECS south of 28°N to the whole study area were highest during the study period, with values ranging from 80.0 to 95.8%. In spring, the ratios in the southern ECS were still high (34.3–88.8%), although the values increased slightly in the northern and central ECS. There was no significant interannual variation in the center of larval distribution, suggesting that the formation of spawning grounds would be related to geography rather than hydrographic conditions. Habitat temperature of larvae in the central and southern ECS was approximately 2–4°C higher than that in the northern ECS throughout the study period, indicating that larval growth and survival processes are different between the two areas. In the southern ECS, larval abundances fluctuated largely from year-to-year, and the mean chlorophyll *a* concentrations there explained 56–60% of the interannual variations in larval abundance. However, larval abundance did not correlate with an index of recruited juveniles (approximately 50–75 mm SL) in the ECS, suggesting that mortality during the larval (≥5 mm SL) and juvenile stages is responsible for recruitment success or failure of *T. japonicus*.

October 23, 16:25 (FIS-9652)

Vertical distribution of common squid (*Todarodes pacificus*) paralarvae in the northern East China Sea

Hwa Hyun **Lee**[1], Suam Kim[1] and Chul Park[2]

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Common squid is one of the most important commercial species in Northwestern Pacific countries. The East China Sea is a major spawning ground for several cephalopods, and an investigation of the vertical distribution of common squid paralarvae in the northern East China Sea was carried out. During April 1999 and October 2000, squid larvae were collected using a $1m^2$ MOCNESS sampler, which divided the water column by 20m interval from the surface to 120m or the bottom. More than 90% of common squid larvae were found in the mixed layer of southeastern Jeju Island. The vertical distribution of paralarvae was influenced by the depth of the thermocline. When the thermocline formed in shallow depths (*e.g.*, October 2000), most paralarvae were located near the surface layer (0-60m). However, if there were no thermoclines in the upper 120 m (*e.g.*, April 1999), paralarvae were found to distribute in deeper areas (20-80m). Larval size within the water column also was related to the presence/absence of the thermocline. When the ocean was stratified in the surface layer, larval size below the thermocline was statistically significantly larger than those in mixed layer: larval sizes progressively increased from 1.74mm in the surface to 3.43mm below the mixed layer. Larval sizes through the water column, however, were not significantly different where there was no thermocline in the upper 120m. Mean sea water temperatures, where the most paralarvae existed, were 15.4°C and 21.4°C in April 1999 and October 2000, respectively.

October 23, 16:45 (FIS-9720)

Short term exposure of migratory coho salmon *Oncorhynchus kisutch* to increased CO_2 concentrations impairs olfactory sensitivity to homing cues

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This study was conducted to examine the effects of elevated CO_2 concentrations on coho salmon's olfactory sensitivity to homing cues during migration. Migratory coho salmon were treated with ambient (450ppm) and elevated CO_2 (1500pm) tensions for two weeks. Two choice maze experiments were performed to evaluate their preference for control water and 5% hatchery water containing homing cues. Then the staying time and frequency to visit either side of the channel were measured. The control fish group displayed preference to the homing cues (staying time: 683.50±187.60 sec, frequency: 5.50±2.16) over control water (staying time: 22.67±16.81 sec, frequency: 0.83±0.54). However, the fish group treated with 1500ppm CO_2 tension did not display preference behavior to 5% hatchery water (staying time: 354.83±192.88 sec, frequency: 2.17±1.33) compared to control water (staying time: 268.00±190.98 sec, frequency: 1.17±0.60). Results from this study indicate that short term exposure to elevated CO_2 concentrations can impair migratory salmon's olfactory sensitivity, with the potential to disrupt homing migration. Further studies on physiological and molecular mechanisms underlying CO_2 induced olfactory impairment are underway.

October 23, 17:05 (FIS-9674)

A spatially explicit account of California fisheries as ecosystem services

John C. **Field**[1], Rebecca R. Miller[1], Jarrod A. Santora[2], Rosemary Kosaka[1] and Cindy Thomson[1]

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We evaluated spatiotemporal patterns of fisheries catches, including both volume and ex-vessel value, for a unique set of spatially referenced, long-term commercial catch data that were recently recovered for nearly all California (United States) marine fisheries. This dataset includes landings estimates at a 10 by 10 minute spatial resolution from the early 1930s to 2010 and extends the entire length of coastal California (up to approximately 180 kilometers from shore). We filtered the data to minimize implausible catches (based primarily on bathymetric criteria) and mapped climatologies of volume and the value (standardized to 2010 dollars) of catches by broad taxonomic categories (*e.g.*, groundfish, coastal pelagics, crustaceans, salmonids and highly migratory species). We quantified areas of high volume and high value fisheries catches both historically and contemporarily, as well as sequential geographical patterns of fisheries development. Our results indicate that the history of some fisheries (such as groundfish) reflected a development pattern in which catches occurred in deeper habitat, at a greater distance from ports, and in increasingly inclement weather conditions over time. However, this pattern does not hold for other California fisheries, given the nature of the interactions between fishermen and fisheries targets in this ecosystem over nearly a century. These results will contribute to future catch reconstruction (species composition) efforts, as well as marine spatial planning, habitat impact assessments, quantification of ecosystem services, and ultimately to ecosystem-based approaches to management of marine fisheries and other resources.

October 23, 17:25 (FIS-9513)

Pollock fishery and stock assessment

Oleg **Bulatov**

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Pollock is one of the most important commercial species of the world's fisheries. A large scale pollock fishery has been carried out for over 40 years. The main fishing grounds are located currently in the exclusive economic zones of Russia and the United States. In the Gulf of Alaska maximum catch and biomass was observed in the early 1980s reaching 307 thousand tons and more than 3 million tons, respectively. In the eastern Bering Sea maximum yield at the beginning of the 1970s during the unregulated fishery was 1875 thousand tons, with a fish biomass of about 7 million tons. Maximum biomass was observed in the mid-1980s and 1990s, 12 and 13 million tons respectively. In the Navarin area maximum catches at the beginning and end of the 1980s were 852 and 854 thousand tons, respectively. Off the coast of western Kamchatka historical maximum catches in the mid-1970s and mid-1990s were 1,285 thousand tons and 1,250 thousand tons, respectively. In the northern part of the Sea of Okhotsk the only significant catch of pollock occurred in 1990, 946 thousand tons. The most significant variability in pollock catch was observed in the Sea of Japan, where the maximum recorded in the early 1980s was 2057 thousand tons, which seems now implausible. Thus, the history of Alaska pollock fishery indicates a high variability in yield in different fishing grounds.

FIS Paper Session Poster Presentation

FIS-P1

Pelagic ecosystem monitoring in British Columbia, Canada

Jennifer L. **Boldt**[1], Stéphane Gauthier[2], Henrik Kreiberg[1], Doug Bertram[2], Jaclyn Cleary[1], George Cronkite[1], Linnea Flostrand[1], Jackie Detering[1], Vanessa Hodes[1], John Holmes[1], Moira Galbraith[2], Kyle Garver[1], Chris Grandin[1], John Holmes[1], Stewart Johnson[1], Jacquelynne King[1], Sean MacConnachie[1], Bruce McCarter[1], Chrys Neville[1], Linda Nichol[1], R. Ian Perry[1], Dennis Rutherford[1], Nathan Taylor[1], Mary Thiess[1], Matt Thompson[1], Marc Trudel[1] and Greg Workman[1]

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The need to provide science advice to marine management clients across a broad range of species under changing environmental conditions is an emerging priority for Fisheries and Oceans Canada (DFO) as it is for many agencies worldwide. Scientific support is therefore needed for understanding pelagic ecosystem dynamics, including species relative abundance and distribution, predator-prey dynamics, and factors affecting pelagic ecosystems, in order to achieve integrated management goals. Efficiently addressing this need, while minimizing costs, requires the use of existing information and surveys. Recognizing the importance of a broader science perspective, a Pelagic Integrated Ecosystem Science (PIES) team was formed to explore the future of integrating and collaborating on pelagic fish sampling plans and science questions in British Columbia (BC). The PIES team is an informal "coalition of the willing" and a diversely skilled group of people from a variety of ecosystem monitoring programs, sections and divisions within DFO. This group was formed from the "bottom-up" and is intended to provide a way for Science staff, with common research interests in pelagic species and ecosystems, to achieve more together than may be possible individually. The PIES team mission is to implement collaborative monitoring and integrated research plans on pelagic ecosystems in BC that contribute to the understanding and inform fisheries management of factors that affect pelagic ecosystem components. As a first step towards achieving this mission, the PIES team discussed desired outcomes of pelagic ecosystem monitoring programs, identified needs to accomplish those outcomes, and concluded that there is value in continued and improved collaboration across programs implemented through incremental changes over an extended time period.

MEQ Paper Session

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

Papers are 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).

Wednesday, October 22 (09:00-11:30)

09:00   ***Introduction by Session Convenors***

09:05   **Arrival of Fukushima radioactivity in North American continental waters**
John N. <u>Smith</u>, Robin M. Brown, Marie Robert, William J. Williams and Richard Nelson

09:25   **Accumulation of $^{239+240}$Pu and ^{210}Po in the marine biota around Korean Peninsula**
Suk Hyun <u>Kim</u>, Gi Hoon Hong, Hyun Mi Lee, Young Il Kim, Hee Young Park and Bo Eun Cho

09:45   **Numerical modeling of marine pollution in Kamaishi Bay (Japan) following the 2011 Earthquake and Tsunami**
Md. Nazrul <u>Islam</u> and Daisuke Kitazawa

10:05   **Legacy POPs: Are they finally fading from marine foodchains?**
John E. <u>Elliott</u>, Aroha Miller, Kyle H. Elliott, Melanie F. Guigueno and Sandi Lee

10:25   ***Coffee/Tea Break***

10:45   **POPs biotransport by Pacific salmon to the Russian coast of the Northwestern Pacific**
Olga <u>Lukyanova</u>, Vasiliy Tsygankov, Margarita Boyarova and Nadezhda Khrisoforova

11:05   **Comparison of oil exposure methods to filter feeding bivalve**
Andrew Jin Yi <u>Loh</u>, Un Hyuk Yim, Sung Yong Ha, Joon Geon An and Won Joon Shim

11:25   Summary

11:30   ***Session Ends***

MEQ Paper Posters

MEQ-P1   **Assessment of marine environment quality in Peter the Great Bay (the Sea of Japan)**
Tatyana A. <u>Belan</u>, Alexander V. Moshchenko, Boris M. Borisov, Tatiana S. Lishavskaya and Alexander V. Sevastianov

MEQ-P2   **Marine environmental impacts of the Japanese nuclear power plant "Fukushima-1" accident in the Far Eastern seas**
Eugene V. <u>Karasev</u>, Emiliya L. Chaikovskaya and Tatiana S. Lishavskaya

MEQ-P3   **Toxic elements in seaweed *Undaria pinnatifida*, *Laminaria saccharina*, *Cystoseira barbata*, *Costaria costata* from the Peter the Great Bay (Japan Sea)**
Lidia T. <u>Kovekovdova</u>, Denis P. Kiku and Irina S. Kasyanenko

MEQ-P4   **The pollution of coastal waters of the Possyet Bay (Peter the Great Bay, Japan/East Sea)**
Ludmila Nigmatulina and Andrey <u>Chernyaev</u>

MEQ-P5   **Investigation of content of artificial radionuclides in the commercial crustacea in the North West part of the Japan Sea**
Galina S. Borisenko and Yury G. Blinov

MEQ-P6   **Monitoring of mercury in the Russian Far Eastern Seas**
Mikhail V. Simokon and Irina S. Kasyanenko

MEQ-P7   **Integrative assessment of sediment contamination by toxic organic contaminants in an enclosed bay in South Korea**
Gi Myung Han, Sang Hee Hong, Won Joon Shim, Sung Yong Ha, Nam Sook Kim, Joon Geon An and Un Hyuk Yim

MEQ-P8   **Effects of solvents on the photooxidation of phenanthrene and identification of its photoproducts**
Ravi Shankar, Un Hyuk Yim, Song Yong Ha, Joon Geon An and Won Joon Shim

MEQ-P9   **Summer variations in interleukin-1α-like substance levels in phagocytes of holothurian *eupentacta fraudatrix* in Peter the Great Bay, Sea of Japan**
Liudmila Dolmatova and Olga Ulanova

MEQ Paper Session Oral Presentations

October 22, 09:05 (MEQ-9530)

Arrival of Fukushima radioactivity in North American continental waters

John N. **Smith**[1], Robin M. Brown[2], Marie Robert[2], William J. Williams[2] and Richard Nelson[1]

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An earthquake-triggered tsunami on March 11, 2011 caused extensive damage to the nuclear power facilities in Fukushima, Japan resulting in the discharge of large quantities of radioactivity into the western North Pacific. The radioactivity plume was transported northeastward towards North America by the Kuroshio Current. A Canadian monitoring program was immediately established to detect the arrival of Fukushima radioactivity in the eastern North Pacific and Arctic Oceans. Water samples were collected for the detection of radioactivity on four missions of the CCGS Tully in June of 2011, 2012 and 2013 and February, 2014 on a line (Line P) extending to a location (Sta. P26), approximately 1500 km west of Victoria, BC. Measurements of Cs isotopes in June, 2011 are consistent with background fallout sources of radioactivity. However, Cs measurements on water samples collected in June, 2012 at Sta. P26 detected ^{134}Cs at levels indicating the presence of contamination from the Fukushima nuclear reactor accident. The 2013 results revealed the presence of ^{134}Cs in the upper 100 m along the entire length of Line P indicating that the Fukushima signal had fully arrived in Canadian territorial waters. Levels of Fukushima ^{137}Cs were about 1 Bq/m^3 in June, 2013 which is equivalent to previous background levels of ^{137}Cs from atmospheric fallout. These levels had increased to values of about 2 Bq/m^3 by February, 2014. These ^{137}Cs concentrations are significant, but are several orders of magnitude below those that would be considered a threat to the environment or human health.

October 22, 09:25 (MEQ-9615)

Accumulation of $^{239+240}$Pu and ^{210}Po in the marine biota around Korean Peninsula

Suk Hyun **Kim**, Gi Hoon Hong, Hyun Mi Lee, Young Il Kim, Hee Young Park and Bo Eun Cho

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The concentrations of $^{239+240}$Pu and ^{210}Po were determined in the marine biota of several tropic levels around Korean Peninsula to understand the bioaccumulation of these alpha emitter radionuclides. Marine biota including phytoplankton, zooplankton, macroalgae, crustaceans, mollusks, surface water fish, bottom water fish and cephalopods were collected in 2014. The concentrations were measured in the parts of skin, muscle and internal organs if possible to be separated. The concentrations of $^{239+240}$Pu in collected biota were the highest in phytoplankton with 68.5±0.3 mBq/kg·ww and had descending order of phytoplankton > zooplankton (8.73±0.03) > abalone (5.38±0.02) > sea mustard (0.821±0.004) > laver (0.448±0.002) > flat fish (0.368±0.010) > anchovy (0.305±0.001) > mackerel (0.281±0.010) > squid (0.274±0.010) > red-banded lobster (0.139±0.010). This indicates that $^{239+240}$Pu is highly accumulated in phytoplankton but the accumulation factor does not increase in upper tropic levels. The concentrations of ^{210}Po in phytoplankton and zooplankton were 137±4 and 111±4 Bq/kg·ww, respectively. The concentrations of ^{210}Po in the whole body of anchovy preying on zooplankton was 392±13 Bq/kg·ww which is higher than that in zooplankton. The concentrations of ^{210}Po in the muscle of squid, abalone, red-banded lobster, mackerel and flat fish were 8.6±0.3, 3.4±0.1, 2.8±0.1, 0.8±0.03 and 0.5±0.02 Bq/kg·ww. However, the concentrations of ^{210}Po in the internal organs of these species were two or three order higher than reported in muscle tissues. This means that ^{210}Po transferred through food chain is not easily accumulated in muscle but is highly so in internal organs.

MEQ PAPER

October 22, 09:45 (MEQ-9288)

Numerical modeling of marine pollution in Kamaishi Bay (Japan) following the 2011 Earthquake and Tsunami

Md. Nazrul **Islam**[1,2] and Daisuke Kitazawa[1]

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A three dimensional Marine Environmental Committee (MEC) model was used to describe wind and tidal forcing effects on circulation and hydrography in Kamaishi Bay at Miyagi Prefecture in the Great East Japan. The major purpose of thismodeling was to study the diffusion and potential ecological effects of marine pollution resulting from the 2011 Earthquake and Tsunami. The model was used to simulate changes in water quality and effects on marine ecosystem structure from January 2009 to December 2012. The MEC model was used to predict the distributions of various key water quality indicators and tide flow in the different layers of Kamaishi Bay. High correlations were obtained between simulation- and measurement-derived tidal characteristics. One of the physical structures that was damaged by the tsunami was the breakwater at the mouth of Kamaishi Bay (> 60 m). We also simulated the effects of breaking water effects on the tide, currents and integrating aquaculture and fisheries. The wind driven flows, modeled using mean seasonal winds (NE, SE, and SW), results in variable hydrographic conditions and circulation patterns in the shallow waters of r Kamaishi Bay. The distribution of marine pollutants associated with increased discharges of domestic and industrial wastes and contaminant following the 2011 event is affected by this variability and helps explain observed concentration levels in the bay ecosystem. Before the tsunami (2010) at the station 4 (depth 5m) in Kamaishi Bay average concentration of environemtal indicators *i.e.* DO (mg/L), salinity (psu), NH4-N [μmol/L], PO4-P [μmol/L], NO3-N [μmol/L], NO2-N [μmol/L] and SiO2-Si [μmol/L] was 14.20, 32.34, 0.72, 20.15, 1.56, 0.16, and 4.01 accordingly. After the tsunami (2012) at the same station environemtal indicators average concentration was 13.98, 33.01, 0.78, 0.23, 1.63, 0.17, and 4.48 accordingly. The observation and simulation results of nutrients concentration in the month of August 2010 and 2012 are shown a good agreement. Model results and field measurements indicate the marine contamination does not exceed the environmental standards of Japan. Observed and simulated DO, T-N and T-P concentrations are not significantly different from those reported before the disaster.

October 22, 10:05 (MEQ-9694)

Legacy POPs: Are they finally fading from marine foodchains?

John E. **Elliott**[1,2], Aroha Miller[1,2], Kyle H. Elliott[3], Melanie F. Guigueno[3] and Sandi Lee[1]

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Legacy POPs (persistent organic pollutants) such as the industrial polychlorinated biphenyl (PCB) compounds and the organochlorine insecticides such as DDT have been heavily restricted or banned in North America for many decades. They constitute the key elements of the dirty dozen of chemicals classified as the incipient POPs under the Stockholm Convention. Marine ecosystems are the ultimate sink for POPs, and thus there is a continuing need to monitor such contamination. Eggs of marine birds have proven to be an efficient and effective means of measuring and tracking xenobiotic compounds which are transferred from the female bird to the egg via yolk lipids or proteins. Here we report and discuss data from long term monitoring of these legacy POPs in seabird eggs from the northeast Pacific. For this program, the marine system was divided, and representative species selected. The nearshore subsurface is monitored using two cormorant, *Phalacrocorax*, species, *auritus* and pelagicus, both feed on a variety of benthic and pelagic fish. The inshore and estuarine zone is monitored using the great blue heron, *Adea Herodias*. Nearshore data will be compared to data from the offshore subsurface monitored using the rhinoceros auklet, *Cerorhinca monocerata*, a feeder mainly on small pelagic fishes, and the offshore surface species, the Leach's storm-petrel, *Oceanodroma leucorhoa*, which feeds mainly on surface plankton and larval fishes. At three breeding colonies each along the Pacific coast of Canada and at four year intervals 15 eggs are collected and archived. Analysis of the most recent temporal trend data, which includes retrospective data from archived samples, shows, as reported for some more polluted environments, that PCBs and DDE, following

several decades of flat trends, have declined significantly. The possible role of dietary variation, potentially related to marine regime shifts, will be examined by use of stable isotopes in variation in contaminant levels in these monitored seabirds.

October 22, 10:45 (MEQ-9492)

POPs biotransport by Pacific salmon to the Russian coast of the Northwestern Pacific

Olga **Lukyanova**[1,2], Vasiliy Tsygankov[2], Margarita Boyarova[2] and Nadezhda Khrisoforova[2]

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Persistent organic pollutants (POPs) are toxic xenobiotics that circulate in the biosphere over decades. Along with the atmospheric transport, POPs are dispersed in the ocean by currents and in marine organisms that migrate over long distances. In fishes, the biotransport of POPs is primarily in salmon and the amount has increased and is estimated to be between 1.0–1.5 million tons in the north Pacific. Salmon feeding and migration occurs in the upper layer of the epipelagial zone at depths from 0 to 50 m. It is precisely in this layer that atmospheric precipitations - pollutants deposited on suspended particles - and toxic products of decomposed plastic may concentrate and be accumulated by salmon and their prey. The number of salmon migrating to the Russian coast varies from year to year, but the structure of migratory fish remains the same: pink salmon constitute 60–65%, chum salmon 20–25%, and sockeye salmon 10–12%. Chum salmon and pink salmon are the main migratory fish in the eastern coast of Kamchatka, eastern Sakhalin Island, the continental coast of the Sea of Okhotsk, and in the Amur River basin. Analytical data show that one specimen of pink salmon contained 90 μg of pesticides (DDT+HCH) and one specimen of chum salmon contained 640 μg of pesticides. The total amount of POPs transported by salmon to the Russian coast, , is estimated to be more than 30 kg. Salmon are considered to be an important vector in the transport of pollutants in the North Pacific.

October 22, 11:05 (MEQ-9544)

Comparison of oil exposure methods to filter feeding bivalve

Andrew Jin Yi **Loh**[1,2], Un Hyuk Yim[1,2], Sung Yong Ha[1], Joon Geon An[1] and Won Joon Shim[1,2]

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Oyster, a representative filter feeder is commonly used for environmental monitoring. After the Hebei Spirit Oil Spill (HSOS), long term monitoring of petrogenic PAHs using oyster showed persistently high concentration for more than one year which could not be explained by the traditional oil exposure scenario. This study aimed to compare various exposure methods including water accommodated fraction (WAF), mechanically dispersed oil (MDO), and oil-SPM aggregates (OSA), and to measure petroleum hydrocarbons accumulated in oyster according to exposure method. Oil concentrations used were 24 g/l for WAF and MDO, 0.12 g/l for OSA respectively. Oysters were exposed to WAF, MDO and OSA for 48 hours and this test was performed in triplicate. Concentration of petroleum hydrocarbons (TPH, UCM, 16 PAHs, alkyl PAHs) in oysters exposed were in the order of MDO>OSA>WAF. Accumulated concentrations of TPH and PAHs in oysters exposed to OSA were as high as half of those exposed to MDO although only 1/200 of oil was used for OSA. This result implied that OSA is the more vulnerable form of exposure to filter feeding oyster. Composition profiles of petroleum hydrocarbons in oyster exposed to MDO and OSA were similar with exposed oil. This similarity was also found at field collected oysters right after the spill. Meanwhile, oysters exposed to WAF only showed low molecular weight hydrocarbons with relatively high solubility. Oil fingerprinting ratio plots revealed that oysters exposed to MDO and OSA has similar composition profiles that of oil. These results suggest that right after the HSOS, intertidal oysters were exposed to dispersed MDO or OSA. OSA could be preferentially formed in the turbid environment, and our study revealed that OSA may act as a continuous route of exposure to filter feeders.

MEQ PAPER

MEQ Paper Session Poster Presentations

MEQ-P1

Assessment of marine environment quality in Peter the Great Bay (the Sea of Japan)

Tatyana A. **Belan**[1], Alexander V. Moshchenko[2], Boris M. Borisov[1], Tatiana S. Lishavskaya[1] and Alexander V. Sevastianov[1]

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Three areas with different pollution load were detected in the Peter the Great Bay in 2001. Golden Horn and Dyomid Inlets were considered to be as extremely highly polluted. Eastern part of Amursky Bay was characterized by high and moderate levels of sediment pollution. These are semi-closed areas with slow circulation and transport of silty sediments and high concentration of organic carbon (up to 127.4 mg/g), petroleum hydrocarbons (up to 2.83 mg/g) and trace metals. Benthic communities are characterized by low values of species diversity, richness, and biomass. Species more tolerant to pollution are dominated in numerically abundance by the polychaetes *Tharyx pacifica, Capitella capitata, Schistomeringos japonica, Cirratulus cirratus.*

Low pollution of bottom sediments registered in the inner parts of Amursky and Ussuryisky Bays. The polychaetes *Lumbrineris longifolia, Sigambra bassi, Maldane sarsi* were the most numerically abundant. The total biomass was formed by the large *Scapharca broughtoni, Dosinia angulosa, Callithaca adamsi, Macoma tokyoensis* in the inner bays. In this paper, we relate quantitative and structural parameters of benthic communities to the different pollution pressure. The strongest correlations between pollution loads and community structure were observed in extremely high and high polluted areas - Golden Horn and Dyomid Inlets, and in the eastern part of Amursky Bay.

MEQ-P2

Marine environmental impacts of the Japanese nuclear power plant "Fukushima-1" accident in the Far Eastern seas

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The potential impacts of radionuclide pollution following the accident at the nuclear power plant "Fukushima -1" in 2011 to Sea of Japan, Sea of Okhotsk, and northwestern Pacific Ocean are of great environmental concern. Survey data collected during 2011-2012 are used to evaluate this concern by comparisons with similar observations obtained in 2010. Data collection was conducted by Russian and Japanese scientists at sampling locations in the Sea of Japan, Sea of Okhotsk, along the Kuril Islands, and the northern boundary of Kuroshio Current near "Fukushima-1". In 2011 marine contamination of the Sea of Japan was negligible and was related to the atmospheric deposition of radioactive elements. It posed no hazard to the Russian coast. No radionuclide contamination from the power plant accident was detected in the northern part of the Sea of Okhotsk near Sakhalin Island. Observed concentrations of radionuclides in marine waters near the Kuril Islands also were negligible. Survey results indicate that contamination was greatest in the latitudinal zone between 35°30'N and 38°30'N.

MEQ-P3

Toxic elements in seaweed *Undaria pinnatifida*, *Laminaria saccharina*, *Cystoseira barbata*, *Costaria costata* from the Peter the Great Bay (Japan Sea)

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Environmental conditions in the Peter the Great Bay contribute to the development many species water plants. Many of these plants are used in foods and medicines. Samples of seaweed *Undaria pinnatifida*, *Laminaria saccharina*, *Cystoseira barbata*, *Costaria costata*, were collected in the summer in 2013 year in the Peter Great Bay and analyzed for As, Cd, Cu, Hg, Pb, Zn. Content of arsenic in *Laminaria saccharina* (31.6 mg/g) and *Cystoseira barbata* (40.6 mg/g) was higher than the maximum permissible levels. Concentration of toxic elements Cd (0.08–0,12); Pb (0.08–0.30); Hg (0.01–0.02) in the seaweed does not exceed the maximum permissible levels. Elevated levels of As indicate a further needs to (1) determine what forms of arsenic compounds are found in the algae due to their varying toxicity; and (2) revise the maximum permissible levels of arsenic in seaweed.

MEQ-P4

The pollution of coastal waters of the Possyet Bay (Peter the Great Bay, Japan/East Sea)

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Possyet Bay is the main center of commercial invertebrate reproduction in the south of Primorsky Kray (Russian Federation). Coastal waters of the Possyet Bay assimilate pollution coming from the coasts and river basins. Local anthropogenic pollution batteries are harbours and bays, where port infrastructure is situated. Significant contribution to the pollution of the Possyet Bay comes from the Tumen River. About 70% of the catchment area belongs to China; 29% to the Democratic People of the Republic of Korea (DPRK); and less than 1% to Russia. The volume of wastewater entering the bay is 1.18 million m^3 per year. Categories of "untreated" and "not enough-treated" represent about 94% of the total incoming water. Possyet Bay receives about 700 tons of pollutants annually from coastal anthropogenic discharges. Suspended and dissolved organic matter contribute disproportionately to the overall mass associated with pollution impact. The specific index calculated for the Possyet Bay (0.081 g/m^3). Distribution of petroleum hydrocarbons in coastal waters of the Possyet Bay ranged from 0.025 to 0.065 mg/dm^3 and is considered to be of minor impact.

MEQ-P5

Investigation of content of artificial radionuclides in the commercial crustacea in the North West part of the Japan Sea

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The flesh of crustaceans is delicacy and source of full value of protein. We determined the content of toxic radionuclides Cs-137 and Sr-90 in eatable tissue of crustacea and conducted a sanitary-hygienic assessment of fishery resources relative to contaminant standards of safety. Our study examined crustacea from the Great Peter Bay and Primorye subarea of Japan Sea and included species such as pink shrimp (*Pandalus borealis)*, humpback shrimp*(P. hypsinotus*), bear-cub shrimp (*Sclerocrangon salebrosa*) opilio crab (*Chionoecetes opilio*), red king crab (*Paralithodes camtchaticus*). Determination of radionuclides was performed by the radiochemical method with a subsequent measurement of activity of isolated radioisotopes Cs-137 and Sr-90 on the spectrometer. The mistake of radiochemical method did not exceed 8%. The results show that the content of Cs-137 in both species of *Pandalus* was similar (between 1.0–1.2 Bk/kg), higher for the bear-cub shrimp (1.7-1.9 Bk/kg) and higher yet for both species of crabs (2.0–2.6 Bk/kg w.w.). The differences in observed concentrations are determined by food habits. The content of Sr-90 in flesh of crustacea did not exceed 0.6 Bk/kg. It is known, that radioisotope Sr-90 is accumulated mainly in bones and mineralized tissues. Toxic radionuclides levels of concentrations in crustacea are regulated by the sanitary demands and food quality of foodstuffs (SanR&N 2.3.2.1078-01) and should not exceed 200 Bk/kg Cs-137 and 100 Bk/kg Sr-90. Our data indicate the radiation safety of crustacea in our study area.

MEQ-P6

Monitoring of mercury in the Russian Far Eastern Seas

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Mercury (Hg) in the environment is a major concern due to its persistency, mobility and high toxicity for living beings. Hg demonstrates complex biogeochemistry that varies with its chemical form (speciation) and redox state. It exists in various inorganic and organic forms in the environment, of which monomethylmercury is of a particular interest. Monomethylmercury is a neurotoxin that readily biomagnifies up the aquatic food chain. Bioaccumulation and biomagnification of mercury concentrations in fish are generally influenced by fish size, trophic position, and life history. Furthermore, Hg levels in fish also vary by geographic area. For these reasons the concentration and behaviour of Hg in aquatic systems have been of great interest and importance. Compared to the situation for many freshwater fishes and ecosystems, there are relatively fewer monitoring data for Hg in marine fishes. Monitoring of Hg in commercial marine fishes, invertebrates and seaweeds was conducted in the main fishing areas of Russian Far Eastern Seas (from 2011 to 2014) to inform decisions regarding their safety for human consumption. In spite of habitat differences, total Hg concentrations in fish species (pollock, salmon, herring, and flatfishes) were low and and ranged from 0.018 to 0.049 mg/kg, far below the ecological quality standard (EQS) of 0.5 mg/kg. Mercury concentrations in crustacean species (crabs and shrimps) ranged from 0.019 to 0.050 mg/kg and didn't exceed the EQS of 0.2 mg/kg.

MEQ-P7

Integrative assessment of sediment contamination by toxic organic contaminants in an enclosed bay in South Korea

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Jinhae Bay is the largest semi-enclosed bay in South Korea and is surrounded by a high population density and various industries. Activities from this human population and development have created complicated environmental problems in the bay including hazardous chemical contamination. In order to assess the contamination status and identify the priority substances in Jinhae Bay, intensive sediment sampling was conducted and organic contaminants were analyzed. Organic contaminants were found to be widely distributed across the bay. Among the target compounds, BTs showed the highest concentration, followed by PAHs, NP, PBDEs, PCBs, DDTs, CHLs, and HCHs. The spatial distributions of the chemicals are not uniform due to geographic variability in physical environmental conditions and differences if proximity to sources of pollution.. The highest concentration of BTs and PAHs were measured near a ship-building area. In contrast, the concentrations of PCBs, DDTs, PBDEs, and nonylphenol were highest at the inner parts of highly urbanized/industrialized areas with a tendency of declining from inner to outer bay. The results indicate a great loading of anthropogenic pollutants via rivers and streams flowing through industrial areas and populated cities. A wastewater treatment plant was also identified as an important source of organic contaminant in this bay. A comparison of the contaminant data from Jinhae Bay with sediment quality guidelines (SQG) derived by Canada and New Zealand/Australia, indicate that many of the sampling sites (95%) exceeded the low-SQGs of PAHs, lindane, DDTs, dieldrin and TBT. TBT was the compound most frequently found to exceed its low- and high-SQGs, indicating that it should be the main target of concern in Jinhae Bay.

MEQ-P8

Effects of solvents on the photooxidation of phenanthrene and identification of its photoproducts

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Petrogenic polycyclic aromatic hydrocarbons (PAHs) are one of the major sources of pollution in the marine environment. PAHs present in the marine environment are subject to weathering processes such as evaporation, dissolution, sedimentation, photooxidation and biodegradation. Among them photooxidation is an important factor in the transformation of PAHs to their oxygenated forms increasing their polarity. The transformation pathway and the environmental impact of the majority of petrogenic PAH photoproducts are still unknown. In view of this, a systematic study on the photooxidation of PAHs under simulated environmental conditions was carried out *in vitro*. Phenanthrene, one of the major petrogenic PAHs was used as a model compound and its photooxidation process was examined using different organic solvents such as isooctane, acetonitrile, acetonitrile/water (50/50) and methanol. Photooxidation was conducted in a lab-made photooxidation chamber at an irradiance of 80 W/m^2 with a cutoff at 300 nm closely approximating sunlight. A tiered analytical approach using FT-IR, GC-MS, and LC-MS/MS were used to investigate the kinetics of photooxidation and to identify its photoproducts. Concentration of phenanthrene decreased exponentially with exposure time in all the tested solvents. FT-IR analysis showed the formation of characteristic bands corresponding to carboxylic acids and ketones. Results produced from the GC-MS analyses of derivatized samples showed the formation of polar photoproducts such as aliphatic acids, aromatic acids, ketones and alcohols. Isooctane appeared to be the most suitable solvent for photooxidation considering its miscibility and noninterference with target compounds.

MEQ-P9

Summer variations in interleukin-1α-like substance levels in phagocytes of holothurian *eupentacta fraudatrix* in Peter the Great Bay, Sea of Japan

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System of cytokins, including interleukin-1α (IL-1α),, is known to regulate immune response in vertebrates. IL-1α-like substance (IL-1α-LS) were found in echinoderms too. However, little or no data is available on their functional role and seasonal levels in holothurians. The aim of the study was to measure the summer levels of the IL-1α-LS in phagocytes of the holothurian *Eupentacta fraudatrix* and to evaluate its dependence on seawater temperature. The species were collected in summer, 2009, in Alexeev Bay, Peter the Great bay, Sea of Japan at the depth of 1-1.5 m. Phagocytes (fraction 1, 98% purity) were isolated from coelomic fluid by ficoll-verographine density gradient centrifugation as described earlier (Dolmatova *et al.*, 2004). Concentration of IL-1α-LS was determined in nuclear-free supernatants of the cells using the commercial kit ("Cytokin", Russia) for human IL-1α content measuring. Since early June to early August, concentration of IL-1α-LS gradually increased and reached a maximum 2-fold increase compared to early June, and then decreased 3-fold in early September, compared to early August. Seawater temperature increased from 11°C in early June to 18°C in early August. Maximal temperature of 21.5°C was registered on mid-August, and temperature of 18°C was shown already by the late August. By mid September, temperature declined to 15°C. The data obtained indicate that variations in IL-1α-LS level directly corresponded to changes in seawater temperature. Taking into consideration the sensitivity of holothurians to temperature stress, it seems possible that IL-1α-LS plays the role in stress-protective activity of phagocytes.

POC Paper Session

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

Papers are 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).

Day 1, Thursday, October 23 (14:00-17:50)

14:00   ***Introduction by Session Convenors***

14:05   **Observations of turbulence in the summer East China Sea**
Naoki <u>Furuichi</u>, Hironori Higashi, Hiroshi Koshikawa, Toru Hasegawa, Kou Nishiuchi and Haruya Yamada

14:25   **Properties of internal tides and vertical mixing observed on the continental slope of the southwestern East Sea**
Seongbong <u>Seo</u>, Young-Gyu Park, Jae-Hun Park, Chang-Soo Hong, Dong Guk Kim and Jae-Hak Lee

14:45   **Second-mode semi-diurnal internal tides on the continental slope of the southwestern East/ Japan Sea**
Hee-Yeol <u>Lee</u>, Jae-Hun Park, Chanhyung Jeon, Seongbong Seo, Young-Gyu Park and Sung-Dae Kim

15:05   **Investigation of wave processes on the eastern shelf of Sakhalin Island influenced by tidal currents (Sea of Okhotsk)**
Evgeniya <u>Maryina</u> and Margarita Grishina

15:25   ***Coffee / Tea Break***

15:45   **Climate variability and the 3-dimensional structure of coastal upwelling**
Michael G. <u>Jacox</u>, Andrew M. Moore, Christopher Edwards and Jerome Fiechter

16:05   **Vertical motions of fluid particles near mesoscale ocean eddies and the effect of submesoscales**
Yeon S. <u>Chang</u> and Young-Gyu Park

16:25   **Simulating water-borne disease transmission among salmon farms in the Discovery Islands, Canada**
Michael <u>Foreman</u>, Kyle Garver, Dario Stucchi, Ming Guo, Peter Chandler, John Morrison and Darren Tuele

16:45   **On the physical and biological interactions between coastal and open sea waters**
Vadim <u>Navrotsky</u>, Valeriy Liapidevskii, Vyacheslav Lobanov, Elena Pavlova and Fedor Khrapchenkov

17:05   **Improvement and seasonal variations of sea surface salinity data in the East Sea derived from Aquarius/SAC-D images**
Jin-Wook <u>Lim</u>, Sang-Woo Kim, Chung-Il Lee and Hee-Dong Jeong

17:25   **Sea surface height variability from satellite altimetry and pressure-recording inverted echo sounders in the North Equatorial Current region**
Chanhyung <u>Jeon</u>, Jae-Hun Park, Dong Guk Kim, Eung Kim, Dongchull Jeon and D. Randolph Watts

17:45   Summary

17:50   *Session Ends*

Day 2, Friday October 24 (09:00-12:30)

09:00   *Introduction by Session Convenors*

09:05   **Decadal changes of pCO$_2$ and ocean acidification in the Western Arctic Ocean**
Zhongyong Gao, Liqi Chen, Heng Sun, Zhenglin Xiao and Di Qi

09:25   **Variability of the flow through the Kerama Gap between the East China Sea and the Northwestern Pacific induced by mesoscale eddy activities**
Hanna Na, Jae-Hun Park, Mark Wimbush, Hirohiko Nakamura, Ayako Nishina and Xiao-Hua Zhu

09:45   **Simulation of river runoff in Eastern Siberia and the propagation of this river water in the Arctic**
Viktor Kuzin, Gennady Platov, Elena Golubeva and Natalya Lapteva

10:05   **Features of climatic variability in the Tatar Strait (Japan/East Sea)**
Elena I. Ustinova and Yury D. Sorokin

10:25   *Coffee / Tea Break*

10:45   **Long-term warming trend of sea surface temperature in the South China Sea**
A-Ra Choi, Young-Gyu Park and Jae-Hun Park

11:05   **An overview of the oceanographic component of the World Class Tanker Safety Initiative**
Charles Hannah, Patrick Cummins, Michael Foreman, Diane Masson, Pramod Thupaki, Svein Vagle and Di Wan

11:25   **Modeling of deep currents in the Japan/East Sea**
Olga Trusenkova

11:45   **Cascading of dense water along Peter the Great Bay slope in the northwestern Japan Sea**
Vyacheslav Lobanov, Aleksandr Sergeev, Igor Gorin, Pavel Scherbinin, Aleksandr Voronin, Dmitry Kaplunenko, Oleg Popov, Timofei Gulenko and Svetlana Ladychenko

12:05   **Western North Pacific Integrated Physical-Biogeochemical Ocean Observation Experiment: Summary of the intensive observation around the biogeochemical mooring S1 (S1-INBOX)**
Toshio Suga, Ryuichiro Inoue, Shinya Kouketsu, Shigeki Hosoda, Taiyo Kobayashi, Kanako Sato, Hiroyuki Nakajima, Makio Honda, Tetsuichi Fujiki, Kazuhiko Matsumoto, Takeshi Kawano and Toshiro Saino

12:25   Summary

12:30   *Session Ends*

POC Paper Session Posters

POC-P1   **Regeneration of a warm anticyclonic ring by cold water masses within the western subarctic gyre of the North Pacific**
Sachihiko Itoh, Ichiro Yasuda, Hiromichi Ueno, Toshio Suga and Shigeho Kakehi

POC-P2   **Properties of altimetry-derived transport of the Oyashio on the A-line, off the southeastern coast of Hokkaido, Japan**
Hiroshi Kuroda, Taku Wagawa, Yugo Shimizu, Shin-ichi Ito, Shigeho Kakehi, Takeshi Okunishi, Sosuke Ohno and Akira Kusaka

POC-P3   **Distribution and seasonal variation of the halocline in the world ocean**
Hiromichi Ueno and Katsura Yasui

POC-P4   **Vertical structure of current velocity measured by a lowered acoustic Doppler current profiler in the southwestern part of the East Sea in July 2005**
Chang-Woong Shin and Dong Guk Kim

POC-P5   **Observation of an anticyclonic warm core eddy east of Japan**
Vincent Faure, Ryuichiro Inoue, Shinya Kouketsu, Toshio Suga, Shigeki Hosoda and Kanako Sato

POC-P6   **Variation of Sea Surface Salinity on the Southwestern coast of the East Sea since the first half of the 20 Century**
Hee Dong Jeong, Sang Woo Kim, Jin Wook Lim, Yong Kyu Choi, Jeong Min Shim, Kee Young Kwon and Yong Hwa Lee

POC-P7   **Hydrological factors in Prostor Bay (Iturup Island, the Sea of Okhotsk) influencing Pacific Salmon during their early marine life stage**
Kirill Kivva and Sergey Lapin

POC-P8   **Recent climatic tendencies over the Kamchatka Peninsula and adjacent waters**
Lubov N. Vasilevskaya, Olga A. Shkaberda and Elena I. Ustinova

POC-P9   **Summer surface salinity variability in the Yellow and East China Seas: ENSO effects**
Chan Joo Jang and Taewook Park

POC-P10   **Changes in seasonal air temperatures and precipitation in the Far North-East of Russia**
Julia V. Stochkute and Lubov N. Vasilevskaya

POC-P11   **Processes leading to the second-year cooling of the 2010-12 La Niña event, diagnosed using GODAS**
Licheng Feng, Rong-Hua Zhang, Zhanggui Wang and Xingrong Chen

POC-P12   **Coordinated international activities on the climate study of ocean-atmosphere interactions**
Nico Caltabiano and Valery Detemmerman

POC-P13   **Cyclone statistics in northwest Pacific and relationships with climate factors**
Wei Lixin, Ting Qin, Bin Cheng and Timo Vihma

POC Paper Session Oral Presentations, Day 1

October 23, 14:05 (POC-9501)

Observations of turbulence in the summer East China Sea

Naoki **Furuichi**[1], Hironori Higashi[1], Hiroshi Koshikawa[1], Toru Hasegawa[2], Kou Nishiuchi[3] and Haruya Yamada[2]

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Turbulent mixing processes impact the heat and material transports in the ocean interior so that effects of the subgrid-scale processes need to be accurately taken into account in the numerical studies on large-scale ocean dynamics, climate change and marine ecosystems. In this study, we made field observations of microstructure measurements in the East China Sea during summer in 2011, 2012 and 2013 to obtain about 80 vertical profiles of turbulent dissipation rate, the physical parameter closely linked with the vertical diffusivity coefficient and therefore several turbulent fluxes, in the areas on the continental shelf and around the shelf edge. The dissipation rates below the surface mixed layer are compared with the velocity and density fields obtained by using an acoustic Doppler current profiler (ADCP) and conductivity-temperature-depth (CTD) sensor to examine their scaling relationships. We find that, near the ocean floor on the shelf, the turbulence dissipation rates increase with enhancement of tidal currents according to the boundary layer scaling, while they tend to be restricted by stable density stratification as the upper transition layer is approached. It is also found that the turbulence dissipation rates above the bottom boundary layer and around the shelf edge are likely to increase with increasing local vertical current shear and increasing buoyancy frequency, in a similar manner to that suggested for other shelf seas.

October 23, 14:25 (POC-9554)

Properties of internal tides and vertical mixing observed on the continental slope of the southwestern East Sea

Seongbong **Seo**[1,2], Young-Gyu Park[1], Jae-Hun Park[1], Chang-Soo Hong[1], Dong Guk Kim[1] and Jae-Hak Lee[1]

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Internal tides and their impact on vertical mixing near the continental slope of the southwestern East Sea were investigated using 3 sets of CTD, LADCP, and free falling Microstructure profiler (TurboMAP) measurements collected for 26 hours at 2-hour intervals. The profiles span the whole water column from the surface to near bottom (~ 260m). The semi-diurnal internal tide was the strongest below the main thermocline (150-200m) where 5ºC isotherm displacements larger than 30 m were observed. Turbulence dissipation rate ε and vertical diffusivity K_z estimated using shear profiles reveal the presence of mixing events below the main thermocline as well as in the mixed layer. The value of K_z below the main thermocline reached in the range of 10^{-3}–10^{-2}m^{2}s^{-1}, two orders of magnitude greater than that in the open ocean. This high value seems to be associated with vertical mixing induced by internal tides. The mean value of K_z through the whole water column was 8×10^{-4}m^{2}s^{-1} and that under the thermocline (about 70 m to bottom) was 3×10^{-4}m^{2}s^{-1}. Methods of vertical diffusivity assessment based on TurboMAP profiles and on density inversion calculated from temperature and salinity profiles were compared.

October 23, 14:45 (POC-9618)

Second-mode semi-diurnal internal tides on the continental slope of the southwestern East/Japan Sea

Hee-Yeol **Lee**[1], Jae-Hun Park[2], Chanhyung Jeon[2], Seongbong Seo[2], Young-Gyu Park[2] and Sung-Dae Kim[2]

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This paper presents second-mode semi-diurnal internal tides observed on the continental shelf-slope of the southwestern East/Japan Sea. During a spring tidal period in early November 2013, we collected 26-hour-long 2 hourly CTD and Lowered ADCP profiles spanning the ~250m water column. The time series of velocity profiles, dominated by semi-diurnal variation, exhibit a three-layer-like vertical structure with an in-phase relationship between the upper and lower layers and an out-of-phase relationship between the upper and middle layers. The baroclinic semi-diurnal signals extracted using a least-squared harmonic fitting demonstrate that energetic second-mode internal tides occurred at the observation site. In order to understand the physical processes generating the second-mode internal tides and their spatio-temporal variations, we utilized 25-month long numerical simulation outputs from a real-time ocean forecasting system of the East/Japan Sea, which includes realistic oceanic circulation and stratification together with tidal forcing of 16 major components along open boundaries. The analysis results reveal that the deepened mixed layer near the semi-diurnal internal tide generation region during the fall months appears to provide a second-mode favorable stratification. The seasonally-varying distributions of second-mode internal tides in the East/Japan Sea will be discussed with their potential impact on the ocean mixing.

October 23, 15:05 (POC-9427)

Investigation of wave processes on the eastern shelf of Sakhalin Island influenced by tidal currents (Sea of Okhotsk)

Evgeniya **Maryina** and Margarita Grishina

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Wave processes on the eastern shelf of Sakhalin Island (Sea of Okhotsk) caused by tidal currents are investigated by analysingtidal stream maps. Tidal stream maps are used to reflect features of the spatial distribution of harmonic constants of tidal currents. Their values are expressed in vector form. Harmonic permanent tidal stream variables are amplitude, phase, the direction of the vector maximum stream and direction of rotation clockwise or counterclockwise. These maps were constructed for 4 diurnal (K1, O1, Q1, P1) and 3 semidiurnal (M2, S2, N2) tidal constituents. Analysis of the tidal stream maps allowed us to unambiguously interpret the results of physical wave processes such as diffraction of tidal and wave-driven currents on obstacles. The processes of diffraction, reflection and interaction of each wave shown on tidal maps generally allows for a more complex analysis of wave processes occurring on the shelf zones of the seas, and helps us to examine all the tidal processes as a whole natural phenomenon.

October 23, 15:45 (POC-9448)

Climate variability and the 3-dimensional structure of coastal upwelling

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Considerable effort has been expended to understand the variability and trends of upwelling off the US west coast, and to predict the evolution of upwelling in a changing climate. However, due to the difficulty of measuring upwelling directly, it is typically inferred from proxies like wind or sea surface temperature. Here, we use a data assimilative model to investigate California Current System (CCS) upwelling transport from 1988 to 2010. The model reveals important structure in the upwelling signal not captured by traditional upwelling indices. In particular, nearshore (<50km from shore) and offshore (50-200km) upwelling intensity anomalies tend to be of opposite sign on interannual time scales. This cross-shore pattern in upwelling variability is strongly correlated to North Pacific climate indices and upwelling source depth, and may be an important mechanism for decadal-scale variability in CCS biology.

October 23, 16:05 (POC-9460)

Vertical motions of fluid particles near mesoscale ocean eddies and the effect of submesoscales

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The effects of small-scale flow structures on the vertical dispersions of fluid particles are investigated using a HYbrid Coordinate Ocean Model (HYCOM). Numerically simulated flow structures in the regions with/without mesoscale rings are compared in the recirculating region of the Gulf Stream between two different horizontal resolutions at two different seasons - summer and winter. The analysis of the Finite Size Lyapunov Exponent (FSLE) shows that FSLE ridges are found in the rings with extension of surface ridges into ocean interiors, and the small-scale flow structures with size of O(1~10) km that are still found below the mixed layer although their strength sharply decreases with depth. These small-scales cause the fluids to move more irregularly around the rings, thus their different distributions according to the model resolution and to the seasonal variation affect the vertical dispersion rates as well. When the two dispersion rates are compared, the relative vertical dispersion coefficient (Y_z) gives better estimates than the absolute dispersion coefficient (K_z) because the magnitudes of K_z are overestimated, for the large resolutions (LR) especially, due to the large-scale vertical fluid motions such as the motions along the orbital planes of the rings. Thus, Y_z of the high resolutions (HR) gives the most reasonable estimates as the effect of the small-scale structures is most clearly reflected while the effect from the orbital trajectories is significantly reduced by this measure. Specially, the Y_z profiles of the HR winter cases have peaks at shallow depths which are caused by the small-scales in the mixed layer. If these small-scales are developed near the mesoscale rings, these peaks at the shallow depths extend into the deeper part of the ocean. If there are no mesoscale rings, however, the peaks of Y_z are only confined in the shallow depths and the surface small-scale structures do not have an affect on the ocean interiors. Thus, the interaction between the mesoscale rings and the small-scale fluid structures is likely important because it can enhance vertical fluid motions and thus it may cause significant vertical transport as well.

October 23, 16:25 (POC-9442)

Simulating water-borne disease transmission among salmon farms in the Discovery Islands, Canada

Michael **Foreman**[1], Kyle Garver[2], Dario Stucchi[1], Ming Guo[1], Peter Chandler[1], John Morrison[1] and Darren Tuele[1]

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Finite volume ocean circulation and particle tracking models are used to simulate water-borne transmission of the *infectious hematopoietic necrosis virus* (IHNV) among Atlantic salmon (*Salmo salar*) farms in the Discovery Islands region of British Columbia, Canada. Historical simulations have been carried out for variable river discharge, wind, solar/UV radiation, and air temperature conditions to determine their direct impact on near-surface currents and water properties, and subsequent impact on viral dispersion and survival. Particles released from infected farm fish in accordance with IHNV shedding rates estimated through laboratory experiments are dispersed by model oceanic flows and die in accordance with ultra-violet radiation levels that have also been determined through laboratory studies. Temporally- and spatially-evolving viral concentration maps are produced and combined with lab-determined minimum infectious dosages to estimate how infections might spread among farms. The development and validation of the circulation and biological model components will be briefly discussed, along with applications to aquaculture management and farm siting issues.

October 23, 16:45 (POC-9457)

On the physical and biological interactions between coastal and open sea waters

Vadim **Navrotsky**[1], Valeriy Liapidevskii[2], Vyacheslav Lobanov[1], Elena Pavlova[1] and Fedor Khrapchenkov[1]

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Anthropogenic effects on oceanic ecosystems are due mainly to terrigenous matter delivered into coastal waters by surface and subsurface flows from land. That process can be positive (elevated production) or negative (pollution), depending strongly on horizontal and vertical mixing. Analysis of our experiments and observations *in situ* in the Sea of Japan combined with satellite data shows how, when and where very different mechanisms at different scales define specific hydrophysical and biological structures in shelf and open sea waters. Dependence of such regional processes on climate variability is also discussed.

October 23, 17:05 (POC-9703)

Improvement and seasonal variations of sea surface salinity data in the East Sea derived from Aquarius/SAC-D images

Jin-Wook **Lim**[1,2], Sang-Woo Kim[1], Chung-Il Lee[3] and Hee-Dong Jeong[1]

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Ocean circulation is driven in large part by changes in density, which is determined by temperature and salinity. Salinity is one of the major physical parameters used to understand sea water properties. The Aquarius/SAC-D satellite, used to observe sea surface salinity (SSS), has been operating since June 2011. Aquarius' measurements of ocean salinity will provide a new perspective on the ocean. In this study we conducted the validation of monthly SSS derived from the Aquarius satellite (ASSS) over the last 3 years (2011-2013), and the seasonal variations, in the East Sea. We used the linear regression in order to validate between ASSS data and in-situ SSS data, which were provided by NEAR-GOOS, WOD2013 and NFRDI. We then employed monthly mean in-situ SSS and ASSS data with spatial resolution on a 1°×1° grid, which is calculated for each month. Salinity validation show an underestimation by 0.42 in spring, 0.32 in summer, 0.99 in autumn and 1.41 in winter, respectively. Here, we suggest the estimated salinity (ES) which has applied equations of the linear regression to improve underestimated salinity showed a 95% confidence. The ES in all regions showed high values in winter (34.1) and spring (34.0).

In summer low ES values (32.6 to 33.1) appeared in the southern region, and relatively high salinity of 33.2-33.4 appeared in the northern region except for the Russian coastal region. In autumn, the ES ranged from 33.4 to 33.7. We hope that this study will contribute to understanding the variability of SSS in the East Sea.

October 23, 17:25 (POC-9524)

Sea surface height variability from satellite altimetry and pressure-recording inverted echo sounders in the North Equatorial Current region

Chanhyung **Jeon**[1], Jae-Hun Park[1], Dong Guk Kim[1], Eung Kim[1], Dongchull Jeon[1] and D. Randolph Watts[2]

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An array of 4 pressure-recording inverted echo sounders (PIESs) was deployed across the North Equatorial Current (NEC) in the Northwestern Pacific Equatorial (NPE) region. The PIES measures bottom pressure and round-trip acoustic travel time from the sea floor to the sea surface. The mass-loading and steric height variations in sea surface height (SSH) anomaly are estimated with the bottom pressure and round-trip acoustic travel time measurements, respectively. *In situ* SSH anomaly measurements from the PIESs are compared with three sets of satellite-measured SSH anomaly products from AVISO: mono-mission and multi-mission along-track delayed-time products, and a reference merged (gridded) delayed-time product (Ref-MSLA). Out of the three AVISO products, Ref-MSLA shows the best match with PIES-derived SSH anomaly in the range of 0.68 to 0.78 correlations. Outstanding error-reduced results in Ref-MSLA are accounted for in the merging process conducted by AVISO. This work suggests that Ref-MSLA is the preferable data set to investigate the SSH variability in the NPE region rather than along-track products.

POC Paper Session Oral Presentations, Day 2

October 24, 09:05 (POC-9656)

Decadal changes of pCO$_2$ and ocean acidification in the Western Arctic Ocean

Zhongyong **Gao**[1], Liqi Chen[1,2], Heng Sun[1,2], Zhenglin Xiao[1,2] and Di Qi[1,2]

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Underway measurements of surface seawater and atmospheric partial pressure of CO$_2$ (pCO$_2$) along the BR section in the Western Arctic Ocean (WAO) were conducted during 5 summer cruises of the Chinese National Arctic Research Expedition (CHINARE) from 1999 to 2012. CO$_2$ system parameters were measured in discrete water column samples as well. Latitudinal distributions of pCO$_2$ in the WAO and their relationships with physical and chemical parameters will be discussed. According to the CO$_2$ uptake capacity, the WAO was divided into 4 regions: an exchange area of the Arctic Ocean and the Pacific Ocean (Chukchi Sea), marginal ice zone, pack ice zone, and unknown water under ice cover. Judging from decadal changes of pCO$_2$ in Section R in the WAO, the Chukchi Sea maintains high carbon fluxes due to the plentiful nutrients supplements. Basin areas offer high carbon uptake only when they change into a seasonal floating ice zone, and decrease dramatically when they change back into ice-free areas; the unknown water under ice cover in the high latitude ocean keeps a relative low pCO$_2$ level, the same as that in t hepre-industrialized period, and has high potential for carbon uptake. Ocean acidification is also discussed as a carbonate parameter. From 1997 to 2014, surface and subsurface waters were acidified within the context of large-scale water mass exchange and local physical and biogeochemical processes along a section from the northern North Pacific to Western Arctic Ocean.

October 24, 09:25 (POC-9673)

Variability of the flow through the Kerama Gap between the East China Sea and the Northwestern Pacific induced by mesoscale eddy activities

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The Kerama Gap (KG), near the middle of the Ryukyu Island chain, is the deepest channel with a sill depth of 1050 m connecting the East China Sea (ECS) to the Northwestern Pacific. The observed mean flow through the KG from June 2009 to June 2011 is 2.0 ± 0.7 Sv into the ECS. A good correlation is obtained between the satellite altimetry-measured sea-level anomaly difference across the KG and 2-year-long *in situ*-measured volume transport, which allows us to produce 7-day interval 20-year time series of the KG volume transport. The 20-year mean volume transport is 1.5 ± 0.2 Sv with standard deviation of 2.5 Sv. Comparison of KG volume transport time series with satellite-measured sea surface height maps reveals that the KG transport fluctuations at 40−150-day periods is strongly affected by mesoscale eddies around the KG. Consequently, its interannual to decadal amplitude changes are associated with interannual to decadal eddy field changes to the east of the Ryukyu Island chain in the Northwestern Pacific, which also determine the time-varying correlations between the KG throughflow and the Ryukyu Current volume transport south of Okinawa.

October 24, 09:45 (POC-9578)

Simulation of river runoff in Eastern Siberia and the propagation of this river water in the Arctic

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Using a climate model of river flow, a time variation of river runoff is calculated for Eastern Siberia Rivers: Khatanga, Anabar, Olenek, Lena, Yana, Indigirka and Kolyma. The runoff model is a linear reservoir with surface, underground and river runoffs. Conditions of runoff formation were determined based on the results of a reanalysis. For comparison, we examined NCEP/NCAR, ERA40 and GMAO MERRA data. In the numerical experiments, we found some differences for individual reanalysis, which are examined in this article.

Further propagation of Siberian river waters in the Arctic was performed by using a coupled ocean and the sea-ice model of the Arctic and the North Atlantic. The simulation results, based on calculated transport of the above Siberian Rivers, were compared with the results, obtained using mean climatological seasonal variation of their runoff. The specifics of how river water anomalies propagate in the Arctic and North Atlantic show that river water plays an important role in regulating the vertical mixing both in the Arctic and in the North Atlantic. Significant changes in water circulation and ice dynamics are not revealed. However, there is some redistribution of Arctic freshwater export between the Fram Strait and the straits of the Canadian Arctic Archipelago.

October 24, 10:05 (POC-9707)

Features of climatic variability in the Tatar Strait (Japan/East Sea)

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In the present study, climatic variability and changes in the Tatar Strait were analyzed using regional data sets based on historical observations (multi-year data on ice cover, air and water temperature from the meteorological stations located at the coast and gridded SST from the NEAR-GOOS Real Time Data Base and HadISST). The main feature of the changes is warming of the surface layer in June-October (0.2-0.5°C per decade with a maximum in September). Reduction of mean winter ice extent in the Tatar Strait is not statistically significant during the period 1960-2014. Among "ice months" the maximal reduction of the ice extent occurred in March and April. Contribution of the periodical components in total variance is 30% (for ice) or 26% (for SST). The formation of strong winter atmospheric anomalies over the Japan/East Sea and adjacent regions causes the very fast response in large ice cover anomalies. The extreme warm and cold winters were characterized by strong atmospheric anomalies, with changes in the paths of the storms. Correlation between regional thermal parameters and the majority of large-scale climatic indices is not high. Changes in the sign correlation between some large-scale climate indices (*e.g.*, AO, ENSO, *etc.*) and regional climatic parameters occur over the Tatar Strait. The Victoria SST pattern is more representative for the Strait than the PDO. The winter monsoon index is an important factor here. Integrated impacts of cyclones on the thermal variability are discussed, too. Among well-known large-scale climate regime shifts, the shift of 1988/89 is strongest for the Tatar Strait.

October 24, 10:45 (POC-9658)

Long-term warming trend of sea surface temperature in the South China Sea

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Using the Hadley Centre Global Sea Ice and Sea Surface Temperature (HAdISST), the long-term trend in the South China Sea (SCS) sea surface temperature (SST) between 1950 and 2008 is investigated. In general, SST has increased since 1950, but the rate of increase is spatiotemporally uneven. Temporally, the winter warming rate is greater than that of summer. In addition, the rate of increase is greater during 1980s. Spatially, during winter the warming rate is greater in the deep basin and during summer over the southeastern SCS. To find the cause of the warming, winds and air-sea heat fluxes are also analyzed. In summer the weakening of southwesterly monsoon reduces upwelling east of Vietnam to warm the surface. The net surface heat flux, however, is reduced and cannot contribute to the warming. In winter the net heat flux into the sea increases and could contribute to the warming. The spatial pattern of the heat flux, however, is different from that of the warming. The heat flux is increased over the coastal area where warming is small, but decreases in the deeper part where warming is greater. After the 1980s the northeasterly monsoon winds weaken to reduce the southward western boundary currents, and subsequently cold advection. The decreasing cold advection by changing ocean currents, in particular, plays an important role in the SST warming.

October 24, 11:05 (POC-9516)

An overview of the oceanographic component of the World Class Tanker Safety Initiative

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The World Class Tanker Safety Initiative is a major program of the Government of Canada to improve the overall regime under which oil tankers operate in Canada. Oceanography plays a small but vital role in this Initiative. This presentation will provide an overview of the oceanographic program for the North Coast of British Columbia. This includes results from deployments of a new low-cost satellite-tracked surface drifter, observation of flow over a shallow sill, and the development of a high resolution circulation model for the fjord system of the North Coast of BC.

October 24, 11:25 (POC-9521)

Modeling of deep currents in the Japan/East Sea

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Geostrophic deep circulation is modeled in the Japan/East Sea using the primitive equation multilayer model (Shapiro, 1998). It is consistent with the circulation schemes based on observations (Senjyu *et al.*, 2005; Choi, Yoon, 2010). There are cyclonic gyres around the sea margins and in the deep basins and anticyclonic circulation within the underwater rises. The most intense cyclonic gyre is simulated in the eastern Japan Basin where velocity is up to 6–8 см/s. Seasonal variation of the deep circulation is captured by the first mode of variability derived from velocity in the lowest model layer. This mode accounts for more than 30% of the total variance. In the cold season the deep cyclonic gyre in the entire Japan Basin intensifies, especially strongly in the eastern part, while in the southern Sea the deep circulation weakens. The opposite phase of the deep circulation develops by the late warm season and the seasonal extremes are reached in March and September–October. The intensified cyclonic gyre in the Japan Basin shrinks and velocity decreases at its periphery. This can explain an unclear seasonal signal at the deep mooring site at the eastern slope of the Japan Basin (Takematsu *et al.*, 1999). In winter the cyclonic gyre in the Japan Basin strengthens from the surface to bottom, forced by the cyclonic wind stress curl. In summer the gyre strengthens in the upper layer only, due to the general intensification of circulation under the thermal forcing of the flowthrough from the Korea Strait.

October 24, 11:45 (POC-9675)

Cascading of dense water along Peter the Great Bay slope in the northwestern Japan Sea

Vyacheslav **Lobanov**, Aleksandr Sergeev, Igor Gorin, Pavel Scherbinin, Aleksandr Voronin, Dmitry Kaplunenko, Oleg Popov, Timofei Gulenko and Svetlana Ladychenko

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Slope convection at Peter the Great Bay in the northwestern Japan Sea is one of the processes that ventilate the sea interior. Direct observations of dense water cascading along the slope of Peter the Great Bay with measurements of currents and oceanographic parameters by mooring systems and repeated CTD surveys implemented during winters of 2010-2014 are presented. It is shown that cascading events usually happen in February-March. Their duration and intensity vary from a few days to 3 weeks in different years. During the winter of 2012, a larger volume of dense shelf water passed over the moorings continuously in mid-February-early March and for a few days in late March. This resulted in a cascading of dense water down the slope resulting in a number of intrusions of colder, less saline, higher oxygen content and turbidity water detected by CTD casts. Their thicknesses varied typically around 50-150 m. Most of them occurred between 200 and 700 m depth thus ventilating a layer of intermediate high salinity water, while some signals of higher oxygen were observed down to 2000-2800 m indicating ventilation down to the bottom of the slope. Nevertheless, this has not resulted in significant renewal of Japan Basin bottom waters comparable with the one that occurred in the winter of 2001.

October 24, 12:05 (POC-9795)

Western North Pacific Integrated Physical-Biogeochemical Ocean Observation Experiment: Summary of the intensive observation around the biogeochemical mooring S1 (S1-INBOX)

Toshio **Suga**[1,2], Ryuichiro Inoue[1], Shinya Kouketsu[1], Shigeki Hosoda[1], Taiyo Kobayashi[1], Kanako Sato[1], Hiroyuki Nakajima[3], Makio Honda[1], Tetsuichi Fujiki[1], Kazuhiko Matsumoto[1], Takeshi Kawano[1] and Toshiro Saino*

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The interdisciplinary project called the Western North Pacific Integrated Physical-Biogeochemical Experiment (INBOX) has been conducted since 2011. As the first phase of INBOX, more than 20 profiling floats with a dissolved oxygen sensor were deployed in late July 2011 within the 150-km square area centered at the biogeochemical mooring site S1 (30N, 145E) in the oligotrophic subtropics. The horizontal (30 km) and temporal (2 days) resolutions of the float array were set in order to capture relationship between biogeochemical phenomena and physical processes such as westward propagating eddies and atmospheric disturbances. The observations of large mass flux at 200 m, a high chlorophyll *a* concentration in the deep chlorophyll maximum layer, large F_v/F_m ration and high dissolved oxygen concentration in the shallow oxygen maximum layer will be summarized and interpreted as biogeochemical responses to physical processes in and around mesoscale eddies including submesoscale motions, diapycnal mixing and surface wind forcing.

POC Paper Session Poster Presentations

POC-P1

Regeneration of a warm anticyclonic ring by cold water masses within the western subarctic gyre of the North Pacific

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Regeneration of a warm anticyclonic ring as a result of interaction with cold water masses was observed within the western subarctic gyre of the North Pacific. Satellite, profiling float, and shipboard observations revealed that a warm-core ring originated from the Kuroshio Extension, propagating northeastwards, entrained cold and fresh water masses from the coastal area of Hokkaido, which are typically recognized within the ring as water that is colder than 2.5°C. The potential temperature and planetary contribution of potential vorticity of the cold water in the coastal area of Hokkaido were less than 2°C and 15×10^{-11} m^{-1}s^{-1}, respectively, suggesting that it originated from the Sea of Okhotsk. After the intrusion, the warm core of the ring cooled, freshened, and contracted, while the outer and lower parts became occupied by the cold and fresh water; however, even after the cooling, the positive surface elevation and downward depression of the main pycnocline, typical of an anticyclonic ring, were still evident. The ring continued to propagate northeastwards, with the main part of its structure occupied by the cold water, but changed its direction of travel from northwest to west-southwest 8 months after the cold-water event, and was finally absorbed into another warm-core ring. It is suggested that these anticyclonic rings, which transported and mixed warm and cold water masses, play important roles in the cross-gyre exchange of subtropical and subarctic waters in the North Pacific.

POC-P2

Properties of altimetry-derived transport of the Oyashio on the A-line, off the southeastern coast of Hokkaido, Japan

Hiroshi **Kuroda**[1,3], Taku Wagawa[2], Yugo Shimizu[3], Shin-ichi Ito[2], Shigeho Kakehi[2], Takeshi Okunishi[2], Sosuke Ohno[2] and Akira Kusaka[3]

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Regular hydrographic measurements on the A-line, off the southeastern coast of Hokkaido, have been carried out since 1987, and variations of the Oyashio have been monitored at a frequency of about 5 times per year. Since the monitoring frequency is not enough to describe seasonal variations of the Oyashio transport only from A-line data, we estimated a continuous weekly time series of the Oyashio transport crossing the A-line by combining gridded altimetry data and A-line CTD data from 1993-2013. Regression lines were calculated between CTD-derived geostrophic transport at a reference level of 3000db and altimetry-derived sea level anomaly difference. The regression lines were computed for pairs of adjacent stations on the A-line by minimizing a cost function newly proposed in this study. We then constructed a weekly time series of transport between the pairs of stations using the regression lines and weekly time series of altimetry-derived sea level anomaly difference. The climatological mean of the estimated transport exhibits, in order from the north to south, the southwestward transport on the continental slope associated with the First Oyashio Intrusion (SW-1), the northeastward transport near the Kuril-Kamchatka Trench (NE-2), the southwestward transport associated with the Second Oyashio Intrusion (SW-3), and the northeastward transport around the subarctic front (NE-4). The NE-2 and NE-4 exhibit the largest stability ($\sim$0.85), followed by SW-1 ($\sim$0.75), and SW-3 the smallest ($\sim$0.6). The maximum value of southwestward transport integrated from the northernmost station was estimated as 8.0Sv. Properties of seasonal variations of the altimetry-derived Oyashio transport are also described in our presentation.

POC-P3

Distribution and seasonal variation of the halocline in the world ocean

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The distribution and seasonal variation of the halocline in the world ocean, especially in the North Pacific, were investigated using a simple halocline definition. The halocline was observed in the tropics, equatorward subtropical regions, and subpolar regions, but it was absent in the central subtropical regions. A strong halocline tended to occur in the area where sea surface salinity (SSS) was low. The seasonal variation in halocline strength was also correlated with variation in SSS. The correlation coefficient was mostly negative; the halocline was strong when the SSS was low. However, in the Gulf of Alaska in the northeastern North Pacific, the correlation coefficient was positive. There, the halocline was strong when the SSS was high, probably due to the entrainment effect.

POC-P4

Vertical structure of current velocity measured by a lowered acoustic Doppler current profiler in the southwestern part of the East Sea in July 2005

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To investigate the vertical structure of current velocity in the southwestern part of the East Sea, current data surveyed in July 2005 were analyzed. The currents were measured with both ship-mounted and lowered acoustic Doppler current profilers. The Tsushima Warm Current flowed into the East Sea and a part of the current formed the East Korea Warm Current (EKWC) that flowed northward along the east coast of Korea. The EKWC separated from the coast off Pohang and the Ulleung Warm Eddy circulated clockwise. Current speeds were abruptly reduced at a boundary between the Tsushima Warm Current Water and the East Sea Intermediate Water. Current directions were also changed at the boundary. Thus the effect of the warm eddy on the deep current was small, although potential temperature and salinity showed a warm eddy shape in the deep layer. The boundary that divides the upper and lower layers was matched with a level of sigma-0=26.9 kg/m^3. Mean speed of the upper layer was 20.56±12.73 cm/s while the lower layer was 7.11±3.98 cm/s. The most conspicuous current in the lower layer was inflow to the Ulleung Basin in the western part of Ulleung Interplain Gap. The Dokdo Abyssal Current, however, was not conspicuous compared with the inflow. Current speeds were nearly the same or decreased gradually with depth in the lower layer except at one station located in the mid-eastern part of Ulleung Basin.

POC-P5

Observation of an anticyclonic warm core eddy east of Japan

Vincent **Faure**[1], Ryuichiro Inoue[1], Shinya Kouketsu[1], Toshio Suga[1,2], Shigeki Hosoda[1] and Kanako Sato[1]

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Anticyclonic warm core eddies east of Japan are of particular interest because, among other reasons, they transport biomass of subtropical origin toward high latitudes. We observed an anticyclonic warm eddy east of Northern Japan at the Oyashio and Kuroshio Extension confluence using a cluster of profiling floats deployed near the eddy center. We obtained temperature, salinity and dissolved oxygen observations for a period of nearly 1 year (floats were released during 4 cruises) in the depth range 0–2000dbar with a 2-dbar vertical resolution. Eddy-trapped float trajectories were used to estimate the eddy ellipticity and center position. Sea surface height and sea surface temperature measured from satellites, and nearby Argo float data were also employed to complement the study.

The eddy formed just south of the Oyashio Front, after which it propagated over only short distances (about 200km). Its radius was about 100 km; the typical azimuthal surface velocity field was of the order of 0.25ms^{-1}. Its vertical baroclinic signature extended deeper than the 2000-dbar maximum depth reached by the floats.

The eddy interacted twice with an anticyclonic eddy similar in size, causing it to become more elongated. The first interaction had a limited effect on the eddy water mass properties. Following the second interaction, a cold/fresh signal in the eddy core suggests that waters from the subarctic gyre or Oyashio intruded the eddy. Subsequently, lateral exchanges between the warm/salty eddy core and colder/fresher subarctic waters were investigated by analyzing diapycnal variations of spiciness.

POC-P6

Variation of Sea Surface Salinity on the Southwestern coast of the East Sea since the first half of the 20th Century

Hee Dong **Jeong**, Sang Woo Kim, Jin Wook Lim, Yong Kyu Choi, Jeong Min Shim, Kee Young Kwon and Yong Hwa Lee

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Sea surface salinity off the eastern coast of Korea has remarkable seasonal variation with high values in the winter season and low ones in the summer season. This seasonal variation is caused mainly by the seasonal variation of the local precipitation and that of the fresh water discharge from the Yangtze River. Recently, we found that the North Korean Low Saline Surface Water, which initiates from the tip of the northeastern coast of Korea and flows southward, contributes to the seasonal variations of surface salinity in the study area. In records from the 1930s, we also found a lower salinity, less than 34.00 from Feb. to Dec. off the coast of Hamgyeong-Do (Line A). An annual pattern of salinity distribution off the coast Jumunjin, Gangwon-Do (Line C) is closer to that of Hamgyeong-Do than to that of the Pohang coastal area in Kyeongbuk Province (Line E). This means that low salinity distributions off the middle eastern coast of Korea in the summer season during the first half of the 20th Century is the result of the southward flow of North Korean Low Saline Surface Water.

POC-P7

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

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A series of investigations on the early marine life of natural and farmed Pacific Salmon recruits was carried out in Prostor Bay in the Sea of Okhotsk (Iturup Island, Kurils) in 2013 and 2014. Field work included CTD observations at 185 stations in May and July of 2013 and 184 stations in May-June of 2014 which covered the entire bay and allowed us to assess spring as well as summer conditions. Measurements were taken at sections and polygons, most of which were repeated several times during every season. A cold intermediate layer existed within the bay during all examined seasons, and the surface layer heated slowly. The existence of a mixed layer was unusual, probably due to fast heat transmission into deeper layers. During south-eastern winds, which were characteristic approximately 20% of the time, the wide southern part of the bay was affected by upwelling. For instance, on 28th of May, 2014, a rapid upward motion of the 0°C isotherm was observed, and surface temperature dropped to 0.3-0.6°C, but two days later such a temperature submerged to the depth of 50-80 m. Surface horizontal temperature gradients in summer often reached 1 °C km^{-1}, reflecting a variable and patchy picture of temperature distribution. If we consider a temperature of 5°C as the lowest comfortable temperature for Pacific Salmon recruits, we canconclude that comfortable conditions for Pacific Salmon to mature in the bay can be as late as the middle of June.

POC-P8

Recent climatic tendencies over the Kamchatka Peninsula and adjacent waters

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We estimated the regional climatic tendencies over the Kamchatka Peninsula and adjacent waters using a regional data set on air temperature, wind speed and SST data in representative areas of the Okhotsk and the Bering seas. In most parts of the region a statistically steady decrease of the annual wind speeds is detected; however, on the east coast the tendency of increasing speeds is observed. The warming processes predominate throughout the Kamchatka, the most pronounced from 1981 to 1990. The most significant warming occurs on the west and east coasts, in the valley of Kamchatka River and in the mountainous region. Slight cooling is observed in the far-northern and north-eastern Kamchatka in the first half of the winter (December-January). The main feature of the changes in the adjacent waters is warming of the surface layer in April-December. In the area to the west from Kamchatka maximal warming occurs in April (0,3°C per decade) and October (0,21°C per decade). In the Bering Sea to the east from Kamchatka intensive warming is observed in October-December (0,16-0,22°C per decade). The large-scale climate indices such as PNA, WP, AL and Blinova's index related to the circulation and temperature regime in the Kamchatka most strongly. Besides, the linkages between the regimes of wind and air temperature and the regional "Bering Sea index" BI are revealed. BI is the pressure difference at the meteorological stations Korf and Bering Island characterizing the intensity of the zonal transport over the western Bering Sea. Natural climate variability under the influence of atmospheric circulation contributes to the recent warming on the Kamchatka differently in different climatic areas of Kamchatka.

POC-P9

Summer surface salinity variability in the Yellow and East China Seas: ENSO effects

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The Yellow and East China Seas (YECS) show interannual variability in both physical and biological aspects in relation with El Niño–Southern Oscillation (ENSO). We investigate the interannual variability of summer sea surface salinity (SSS) in the YECS and its linkage with ENSO, using a global ocean general circulation model (OGCM) with a regional focus on the YECS. The OGCM experiment reveals that the dominant interannual variability of the SSS in the YECS is attributed to a variability of the Changjiang River discharge (CRD). The variability of the CRD is linked to ENSO-related precipitation over the Changjiang River; when El Niño events occur in winter, precipitation over the Changjiang River increases in the rainy season of the following years. The increased precipitation in El Niño years results from enhanced southwesterly moisture flux from the South China Sea into southern China. In addition to salinity variability, increased CRD in El Niño years tends to increase Chl-*a* concentration by supplying more nutrients into the YECS, suggesting that the ENSO-related variability of CRD is likely to affect biological production in the YECS. Our finding suggests that ENSO contributes to interannual variability of both physical and biological processes in the YECS by modulating CRD through precipitation changes over the Changjiang River.

POC-P10

Changes in seasonal air temperatures and precipitation in the Far North-East of Russia

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We investigated the features of spatial-temporal distribution of air temperature (1950 to 2010) and precipitation (1963 to 2010) in the far North-East of Russia. The average annual air temperature varies from -12°C to -3°C over the area. The air temperature is the most stable during the cold period (CV is 10-20%), and is quite variable is in the summer months (CV often exceeds 100%). Over the past 60 years increasing temperature varies from 0.5 to 3.0°C. The greatest warming was observed in the north (by 3.0°C), then in the west (by 2.5°C), in the eastern and central regions the warming was about 1.5°C; the least amount of warming was in the southern region (1°C). The transitional seasons (spring and autumn) make the greatest contribution to the warming; in the summer this increase is not as large. In winter on the east and central part of the region there is, on the contrary, a decrease of temperature. Most precipitation falls in the southern and western regions (up to 69 mm); the most arid region is in the north (about 30 mm). The coefficient of variation is more than 50% in all seasons, indicating instability of the moistening regime over this area. The highest amount of precipitation is in the autumn and summer over the study area (from 20 mm in the central region to 68mm in the south). In other seasons it is not as large (from 7 to 15 mm in the central region and in the north, and from 15 to 28 mm in other areas). A negative trend is observed in the long-term course of precipitation except in the western region, which characterized by a weak positive trend. Precipitation has decreased from 2 mm in the north to 20 mm in the south over the past 58 years. The largest decrease occurred in the eastern region (20 mm) and the south (10mm). In the northern and central regions the precipitation decreased slightly (3mm) and in the western region there is a weak positive trend (4 mm).

POC-P11

Processes leading to the second-year cooling of the 2010-12 La Niña event, diagnosed using GODAS

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By using the Global Ocean Data Assimilation System (GODAS) products, oceanic processes the responsible for the second-year cooling of the 2010-12 La Niña event are examined; isopycnal analyses are performed to more clearly illustrate the three-dimensional structure and evolution of thermal anomalies in the tropical Pacific Ocean. A sequence is described to demonstrate how cold sea surface temperature (SST) anomalies (SSTAs) are generated in the central-eastern basin in the fall of 2011. In 2010-12, a horseshoe-like pattern is seen that connects negative temperature anomalies off and on the equator, with a dominant influence from the South Pacific. During the 2010 La Niña event, warm waters piled up at subsurface depths in the western tropical Pacific. Beginning in early 2011, these warm subsurface anomalies propagated along the equator toward the eastern basin, acting to reverse the sign of SSTAs there and initiate a warm SSTA; in mid-2011, near normal SST conditions were indeed seen in the eastern equatorial Pacific. However, throughout early 2011, pronounced negative anomalies persisted off the equator at subsurface depths in the South Pacific. As isopycnal surfaces outcrop in the central equatorial Pacific, negative anomalies from the subsurface spread upward along with mean circulation pathways, naturally initializing a cold SSTA. In the summer, a cold SSTA, which strengthened arising from the off-equatorial effects mostly in the South Pacific, re-appeared in the central basin. These SSTAs acted to initiate local coupled air-sea interactions generating atmospheric-oceanic anomalies that developed and evolved with the second-year cooling in the fall of 2011.

POC-P12

Coordinated international activities on the climate study of ocean-atmosphere interactions

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Historically CLIVAR, as one of the World Climate Research Programme's (WCRP) core projects, has worked towards the coordination of regional and global scientific projects directed at increased understanding and prediction of the physical processes that control the ocean's role in atmospheric climate. These studies include timescales from subseasonal to centennial. This year has been a year of changes and challenges. CLIVAR, now named "Climate and Ocean: Variability, Predictability, and Change" project, has gone through an organizational restructure which has responded to the discussions of WCRP's definition of the scientific grand challenges. These will guide and focus the developments of climate research for the next 5-10 years. As part of the new structure and the greater focus on ocean-atmosphere interaction that CLIVAR will have, implementation of its main objectives requires some specific challenges to be addressed. In order to facilitate the international coordination of those, CLIVAR has established the possibility for the community to define and implement Research Foci. These Research Foci provide the CLIVAR project with the ability to remain flexible in the changing landscape of scientific research priorities, whilst the traditional CLIVAR panels maintain a focus on the core activities critical to advancing CLIVAR and WCRP goals. The currently seven Research Foci are:

- Intraseasonal, seasonal and interannual variability and predictability of monsoon systems
- Decadal variability and predictability of ocean and climate variability
- Science Underpinning the Prediction and Attribution of Extreme Events
- Marine biophysical interactions and dynamics of upwelling systems
- Dynamics of regional sea level variability
- Consistency between planetary heat balance and ocean heat storage
- ENSO in a changing climate

More detailed information can be found on CLIVAR's website (http://www.clivar.org/science/clivar-research-foci).

POC-P13

Cyclone statistics in northwest Pacific and relationships with climate factors

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The extra tropical cyclone in northwest Pacific is one of the most important synoptic weather systems in Northern Hemisphere. It plays an important role in the general atmosphere circulation as well as in mid-high latitude atmosphere-sea ice-ocean interaction. Better understanding the characteristics of temporal and spatial distribution of these cyclones and the relationship between cyclones and Northern Hemisphere atmospheric, oceanic and climate factors is of great significance to our knowledge of the weather and climate in the Northern hemisphere.

In this study, we investigate the extra tropical cyclones in north- west Pacific .The 6-hour sea level pressure from the European Centre for Medium-Range Weather Forecasts (ECMWF) ERA-Interim reanalysis for the period of 1979-2013 was studied using automated cyclone detection and tracking algorithm developed by the University of Reading. We focus on the cyclones that have life time longer than 2 days and at least 1000km moving distance. We have identified various characteristics of the cyclone, such as source (total numbers), distribution, intensity, frequency, life time, annual and seasonal variability. The relationship between cyclone anomalies with AO, ENSO and the SST gradient were also investigated.

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Matthew R. <u>Baker</u>

GP-P1

Competition between the bloom-forming dinoflagellates *Prorocentrum donghaiense* and Karenia mikimotoi under phosphorus limitation and at different temperatures

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Prorocentrum donghaiense and *Karenia mikimotoi* are major harmful algal blooms dinoflagellates species in coastal waters of the East China Sea in spring, which have occurred annually since 2000 and 2004. Competition between *P. donghaiense* and *K. mikimotoi* was investigated using bi-algal cultures under phosphorus limitation at different temperatures. When the temperature of culture was 16°C, the growth of *P. donghaiense* was suppressed by *K. mikimotoi* in the initial density ratios were 2:1 and 1:1, and the growth of *K. mikimotoi* was suppressed by *P. donghaiense* in the initial density ratios was 1:2. When the temperature of culture was 20°C, the growth of *P. donghaiense* was suppressed by *K. mikimotoi* in the initial density ratios were 2:1, 1:2 and 1:4. When the temperatures of culture were 24°C and 28°C, *P. donghaiense* was affected by *K. mikimotoi*, but *K. mikimotoi* was not affected by *P. donghaiense* at any of the initial density ratios. The results reveal that the initial cell density and the temperature are important factors that influence *P. donghaiense* and *K. mikimotoi* competition in phosphorus-limiting conditions. In addition, long-term data indicates that the mean surface sea temperatures when *P. donghaiense* bloomed, *P. donghaiense* & *K. mikimotoi* bloomed and *K. mikimotoi* bloomed occur were 20.30°C, 20.79°C and 23.42°C, respectively. Combining with the laboratory and field results, *K. mikimotoi* has a superior survival strategy to that of *P. donghaiense* in both of bi-algal cultures and its marine habitat in phosphorus-limiting conditions at the higher temperature.

GP-P2

Features of distribution of some flying fishes of the genera *Exocoetus*, *Hirundichthys* and *Cypselurus* in the World Ocean

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Taxonomic studies of the flying fishes of genera *Exocoetus*, *Hirundichthys* (subgenus *Hirundichthys*) and *Cypselurus* ("*C. poecilopterus*" species group) have made it possible to define more exactly areas of species and subspecies of these groups. Ranges of *Exocoetus* species (except *E. volitans*) are largely determined by surface water circulation. *E. gibbosus* inhabits waters of south subtropical gyre of the Pacific (and, presumably, the Indian) Ocean to the south of southern subtropical convergence (SSTC, see Burkov *et al.*, 1973), whereas *E. monocirrhus* in the Pacific and Indian oceans dwells to the north of SSTC. *E. gibbosus* inhabits waters where eastern flows prevail and *E. monocirrhus* inhabits waters of the South Equatorial Current where the westward flows prevail. Only in the areas with northern or southern meridional currents these two species cross the convergence. *E. peruvianus* is found in waters of the southern Pacific tropical cyclonic gyre. Atlantic species *E. obtusirostris* inhabits waters of southern and northern subtropical gyres (like *E. gibbosus* mainly to the south (north) of convergence) as well as in waters of southern and northern tropical cyclonic gyres. The boundary between areas of subgenus *Hirundichthys* species passes along the border between nerito-oceanic and oceanic areas. *H. speculiger* and *H. indicus* occur mostly in open ocean waters. *H. oxycephalus* and *H. affinis*, by contrast, dwell mainly in neritic and nerito-oceanic areas. Distribution ranges of species and subspecies of "*C. poecilopterus*" group are critically influenced by surface salinity and distance from shores. Boundary between species areas rather well matches 35.0‰ isohaline.

GP-P3

Comparison of various exposure test method for oil

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Oyster, a representative filter feeder is commonly used for environmental monitoring. After the Hebei Spirit Oil Spill (HSOS), long term monitoring of petrogenic PAHs using oyster showed persistently high concentration for more than one year which could not be explained by the traditional oil exposure scenario. This study aimed to compare various exposure methods including water accommodated fraction (WAF), mechanically dispersed oil (MDO), and oil-SPM aggregates (OSA), and to measure petroleum hydrocarbons accumulated in oyster according to exposure method. Oil concentrations used were 24 g/l for WAF and MDO, 0.12 g/l for OSA respectively. Oysters were exposed to WAF, MDO and OSA for 48 hours and this test was performed in triplicate. Concentration of petroleum hydrocarbons (TPH, UCM, 16 PAHs, alkyl PAHs) in oysters exposed were in the order of MDO>OSA>WAF. Accumulated concentrations of TPH and PAHs in oysters exposed to OSA were as high as half of those exposed to MDO although only 1/200 of oil was used for OSA. This result implied that OSA is more vulnerable form of exposure to filter feeding oyster. Composition profiles of petroleum hydrocarbons in oyster exposed to MDO and OSA were similar with exposed oil. This similarity was also found at field collected oysters right after the spill. Meanwhile, oysters exposed to WAF only showed low molecular weight hydrocarbons with relatively high solubility. Oil fingerprinting ratio plots revealed that oysters exposed to MDO and OSA has similar composition profiles that of oil. These results suggest that right after the spill, intertidal oysters were exposed to dispersed MDO or OSA. OSA could be preferentially formed in the turbid environment, and our study revealed that OSA may act as a continuous route of exposure to filter feeders.

GP-P4

Data site of atmospheric and oceanic CO_2 observation for the Ship-of–Opportunity program of NIES

Chisato **Wada**[1], Yukihiro Nojiri[1], Shin-ichiro Nakaoka[1], Sumiko Harasawa[1], Sayaka Yasunaka[2], Chihiro Miyazaki[3], Hiroshi Tanimoto[1], Hideki Nara[1], Fumiyoshi Kondo[1], Yasunori Tohjima[1], Yukio Terao[1], Toshinobu Machida[1] and Hitoshi Mukai[1]

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National Institute for Environmental Studies (NIES) has carried out atmospheric and oceanic CO_2 observations by the Ship-of-Opportunity program between Japan and North America (1995−present), between Japan and Oceania (2003−present), and between Japan and South-Eastern Asia (2007−present) utilizing volunteer cargo ships with supports of shipping companies.

NIES observation data can be used through the website of NIES Ship-of-Opportunity (SOOP: http://soop.jp) which was designed for quick data release.

At present, SOOP has provided about 1,010,000 atmospheric CO_2 data and 630,000 oceanic CO_2 data obtained from 920 cruises. These data are available as individual cruise data. The individual cruise data provide access to the route map and plots of ocean pCO_2 and air xCO_2 averaged values. In addition, pCO_2, and DIC mapped data are also available in the website. In this meeting, we will introduce web site of atmospheric and oceanic CO_2 data for SOOP.

GP-P5

Monthly variations in proximate composition of Japanese jack mackerel (*Trachurus japonicus*) in the South Sea of Korea

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In general, the analysis of length/weight of fish gives a good indication for the general condition of the fish population. However, proximate analysis for the determination of proportions of proteins, water, lipids and ash of a fish tissue provides a very powerful insight to obtain fitness information for the fish population being studied. In this study, the proximate compositions of water, lipids, proteins, and ash for *Trachurus japonicus* were analyzed using an original proximate analysis. Samplings were taken in the South Sea of Korea during May to November, 2013. Each proximate composition of the jack mackerel ranged from 64.41 to 82.83 % (mean±S.D=70.69±4.85%) for water, 0.77 to 7.16% (mean±S.D=3.53±2.12 %) for lipids, 12.33 to 28.06% (mean±S.D=22.07±3.71%) for proteins, and 2.28 to 4.88% (mean±S.D=3.71±0.68 %) for ash, respectively. During the study period, protein and ash contents were highest, whereas lipid content was lowest on May. Generally, the proteins decreased from May to September and then increased until November, whereas the lipid pattern was opposite to that of proteins. Based on Pearson's correlation analysis, lipid contents had negative correlations with protein contents (r=-0.725, n=14, p<0.01) and ash (r=-0.648, n=14, p<0.05) on dry weight. Overall, lower lipid contents during May and June were consistent with the spawning season reported previously since they normally use lipids for their spawning.

GP-P6

The comparison of the remote sensing reflectance empirical orthogonal functions for the Russian Far Eastern Seas

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The optical properties of the water in the Russian Far Eastern Seas are influenced by many factors. From the optical point of view such water types are called case 2 water. A number of statistical and analytical methods are used in the satellite remote sensing for the description of the optical properties variability and for searching the relations between the water optical properties and the availability and concentration of the water constituents. One of them is the statistical approach based on the empirical orthogonal functions (EOF) analysis, also called the principal component analysis (PCA). The essence of the method is to represent each measured spectrum as a vector in a multidimensional space with the empirical orthogonal functions as a basis. The choice of EOFs – normalize eigenvectors of the remote-sensing reflectance covariance matrix – depends on the measured set of data. However, if the annual set of the remote sensing reflectance is used to calculate the covariance matrix, there is a hope that the most part of variability is taken into account. The main features of empirical orthogonal functions of remote sensing reflectance for the Japan/East Sea, the Sea of Okhotsk and the Bering Sea are presented. The annual sets of MODIS Aqua data are used for each sea. The time period is 2003–2013 years. Before the covariance matrix calculation, each spectrum is normalized by its integral. The comparative analysis of the results shows that in main features the empirical orthogonal functions are close for all seas.

GP-P7

New method for making the decision of trophic position of Pacific salmon based on both stomach contents survey and stable isotope analysis

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Known trophic position (previous TP) of a consumer was estimated from fixed trophic level and $\delta^{15}N$ of a prey baseline (*e.g.*, Trophic position = (($\delta^{15}N_{consumer}$ - $\delta^{15}N_{baseline}$)/3.4) + 2; Vander Zanden *et al.* 2000). However, Pacific salmon, *Oncorhynchus* spp., fed on several prey animals which differed trophic positions such as phytoplanktivores and zooplanktivores (Kaeriyama *et al.* 2004). Thus, we expanded upon the formula of trophic position for Pacific salmon (*Salmon TP*) as mentioned below; Prey baseline TL = $\Sigma(TL_i \times P_i)$, Prey baseline $\delta^{15}N = \Sigma(\delta^{15}N_i \times P_i)$, Salmon TP = (Salmon $\delta^{15}N$ – Prey baseline $\delta^{15}N$) / 3.4 + Prey baseline TL, where P_i, TL_i and $\delta^{15}N_i$ are percentage, trophic level, and $\delta^{15}N$ of a prey species *i* in the stomach contents. The trophic position of each species in sockeye (3.8), chum (3.5), and pink salmon (3.5) indicated fixed values in the North Pacific Ocean ecosystems except for the northern Bering Sea. Based on the new Salmon TP, the previous TP indicated underestimate for piscivores, while overestimate for zooplanktivores.

GP-P8

Modeling surface ocean CO$_2$ variations by a feed-forward neural network: 1990-2011

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Obtaining accurate surface ocean CO$_2$ distributions plays an important role in estimating the contribution of oceans to the global carbon budget. We applied a feed-forward neural network (FNN) to model monthly CO$_2$ variations in the global oceans as a nonlinear function of month, latitude, longitude, sea surface temperature, sea surface salinity, and chlorophyll concentration. First, we used the FNN to estimate the long-term trend of CO$_2$ by recursively modeling the dependence of CO$_2$ on independent model variables, regressing the predicted CO$_2$ with time to obtain a trend, and then training the FNN with trend-removed CO$_2$. The procedures were ended when the difference between modeled and observed CO$_2$ became stable. Then, we normalized the CO$_2$ in 1990 to 2011 to the reference year 2000 and used the yielded CO$_2$ climatology to obtain a working FNN for making prediction. Finally, the working FNN was used to estimate monthly CO$_2$ in 1990 to 2011 using the estimated trend and the time variant sea surface temperature. The results agree well with both the scattered measurements and the CO$_2$ product of Lamont-Doherty Earth Observatory for year 2000, which is currently the most frequently used product. We compared the FNN results with those obtained by using a self-organization map, another type of neural network, for the Pacific. The overall difference is small. Our model indicates that while the annual global ocean CO$_2$ update remained at the level of 2.3 PgC yr^{-1} from 1990 to 2001, the uptake gradually increased to 3.3 PgC yr^{-1} in 2011.

GP-P9

Did farmed Coho salmon that escaped by the earthquake and tsunami disaster of 2011 affect native salmon?

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By the Great East Japan Earthquake of March 11, 2011, several million farmed coho salmon (*Oncorhynchus kisutch*) escaped in the Northeast Pacific Ocean, Tohoku, Japan. In the fall of that year, sexually mature coho salmon migrated up rivers in this area. Farmed coho salmon that migrate up rivers to breed may affect the genetic material of native salmon species and result in weakened populations. Especially, there is strong concern that coho salmon may cross with the native masu salmon (*Oncorhynchus masou*); it is known that hybrids of these species have survivability. Assuming that hybrids are present, it is unclear how many years they will need to mature. However, based on the maturation age of both species, the possibility that hybrids return in spring 2014 is considered to be high. In this study, we surveyed masu salmon landed at a local fish market, using genetic and morphological methods in order to determine whether there are hybrids. And we also surveyed whether there are naturally-spawning coho salmon. As a result, hybrids were not found in this survey. Therefore, at this moment the impact on the genetic resources of masu salmon considered to be least. However a few naturally-spawning coho salmon were detected. There is a need to carefully monitor the occurrence of hybrids in the future.

GP-P10

Swimming types selectivity of ribbonfish revealed by acceleration data-logger

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Most fish species select more effectively swimming types for their energy and feeding tactics. In general, fish swimming types have been classified into BCF (greater thrust and acceleration by Body and/or Caudal Fin movement) and MPF (slow speeds and greater maneuvering by Median and/or Paired Fin propulsion). Swimming of ribbonfish (*Trichiurus lepturus*) by undulating dorsal fin known to be composed a swimming with horizontal pitch angles and vertical pitch angles while heading up. However, kinematic characteristics of these swimming types and the influence by selectivity of swimming types are not clear. In this study, we evaluated kinematic characteristics of ribbonfish using acceleration data-logger in the laboratory experiment. Ten adult ribbonfish were collected and measured their swimming (angle, speed, cycle, and duration) in the water tank using two-dimensional acceleration data-logger and digital video camera. In the results of experiment, ribbonfish mainly hovered and swam by slow speed with vertical or median angles (ave. ± sd., 83.9°± 4.4, 47.0°±7.6), while sometimes accelerated with horizontal angles (25.5°±3.4). From these result, it is considered they mainly selected MPF and sometimes used BCF as responding to some situations. The recent study showed the ribbonfish have a diurnal pattern, which stay at sea bottom in day time while disperse at surface to forage in night time. Our study suggested that they hovered and swam by slow speed for resting in day time and sometimes accelerated for efficient foraging in night time.

GP-P11

Status of abalone resources before and after the Great East Japan Earthquake along the coast of northeastern Japan

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In the rocky shore along the northeastern coast of Japan, fisheries for purposing abalone are operated. The major fisheries are skin diving and hooking by rod. Fishery rights for coastal stationary resources are managed by local fisheries cooperative associations, and the only members of the coop can fish. Opening days, operating hours, size limitation and fishing gears are tightly controlled in many areas, but volume control system such as IQ and TAC are not generally adopted. On the other hand, artificially produced juvenile of abalone have been stocked for resources enhancement widely; the ratio of released animals among landed abalone has been around 40%.

On March 11, 2011, significant depletion of 2009 and 2010 year class juvenile was caused by the Great East Japan Earthquake. Furthermore, abalone hatcheries were destroyed and enhancement projects were forced to abort for three years. Since the age at first capture is around 5-year-old, the reduction of resources through the years after the earthquake is concerned.

We evaluated stock abundance of adults before and after the earthquake on some districts by using maximum likelihood estimation method of the DeLury (Akamine 1992) on the basis of the catch and vessel-days data in 1989-2013.

As the results, the stock abundance of adult was comparatively stable before and after the earthquake, and there were no signs of overfishing during the years. Future, the abundance will be gradually decreased with the recruits of the affected year class.

GP-P12

Balloon effects in marine capture fisheries

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We are examining the evidence for a series of so-called "balloon effects" in marine fisheries as well as their impact on the stability of cooperative agreements and sustainable fisheries management. The term "balloon effect" has been used to describe large-scale displacement of activities, often as the unintended result of targeted control measures. Most notably, balloon effects have been observed as a result of anti-trafficking activities that have caused the displacement of illicit activities into areas of limited statehood, leading to increased instability. In this study, we introduce a typology for several categories of balloon effects, including notable examples from the North Pacific. One such example is the collapse of the Alaska Pollock fishery in the 1990s within the international waters of the Donut Hole due to displacement of fishing activities by distant water fishing fleets following the formalization of the EEZ boundaries of the USA and USSR. An initial survey conducted by the authors suggests at least three distinct types of balloon effects in the marine fisheries caused by institutional pressures, environmental pressures, and control/enforcement pressures. Among other things, this research aims to build on theoretical work from other disciplines in which such effects have been observed and studied, leading to a departure from targeted interventions in favor of regional approaches. In addition, this typology will contribute to enhanced global comparability of fisheries facing similar pressures in order to suggest appropriate and considered responses.

GP-P13

New insights on the life cycle stages of the ichthyotoxic dinoflagellate *Cochlodinium polykrikoides* Margalef

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The dinoflagellate *Cochlodinium polykrikoides* Margalef is the most notorious causative species of dense blooms that have occurred recently in many coastal areas of the world. These blooms have caused major economic losses to the aquaculture industry. For this reason, the physiological and ecological characteristics of *C. polykrikoides* have been frequently reported, however information on the life cycle stages is rather scarce. To provide the clear evidence for the life cycle of *C. polykrikoides*, in this study we investigated the morphological variability in the motile and resting stages using high-resolution time-lapse microscope, scanning electron microscope and nuclear staining techniques combined with traditional light microscopy. The vegetative cells collected from water column and germinated from resting cysts were cultured. During sexual reproduction, *C. polykrikoides* produced the isogametes, planozygotes and hyaline cells (temporary cysts), however resting cysts and armored cells, which is reported previously, were not observed in this study. The hyaline cells are immobile and surrounded by a thin transparent membrane. The size is similar to that of the motile cells, and only faint traces of the sulcus and the cingulum are present on the surface. Interestingly, two-cell chains of *C. polykrikoides* were continuously generated from the hyaline cells. Individual motile cells were not observed during the generation processes. Increase in hyaline cell production was higher under continuous dark condition, and the two-cell chains were generated in light condition within 12h. This results indicates that the hyaline cells can play an important role for the survival of *C. polykikoides*. These novel observations provide better understanding of the initiation and development of *C. polykrikoides* blooms.

GP-P14

Ocean surface *p*CO$_2$ and air-sea CO$_2$ flux distributions in the Pacific Ocean from 1998 to 2009

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This study produces monthly maps of the ocean surface partial pressure of CO$_2$ (*p*CO$_2$) in the Pacific from 1998 to 2009. The *p*CO$_2$ values are estimated by using a self-organizing map neural network technique to explain the non-linear relationships between observed *p*CO$_2$ data and four oceanic parameters: sea surface temperature (SST), sea surface salinity (SSS), mixed layer depth (MLD), chlorophyll *a* concentration (CHL). The observed *p*CO$_2$ data were obtained from Surface Ocean CO$_2$ Atlas (SOCAT) database version 2. The SST, SSS MLD datasets were obtained from the Mercator-Ocean global reanalysis and the Satellite CHL dataset were from MODIS-Aqua and SeaWiFS Level 3 standard products. Uniform increasing trend of *p*CO$_2$ in the whole of Pacific was evaluated thorough the SOM process. The calculated monthly *p*CO$_2$ distributions were not only similar to Lamont-Doherty Earth Observatory *p*CO$_2$ climatology, but also clearly reconstruct the difference of *p*CO$_2$ distributions in the eastern equatorial Pacific in 1998 of the El niño and 2008 of the La niña. We also present temporal and spatial variability in air-sea CO$_2$ flux in the Pacific Ocean and discuss its interannual variation.

GP-P15

Fecundity of *Archaeomysis vulgaris* in Hakampo beach on the west coast of Korea

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This study is indirectly understanding for inhabit in the surf-zone of *Archaomysis vulgaris* number of embryos and larvae in each stage showed monthly and seasonal variations, Fecundity for nature condition.

An ovigerous females of *A. vulgaris* was collected by a sledge net (0.3mm mesh) on surf-zone at depth of 30-100cm on each monthly the flood tide, 2011 in Hakampo, Chung-nam, Korea. The ovigerous females with embryos and larvae in the marsupium dissecting microscope (100x magnification) were counted as a development stage.

Fecundity measured in the female of the embryonic stage was 32 embryos per brood. The monthly appearance density of the larvae form May (spring) to September (summer) were higher, marsupium in the embryonic stage (38%) embryos and larvae showed that the highest, marsupium in the nauplioid stage and postnauplioid stage each showed 31%. The spring generation (34.5±1.9) produced more embryos than the overwintering generation (29.4±1.0). The embryos and larvae in marsupium of annual according to the each development stage was similar number of an individual. The number of embryos and larvae in each generation showed positive linear regression to the increase of carapace length of the female. The size of embryos and larvae were not difference in each generation.

GP-P16

Construction of advanced biologging systems for high rates of data-recovery - A challenging study to clarify the dynamics of fish populations and communities

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The monitoring of marine top predators, primarily fish species, provides important insights into marine ecosystems. Recently, biologging techniques involving electronic data-storage tags and acoustic transmitters have been increasingly used to understand migratory fish movements and behaviours. The number of tags, however, is normally limited due to costs, and the tag recovery rate is still low. In this study, therefore, to reveal the population and community dynamics of fishes in open waters, we will develop a new variety of small, low-cost, large-data-capacity and multifunctional tags, and implement the high recovery rate of the data. This study consists of the following four development: (1) two types of archival tags (small-sized tags and customizable-multifunctional tags), (2) the energy harvesting system installed in the tag, (3) the data receiving system onboard multi-platforms, and (4) the inter-individual communication system based on hydro-acoustic methods. Lastly, combining them, we will develop a new biologging system and test the practical utility of this system using wild herrings and bonitos in open waters off Japan. The new technology will overcome the bottleneck of conventional biologging techniques, and will lead to a breakthrough in marine ecosystem studies.

GP-P17

Data processing for atmospheric and oceanic CO$_2$ measurement by Voluntary Observing Ship

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NIES has been conducting atmospheric and oceanic CO$_2$ observation in the Pacific using VOSs since 1995. Data quality has been improved with the improvement of onboard measurement systems, auxiliary measurements, and data processing from the initial stage of the program to the present. Here, we show the recent instrumentation and data processing in the VOS program. Tandem-type-equilibrator installed on the vessels allows continuous measurements of surface seawater pCO$_2$. Seawater is continuously pumped to the equilibrator. Salinity is measured by two thermosalinographs to avoid measurement problem, typically by clogging of conductivity cell. Salinity is calibrated by bottle analysis. Atmospheric-pressure is one of the most important auxiliary measurements for calculating seawater pCO$_2$ from observed xCO$_2$ in the equilibrated air. For the purpose, barometers at the ship's bridge, seawater observation room, and pCO$_2$ equilibrator are calibrated with one another. Atmospheric-CO$_2$ is also measured. Four standard gases are fed to the infra-red analyzer both for atmospheric and oceanic CO$_2$ measurements. xCO$_2$ in the atmosphere and equilibrated air are calculated by calibration with least-square-fit of the quadratic of the standard-gas measurements. pCO$_2$ and fCO$_2$ are calculated from the calibrated xCO$_2$, calibrated pressure, salinity and temperature. Outliers are determined and eliminated after detection and careful evaluation. The final product is 10-minute averaged data set from 10 seconds data with standard deviations for each parameter. Data logging system are designed to archive all atmosphere and seawater measurements along with GPS time and position. According to the improvement of data processing scheme, prompt data upload is now operational.

GP-P18 (e-poster)

CDIAC data management support for ocean carbon dioxide measurements

Alex **Kozyr**[1] and Robert Key[2]

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Rising atmospheric CO$_2$ and climate change are increasing ocean temperatures and affecting ocean chemistry (*e.g.*, ocean acidification). Monitoring these important changes using ships and other platforms generates large amounts of data from heterogenous sources. Since its inception in 1993, when it became a member of the DOE/NOAA Ocean Carbon Science Team engaged in the World Ocean Circulation Experiment (WOCE), the CDIAC Ocean Carbon Data Management Project has been organizing, quality assuring, documenting, archiving and distributing ocean carbon-related data collected via a number of U.S. and international ocean-observing programs.

CDIAC's ocean carbon data collection includes discrete and underway measurements from a variety of platforms (*e.g.*, research ships, commercial ships, buoys). The measurements come from deep and shallow waters from all oceans. Technological advances make it possible to deliver ocean carbon data real-time but questions about instrument reliability and data quality limit this practice at this moment. All ocean carbon data CDIAC receives come from individual investigators and groups following initial data review.

GP-P19

North Pacific Research Board investment in integrated ecosystem research – the Arctic

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The North Pacific Research Board (NPRB) supports integrated ecosystem research to further mechanistic understanding of critical processes in marine ecosystems and to investigate the influence of human impacts and natural variability. In 2007 NPRB developed the Bering Sea Project in partnership with the National Science Foundation (NSF) and in 2010 launched the Gulf of Alaska Project. These are multidisciplinary integrated regional-scale investigations on the fundamental structure and function of systems to understand populations they support. NPRB is now developing an Arctic Program in the northern Bering and Chukchi Seas. Research will explore how physical processes (*e.g.* sea ice, advection, wind, seasonal patterns and reset) define temporal or spatial hotpots, influence benthic-pelagic coupling, and determine distribution and phenology of keystone and subsistence species. The program will examine patterns in subsistence use, thresholds and tipping points, networks and interactions, and physical, biological and ecological drivers. NPRB aims to inform baseline understanding of current processes at multiple scales (*e.g.*, analyses of localized phenomena to synthesis with global climate models) and how systems might shift in the context of a changing climate. To leverage resources, NPRB aims to provide a coordinating role in partnership with multiple organizations and agencies to develop common research priorities and objectives, ensure collaborative and directed research, enable data sharing, and promote integration and synthesis. NPRB is actively interested in opportunities for partnership, including international collaborations (*e.g.*, RUSALCA) and comparisons between the US Arctic and other regional Arctic seas (*e.g.*, Barents Sea Nansen's Legacy Project).

GP-P20

North Pacific Research Board investments in long-term monitoring in Alaska marine systems

Matthew R. **Baker**

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Understanding complex and dynamic marine environments and processes that drive them requires data that extends over long time frames. Long-term monitoring programs provide a useful tool to better understand system processes, assess resource trends, and evaluate effectiveness of management actions. The North Pacific Research Board (NPRB) has funded programs that support long-term monitoring, process studies and retrospective analyses through its annual Request for Proposals and its Integrated Ecosystem Research Programs in the Bering Sea and Gulf of Alaska. In 2014, NPRB launched a new program dedicated specifically to long-term monitoring to support new or existing time-series that contribute to understanding ecosystem variability and the effect of that variability on subsistence or commercial marine resources. Research is intended to be interdisciplinary, involve multiple trophic levels and evaluate ecosystem responses to changing ocean conditions. NPRB is currently supporting: (1) a North Pacific Continuous Plankton Recorder Survey that uses commercial ships to collect data on plankton and the physical environment along an east-west transect through the Aleutian Islands and southern Bering Sea and a north-south transect between Washington State and Alaska; (2) oceanographic observations and seabird and marine mammal surveys along the Seward Line in the Gulf of Alaska, and (3) a subsurface ecosystem mooring in the Chukchi Sea that measures physical, chemical and biological data throughout the year. This presentation highlights how long-term monitoring advances understanding of marine systems and how data has been applied in the programs that have existing time series.

W1

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

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

Co-Convenors:

Gerard DiNardo (USA)
Suam Kim (Korea)
Sei-Ichi Saitoh (Japan)
Cisco Werner (USA)

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

The goal of the workshop is to define a scientific framework to assess the dynamics of pelagic fish under climate/environmental variability. We will discuss the overlapping PICES and ISC science missions and outline a Science Plan for a multi-year collaborative effort. Climate variability affects pelagic fish distributions and migration, and ultimately pelagic fisheries, the level of impact depending on the persistence, direction, and magnitude of the variability. Survival and growth rates of pelagic fish are linked to oceanographic conditions, and changes to these conditions can have dramatic impacts on the composition of species assemblages within pelagic ecosystems, as well as the persistence and magnitude of individual pelagic fish populations. Understanding the links between environment and pelagic fish behavior, growth, recruitment, and production are paramount to understanding the impacts of climate variability. Pelagic fishes occupy surface waters of the North Pacific Ocean, from coastal shelf to open ocean ecosystems. Many of these species undertake large-scale feeding, spawning, and ontogenetic migrations linked to seasonal changes in water masses. For example, Pacific bluefin tuna use waters off Japan as a nursery habitat, undertaking an ontogenetic movement eastward to waters off North America where they remain as subadults for 2-3 years. Additionally, many pelagic species have environmental thresholds and preferences which limit the spatial distribution of a species. The most important environmental factors include oxygen, salinity and temperature, and because these factors generally exhibit persistent spatiotemporal patterns, the general distribution of pelagic fishes is known. Knowledge of these relationships allows for the incorporation of climate change into stock assessments, which forms the basis for fisheries management.

Day 1, Thursday, October 16 (09:00-17:15)

09:00   ***Introduction by Workshop Convenors***

09:15   **An ecosystem and optimisation framework for fish population dynamics assessment under the influence of fishing and climate (Invited)**
Patrick <u>Lehodey</u>, Inna Senina, Anne-Cecile Dragon, Anna Conchon, Olivier Titaud, John Hampton, Simon Nicol, Teja Arief Wibawa, Beatriz Calmettes, John Sibert, Hidetada Kyiofuji, Mélanie Abécassis, Olga Hernandez and Philippe Gaspar

09:50   **The International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean**
Gerard T. <u>DiNardo</u>

10:15   **Review of PICES/FUTURE and relation to ISC**
Suam <u>Kim</u>

10:40   ***Coffee/Tea Break***

11:00   **A review of CLIOTOP and related research programs in the North Pacific**
Francisco E. <u>Werner</u>

11:25	**Modeling the Pacific Ocean: Present capabilities and challenges for the next decade in relation to pelagic ecosystems** Enrique <u>Curchitser</u>
11:50	**Oceanographic influences on albacore distribution in the Northeast Pacific: Importance of open ocean and coastal frontal zones** Steven L.H. <u>Teo</u>, Yi Xu, Karen Nieto, Sam McClatchie and John Holmes
12:15	*Lunch*
14:00	**Abundance and growth of larval Pacific anchovy in different water masses and relationship between its growth and sea temperature in the southern waters of Korea** Joon-Taek <u>Yoo</u> and Su-Kyung Kim
14:25	**Projected responses of the central North Pacific pelagic ecosystem to climate-induced changes in micronekton communities** C. Anela <u>Choy</u>, Phoebe Woodworth-Jefcoats and Jeffrey J. Polovina
14:50	**Prominent meanders of the Sub-Tropical Counter Current and pelagic fish catch** Daisuke <u>Hasegawa</u>, Satoshi Mitarai and Koichi Hirate
15:15	*Coffee/Tea Break*
15:30	**Simulation study on the distribution of skipjack tuna in relation to Fish Aggregating Devices (FADs) during ENSO** Eunjung <u>Kim</u> and John R. Sibert
15:55	**The relationship between ecological characteristics of Pacific bluefin tuna (*Thunnus orientalis*) fisheries and environmental factors around Jeju Island** Ari <u>Shin</u>, Sang Chul Yoon and Suam Kim
16:20	Discussion and preparation of questions and charge for Day 2
17:15	*Workshop Ends*

Day 2, Friday, October 17 (09:00-17:15)

09:00	Review of Day 1
09:30	Discussion and preparation of outline for Draft Science Plan
12:00	*Lunch*
12:30	Writing groups meet
15:15	*Coffee/Tea Break*
16:30	Report out
17:15	*Workshop Ends*

W1 Workshop Oral Presentations, Day 1

October 16, 09:15 (W1-9753), Invited

An ecosystem and optimisation framework for fish population dynamics assessment under the influence of fishing and climate

Patrick **Lehodey**[1], Inna Senina[1], Anne-Cecile Dragon[1], Anna Conchon[1], Olivier Titaud[1], John Hampton[2], Simon Nicol[2], Teja Arief Wibawa[1], Beatriz Calmettes[1], John Sibert[3], Hidetada Kyiofuji[4], Mélanie Abécassis[5], Olga Hernandez[1] and Philippe Gaspar[1]

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[3]   SOEST, University of Hawaii at Manoa, Honolulu, USA
[4]   National Research Institute of Far Seas Fisheries (NRIFSF), Shimizu, Shizuoka, Japan
[5]   Pacific Islands Fisheries Science Center, Ecosystems and Oceanography Division, Honolulu, USA

A modelling framework is presented to predict and analyze the spatial dynamics of marine exploited and protected fish species with mechanisms constrained by relationships based on the bio-physical environment predicted from coupled 3D models of ocean physics and biogeochemistry. The development of an optimization approach based on Maximum likelihood techniques and adjoint model provides a robust approach to estimate density distributions of functional groups of zooplankton, pelagic micronekton and of all cohorts of the exploited age-structured fish population simulated, from larvae to oldest adults, using all available data (acoustic, catch and effort, size frequencies, tagging data, eggs and larvae densities). The simulation framework allows reconstructing past history of fish population, to dissociate fishing impacts from natural variability, and to forecast population dynamics under climate change based on IPCC scenarios of release of greenhouse gases. This spatial Eulerian ecosystem and population dynamics model (SEAPODYM) is based on advection-diffusion equations simulating random and oriented movements. Then spatio-temporal dynamics of species of interest are simulated under the influence of environment and fishing pressure. Surface currents passively transport larvae, while young and adult fish movements are driven using habitat indices. A description of multiple fisheries with spatially disaggregated fishing data (effort, catch size frequencies of catch) is included in the model. This model has been used to obtain optimized parameterization and quantitative stock estimates for several tuna species (Pacific skipjack, yellowfin, bigeye and swordfish, and south Pacific and North Atlantic albacore) over past and present fishing periods. Projections under Climate Change scenarios were also explored using forcing variables from Climate Models.

October 16, 09:50 (W1-9786)

The International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean

Gerard T. **DiNardo**

Daniel K. Inouye Regional Center, Honolulu, HI, USA. E-mail: Gerard.DiNardo@noaa.gov

The International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC) was established in 1995 to provide scientific advice on the stocks and fisheries of tuna and tuna-like species in the North Pacific Ocean to the Member governments and regional fisheries management organizations. The two main goals of the ISC are (1) to enhance scientific research and cooperation for conservation and rational utilization of the species of tuna and tuna-like fishes that inhabit the North Pacific Ocean during a part or all of their life cycle; and (2) to establish the scientific groundwork for the conservation and rational utilization of these species in this region. Research is facilitated through the establishment of Working Groups that focus on understanding the dynamics and ecology of highly migratory species (HMS) and associated-species populations, in order to accurately assess stock condition and status. The structure and function of ISC will be presented, as well as current stock assessment modeling structures used to assess HMS stock status and condition. While considerable uncertainty exists in all assessments, uncertainty may be reduced through the incorporation of environmental data into assessment models. Potential ways of integrating environmental data into the assessments and possible benefits will be presented.

October 16, 10:15 (W1-9784)

Review of PICES/FUTURE and relation to ISC

Suam **Kim**

Dept. of Marine Biology, Pukyong National University, Busan, R Korea. E-mail: suamkim@pknu.ac.kr

PICES, the North Pacific Marine Science Organization, is an intergovernmental scientific organization that promotes and coordinates marine research activities in the northern North Pacific to achieve scientific knowledge about the ocean/climate environments, their ecosystems including living resources, and the impacts of human activities. Joint efforts by international organizations are recommended. This presentation reviews the structure of the PICES, and summarizes the routine processes to form expert groups. Details on the functions, membership and leadership of various Expert Groups (Sections, Working Groups, Advisory Panels, Study Groups, *etc.*) will be introduced with some historic and existing examples within PICES. The possibility of cooperative activity with ISC will be discussed, especially focusing on scientific framework to assess the dynamics of pelagic fish under climate/environmental variability.

October 16, 11:00 (W1-9782)

A review of CLIOTOP and related research programs in the North Pacific

Francisco E. **Werner**

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A review of the CLIOTOP (CLimate Impacts on Oceanic TOp Predators) and related programs http://www.imber.info/index.php/Science/Regional-Programmes/CLIOTOP will be presented to provide background of advances in the understanding of physical forcing on the structuring of pelagic ecosystems, with particular attention to North Pacific systems. CLIOTOP, now part of the IMBER Program, was established during GLOBEC with the aim of coordinating large-scale worldwide comparative efforts aimed at elucidating the key processes involved in the impact of both climate variability (at various scales) and fishing on the structure and function of open ocean pelagic ecosystems and their top predator species. The discussion will include the present state of predictive capabilities for the dynamics of top predator populations and oceanic ecosystems that combines fisheries and climate (*i.e.* environmental) effects.

October 16, 11:25 (W1-9793)

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

Enrique **Curchitser**

Department of Environmental Sciences, Rutgers University, New Brunswick, NJ, USA. E-mail: enrique@esm.rutgers.edu

A review of the advances and present capabilities of basin-scale modeling of the North Pacific will be presented. Focus will be on the links between physical and ecosystem components, from lower trophic levels (biogeochemistry, primary and secondary producers) through to the spatially explicit inclusion of fish populations and fishing fleets. Selected examples will be presented on 50-year hindcasts of coastal pelagic species, as well as recently computed results of 100-year forward projections of the California Current Ecosystem under selected climate change scenarios. Finally, challenges for open-ocean/basin scale pelagic populations will be outlined and expected advances during the next decade discussed.

October 16, 11:50 (W1-9762)

Oceanographic influences on albacore distribution in the Northeast Pacific: Importance of open ocean and coastal frontal zones

Steven L.H. **Teo**[1], Yi Xu[1], Karen Nieto[1], Sam McClatchie[1] and John Holmes[2]

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Albacore tuna (*Thunnus alalunga*) is a highly migratory species found primarily in subtropical and temperate waters, and is the target for numerous, highly valuable fisheries. In the Northeast Pacific, albacore are caught in both open ocean and coastal waters but oceanographic conditions and influences on albacore distribution in these areas can be quite different. We examine the spatial and temporal patterns in albacore catch-per-unit-effort (CPUE) in relation to oceanographic conditions in the open ocean and coastal waters, especially the influence of fronts. Frontal features, as indicated by SST gradients, were highly influential on albacore distribution in both open ocean and coastal waters. In the open ocean, high albacore CPUE occurred in regions with high SST gradients like the North Pacific Transition Zone (NPTZ). In the NPTZ, albacore CPUE exhibited seasonal and interannual shifts in distribution that corresponded to shifts in the areas with high SST gradients. In coastal waters, albacore CPUE was highly influenced by SST and chlorophyll at fishing locations, albeit with substantial seasonal and interannual variability. Albacore CPUE was higher near warm, low chlorophyll oceanic waters, and near SST fronts. Model results appeared to be robust and model-predicted albacore CPUE were similar to observations but the model was unable to predict very high CPUEs in some areas. These results suggest that simple extrapolation of future SSTs under various climate change scenarios may not be enough to predict how albacore distribution may change under future climate change.

October 16, 14:00 (W1-9705)

Abundance and growth of larval Pacific anchovy in different water masses and relationship between its growth and sea temperature in the southern waters of Korea

Joon-Taek **Yoo** and Su-Kyung Kim

Yeosu, R Korea. E-mail: yoojt@korea.kr

We examined difference in the abundance and growth of larval Pacific anchovy estimated by RNA/DNA ratio in the water masses coming from the Tsushima Warm Current (TWC) and Changjiang Diluted Water (CDW), and the South Korean Water (SKCW) affecting oceanic environment in the southern waters of Korea in June. The larval anchovy was only collected in the water masses of the SKCW and CDW during the survey. No significant difference was recognized in the abundance between the two water masses, implying that the intrusion of the CDW to the coastal waters could be played a major role to increase abundance of tertiary producers such as fish larvae in coastal pelagic ecosystem. The mean RNA/DNA ratios of the larvae in the water mass of the CDW were higher than those in the water mass of the SKCW. A quadratic relationship between the mean RNA/DNA ratios and the sea surface temperature (SST) suggests that optimal growth temperature during the larval stages of Pacific anchovy in the western North Pacific would be found at SST of 21-22°C.

October 16, 14:25 (W1-9472)

Projected responses of the central North Pacific pelagic ecosystem to climate-induced changes in micronekton communities

C. Anela **Choy**, Phoebe Woodworth-Jefcoats and Jeffrey J. Polovina

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Ecosystem models have been widely used to examine potential food web impacts due to climate induced changes at the base of the marine food web, as well as top down changes induced by fishing removals. Here, we address potential ecosystem changes resulting from direct climate-induced impacts to micronekton food web components (small fishes, crustaceans, and cephalopods ~2-20cm that form the primary forage base for large pelagic fishes). We updated an existing Ecopath with Ecosim (EwE) model for the area of the central North Pacific occupied by the Hawaii-based pelagic longline fishery. Specifically, we focused on representation of the lesser known non-target fish species (*e.g.*, lancetfish, opah, snake mackerel) and mid-trophic micronekton. The model comprises 41 functional groups, organized into approximately five trophic levels where sharks and billfishes occupy the top of the pelagic food web. Detailed diet data argue for specialized niche partitioning amongst large commercially harvested fish species, suggesting that the central North Pacific pelagic ecosystem does not function according to 'wasp-waist' control, as has been previously described from other systems such as the California Current and eastern Australia. The relative impacts between key forage groups and key predators are also presented using EwE. Sensitivity analysis is used to project ecosystem impacts from climate-induced changes to the following micronekton groups: epi-/meso-/bathypelagic fishes, myctophids and gonostomatids epi-/mesopelagic molluscs, decapod crustaceans, and gelatinous zooplankton. Model results can help advance the understanding of overall ecosystem structure of different pelagic systems, particularly how biomass flows through diverse mid-trophic forage groups.

October 16, 14:50 (W1-9467)

Prominent meanders of the Sub-Tropical Counter Current and pelagic fish catch

Daisuke **Hasegawa**[1], Satoshi Mitarai[2] and Koichi Hirate[3]

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In December 2012, pelagic fish catch off the south east of *Ryukyu Islands* was extremely low. While we were trying to identify the reason of the poor catch, we found series of large low-pressure areas at the northern edge of the North Pacific Sub-Tropical Counter Current (STCC) system. The STCC strengthened and turned along the low pressure edges and caused remarkable meanders with meridional oscillations of O (1000 km) at the east of *Ryukyu islands*. The satellite sea surface height and the ship-based observation showed the strengthened STCC jet of the first meander, which reached 1 m/s at the surface associated with a quasi geostrophic density structure. The meander transported tropical water to the north and replaced the subtropical waters with warm and low salinity surface water and high salinity subsurface water. The AVISO time series of the surface geostrophic velocity indicated that this event associated with a meridional jet of O (1 m/s) extended from 20°N to 25°N was the first event ever happened in the last 20 years. The meridionally averaged kinetic energy time series of the area indicated the quick development of the strong meander around 138°E. The timings when the eddies strengthened and merged coincidentally overlapped when some of typhoons stagnated and passed above these cyclonic eddies. This fact suggests that the effect of the typhoon forcing contributed causing this rare STCC meander event.

October 16, 15:30 (W1-9700)

Simulation study on the distribution of skipjack tuna in relation to Fish Aggregating Devices (FADs) during ENSO

Eunjung **Kim** and John R. Sibert

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Tunas and other pelagic fish are often found in association with floating object and remain near the surface. Taking advantage of the behavior, fish aggregating devices (FADs, *i.e.* man-made floating objects) are commonly using for tuna fisheries. Nearly half of the world tuna catch is made from schools associated with FAD as a result of the prevalence in its use in purse seine fishery since early 1990s. Some studies estimated 47,000-105,000 of FADs put into the oceans each year. Drifting FADs (dFADs) are freely in ocean currents in the open ocean unlikely anchored FADs (aFADs) which are commonly found in the coastal waters. The dFADs can carry away the associated tuna with them by the current. The information on FADs is very limited because of the spatial and temporal variability. In this study, we analyzed the distribution of FADs using purse seine sets, and we simulated the distribution of skipjack tuna using the FAD advection-diffusion reaction model (FAD-ADRM) based on the distribution of FADs. In particular, we compared the distribution of skipjack tuna in ENSO and normal condition, which may show the impact of oceanographic change and human disturbance on skipjack tuna movement.

October 16, 15:55 (W1-9686)

The relationship between ecological characteristics of Pacific bluefin tuna (*Thunnus orientalis*) fisheries and environmental factors around Jeju Island

Ari **Shin**[1,2], Sang Chul Yoon[2] and Suam Kim[1]

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[2]   National Fisheries Research and Development Institute, R Korea

Pacific bluefin tuna (*Thunnus orientalis*) is one of the important species in the North Pacific as well as in Korea. Investigation on the important environmental factors for controlling the biology and fisheries of *T. orientalis* was carried out using Korean fishery statistics and climate and oceanographic information. Korean fishermen caught small pelagic fishes such as chub mackerel by offshore large purse seines, and *T. orientalis* accidently were caught mostly by this fishery. The monthly catch of *T. orientalis* around Jeju Island from 2004 to 2013 showed a negative correlation (r=-0.870, p<0.01) with the seawater temperature at 50 m and had a significant positive correlation (r=0.856, p<0.01) with the Pacific Decadal Oscillation (PDO) Index. The highest catch of *T. orientalis* around Jeju Island occurred in the seawater temperature range of 16-17°C or near the frontal area where offshore and coastal water masses collide. The length of *T. orientalis* ranged from 19 cm to 193 cm in folk length (FL). The mean length of *T. orientalis* in each year had a negative correlation (r=-0.592, p<0.01) with the seawater temperature at 50 m and had a significant positive correlation (r=0.688, p<0.05) with the PDO Index.

W2

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

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

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

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

Pacific salmon (genus *Oncorhynchus*) are an important ecological and economic species complex widely distributed throughout the North Pacific Ocean. In recent years, there have been large, often unanticipated, fluctuations in abundance and survival that may be climate-change related. Understanding the causes of variable salmon production will be critical to predicting future abundance levels and harvest opportunities. This has been a major concern for the North Pacific Anadromous Fish Commission (NPAFC), which has responsibility for scientific research and enforcement for conserving anadromous salmon and steelhead trout in the North Pacific Ocean.

This workshop is intended to build on recommendations from a report prepared by the NPAFC/PICES Study Group in the spring of 2014. The workshop will bring together researchers in fisheries and oceanography to improve understanding of the mechanistic linkages between salmon and their ecosystem. Of the many topics of overlapping interest between the two organizations, it is envisaged that this workshop will focus on one question: *Where do Pacific salmon go in the winter and why, and how might this be affected by climate change?* Prior to the workshop, salmon researchers will assemble information on where chum and perhaps pink and sockeye salmon are thought to live during the winter including depth, temperature and salinity. Oceanographers and climate specialists will be provided these data prior to the workshop so that they can do preliminary work on the extent of the habitats suitable for salmon, both currently and subsequently based on various scenarios of climate change.

Friday, October 17 (09:00-18:00)

09:00   ***Introduction by Workshop Convenors***

09:10   **Pacific salmon and steelhead: Life in a changing winter ocean (Invited)**
         Katherine W. <u>Myers</u>, James R. Irvine, Elizabeth A. Logerwell, Shigehiko Urawa, Svetlana V. Naydenko, Alexander V. Zavolokin and Nancy D. Davis

09:40   **Temporal and spatial variation in growth factors of Pacific Salmon**
         Hiromichi <u>Ueno</u>, Moeko Otani, Maki Noguchi Aita, Michio J. Kishi and Masahide Kaeriyama

10:10   **Is winter a critical period for Pacific salmon? A critical review of the "critical-period" hypothesis**
         Marc <u>Trudel</u> and James R. Irvine

10:30   ***Coffee/Tea Break***

10:50   **Russian research on winter dwelling of Pacific salmon in the central and western parts of the Subarctic Front zone**
         Svetlana V. <u>Naydenko</u>

11:10   **Distribution of Pacific salmon in the North Pacific Ocean & adjacent seas, with particular emphasis on winter**
David W. Welch, Yukimasa Ishida, Kazuya Nagasawa and Sonia <u>Batten</u>

11:30   **Distribution and trophic conditions of chum and pink salmon in the North Pacific Ocean during winter under climate change**
Shigehiko <u>Urawa</u>, Toshiki Kaga, Tomonori Azumaya, Shunpei Sato, Masa-aki Fukuwaka and Terry Beacham

11:50   **Winter mortality of Okhotsk Sea pink salmon in the ocean**
Alexander V. <u>Zavolokin</u> and Elena V. Strezhneva

12:10   **Impact of climate variability and change on winter survival of Bristol Bay sockeye salmon**
Edward Farley, Greg Ruggerone, Phil <u>Mundy</u>, Ellen Yasumiishi and Beverly Agler

12:30   *Lunch*

14:00   **Does physical environmental variation influence winter salmon habitat?**
Shoshiro <u>Minobe</u>

14:20   Open Discussion

15:30   *Coffee/Tea Break*

15:50   Open Discussion

18:00   *Workshop Ends*

W2 Workshop Oral Presentations

October 17, 09:10 (W2-9710), Invited

Pacific salmon and steelhead: Life in a changing winter ocean

Katherine W. **Myers**[1], James R. Irvine[2], Elizabeth A. Logerwell[3], Shigehiko Urawa[4], Svetlana V. Naydenko[5], Alexander V. Zavolokin[5] and Nancy D. Davis[6]

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[3]   NOAA Alaska Fisheries Science Center, Seattle, WA, USA
[4]   Salmon Resources Division, Hokkaido National Fisheries Research Institute, Fisheries Research Agency, Sapporo, Japan
[5]   Pacific Scientific Research Fisheries Centre (TINRO-Centre), Vladivostok, Russia
[6]   North Pacific Anadromous Fish Commission, Vancouver, BC, Canada

How Pacific salmon and steelhead (*Oncorhynchus* spp.) respond to seasonal and interannual changes in their marine environment is highly uncertain, in part due to limited information on ocean life history and ecology, especially during winter. We provide an overview of what is known and needs to be known about winter ocean life history and ecology of *Oncorhynchus* to address the central question of this workshop: *Where do Pacific salmon go in the winter and why, and how might this be affected by climate change*? Historical research programs (1950s-1980s) established the 'stock concept' of oceanic distribution of *Oncorhynchus*, determined the dominant oceanographic features (currents, water masses, temperature-salinity) in regions where *Oncorhynchus* migrate, and discovered that *Oncorhynchus* exhibit broad seasonal (north-south) movements, with most Bering Sea salmon overwintering in areas south of the Aleutian Islands chain during winter. In recent decades (1990s-2010s), new fisheries-oceanographic survey methods, stock-identification techniques, remote sensing technologies, and analytical methods have expanded understanding of winter ecology of *Oncorhynchus*, although empirical data are still very limited. In general, we learned that the "why" of ocean distribution of *Oncorhynchus* is complex and variable, depending on spatiotemporal scale and synergies among heredity, environment, population dynamics (abundance and density-dependence), and phenotypic plasticity (ability of an individual fish to alter its biochemisry, physiology, behavior, and life history in response to environmental stimuli and cues). The development of quantitative multispecies, multistage models of ocean distribution of *Oncorhynchus* would help to identify key factors influencing winter distribution and improve understanding of potential climate change effects.

October 17, 09:40 (W2-9495), Invited

Temporal and spatial variation in growth factors of Pacific Salmon

Hiromichi **Ueno**[1], Moeko Otani[1], Maki Noguchi Aita[2], Michio J. Kishi[1] and Masahide Kaeriyama[1]

[1]   Hokkaido University, Sapporo, Japan. E-mail: ueno@fish.hokudai.ac.jp
[2]   JAMSTEC, Yokohama, Japan

Pacific salmon occupy an important role as a keystone species in the North Pacific ecosystem. The abundance and survival of Pacific salmon vary at inter-annual to inter-decadal time-scales. They are related to variations in the physical environment of the North Pacific, especially sea surface temperature (SST), and many studies relate dominant patterns of SST variability in the North Pacific with Pacific salmon production. However, ecosystems in the subarctic North Pacific are also affected by more detailed oceanographic structures, *e.g.* mesoscale eddies, haloclines, temperature inversions, *etc.* This talk will discuss the physical environment in the subarctic North Pacific including these oceanographic structures especially in winter. We also investigate temporal and spatial variation in growth factors (temperature-dependence function and prey-density function for consumption) of Pacific salmon from the view point of bioenergetics. Zooplankton density obtained NEMURO embedded in a 3-D physical model is used for prey density and Empirical Orthogonal Function (EOF) analysis is conducted in the subarctic North Pacific. The first EOF mode for the prey-density function is related to the Pacific Decadal Oscillation.

October 17, 10:10 (W2-9439)

Is winter a critical period for Pacific salmon? A critical review of the "critical-period" hypothesis

Marc **Trudel**[1,2] and James R. Irvine[1]

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[2]   Department of Biology, University of Victoria, Victoria, BC, Canada

In a seminal paper published one hundred years ago, Hjort hypothesized that for Norwegian herring and cod stocks, year-class strength, defined as the abundance of a given cohort, was determined during a critical period very early in the fishes' life history. More recently, Beamish and Mahnken applied the critical period concept to Pacific salmon, proposing two marine critical periods: an early predation-based mortality that occurs during the first few weeks following ocean entry, and a starvation-based mortality period during the first fall and winter at sea. Because the susceptibility to predation and starvation is generally affected by size in fish, they further hypothesized that size-dependent mortality would be apparent in Pacific salmon during these critical periods. In this presentation, we review the research conducted on overwinter mortality of Pacific salmon during their first year at sea. Our review shows there is mounting evidence that overwinter mortality is size-selective in juvenile Pacific salmon. However, there is little evidence to date that year class strength is regulated by overwinter mortality for Pacific salmon. Further tests of the critical period hypothesis will require direct estimation of overwinter mortality over at least several years.

October 17, 10:50 (W2-9496)

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

Svetlana V. **Naydenko**

Pacific Scientific Research Fisheries Centre TINRO-Centre, Vladivostok, Russia. E-mail: naydenko@tinro.ru

Offshore waters of the North Pacific are the main ocean habitat of Pacific salmon during winter and spring periods. To understand the factors that influence survival of salmon during winter and spring in the open ocean, Russian research was conducted from 1986 to 1992 and in 2009, 2010 and 2011. It was established that the distribution of pink salmon and chum salmon is determined by the shape of the landscape zone favorable for their dwelling in winter-spring, which depends on the mode of the western Subarctic gyre in the Northwest Pacific, on the mode of the Subarctic Front, and on the intensity of the ocean branches of the East-Kamchatka Current and the Aleutian Current. In addition, the quantitative parameters of pink salmon distribution depend on fluctuations in its abundance between odd and even years. The results of plankton, nekton and trophological investigations indicate that there are sufficient forage reserves for salmon in the open ocean in winter and spring periods and that there is a lack of rigid limitation of salmon abundance by food. Analysis of the dynamics of the biochemical characteristics of juvenile Pacific salmon muscle tissue during autumn migrations to the Sea of Okhotsk and winter migrations to the northwestern part of the Pacific Ocean was done. As a result information about seasonal energetic reversions in the organism of juvenile Pacific salmon and about their strategic behavioral and biochemical adaptations in the course of the first year of life in the ocean was obtained.

October 17, 11:10 (W2-9529)

Distribution of Pacific salmon in the North Pacific Ocean & adjacent seas, with particular emphasis on winter

David W. Welch[1], Yukimasa Ishida[2], Kazuya Nagasawa[3] and Sonia **Batten**[4]

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[2]   National Research Institute of Far Seas Fisheries, Shimizu, Shizuoka, Japan
[3]   School of Biosphere Science, Hiroshima University, Higashi-Hiroshima, Japan
[4]   Sir Alister Hardy Foundation for Ocean Science, Plymouth, UK

The marine behaviour of Pacific salmon is poorly understood. Several publications in the last two decades have examined the thermal limits of salmon in the offshore. In this presentation we re-visit the complete 40 year dataset compiled by Welch *et al*. covering the period 1956-1996 (N=20,397 sampling locations). Plots of abundance show that the six species have different geographic distributions within the North Pacific and that the locations where they are found change seasonally. Although data for the winter period are limited, all species show a sharp upper (southern) thermal limit on the offshore marine distribution, with sockeye the most coldwater species and steelhead and coho the most warmwater species. The critical temperatures defining the southern (warmer) limit to the salmon distribution vary by species and by season, with acceptable temperatures increasing into the summer and becoming more similar between species.

Recent IPCC projections of the amount of future warming are similar to those predicted two decades ago using simpler steady state models. For several species the available data indicate a near-complete loss of thermally acceptable salmon habitat in major areas of the North Pacific Ocean. The projected impacts of global warming in the ocean could thus jeopardize the billions of dollars national governments invested in salmon restoration efforts and suggest that explicit testing of these apparent thermal limits is called for. A carefully designed tagging study using archival tags could potentially provide the data needed for these tests, but will require that high technical standards are met.

October 17, 11:30 (W2-9599)

Distribution and trophic conditions of chum and pink salmon in the North Pacific Ocean during winter under climate change

Shigehiko **Urawa**[1], Toshiki Kaga[2], Tomonori Azumaya[2], Shunpei Sato[1], Masa-aki Fukuwaka[3] and Terry Beacham[4]

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[3]   Seikai National Fisheries Research Institute, Fisheries Research Agency, Nagasaki, Japan
[4]   Pacific Biological Station, Fisheries & Oceans Canada, Nanaimo, BC, Canada

Winter is believed to be a crucial period for salmon survival in the ocean, but few biological data exist to support this hypothesis. The present paper aims to estimate stock- or age-specific distribution and trophic condition of winter chum and pink salmon and assess the impacts of climate change on their distribution and survival. Fish were caught with a surface trawl on the Japanese R/V *Kaiyo-maru* in the North Pacific Ocean (NPO) and Bering Sea during winter of 1996, 1998 and 2006. Young (ocean age-1) chum and pink salmon were abundant in the western NPO, while older chum salmon were mainly distributed in the Gulf of Alaska (GOA). Genetic stock identification confirmed various chum salmon stocks of Asian and North American origins intermingled in the GOA. North American stocks were dominant in the northern GOA, and Asian stocks were dominant in the southern GOA. Mean SST of winter chum salmon habitats was almost stable among years but differed between regions: around 4ºC in the western NPO and 6ºC in the GOA. Ocean age-1 chum salmon had lower lipid content than older fish, suggesting a critical condition of young fish during their first winter. The total lipid content of chum and pink salmon was significantly lower in the GOA than in the western NPO, perhaps due to higher habitat temperature and/or low availability of prey organisms. Two climate warming scenarios (SST increase of 1.5ºC or 3ºC) have suggested the winter habitat space for chum salmon will be reduced in the GOA, increased in the western NPO, and expanded to the Bering Sea. Future climate warming may affect the ocean distribution, trophic conditions, and survival of overwintering salmon, and the degree of the effects may be different among regional stocks or age groups.

October 17, 11:50 (W2-9543)

Winter mortality of Okhotsk Sea pink salmon in the ocean

Alexander V. **Zavolokin** and Elena V. Strezhneva

Pacific Research Fisheries Centre (TINRO-Centre), Vladivostok, Russia. E-mail: zavolokin@tinro.ru

Winter mortality of Okhotsk Sea pink salmon varies greatly from year to year resulting in uncertainty in the forecast of their returns the following year using data on their abundance in fall surveys. We examined size-selective mortality of pink salmon and determined the possibility of utilizing body size of juvenile pink salmon to forecast their returns. Scale increments of juvenile pink salmon caught in the southern Okhotsk Sea in fall 2007 and 2008 and of adult fish returning the following year were studied. For the 2007 generation of pink salmon that had very low overwinter survival in the ocean, average scale increments during the first year of life for juvenile fish were significantly lower than those of adult fish. For the 2008 generation of pink salmon that had very high overwinter survival, scale increments of juvenile and adult fish were similar. These results corroborate the critical size-critical period hypothesis which states that slowly growing juveniles that did not store up enough energy in summer and fall have a stronger probability to die during the overwinter period compared to rapidly growing fish. Correlation analysis showed significant negative relationships between body length, mass and mortality of pink salmon in the ocean in 2001-2009. However, survival of the last pink generation (2012-2013) was unexpectedly low despite their large body size. We speculate that although rapid growth is important it does not guarantee survival. Wintering conditions can greatly influence pink salmon resulting in variations in their return strength.

October 17, 12:10 (W2-9583)

Impact of climate variability and change on winter survival of Bristol Bay sockeye salmon

Edward Farley[1], Greg Ruggerone[2], Phil **Mundy**[1], Ellen Yasumiishi[1] and Beverly Agler[3]

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[2]   Natural Resources Consultants, Seattle, WA, USA
[3]   Alaska Department of Fish and Game, Mark, Tag and Age Laboratory, Juneau, AK, USA

Overwinter survival of Pacific salmon (*Oncorhynchus* sp.) is believed to be a function of size and energetic status they gain during their first summer at sea. We test this hypothesis for Bristol Bay sockeye salmon (*O. nerka*), utilizing data from large-scale fisheries and oceanographic surveys conducted during mid-August to September 2002 to 2007. Specifically, we compared distributions of mean circuli spacing during the first year at sea between juvenile salmon and adult sockeye salmon scales to evaluate the magnitude of size-selective mortality during this life stage. A probability curve of size-selective mortality in relation to weight (g) of juvenile salmon was constructed. The juvenile size (weight) was then compared to summer/fall oceanographic characteristics on the eastern Bering Sea shelf that may impact their growth rates and probability of survival during winter. This analysis is placed within the context of previously published results on summer/fall and winter marine ecology of Bristol Bay sockeye salmon and how continued warming on the eastern Bering Sea shelf may impact their future growth (during summer and fall) and survival during winter.

October 17, 14:00 (W2-9616)

Does physical environmental variation influence winter salmon habitat?

Shoshiro **Minobe**

Graduate School of Science, Hokkaido University, Sapporo, Japan. E-mail: minobe@sci.hokudai.ac.jp

Physical environmental variation associated with climate change and climate variability can influence marine ecosystems in general, but to identify what aspects of physical variation affect specific marine species is a challenge. In this paper, we examine whether and how the physical environment influences winter habitat of salmon. The physical environmental parameters to be examined include water temperatures, surface current velocities, and atmospheric sea-level pressures. A primary focus will be on past variation, but future changes may also be examined using CMIP5 model outputs where they are appropriate.

W3

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

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

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

Harmful Algal Blooms (HABs) have substantial economic, societal, and human health impacts in coastal waters worldwide, from equatorial to high latitude environments. Our increasing reliance on the economic services of coastal waters is threatened by the apparent increasing frequency and severity of HABs globally. Currently, clay dispersal in Korean waters is the only pragmatic operational program for mitigating HAB effects on coastal aquaculture operations. The trade-off, namely smothering of benthos with rapid sedimentation of clays, is not acceptable in many nations, leaving them with few if any mitigation strategies. This workshop will open with presentations on current rules for testing and implementing mitigation strategies in PICES member countries to set the stage for considering HAB mitigation. Participants then will deliberate on novel physical, chemical, and biological control strategies and research paths that have potential for minimizing or eliminating HAB effects without significant coincident impacts on ecosystem health. The aim of the workshop is to develop independent evaluation of mitigation strategies that are effective, transformative and sustainable for individual PICES member countries, and to provide a framework to advance the scientific collaborations and funding strategies to move mitigation research into the 20th century.

W3

Friday, October 17 (09:00-18:00)

09:00   ***Introduction by Workshop Convenors***

09:10   **Can harmful algal bloom mitigation make the problem worse? Complying with United States environmental laws to advance HAB control and mitigation research (Invited)**
David M. <u>Kidwell</u> and Susan Baker

09:50   **Feeding by the heterotrophic protists on the red-tide ciliate *Mesodinium rubrum***
Kyung Ha <u>Lee</u>, Hae Jin Jeong, Eun Young Yoon, Se Hyeon Jang, Hyung Seop Kim and Wonho Yih

10:10   **Prospect for the biological control of *Heterocapsa circularisquama* bloom by inoculating frozen bottom sediment with HcRNAV viruses**
Natsuko <u>Nakayama</u>, Shinichi Kondo, Naotsugu Hata, Yuji Tomaru, Masami Hamaguchi, Keizo Nagasaki and Shigeru Itakura

10:30   ***Coffee/Tea Break***

10:50   **Isolation and physiological characterization of a new algicidal virus infecting a harmful dinoflagellate *Prorocentrum minimum***
JinJoo <u>Kim</u>, Chang-Hoon Kim, Young-Sang Suh and Tae-Jin Choi

11:10   **Biocontrol of harmful flagellate biomass blooms by utilization of harmless diatoms through germination of resting stage cells in coastal sea**
Ichiro <u>Imai</u>, Yumi Imai, Takuma Toda, Kazuyoshi Miyamura, Makoto Noda, Ken-Ichiro Ishii and Takashi Nakanishi

11:30 **Removal of aquaculture discharges responsible for HABs development by the polychaete-assisted integrated culture system**
Parandavar Hossein, Sung-Kyun Kim, Byung-Kwon Kim, Kyeong-Hun Kim and Chang-Hoon <u>Kim</u>

11:50 **Inhibition of swimming speed and growth of the harmful dinoflagellate *Cochlodinium polykrikoides* by diatoms: Implications for its red tide**
An Suk <u>Lim</u>, Hae Jin Jeong, Tae Young Jang, Se Hyeon Jang and Peter JS Franks

12:10 **The newly toxic microalgae and phycotoxins in Yellow Sea of China**
(cancelled) Ning Wei, Lei Liu, Renyan <u>Liu</u> and Yubo Liang

12:30 *Lunch*

13:40 ***Heterosigma akshiwo* blooms in stratified water of the East China Sea**
Douding <u>Lu</u>, Xinfeng Dai, Dongrong Li, Ping Xia and Weibing Guan

14:00 **Numerical simulation on harmful algae blooms and toxin production performance in a eutrophic Lake, Japan**
Md. Nazrul <u>Islam</u>, Daisuke Kitazawa and Ho-Dong Park

14:20 Open Discussion

15:30 *Coffee/Tea Break*

15:50 Open Discussion

18:00 *Workshop Ends*

W3 Posters

W3-P1 **Gymnodinium algae blooms impact on the recovery of the *Eriocheir sinensis* resource**
(cancelled) Chunjiang <u>Guan</u>, Hao Guo, Xiaodong Li and Xiaoxu Liu

W3-P2 **The recurrent and localized blooms of harmful dinoflagellate *Cochlodinium polykrikoides* in the southeast coastal waters of Korea**
Roksana Jahan, Min-Jeong Ko and Chang-Hoon <u>Kim</u>

W3 Workshop Oral Presentations

October 17, 09:10 (W3-9778), Invited

Can harmful algal bloom mitigation make the problem worse? Complying with United States environmental laws to advance HAB control and mitigation research

David M. **Kidwell** and Susan Baker

NOAA National Centers for Coastal Ocean Science, Silver Spring, MD, USA. E-mail: david.kidwell@noaa.gov

Harmful algal blooms (HABs) have significant impacts to ecological resources, human health, and coastal economies. Techniques for HAB control and mitigation represent a promising area of research. Numerous techniques either in use or under development range from water column mixing, to chemical additives, to the introduction of species with allelopathic properties.   To advance the development and facilitate the transfer of promising techniques to end users, NOAA initiated the Prevention, Control, and Mitigation of Harmful Algal Bloom research program (PCMHAB) in 2010. In the United States of America, environmental concerns have thus far limited efforts for field demonstration of their effectiveness. For example, clay flocculation, particularly on a large scale, may violate national clean water regulations through increased turbidity and benthic sedimentation. These effects could be further amplified if conducted in areas with sensitive habitats (*e.g.*, coral reefs) and/ or species (*e.g.*, manatees). To comply with the US National Environmental Protection Act (NEPA), NOAA recently completed an environmental assessment of PCMHAB field demonstration, evaluating potential impacts of leading techniques and outlining key mitigation and monitoring requirements for potential projects. As a result of this assessment, PCMHAB field demonstration will initially limit both the types of techniques tested and the scope (frequency and scale of application) to the minimum application of a technique anticipated to decrease, but not necessarily eliminate, a HAB. This presentation will discuss the process and findings from the PCMHAB environmental assessment and offer a perspective on advancing HAB control and mitigation within the framework of national environmental legislation.

W3

October 17, 09:50 (W3-9538)

Feeding by the heterotrophic protists on the red-tide ciliate *Mesodinium rubrum*

Kyung Ha **Lee**[1,2], Hae Jin Jeong[1,2], Eun Young Yoon[2], Se Hyeon Jang[1], Hyung Seop Kim[3] and Wonho Yih[3]

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Mesodinium rubrum is a cosmopolitan ciliate that often causes red tides. Predation by heterotrophic protists is a critical factor that affects the population dynamics of red tide species. However, there have been few studies on protistan predators feeding on *M. rubrum*. To investigate heterotrophic protists grazing on *M. rubrum*, we tested whether the heterotrophic dinoflagellates *Gyrodiniellum shiwhaense*, *Gyrodinium dominans*, *Gyrodinium spirale*, *Luciella masanensis*, *Oblea rotunda*, *Oxyrrhis marina*, *Pfiesteria piscicida*, *Polykrikos kofoidii*, *Protoperidinium bipes*, and *Stoeckeria algicida*, and the ciliate *Strombidium* sp. preyed on *M. rubrum*. *G. dominans*, *L. masanensis*, *O. rotunda*, *P. kofoidii*, and *Strombidium* sp. preyed on *M. rubrum*. However, only *G. dominans* had a positive growth feeding on *M. rubrum*. The growth and ingestion rates of *G. dominans* on *M. rubrum* increased rapidly with increasing mean prey concentration <321 ng C mL^{-1}, but became saturated or slowly at higher concentrations. The maximum growth rate of *G. dominans* on *M. rubrum* was 0.48 d^{-1}, while the maximum ingestion rate was 0.55 ng C predator^{-1} d^{-1}. The grazing coefficients by *G. dominans* on populations of *M. rubrum* were up to 0.236 h^{-1}. Thus, *G. dominans* may sometimes have a considerable grazing impact on populations of *M. rubrum*.

October 17, 10:10 (W3-9597)

Prospect for the biological control of *Heterocapsa circularisquama* bloom by inoculating frozen bottom sediment with HcRNAV viruses

Natsuko **Nakayama**[1], Shinichi Kondo[2], Naotsugu Hata[3], Yuji Tomaru[1], Masami Hamaguchi[1], Keizo Nagasaki[1] and Shigeru Itakura[1]

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The marine dinoflagellate *Heterocapsa circularisquama* is one of the most harmful bloom-forming microalgae, which specifically kills bivalves in Japanese coastal waters. *H. circularisquama* and its ssRNA virus (HcRNAV) had showed synchronous fluctuation pattern in abundance under natural environments. Therefore the viral infection is considered to have a significant impact on the host bloom dynamics. Thus, we are studying the application of the virus as a promising tool for preventing the occurrence of *H. circularisquama* bloom. In 2011, an inoculation test was conducted to estimate the practical effect of natural HcRNAV to natural host algal population. Briefly, a frozen field sediment sample which is retaining a variety of HcRNAV (differing in host intraspecies specificity) was thawed and added to a seawater sample collected from Lake Kamo (Niigata, Japan), where *H. circularisquama* formed a bloom in August 2011. Then, the abundance of *H.circularisquama* and the titer of HcRNAV were enumerated at 0, 3, and 6 day postinoculation. *H.circularisquama* showed a remarkable decrease in cell density (from ca. 7,500 to ca.75 cells/mL) and HcRNAV significantly increased (from 40 to 72,000 infectious units/mL) within the 6 days. These results and the control experiments (without sediment inoculation or with addition of autoclaved sediment) indicated that the factor which caused the decrease in abundance of *H.circularisquama* was presumably due to HcRNAV in the sediment. We will also discuss current situations and issues for the biological control of HAB (*H. circularisquama* bloom) by virus.

October 17, 10:50 (W3-9617)

Isolation and physiological characterization of a new algicidal virus infecting a harmful dinoflagellate *Prorocentrum minimum*

JinJoo **Kim**[1], Chang-Hoon Kim[2], Young-Sang Suh[1] and Tae-Jin Choi[2]

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[2] Pukyong National University, Busan, R Korea

Viruses that infect phytoplankton are an important component of aquatic ecosystems, yet they remain largely unstudied. Over 50 different viruses infecting marine eukaryotic algae have been isolated and characterized for the last two decades. To date, virus infection has been reported in chlorophytes, prasinophytes, raphidophytes, bacillariophytes, dinophytes, pelagophytes, phaeophytes, and haptophytes.

Here, we report the isolation and partial characterization of a new giant double-stranded DNA(dsDNA) algal virus from the family *Phycodnaviridae* that infects the harmful dinoflagellate *Prorocentrum minimum* from Korean coastal water. The *Prorocentrum minimum* virus (PmDNAV01) is icosahedral, lacks a tail, and is ca. 175-185nm in diameter. The latent period of PmDNAV01 was estimated to be about 80 hours.

This is the second isolated dinoflagellate infecting virus and its host, *Prorocentrum minimum* is often occur blooms in west-side of Korea every years. In order to investigate the ecological relationship between viruses in the environment and the phytoplankton hosts they infect, it should help to observe patterns of its interaction.

October 17, 11:10 (W3-9679)

Biocontrol of harmful flagellate biomass blooms by utilization of harmless diatoms through germination of resting stage cells in coastal sea

Ichiro **Imai**[1], Yumi Imai[1], Takuma Toda[1], Kazuyoshi Miyamura[2], Makoto Noda[2], Ken-Ichiro Ishii[3] and Takashi Nakanishi[4]

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[2]   Fisheries Research Division, Oita Prefectural Agriculture, Forestry and Fisheries Research Center, Saiki, Japan
[3]   Graduate School of Global Environmental Studies, Kyoto University, Kyoto, Japan
[4]   Faculty of Agriculture, Kinki University, Nara, Japan

It is empirically long known that high biomass HABs by flagellates such as *Chattonella*, *Cochlodinium* and *Karenia* have occurred when diatoms are scarce in water columns. Diatoms form resting stage cells (RSCs) under conditions of nutrient-depletion and low light, and those sink to bottom and disappear in the water columns. Diatom RSCs require light for germination and rejuvenation. Thus the flagellate HABs are presumably induced by disappearance of diatoms and subsequent failure of recruitment by poor germination of RSCs at sea bottom with low light. Giving enough light to abundant diatom RSCs (usually 10^5–$10^6 g^{-1}$ sediment) at sea bottom is expected to enhance their germination, and resultant vegetative cells would rapidly proliferate in water columns eventually overwhelming harmful flagellate populations by the exhaustion of inorganic nutrients. We tried to lift bottom sediments into surface water with a pump and to suspend diatom resting stage cells in euphotic layer in the coastal sea of the Seto Inland Sea, Japan, in September 2012 and May 2013. In the 2012 trial, the diatoms of *Chaetoceros* spp. and *Skeletonema* spp. markedly increased from $<10^3$ cells mL^{-1} to 2~3 x 10^3 cells mL^{-1} within a few days in the water column. In the 2013 trial, mainly *Chaetoceros* cells increased from about 50 cells mL^{-1} to 120 cells mL^{-1} in surface water despite under severe nutrient-depleted conditions (N $<0.5\mu M$, Si $<5\mu M$). It is strongly suggested that sediment-lift is a possible strategy for inducing the phytoplankton flora to harmless diatoms to prevent flagellate HABs.

October 17, 11:30 (W3-9525)

Removal of aquaculture discharges responsible for HABs development by the polychaete-assisted integrated culture system

Parandavar Hossein[1], Sung-Kyun Kim[2], Byung-Kwon Kim[2], Kyeong-Hun Kim[2] and Chang-Hoon **Kim**[1,2]

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Aquaculture is growing rapidly all over the world and the increasing number of fish culture industries has begun to create serious environmental problems due to the impact caused by fish farming wastes. Based on the information on great potential of the polychaete worms for bioremediation and the successful seed production of the polychaete rockworm *Marphysa sanguinea* at Fisheries Science and Technology Center, PKNU, three trials have been conducted to test the water quality improvement and growth performance in the rockworm settlement tanks receiving wastes from olive flounder rearing tanks, in the integrated culture systems with flow-through and semi-recirculation. In comparison between culture systems, the pure production of the worm was 1.5 times higher in flow-through system than in semi-recirculating system. Different effects on the removal efficiency were appeared both in culture systems and among treatments. In flow-through system, the highest removal efficiency showed in TN (56 %) in G2 (0.6~1.5 g/initial weight), TP (59%) in G1 (<0.5 g), TSS (86%) in G2, and COD (30%) in G3 (1.6~2.5 g). In semi-recirculating system, the highest removal efficiency was in TN (63%) in G2, TP (53%) in G3, TSS (80%) in G3, and COD (21%) in G2. These results suggest that the rockworm *M. sanguinea* is an excellent candidate for integrated aquaculture and nutrient removal of aquaculture discharges responsible for HABs development in coastal waters.

W3

October 17, 11:50 (W3-9637)

Inhibition of swimming speed and growth of the harmful dinoflagellate *Cochlodinium polykrikoides* by diatoms: Implications for its red tide

An Suk **Lim**[1], Hae Jin Jeong[1,2], Tae Young Jang[1], Se Hyeon Jang[1] and Peter JS Franks[3]

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[3] UC San Diego, La Jolla, CA, USA

The harmful dinoflagellate *Cochlodinium polykrikoides* is responsible for red tides that cause large fish kills and extensive economic losses for the fishing industry. Diatoms, another component of planktonic communities, may play critical roles in the red tide dynamics of *C. polykrikoides*. Possible inhibition of *C. polykrikoides* growth rate and swimming speed by the common diatoms *Chaetoceros danicus*, *Skeletonema costatum*, and *Thalassiosira decipiens* through physical and chemical mechanisms was explored. *S. costatum*, *C. danicus*, and *T. decipiens* reduced the swimming speed of *C. polykrikoides* at diatom concentrations of > 5000, 25,000, and 1000 cells ml^{-1}, respectively. Filtrates from cultures of *S. costatum*, *C. danicus*, and *T. decipiens* also lowered swimming speeds of *C. polykrikoides,* at diatom concentrations of >250,000, 50,000, and 1000 cells ml^{-1}, respectively. *S. costatum* caused negative growth rates of *C. polykrikoides* at concentrations of >~130,000 cells ml^{-1}, while *C. danicus* caused negative growth rates at concentrations of >~1200 cells ml^{-1}. Simple models parameterized using the experimental data reproduced the changes in *C. polykrikoides* cell concentrations driven by the presence of diatoms. Thus common diatoms may inhibit growth rate and swimming speed of *C. polykrikoides*; reduce the depths reached by *C. polykrikoides* through vertical migration; and, in turn, delay or prevent the outbreak of *C. polykrikoides* red tides.

October 17, 12:10 (W3-9533) - CANCELLED

The newly toxic microalgae and phycotoxins in Yellow Sea of China

Ning Wei, Lei Liu, Renyan **Liu** and Yubo Liang

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The harmful algal blooms have occurred more frequently in the China, the toxic microalgae can produce phycotoxins, which can accumulate in shellfishes by bioconcentration, and poisoning human and other high grade marine animals, which cause great loss and damage to human health, aquaculture industry, and ecological environment. Various toxic microalgae which can produce a variety of phycotoxins, are widely distributed in the sea waters of China. Recently, two spices of toxic microalgae have been found in Yellow Sea. One of them is *Protoceratium reticulatum* which can produce yessotoxins (YTXs), and another is *Prorocentrum rhathymum* which can produce dinophysistoxin (DTXs). Some of lipophilic phycotoxins, including OA and DTXs, PTXs, YTXs and GYM (gymnodimine) have been found in a variety of Chinese shellfishes.

October 17, 13:40 (W3-9475)

Heterosigma akshiwo blooms in stratified water of the East China Sea

Douding **Lu**, Xinfeng Dai, Dongrong Li, Ping Xia and Weibing Guan

Key Laboratory of Marine Ecosystem and Biogeochemistry, Second Institute of Oceanography, SOA, Hangzhou, PR China
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Heterosigma akashiwo bloom was first recorded in Dalian Bay in 1985. Since then, about thirty bloom events of *Heterosigma akashiwo* have been registered and bloom frequency has increased along China coastal waters. This species has mainly formed blooms in the Bohai Sea and the Yellow Sea and recently expanded to other China coastal waters. However, *the* species is poorly recorded in the East China Sea (ECS), partly due to its fragile small cells and difficulty in identification. The bloom dynamics of this species are not well understood. During the CEOHAB cruise in 2011, two strains of flagellates were isolated, which co-occurred with *Prorocentrum donghaiense* blooms in the ECS. The bloom causative species was confirmed as *Heterosigma akashiwo* by using its morphological and molecular characteristics. The bloom patterns were much related with stratified water system in the East China Sea in the spring of 2011.

October 17, 14:00 (W3-9287)

Numerical simulation on harmful algae blooms and toxin production performance in a eutrophic Lake, Japan

Md. Nazrul **Islam**[1,2], Daisuke Kitazawa[1] and Ho-Dong Park[3]

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[2]   Department of Geography and Environment, Jahangirnagar University, Savar, Dhaka, Bangladesh
[3]   Department of Environmental Sciences Faculty of Science, Shinshu University, Matsumoto, Japan

A three dimensional hydrodynamic ecosystem coupled model was employed to simulate algae transition and toxin produced ability under the nutrients limited conditions in eutrophic Lake Kasumigaura, Japan. Numerical simulation was carried out for the four years of the period 2005–2009. Algae have shifted seasonally and annually between 2005 and 2009, between three major algal: Microcystis spp., Planktothrix spp., and Cyclotella spp. The model reproduced well the transitions of dominant algae in the four years by calibrating ecological parameters. The biomass of Planktothrix spp. suddenly increased in the summer of 2008, and Planktothrix spp. became the dominant species. Longer periods of stratification, lower concentration of dissolved oxygen, and higher concentration of dissolved nitrogen were observed in 2008, while the sudden increase in Planktothrix spp. biomass in 2008. We also found that the toxin production is made by *Microcystis* spp., and is proportional to the growth of algae, while it depends on whether phosphorus or nitrogen limits the algal growth. The toxin remains in the cell for respiration. Harmful algae toxin is released with extracellular release and mortality, and advects and diffuses with the surrounding current and turbulence. The degradation of toxin was taken into account by the decay coefficient which crosses the concentration of toxin. Numerical simulation was also tried under the assumption that phosphorus or nitrogen always limits the algal growth. Low dissolved Oxygen (DO) enhances the release of nutrients from sediment and increase dissolved inorganic phosphorus (DIP) concentration. Another reason could be the inflow nutrients come from Tomoe River and connecting Lake Nishiura and Sotonasakura by Wani River.

W3 Workshop Poster Presentations

W3-P1 - CANCELLED

Gymnodinium algae blooms impact on the recovery of the *Eriocheir sinensis* resource

Chunjiang **Guan**[1], Hao Guo[1], Xiaodong Li[2] and Xiaoxu Liu[3]

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[2]   Panjin Guanghe Crab Industry Co. Ltd., Panjin, PR China
[3]   Dalian Ocean University, Dalian, PR China

The life history of *Eriocheir sinensis* H. Milne-Edward has two periods: seawater stage and freshwater stage. In the northern China, the period from reproductive stage to larval stage living in the seawater is about 7 months or so; the period from the development of larvae to sexual maturation stage living in the freshwater is about 17months of time. Widely used in China at present, the breeding of *Eriocheir sinensis* always uses hypaethral earthen ponds to cultivate the Megalopa larva as stock enhancement or seed resources for aquaculture production. Seedlings of *Eriocheir sinensis*, especially in the Zoaea period, is very sensitive to harmful algae such as *Gymnodinium*. *Gymnodinium* over a certain density in the water and becoming the dominant species can cause seedlings suffer from reduction in appetite and vigor, metamorphosis difficulty until death. It may accelerate water eutrophication. HABs are more likely to happen and cause mass mortality of seedlings when inputting amounts of rotifers and other exotic food in the high-density nursery pond. Although the aquatic breeding farm has an area of about 6,700 hectares across the country, the areas of total loss or production cuts are more than 1,300 hectares and the loss of fry is up to 20% on account of harmful algae blooms. At present countermeasures, mainly replacing the subsoil of the pond before seedling production and removal of harmful algae's resting spore from the sources to prevent the occurrence of algae blooms.

W3-P2

The recurrent and localized blooms of harmful dinoflagellate *Cochlodinium polykrikoides* in the southeast coastal waters of Korea

Roksana Jahan[1], Min-Jeong Ko[2] and Chang-Hoon **Kim**[1,2]

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The large endemic outbreaks of *Cochlodinium polykrikoides* in Korean coastal waters are common phenomena and many sophisticated oceanographic studies had been conducted during last two decades but all of the studies particularly focused on offshore blooming events. The purpose of the present research were to consider some regional factors (*i.e.* resting cysts, seed beds, *etc.*) might have great contribution on on-shore (*i.e.* Jaran Bay) blooming patterns, and to draw distinct blooming mechanism between on-shore and off-shore (*i.e.* Mijo and Yeokji coasts). We first confirmed the existence of resting cyst that created local seed-beds responsible for recurrent blooming. The successful germination of resting and hyaline cyst had been observed in July–August and created blooms under favorable environmental conditions (*i.e.* temperature, salinity, *etc.*). The low resting cyst production also controlled the intensity of blooming pattern and responsible for less production of *C. polykrikoides* in Jaran Bay, although some unfavorable conditions had been detected during August 2011. In addition, the high abundances of *Nematodinium* cysts were also shown in water bodies where blooms occurred last year and that regions take the role of point sources of recurrent bloom initiation. Nevertheless, the off-shore blooming mechanisms are largely depending on physical oceanographic factors.

HAB-S Meeting

Saturday, October 18 (09:00-18:00)

09:00   ***Introduction by Convenors: Shigeru Itakura and Vera Trainer***
Welcome, goals of HAB Section meeting, review of terms of reference

Country Reports (2011-12) and HAE-DAT (year 2007) reports

09:15   **Korea**
Changkyu <u>Lee</u>

09:30   **U.S.A.**
Vera L. <u>Trainer</u>

09:45   **Japan**
Shigeru <u>Itakura</u>

10:00   **China**
China Representative

10:15   **Canada**
Charles <u>Trick</u>

10:30   ***Coffee/Tea Break***

11:00   **Russia**
Tatiana <u>Orlova</u>

11:15   **Numerical modeling on the effects of pollutants on ecosystem of Kamaishi Bay (Japan) by using MEC model**
Md. Nazrul <u>Islam</u> and Daisuke Kitazawa

11:45   **Harmful algal blooms on the Russian east coast and its possible economic impacts**
Tatiana <u>Orlova</u>, Tatiana Morozova, Polina Kameneva and Olga Schevchenko

12:15   **Update on MAFF project, Marine Ecosystem Health and Human Well Being**
Charles <u>Trick</u> and Vera L. <u>Trainer</u>

12:30   ***Lunch***

14:00   **Report on joint publication on HABs and Climate, IOC/IPHAB Global HAB report (IOC Project office for IODE to add to discussion if possible)**
Mark <u>Wells</u>

14:15   **Possible joint ICES/PICES/GEOHAB symposium on HABs and Climate Change in Sweden, May 2015**
Mark <u>Wells</u>

14:30   **The joint Harmful Algal Bloom Programme and International Oceanographic Data and Information Exchange Harmful Algae Information System: An update and country maps**
Henrik <u>Enevoldsen</u> and Vera L. <u>Trainer</u>

14:45   **IOC/IPHAB Global HAB report – contribution by PICES member nations**
Vera L. <u>Trainer</u>

HAB-S

15:00   Discussion of workshop proposal, part II, Contrasting conditions for success of selected harmful algal species in the western and eastern Pacific - A comparative ecosystem approach

15:30   ***Coffee/Tea Break***

16:00   Workshop proposal, part II, Contrasting conditions for success of selected harmful algal species in the western and eastern Pacific - A comparative ecosystem approach

16:30   Quick exchange of new findings, significant publications from each country

17:00   Discussion of Proposals for the Future and Review of assignments

18:00   *Meeting Ends*

HAB Section Meeting Oral Presentations

October 18, 11:15 (HAB-S-9289)

Numerical modeling on the effects of pollutants on ecosystem of Kamaishi Bay (Japan) by using MEC model

Md. Nazrul **Islam**[1,2] and Daisuke Kitazawa[1]

[1]   Institute of Industrial Science, The University of Tokyo, Meguro-ku, Tokyo, Japan
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[2]   Department of Geography and Environment, Jahangirnagar University, Savar, Dhaka, Bangladesh

A three dimensional Marine Environmental Committee (MEC) model was conducted to describe the specific circulation patterns of currents, temperature, and salinity driven by wind and tide forcing in Kamaishi Bay at Miyagi Prefecture in the Great East Japan. The major concern of this study is the diffusion of pollutants caused by 2011 Earthquake and Tsunami disaster impacts on marine ecosystem. In this study, we also simulate the changes of water quality and ecosystems structure from January 2009 to December 2012. The MEC model has been used to predict the distributions of various key water quality indicators and tide flow in the different layer of Kamaishi Bay. High correlation is obtained between simulation derived and measurement derived tidal characteristics. One of the broken marine structures was the breakwater of the Kamaishi Bay, which was completed its construction in 2009 at the Bay mouth where the water depth is over 60 m. We also simulated the effects of breaking water effects on the tide, currents and integrating aquaculture and fisheries. The wind driven flow using mean seasonal wind forcing (NE, SE, and SW) creates different circulations over Kamaishi Bay. The current variability in shallow areas is influenced by the prevailing winds. Similarly, the temperature and salinity distribution of Kamaishi Bay waters is characterized by strong seasonal variations. The water quality is intensely affected by pollutants and has continually deteriorated due to increased discharges of domestic and industrial waste as well as an increased loading in anthropogenic contamination into the Bay. The results were found that measured and simulated contaminations of pollutants were under the environmental standards in Japan. Observed and simulated DO, T-N and T-P concentrations were not so large different from those before the disaster.

October 18, 11:45 (HAB-S-9473)

Harmful algal blooms on the Russian east coast and its possible economic impacts

Tatiana **Orlova**[1], Tatiana Morozova[1], Polina Kameneva[1] and Olga Schevchenko[1,2]

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[2]   Research and Educational Center "Primorsky Aquarium", FEB RAS, Vladivostok, 690041, Russia

The problem of HAB has a serious economic impacts and harm for people's health in countries of PICES region. This issue has the same impact for Northern Pacific part of Russia as well. The specific monitoring program aimed to analyze the presence of HAB species in coastal waters of Primorsky Krai and screen for phycotoxins in shellfish was launched in 2007. Data of this monitoring program revealed the real threat of diarhetic shellfish poisoning, due to having excess of the guidance limit of okadaic acid derivatives in shellfish. Nevertheless, there is no effective governmental monitoring of HAB and phycotoxins in Russia even though there is a law about appropriate concentrations of phycotoxins in seafood. There are no practical methods for analyzing phycotoxins and as a consequence it is impossible to register poisons by any of these toxins in medical or sanitary organization. All of these are the reasons of not having data about real economic impacts and harm for people's health for Primorsky Krai and for the whole Far Eastern region of Russia. In this report we will make a first attempt to estimate the possible economic impacts and harm for people's health caused by HAB based on analysis of data obtained by Center for Monitoring of HABs and Biotoxins of IMB FEB RAS www.imb.dvo.ru/misc/toxicalgae/index.ttm.

W4

MONITOR Workshop
Networking ocean observatories around the North Pacific Ocean

Co-sponsored by Ocean Network Canada

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

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

In the North Pacific Ocean, various cabled ocean observatories are operating or under development. In addition there exist several long-term time series programs, and the Argo drifter program. It seems timely to hold a workshop with the following objectives:

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

Most of these facilities are in the North Pacific, and are regional and coastal in scope, making PICES the ideal organization to host such a workshop. The need for such a network of observing facilities was articulated in the conference description of the recent Joint PICES/ICES Workshop on "*Global assessment of the implications of climate change on the spatial distribution of fish and fisheries*" held in May 2013 in St. Petersburg, Russia: "… observations and model projections (are) needed to develop a global synthesis of the implications of climate change on fish and fisheries". In the past, correlations of sardine and anchovy long-term changes have been established between populations off California, Chile and Japan, so it seems prudent to make the scope of such a workshop the whole Pacific Ocean. The following format for the workshop is expected: a) a series of talks describing the capabilities of the various long-term systematic ocean observing facilities in the Pacific Ocean, b) a series of talks representing various modelling efforts around the Pacific and c) a discussion on setting up a group to develop a plan for achieving objective ii) above.

Friday, October 17 (09:00-13:10)

09:00   ***Introduction by Workshop Convenors***

09:10   **The status of ocean monitoring in Korea**
          Jae Hak <u>Lee</u>

09:30   **Ten-year retrospective of the Northwest Association of Networked Ocean Observing Systems (NANOOS)**
          Jan A. Newton, John A. <u>Barth</u>, David L. Martin, Michael P. Kosro, Jonathan Allan, Emilio Mayorga and many NANOOS Colleagues

09:50   ***OIST Ocean Cube*, a new coastal cabled observatory in Okinawa, Japan**
          Mary M. <u>Grossmann</u>, Satoshi Mitarai and Scott M. Gallager

10:10   **Joint Environmental Data Integration System: JEDI System**
          Hidekatsu <u>Yamazaki</u>, Scott Gallager, Hayato Kondo and Kunihisa Yamaguchi

10:30	***Coffee/Tea Break with a poster presentation and ONC Demo***
11:00	**COSYNA, the Coastal Observing System for Northern and Arctic Seas – A regional, European perspective and the global coast (Invited)** Holger <u>Brix</u> and Burkard Baschek
11:30	**Cabled ocean observatories as tools for studying biodiversity change** S. Kim <u>Juniper</u> and Fabio De Leo
11:50 (cancelled)	**Networking ocean observations around the North Pacific: Why zooplankton and fisheries biologists need real-time indices of advection in the northern California Current** William <u>Peterson</u>, Jay Peterson and Jennifer Fisher
12:10	**Using autonomous underwater gliders to observe continental margins and oceanic boundary currents** John A. <u>Barth</u>
12:30	Open Discussion & Recommendations
13:10	*Workshop Ends*

W4 Poster

| W4-P1 | **NEAR-GOOS Cross-Basin Climate Monitoring Section: First results of a pilot project**
Vyacheslav <u>Lobanov</u>, Sho Hibino, Dmitry Kaplunenko, Aleksandr Lazaryuk, Toshiya Nakano, Satoshi Ogawa and Pavel Tishchenko |

W4 Workshop Oral Presentations

October 17, 09:10 (W4-9749)

The status of ocean monitoring in Korea

Jae Hak **Lee**

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Most of the ocean monitoring in Korea is focusing on regional and coastal seas, though the activity in the open ocean has been increasing for research purposes. Recent studies in relation to long-term ocean changes in the seas adjacent to Korea indicate that both sea water temperature and sea level are increasing. Ocean acidification is ongoing by an amount about two to three times larger and faster than found for global ocean means. It is also suggested that such changes are possibly influenced by the changes in both large-scale atmospheric and oceanic forcing. However, the dynamics for the ocean link between the marginal seas and the North Pacific Ocean are less analyzed than those for the interaction between the marginal seas and large-scale atmospheric forcing because of the lack of oceanic time series data. It is necessary to develop an integrated observation system linking marginal seas and the North Pacific Ocean. The status of ocean monitoring in Korea will be explained and the suggestion to develop a marginal sea and open-ocean networking system will be presented.

October 17, 09:30 (W4-9614)

Ten-year retrospective of the Northwest Association of Networked Ocean Observing Systems (NANOOS)

Jan A. Newton[1], John A. **Barth**[2], David L. Martin[1], Michael P. Kosro[2], Jonathan Allan[3], Emilio Mayorga[1] and many NANOOS Colleagues

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NANOOS, the Northwest Association of Networked Ocean Observing Systems, serves the Washington, Oregon, and northern California region as part of the U.S. Integrated Ocean Observing System, a national effort designed to enable the broadest access to coastal and ocean data, tools, products, and knowledge. The region includes the eastern Pacific Ocean and California Current, the Strait of Juan de Fuca, Puget Sound, the Columbia River, and several smaller estuaries in each of the states. Membership includes academic and research institutions, tribal, state, and local governments, and industry. Over the last ten years, NANOOS has worked both at the local and national level to sustain an integrated coastal ocean, shoreline, and estuarine observing system that is responsive to user needs in the Pacific Northwest. Examples include forecasts for tuna fishers, tsunami planning tools, real-time water quality data optimized for shellfish growers in light of ocean acidification, coastal currents for Coast Guard search and rescue efforts, and relevant data and forecasts for maritime transport and recreational boating communities. This ability to serve multiple needs from a sustained observing system has arisen from consistent planning of the data delivery system known as the NANOOS Visualization System, or NVS. With the advent of the Ocean Observatories Initiative (OOI), NANOOS is adapting its observing system, for instance, moving a glider track from Oregon to northern California, thus expanding the range of data acquisition. This year NANOOS will achieve the seamless integration of data from OOI and Argo into NVS, thus linking coastal and open-ocean observatories.

W4

October 17, 09:50 (W4-9432)

OIST Ocean Cube, a new coastal cabled observatory in Okinawa, Japan

Mary M. **Grossmann**[1], Satoshi Mitarai[1] and Scott M. Gallager[2]

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Global warming, anthropogenic stress, acidification, bleaching. These have all become common concepts in the world of shallow coral reef ecosystems. Laboratory experiments aiming to qualify and quantify the causes and effects of environmental changes on the structure and well-being of coral ecosystems are flourishing, and, unfortunately, so are the number of *in-situ* records of bleaching, disturbance or collapse of these fragile ecosystems. However, as with many other marine systems, there is a lack of knowledge of the normal background variability of corals and their associated communities, with which to compare extreme events: a lack of constant, long-term monitoring of reef ecosystems.

In order to provide background information on the physical and biological variability of a coral reef at both large and small time scales, an *in-situ* cabled observatory system, the *OIST Ocean Cube*, was installed on a coral reef off the north-western shore of Okinawa Island in Japan in 2013. This area of *Acropora*-dominated reef is relatively protected from the damage of typhoons, and has been spared from any major bleaching events. The observatory started recording in September 2013, and we present here a brief overview of the system and some preliminary results on the temporal variations in the structure and composition of the plankton community found above the coral reef.

October 17, 10:10 (W4-9488)

Joint Environmental Data Integration System: JEDI System

Hidekatsu **Yamazaki**[1], Scott Gallager[2], Hayato Kondo[1] and Kunihisa Yamaguchi[3]

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The JEDI System is a JST (Japan Science and Technology Agency) -funded CREST project entitled "Novel technologies to evaluate multi-scale variations of pelagic marine communities and biodiversity under the influence of the Kuroshio Current and internal waves in coastal habitats". This project has two main goals: 1) To develop and apply advanced field methods to monitor dynamic changes, diversity and processes in planktonic communities under the influence of strong physical forcing (Kuroshio and internal waves) and 2) To develop a new ecosystem model for open waters using a closure approach and to validate it using field observations. The JEDI System consists of five subprograms: S1) Multi-biodiversity statistical model, S2) New NPZ closure model, S3) Regional/local hydrodynamic model, S4) Biodiversity and environmental monitoring system and S5) Prediction of biodiversity from S3. We are developing a unique monitoring system that combines a cabled observatory (CO) and a new AUV. The monitoring system (Oshima Coastal Environment data Acquisition Network System, OCEANS) will be deployed at the southern tip of Oshima Island where the Kuroshio flows near the coast. Both the CO and the AUV carry a new plankton imaging system (Continuous Plankton Identifying Camera System, CPICS), and measure various physical/biological parameters simultaneously. The AUV also carries a microstructure package (TurboMAP) in addition to CPICS. We will present the technical details of OCEANS and the types of data we are collecting from the field.

October 17, 11:00 (W4-9550), Invited

COSYNA, the Coastal Observing System for Northern and Arctic Seas – A regional, European perspective and the global coast

Holger **Brix** and Burkard Baschek

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The automated observing and modeling network COSYNA has been established in order to better understand the complex interdisciplinary processes of Northern Seas and the Arctic coast, to assess the impact of anthropogenic changes, and to provide a scientific infrastructure. COSYNA aims to significantly advance the scientific understanding of hydrodynamic processes, improve operational models, provide products for various interest groups, and support technological development, *e.g.*, for automated, quality controlled routine measurements or for error and data analysis. The principal objective of observations and instrument development is to improve our understanding of the interdisciplinary interactions between physics, biogeochemistry and ecology of coastal seas, to investigate how they can be best described at present, and how they will evolve in the future. Since COSYNA is one of the densest observing systems located in one of the most heavily used coastal areas in the world, it may serve as a role model for other parts of the "Global Coast". Many global problems such as climate change, sea level rise, or ocean acidification influence in particular the ecosystems and communities along the coasts. The impact of these problems as well as the choice of the tools for their management, however, varies strongly with region. This presentation intends to start a discussion on how groups working on a variety of coastal problems worldwide can interact and cooperate to tackle the difficult questions we all face.

October 17, 11:30 (W4-9660)

Cabled ocean observatories as tools for studying biodiversity change

S. Kim **Juniper** and Fabio De Leo

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The construction of cabled ocean observatories on the eastern (VENUS, NEPTUNE, OOI) and western (DONET, MACHO) shores of the North Pacific provides interesting opportunities for long-term observations of biodiversity change, from the coastal zone down to abyssal depths. Current cabled observatory technology permits the real-time, continuous monitoring of oceanographic variables and biological features that can be detected using video and still cameras. The planned, multi-decadal lifetimes of cabled observatories should allow seasonal and inter-annual variability to be distinguished from longer term trends that could be related to climate change. International organizations such as the Group on Earth Observations' Biodiversity Observation Network (GEO-BON) are developing suites of 'Essential Biodiversity Variables' that are intended to establish a standardized, global framework for detecting biodiversity change, based on scientific principles. This presentation will consider how some of these essential variables can be monitored at cabled ocean observatories using current technologies, with the aim of encouraging the development of an international program. We will use examples from the VENUS and NEPTUNE observatories operated by Ocean Networks Canada, to illustrate how observatory cameras and sensors can be used to quantify seasonal shifts in community composition, responses to rapid changes in oceanographic conditions, and ecosystem service activities such as bioturbation.

W4

October 17, 11:50 (W4-9667)

Networking ocean observations around the North Pacific: Why zooplankton and fisheries biologists need real-time indices of advection in the northern California Current

William **Peterson**[1], Jay Peterson[2] and Jennifer Fisher[2]

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The Peterson lab has been going to sea fortnightly since 1996 studying the seasonal-to-decadal variations in physical drivers and subsequent pelagic ecosystem responses in the coastal upwelling zone of the northern California Current (NCC). Seven stations are sampled along a transect that spans continental shelf and slope waters. Parameters measured include temperature, salinity, fluorescence and oxygen profiles, water sampling for nutrients, chlorophyll and phytoplankton, and plankton net tows for zooplankton and krill. The relative proportions of 'northern' and 'southern' copepods are indicators of 'lipid-rich' and 'lipid-depleted' food chains, respectively, as are the proportions of lipid-rich and lipid-depleted euphausiids. Significant correlations are found between the copepods, euphausiids, salmon returns (coho and Chinook salmon) and other fishes. Differences in food chain structure seem to be driven largely by differences in advection. On a seasonal scale, intra-annual oscillations in local winds (poleward downwelling-favorable winds in winter and equatorward upwelling-favorable winds in summer) influence alongshore currents that modify the mesozooplankton community structure of the NCC by advection. At interannual and decadal scales, ENSO and changes in the sign of the PDO are associated with similar community responses, thus must be associated with changes in advection associated with changes to these basin-scale indicators. Therefore, fisheries forecasting would benefit from real-time data on advection of the source waters which feed the NCC. Therefore, a useful application of the coastal observatories would be to produce real-time estimates of alongshore advection and the types of source waters which feed the NCC.

October 17, 12:10 (W4-9613)

Using autonomous underwater gliders to observe continental margins and oceanic boundary currents

John A. **Barth**

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Continental margins, spanning from the shallow (< 50 m) inner shelf, across the continental shelf and slope, and reaching out into the adjacent deep ocean, are regions of vigorous, time-dependent three-dimensional circulation, high primary productivity, and key fisheries. The boundary currents are challenging to observe because swift currents sweep water-following floats out of the regions of interest and because a full range of physical and biogeochemical sensors are required to characterize the ecosystem response in these regions. Observations must be sustained over many years because the boundary current regions are subject to large inter-annual and inter-decadal variability, for example, El Niño/La Niña signals transmitted by coastally trapped waves. The international community has recognized the importance of observing boundary currents as described, for example, in several OceanObs'09 community white papers (http://www.oceanobs09.net). As an example of a boundary current observing system, we have been making observations in the northern California Current for over 8 years using autonomous underwater gliders. Glider observations are combined with data from ocean moorings, satellites and ship-based measurements to understand the physical circulation and ecosystem response associated with a variety of phenomena including wind and freshwater forcing, low-oxygen "hypoxia" events, and El Niño/La Niña. Beginning in 2014, ocean observing platforms will be installed in the northeast Pacific as part of the Ocean Observatories Initiative, a long-term program funded by the U.S. National Science Foundation. A description of how the OOI observing elements (gliders, moorings, cabled seafloor laboratories) will be used to understand boundary current dynamics will be presented.

W4 Workshop Poster Presentation

W4-P1

NEAR-GOOS Cross-Basin Climate Monitoring Section: First results of a pilot project

Vyacheslav **Lobanov**[1], Sho Hibino[2], Dmitry Kaplunenko[1], Aleksandr Lazaryuk[1], Toshiya Nakano[2], Satoshi Ogawa[2] and Pavel Tishchenko[1]

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Since 2011 V.I. Il'ichev Pacific Oceanological Institute (POI), Far Eastern Branch, Russian Academy of Sciences and Japan Meteorological Agency (JMA) had started a pilot project on the NEAR-GOOS Cross-Basin Climate Monitoring Section with the objectives to monitor water mass properties in the Japan Sea and to detect their variability caused by climate change. The section is based on the PM line routinely implemented by JMA from the Japanese coast up to the Yamato Rise and the 134E section implemented by POI from the Russian coast down to the Yamato Rise. In total it consists of 25 stations with CTD observations and water sampling for chemical analyses from surface to bottom. Observations have been carried out in October-November periods of every year, simultaneously by both sides. When combining data obtained by different instruments and methods, an inter-comparison and validation of data are important. The data were adjusted using results of salinity measurements by a salinometer and post-processed to remove biases caused by temporal changes and pressure dependences specific to each sensor. Coupling of PM and 134E sections allows the analysis of water mass structure of the Japan Sea and estimates of the lateral distribution of intermediate, deep and bottom waters, and water exchange between the Japan and Yamato basins. Comparison of recent observations with historical data shows a clear trend of water temperature increase and decrease of dissolved oxygen in bottom waters of the Japan Basin, which should be associated with climate change and a warming tendency of regional winter conditions.

W4

W5

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

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

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

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

Friday, October 17 (14:00-18:00)

14:00   Introduction to SOLAS renewal proposal

14:20   Short presentations on SOLAS trends by national representatives

15:45   ***Coffee/Tea Break***

16:05   Additional presentations and discussion

17:40   Wrap-up and overview by SOLAS representatives

18:00   Workshop Ends

W5

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REGISTRANTS

AOOS	Alaska Ocean Observing System www.aoos.org/
Argo	Observing the Oceans in Real Time http://www.argo.net/
CeNCOOS	The Central and Northern California Ocean Observing System www.cencoos.org/
CLIVAR	Climate Variability and Predictability Program http://www.clivar.org/
ESSAS	Ecosystem Studies of Sub-Arctic Seas www.imr.no/essas
GCOS	Global Climate Observing System http://www.wmo.int/pages/prog/gcos/
GESAMP	Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection www.gesamp.org/
GOOS	Global Ocean Observing System http://www.ioc-goos.org
ICES	International Council for the Exploration of the Sea www.ices.dk/indexfla.asp
IMBER	Integrated Marine Biogeochemistry and Ecosystem Research www.imber.info/
IOC	Intergovernmental Oceanographic Commission of UNESCO http://ioc-unesco.org
IOCCP	International Ocean Carbon Coordination Project www.ioccp.org/
IODE	IOC International Oceanographic Data and Information Exchange www.iode.org/
IPCC	Intergovernmental Panel on Climate Change http://www.ipcc.ch/
ISC	International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean http://isc.ac.affrc.go.jp
IWC	International Whaling Commission http://iwcoffice.org/
NANOOS	Northwest Association of Networked Ocean Observing Systems www.nanoos.org/
NEAR-GOOS	North-East Asian Regional GOOS program http://near-goos.coi.gov.cn/
NOWPAP	Action Plan for the Protection, Management and Development of the Marine and Coastal Environment of the Northwest Pacific Region www.nowpap.org/
NPAFC	North Pacific Anadromous Fish Commission www.npafc.org
NPFMC	North Pacific Fishery Management Council www.fakr.noaa.gov/npfmc

NPRB	North Pacific Research Board
	www.nprb.org/
PSC	Pacific Salmon Commission
	http://www.psc.org/
PAG	Pacific Arctic Group
	http://pag.arcticportal.org/
POGO	Partnership for Observation of the Global Oceans
	http://ocean-partners.org
PSG	Pacific Seabird Group
	http://www.pacificseabirdgroup.org
SAHFOS	Sir Alister Hardy Foundation for Ocean Science
	www.sahfos.ac.uk/
SCCOOS	Southern California Coastal Ocean Observing System
	www.sccoos.org/
SCOR	Scientific Committee on Oceanic Research
	http://www.scor-int.org/
SOLAS	Surface Ocean - Lower Atmosphere Study
	www.solas-int.org/
WESTPAC	IOC Sub-Commission for the Western Pacific
	www.unescobkk.org/westpac/about-us/ioc-westpac/ioc-westpac/

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