PICES-2009

Understanding ecosystem dynamics and pursuing ecosystem approaches to management

North Pacific Marine Science Organization

October 23 – November 1, 2009
Jeju, Republic of Korea

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Abstracts for oral presentations are sorted first by session and then by presentation time. Abstracts for posters are sorted by session and then by paper ID number. Presenter name is in bold-face type and underlined. Some abstracts in this collection are not edited and are printed in the condition they were received.

Notes for Guidance

This Annual Meeting is hosted by the Ministry of Land, Transport and Maritime Affairs (MLTM), in coordination with the PICES Secretariat. Local arrangements are made by the Jeju Special Self-Governing Province, the National Fisheries Research & Development Institute (NFRDI) and the Korea Ocean Research & Development Institute (KORDI). All sessions and workshops will be held at the Jeju International Convention Center.

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 will be on display from October 27 (a.m.) until October 30 (a.m.). The Wine & Cheese Poster Session will be held from 18:00-20:30 on October 29 (International Convention Center, 3rd floor lobby), when poster presenters are expected to be available to answer questions. Posters must be removed on the morning of October 30.

Internet access

Internet access via wireless LAN will be available at the International Convention Center. A few desktop computers will also be available for participants.

Social activities

October 26 (18:30-21:00)

Welcome Reception

The Welcome Reception for all participants will be hosted by the Governor of the Jeju Special Self-Governing Province, and held at the Ocean View Hall of the International Convention Center (5th floor).

October 27

Soccer tournament

The event will be held at the Kang Chang Hak Stadium, international standards venue, situated at the foot of Halla Mountain and overlooking the ocean. A free barbecue will be provided. The attendance is limited to 100 people, soccer players and spectators included; therefore, participation will be on a first come first served basis. There will be 2 teams: host team and PICES team.
Contact: Mr. Yongling Zhu (at the registration desk).
Please specify whether you want to play on the teams or be a spectator.

October 28

Extravaganza Dinner

The Extravaganza Dinner will be at the Chun Jae Yun Restaurant. This restaurant is in a beautiful location not far from the Jeju Conference Center. It offers authentic Korean/Jeju cuisine and uses local Jeju ingredients. Some Korean liquors/drinks will be paired with the courses. Western wines or beer can be purchased separately. The ticket price of the dinner is CAD$100. The capacity of the restaurant is limited.
Contact: Ms. Christina Chiu (at the registration desk).

Meeting Timetable

Friday, October 23						
09:00 18:00	FIS Workshop (W5)	MEQ Workshop (W6)- lab demo	POC/BIO Workshop (W9)	*WG-23* *Meeting*	POC/BIO Workshop (W10)	*WG-21* *Meeting*
Saturday, October 24						
09:00 12:30	MEQ Workshop (W6)	BIO Workshop (W4)	MEQ/FIS Workshop (W7)	POC Workshop (W8)	POC/BIO Workshop (W10)	*WG-21* *Meeting*
14:00 18:00	BIO Workshop (W2)				*CC-S* *Meeting*	
Sunday, October 25						
09:00 12:30	BIO Workshop (W1)	BIO Workshop (W4)	MEQ/FIS Workshop (W7)	POC Workshop (W8)	*HAB-S* *Meeting*	*SG-COM* *Meeting*
12:30 14:00	*Science Board Lunch Meeting**					
14:00 18:00	BIO Workshop (W1) *WG-22* *Meeting*	BIO Workshop (W4)	*WG-20* *Meeting*	*WG-24* *Meeting*	*HAB-S* *Meeting*	*SG-COM* *Meeting*
18:00 21:00	*CPR-AP Meeting*		*CREAMS-AP Meeting*		16:00 21:00	*WG-FCCIFS* *Meeting*
Monday, October 26						
09:00 10:00	**OPENING SESSION**					
10:00 18:00	Science Board Symposium (S1)					
Tuesday, October 27						
09:00 12:30	FIS Topic Session (S2)		MEQ Topic Session (S4)		POC/BIO Topic Session (S8)	
14:00 18:00			BIO Workshop (W3)			
16:00 18:00	*AICE-AP Meeting*		*COVE-AP Meeting*		*SOFE-AP Meeting*	
18:00 21:00	*joint AICE/COVE/SOFE-AP Meeting*				*MBM-AP Meeting*	
Wednesday, October 28						
09:00 12:30	FIS/BIO Topic Session (S3) - Part I		MEQ Topic Session (S5)		POC/FUTURE Topic Session (S9) - Part I	*F&A* *Meeting**
14:00 18:00	*BIO* *Meeting*	*FIS* *Meeting*	*MEQ* *Meeting*	*POC* *Meeting*	*TCODE* *Meeting*	*MONITOR* *Meeting*
Thursday, October 29						
09:00 12:30	FIS/BIO Topic Session (S3) - Part II		MONITOR Topic Session (S7)		FIS Paper Session	
14:00 18:00	POC/FUTURE Topic Session (S9) - Part II					
18:00 20:30	**POSTER SESSION**					
Friday, October 30						
09:00 17:30	MEQ/FIS Topic Session (S6)		BIO Paper Session		POC Paper Session	
18:00 20:30	**CLOSING SESSION**					

Saturday, October 31		
09:00 18:00	*Science Board Meeting**	*Governing Council Meeting**
Sunday, November 1		
09:00 18:00	*Governing Council Meeting**	

* Closed Session

Sessions/Workshops

S1	Understanding ecosystem dynamics and pursuing ecosystem approaches to management
S2	Ecosystem-based approaches for the assessment of fisheries under data-limited situations
S3	Early life stages of marine resources as indicators of climate variability and ecosystem resilience
S4	Mitigation of harmful algal blooms
S5	The role of submerged aquatic vegetation in the context of climate change
S6	Marine spatial planning in support of integrated management – tools, methods, and approaches
S7	State of the art of real-time monitoring and its implication for the FUTURE oceanographic study
S8	Anthropogenic perturbations of the carbon cycle and their impacts in the North Pacific
S9	Outlooks and forecasts of marine ecosystems from an earth system science perspective: Challenges and opportunities
BIO-P	BIO Paper Session
FIS-P	FIS Paper Session
POC-P	POC Paper Session
W1	Natural supplies of iron to the North Pacific and linkages between iron supply and ecosystem responses
W2	Standardizing methods for estimating jellyfish concentration and development of an international monitoring network
W3	Integrating marine mammal populations and rates of prey consumption in models and forecasts of climate change-ecosystem change in the North Pacific and North Atlantic Oceans
W4	Marine ecosystem model inter-comparisons (II)
W5	Understanding the links between fishing technology, bycatch, marine ecosystems and ecosystem-based management
W6	Review of selected harmful algae in the PICES Region: V. Cyst forming HAB species
W7	Interactions between aquaculture and marine eco-systems
W8	Exploring the predictability and mechanisms of Pacific low frequency variability beyond inter-annual time scales
W9	Mesoscale eddies and their roles in North Pacific ecosystems
W10	Carbon data synthesis workshop

Meetings

AICE-AP	Advisory Panel on Anthropogenic Influences on Coastal Ecosystems (*belongs to FUTURE Science Program*)
BIO	**Biological Oceanography Committee**
COVE-AP	Advisory Panel on Climate, Oceanographic Variability and Ecosystems (*belongs to FUTURE Science Program*)
CPR-AP	Advisory Panel on the Continuous Plankton Recorder Survey in the North Pacific (*belongs to MONITOR Committee*)
CREAMS-AP	Advisory Panel for a CREAMS/PICES Program in East Asian Marginal Seas (*belongs to MONITOR and POC Committees*)
CC-S	Section on Carbon and Climate (*belongs to BIO and POC Committees*)
FIS	**Fishery Science Committee**
FUTURE	**Forecasting and Understanding Trends, Uncertainty and Responses of the North Pacific Ecosystem Science Program**
HAB-S	Harmful Algal Blooms Section (*belongs to MEQ Committee*)
MBM-AP	Advisory Panel on Marine Birds and Mammals (*belongs to BIO Committee*)
MEQ	**Marine Environmental Quality Committee**
MONITOR	**Technical Committee on Monitoring**
POC	**Physical Oceanography and Climate Committee**
SG-COM	Study Group on "PICES Communication" (*belongs to Governing Council*)
SOFE-AP	Advisory Panel on Status, Outlooks, Forecasts, and Engagement (*belongs to FUTURE Science Program*)
TCODE	**Technical Committee on Data Exchange**
WG-FCCIFS	Joint PICES/ICES Working Group on Forecasting Climate Change Impacts on Fish and Shellfish (*belongs to FIS and POC PICES Committees and OCC ICES Committee*)
WG-20	Working Group on Evaluations of Climate Change Projections (*belongs to POC Committee*)
WG-21	Working Group on Non-indigenous Aquatic Species (*belongs to MEQ Committee*)
WG-22	Working Group on Iron Supply and its Impact on Biogeochemistry and Ecosystems in the North Pacific Ocean (*belongs to BIO Committee*)
WG-23	Working Group on Comparative Ecology of Krill in Coastal and Oceanic Waters around the Pacific Rim (*belongs to BIO Committee*)
WG-24	Working Group on Environmental Interactions of Marine Aquaculture (*belongs to FIS and MEQ Committees*)

Keynote Lecture

October 26, 10:00

Ecosystem-based fisheries assessment and management: A step towards FUTURE Implementation of ecosystem approaches to management

Chang Ik **Zhang**

Pukyong National University, Busan, 608-737, R Korea. E-mail: cizhang@pknu.ac.k

North Pacific marine ecosystems in the PICES region have been utilized in a variety of ways. In the western North Pacific, large coastal populations, with a long history of full exploitation of most harvestable renewable resources, are confronted with overfishing and habitat degradation. In the eastern North Pacific, coastal population growth and economic development have proceeded at a much slower pace, exerting less pressure on fishery resources. Marine living resources exploited by fisheries are part of complex marine ecosystems where many species interact. Ecosystem-based management is becoming a global theme of marine science in the 21st century. The World Summit on Sustainable Development (WSSD) recommended the implementation of the ecosystem approach by 2010. This holistic approach should consider fisheries resources and their associated habitats by examining ecological interactions of target species with predators, competitors, and prey species, interactions between fishes and their habitats, and the effects of fishing on these processes. A pragmatic ecosystem-based approach has been developed for the assessment of fisheries resources involving four management objectives: maintaining sustainability, biodiversity, habitat quality, and socio-economic benefits. It is a two-tier analytical system. Tier 1 is designed for situations where sufficient information is available to allow for a quantitative evaluation of the status of the system, whereas Tier 2 is designed for situations where only a semi-quantitative or qualitative assessment is possible. A number of indicators are used to assess ecosystem status. Target and limit reference points were chosen for each indicator to assess the status of species, fisheries and ecosystems. The approach was applied to several ecosystems and was found to be useful in comparing the status of species, fisheries and ecosystems spatially and temporally using an ecosystem perspective. A forecasting version of this approach is in the process of development with an aim to forecast the impacts of fishing activities and climate changes on the ecosystem. PICES has undertaken a new science program, FUTURE, with a goal to develop an understanding of the responses of marine ecosystems in the North Pacific to climate change and human activities, and to forecast ecosystem status based on an understanding of ecosystem functions. Conduct of the FUTURE program will enhance the limited understanding of ecosystem structure and function, and improve the ability to forecast the impacts of human activities and climate on marine ecosystems.

Schedules and Abstracts

S1 Science Board Symposium
Understanding ecosystem dynamics and pursuing ecosystem approaches to management

Co-Convenors: John E. Stein (SB), Michael J. Dagg (BIO), Mikhail Stepanenko (FIS), Glen Jamieson (MEQ), Hiroya Sugisaki (MONITOR), Michael G. Foreman (POC), Bernard A. Megrey (TCODE), Harold P. Batchelder (CCCC), Michio J. Kishi (CCCC), Fangli Qiao (China) and Sinjae Yoo (Korea)

PICES undertakes a new science program, FUTURE (**F**orecasting and **U**nderstanding **T**rends, **U**ncertainty and **R**esponses of North Pacific Marine **E**cosystems), to understand the responses of marine ecosystems in the North Pacific to climate change and human activities, having the major questions: 1) How does ecosystem structure and function determine an ecosystem's response to natural and anthropogenic forcing? 2) How do physical and chemical processes respond to natural and anthropogenic forcing and how are ecosystems likely to respond to these changes in abiotic processes? 3) How do human activities impact coastal marine ecosystems and their interactions with offshore and terrestrial systems. We have only a limited ability to forecast how marine ecosystems will be affected by the changing global climate. Consequently, we still have limited knowledge on the assessment and management of marine ecosystems. Under this situation, it is necessary to improve our understanding of ecosystem structure and function, ecosystem stability and resilience, and to understand and quantify the impacts of human activities and climate on marine ecosystems. It is urgent that we develop and adopt a comprehensive ecosystem-based approach which will be required to manage depleted and deteriorated marine ecosystems. To this end, breakthroughs have to be made in many areas, including evaluation of ecosystem status.

Monday, October 26 (11:00-17:45)

10:00 **Chang Ik Zhang (Keynote)**
Ecosystem-based fisheries assessment and management: A step towards FUTURE implementation of ecosystem approaches to management

10:40 ***Coffee / tea break***

11:00 **John K. Pinnegar, Steven Mackinson, Kathryn Keeble and Georg H. Engelhard (Invited)**
How does ecosystem structure and function determine the response to natural and anthropogenic forcing? (S1-5817)

11:25 **Suam Kim, Ana L. Rosa, Sang-Wook Yeh, Chung I. Lee, Sukyung Kang, Sinjae Yoo, Hyunwoo Kang and Yasunori Sakurai (Invited)**
Effects of atmospheric and oceanographic variability on the common squid (*Todarodes pacificus*) in Korean and Japanese waters during the last 30 years (S1-5811)

11:50 **William Crawford and James Irvine**
A group approach to understanding ecosystem dynamics in the northeast Pacific (S1-5887)

12:10 **William J. Sydeman, Jarrod A. Santora, Stephen Ralston, Nandita Sarkar, Steven J. Bograd, and Robert M. Suryan**
Krill of the California Current: Predictive habitat modeling for ecosystem protection? (S1-5800)

12:30 ***Lunch***

14:00 **Mitsutaku Makino, Chikako Watanabe, Masahito Hirota and Takumi Mitani (Invited)**
Understanding the interactions between ecosystem structure and fisheries structure: The case of the sardine, anchovy, chub mackerel, and purse seine fisheries in Japan (S1-5986)

14:25 **Franz J. Mueter and Michael A. Litzow (Invited)**
The spatial footprint of biological re-organization in a demersal community (S1-5761)

14:50 **Hiroshige Tanaka, Seiji Ohshimo and Yoshiaki Hiyama**
Long-term fluctuations in the biomass of sardine *Sardinops melanostictus* in the western Japanese waters (Sea of Japan and East China Sea) from 1953 to 2008, in relation to climate variability (S1-5855)

15:10 **Chang Ik Zhang, Jennifer Boldt, Angie Greig, Anne B. Hollowed and Patricia Livingston**
An assessment of fisheries management strategies in Alaska relative to the goals of ecosystem approaches to management (S1-5830)

15:30 ***Coffee / tea break***

15:50 **Michael Sinclair (Invited)**
Ecosystem approach to management: The Scotian Shelf example (S1-5778)

16:15 **Erlend Moksness (Invited)**
Major human activities affecting Norwegian coastal marine ecosystems: Present status and challenges (S1-5578)

16:40 **Tony Smith, Beth Fulton and David Smith (Invited)**
Ecosystem approaches to managing marine systems – the human dimension (S1-5975)

17:05 **Wei Zheng, Zongling Wang and Mingyuan Zhu**
Impact of human activities on marine ecosystem services (S1-5618)

17:25 **Peter S. Ross**
The pulse of the Pacific: Can science respond effectively to a changing ocean? (S1-5721)

17:45 ***Session ends***

S1 Posters

S1-5536 **Lidia T. Kovekovdova and Mikhail V. Simokon**
Environmental assessment of the rivers of Peter the Great Bay basin (Japan/East Sea)

S1-5537 **Mayuko Tomida, Nobuyuki Miyazaki and Masahide Kaeriyama**
Biotransport of POPs by salmonids in the North Pacific

S1-5558 **Olga N. Lukyanova, Andrey P. Chernyaev, Nikolay V. Kolpakov and Anna S. Vazhova**
Environmental impact assessment in the estuarine ecosystems of Peter the Great Bay (Japan/East Sea)

S1-5603 **Sanae Chiba, Kazuaki Tadokoro, Akira Kuwata and Hiroya Sugisaki**
Bottom-up control of multi-decadal variation of the western North Pacific ecosystem revealed by stable isotope ratio analysis

S1-5627 **Shan Gao, Hui Wang, Guimei Liu and Liyin Wan**
Temporal and spatial distribution of marine primary production in the South China Sea (SCS)

S1-5633 **Hai Li, Jing Yang and Qin-Zheng Liu**
Numerical simulation study on primary production in the Bohai Sea in summer, 2006

S1-5638 **Hui Wang, Guimei Liu, Shan Gao and Hua Jiang**
Response of marine primary production to monsoon variations in the South China Sea

S1-5753 **Hyunju Seo, Hideaki Kudo and Masahide Kaeriyama**
Causal linkage among growth, survival, and intra-population interactions of Hokkaido chum salmon related to climate changes in 1945-2005

S1-5789 **Vladimir Krapivin and Ferdenant Mkrtchyan**
An adaptive technology for Nature/Society System biocomplexity assessments

S1-5831 **An-Yi Tsai, Kuo-Ping Chiang, Ciou-Jyu Wang and Gwo-Ching Gong**
The impact of the Changjiang River plume extension on the nanoflagellate community in the East China Sea

S1-5880 **Felipe Hurtado-Ferro**
The role of uncertainty in hypothetical top predator culling programs

S1-5902 **Pavel A. Salyuk, Oleg A. Bukin, Alexander Yu. Mayor, Andrey N. Pavlov and Konstantin A. Shmirko**
Atmosphere aerosol and marine ecosystems after Sarychev Peak volcano eruption of June 2009

S1-5935 **Joong Ki Choi, Jae Hoon Noh, Sung Hwan Cho, Seung Yoon Park and Youngju Lee**
Long term change of phytoplankton ecology in the eastern part of the Yellow Sea

S1-5946 **Seok-Hyun Youn, Yu-Mi Jun, Jae-Dong Hwang, Yong-Hwa Lee, Hyun-Gook Jin, Jung-Min Shim, Young-Suk Kim and Ki-Young Kwon**
Egg production of copepod *Acartia omorii* in the coastal waters of Korea

S1-5948 **Young-Sang Suh, Ki-Tack Seong, Jae-Dong Hwang, and Yeong Gong**
Mixed layer depth in the high production region off Korea

S1-5965 **Jae Bong Lee, Dong Woo Lee, Yeong Min Choi, Chang Ik Zhang, Myoung Ho Sohn, Sung Il Lee, Young Il Seo, Sang Chul Yoon, Yoo Jung Kwon, Jong Hee Lee, Hee Won Park, Young Jae Shin, Do Hoon Kim, In-Ja Yeon, Heui Chun An and Dae Soo Chang**
A comparative study on the ecosystem risk indices of Korean waters

S1 Oral Presentations

26 October, 11:00 (S1-5817), Invited

How does ecosystem structure and function determine the response to natural and anthropogenic forcing?

John K. **Pinnegar**, Steven Mackinson, Kathryn Keeble and Georg H. Engelhard

Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Pakefield Rd., Lowestoft, Suffolk, NR33 0HT, UK
E-mail: john.pinnegar@cefas.co.uk

Much has changed in the North Sea over the past 100 or so years; particular fisheries have come and gone, certain species (*e.g.* blue-fin tuna, common skate and sturgeon) have virtually disappeared and at the same time environmental conditions have changed appreciably with a general warming of surface waters, although there have also been periods of cooling. In this study we make use of a complex food-web model, constructed to represent the period immediately prior to the onset of intensive steam trawling (*i.e.* the 1880s and 1890s), and we 'force' this model forward in time up to the present day, using reconstructed time series of international fisheries catch data as well as climate indices. We examine the relative importance of fishing and climate when trying to 'fit' the model to observed data on fish or planktonic biomasses. We consider whether the widely-reported 'gadoid outburst' of the 1960s and 1970s was largely driven by 'bottom up' (environmental) or 'top down' (exploitation) processes, and whether the most recent warming period might negatively impact population recovery in certain depleted fish stocks. We present hitherto unpublished data series on sea temperatures in the North Sea throughout the 20th Century, as well as a 115 year time series of fisheries catch data. This study considers long-term changes in the structure and functioning of marine food webs, and attempts to draw conclusions with regard to underlying processes and their impact upon marine fish resources.

26 October, 11:25 (S1-5811), Invited

Effects of atmospheric and oceanographic variability on the common squid (*Todarodes pacificus*) in Korean and Japanese waters during the last 30 years

Suam **Kim**[1], Ana L. Rosa[2], Sang-Wook Yeh[3], Chung I. Lee[4], Sukyung Kang[5], Sinjae Yoo[3], Hyunwoo Kang[3] and Yasunori Sakurai[2]

[1] Department of Marine Biology, Pukyong National University, 599-1 Daeyeon3-dong, Nam-gu, Busan, 608-737, R Korea
E-mail: suamkim@pknu.ac.kr
[2] Graduate School of Fisheries Sciences, Hokkaido University, 3-1-1 Minato-cho, Hakodate, Hokkaido, 041-8611, Japan
[3] Korea Ocean Research and Development Institute, Ansan P.O. Box 29, 425-600, Seoul, R Korea
[4] Gangneung, Kangnung-Wonju National University, 120 Gangneung Daehangno, Gangwon-do, 210-702, R Korea
[5] National Fisheries Research and Development Institute, 152-1 Haean-ro, Gijang-gun, Busan, 619-705, R Korea

The common squid, *Todarodes pacificus*, is one of the most important ecological and fishery components of the northwestern Pacific Ocean. They spawn mostly in the East China Sea (ECS) and around the Tsushima Strait during autumn-winter, and migrate to the sea between the Asian mainland and Japanese Islands for feeding. In the past decades, pronounced changes were observed in the ECS: since the late 1980s, the water temperature shifted to a warming phase, and zooplankton biomass and squid catches have dramatically increased concurrently. Multi-institutional cooperative research on common squid has been conducted to identify the possible controlling environmental factors of abundance and recruitment. Considering the importance of the early survival to recruitment, we examined fishery information since 1978, because extensive sampling efforts on zooplankton and squid paralarvae started in Korea and Japan, respectively, from that year. Climate indices, observed and assimilated seawater properties in spawning and nursery grounds, simulated wind and current velocities and directions, water mass transport, estimated spawning area, mixed layer depth (MLD), and plankton production were compared to fishery data. The interannual fluctuation of the first empirical orthogonal functional component of sea surface temperature resembles that of squid catch anomaly. Seawater temperature of the spawning and nursery areas showed a statistically significant relationship with squid catch in the following year. During the course of the warming after the late 1980s, wind intensity is closely related to the MLD which is negatively correlated with squid catch. The size of the spawning area also seems to have a strong correlation with squid catch.

26 October, 11:50 (S1-5887)

A group approach to understanding ecosystem dynamics in the northeast Pacific

William **Crawford**[1] and James Irvine[2]

[1] Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, V8L 4B2, Canada. E-mail: bill.crawford@dfo-mpo.gc.ca
[2] Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, BC, Canada

About forty marine scientists meet every winter to discuss recent conditions in the northeast sector of the Pacific Ocean, including its marine life. Each scientist presents observations as an update of a time series of a specific physical indicator or marine species in one or more sub-regions, providing comparison with previous years. In most years an ecological pattern emerges. The overall view provides insight into how interannual changes in weather and oceans impact the ecosystems of Canadian and neighbouring oceanic domains. A full report is published by spring and gives resource users and agencies advice on how to manage the native, commercial and sports fisheries that generally have peak activity in the summer and early autumn (http://www.pac.dfo-mpo.gc.ca/sci/psarc/OSRs/Ocean_SSR_e.htm). The strength of this particular ecological approach lies in the rapid development of insights based on collaborative expert knowledge and assimilation of this insight into management decisions. For example, this process has revealed how years of warmer ocean waters impact the ecosystem of the west coast of Vancouver Island more strongly than neighbouring regions, likely related to the groups of zooplankton that dominate in warm waters and impact survival of fish and seabirds. As another example, by combining observations of juvenile seabird survival, ocean temperature measurements and time series of chlorophyll concentrations measured from space, we have been able to identify specific seasons whose ocean conditions determine critical marine survival. These and other ecological patterns provide insight into how the ecosystem is expected to adapt to climate change.

26 October, 12:10 (S1-5800)

Krill of the California Current: Predictive habitat modeling for ecosystem protection?

William J. **Sydeman**[1], Jarrod A. Santora[1], Stephen Ralston[2], Nandita Sarkar[3], Steven J. Bograd[3], and Robert M. Suryan[4]

[1] Farallon Institute for Advanced Ecosystem Research, P.O. Box 750756, Petaluma, CA, 94975, USA. E-mail: wsydeman@comcast.net
[2] NOAA Fisheries, Southwest Fisheries Science Center, 110 Shaffer Rd., Santa Cruz, CA, 95060, USA
[3] Pacific Fisheries Environmental Laboratory 1352 Lighthouse Ave., Pacific Grove, CA, 93950-2097, USA
[4] Oregon State University, Hatfield Marine Science Center 2030 SE Marine Science Dr, Newport, OR, 97365, USA

With respect to ecosystem-based management and protection (*e.g.*, design of marine protected areas, recognition of areas of special biological significance), it is important to understand, and if possible, predict the spatial distribution of key mid trophic level prey species. Krill are an integral component of the California Current Ecosystem (CCE) and support a myriad of commercially valuable as well as protected top predator species including fish, birds and mammals. It has been postulated that krill have affinities for particular bathymetric and hydrographic habitats (*i.e.* canyons, isobaths, fronts), but it is unclear how these factors collectively influence krill aggregations (patches). We surveyed the spatial distribution of krill using hydroacoustics in May-June 2002-2006 in central-northern California, and have modeled the distribution of krill patches in relation to bathymetric slope, distance from shelf break/canyon heads, fronts, Chl-*a* persistence, and sea-surface height anomalies (representing eddy structures). The model outputs spatially explicit probability density functions, which can be used to understand habitat preferences and predict sites of krill utilization. Using this information, we upscale the model to regions of the central-northern California Current not sampled by our field program. Application of these results to fisheries management and ecosystem protection (*e.g.*, design of a network of offshore marine protected areas) for this region will be discussed.

26 October, 14:00 (S1-5986), Invited

Understanding the interactions between ecosystem structure and fisheries structure: The case of the sardine, anchovy, chub mackerel, and purse seine fisheries in Japan

Mitsutaku **Makino**[1], Chikako Watanabe[2], Masahito Hirota[1] and Takumi Mitani[1]

[1] Fisheries Economy Division, National Research Institute of Fisheries Science, Fisheries Research Agency, 2-12-4, Fukuura, Kanazawa, Yokohama, 236-8648, Japan. E-mail: mmakino@affrc.go.jp
[2] Stock Assessment Division, National Research Institute of Fisheries Science, Fisheries Research Agency, 2-12-4, Fukuura, Kanazawa, Yokohama, 236-8648, Japan

In the northwestern Pacific, a fish alternation phenomenon amongst sardine, anchovy and chub mackerel has been observed. Sardine biomass has been drastically declining since 1988, presumably as an ecosystem response to the atmospheric and oceanographic regime shift. However, an increase in the chub mackerel biomass, which is expected to happen according to fish alternation theory, has not yet been observed. In order to understand this situation, we analyzed the inter-relationships between the resource dynamics of the related species and the economic dynamics of the purse seine fishery. We found that intensive capital investment on fishing vessels during sardine-abundant periods (the 1980s) was the most important cause for the non-recovery of chub mackerel biomass in the later years. In other words, human decisions without due regard to the species alternation phenomenon have inhibited the successive species alternation phenomenon to emerge. As an example of better management measures which take species alternation into account, we estimated the benefits of hypothetical governmental interventions during the sardine-abundant period in terms of expected catch value, biomass, and food supply in the later years. With these results, this study tried to show that, only through an inter-disciplinary collaboration between natural science on ecosystem mechanisms and social science on human activity mechanisms, can we better understand ecosystem dynamics and discuss management measures for the sustainable use of ecosystem services.

26 October, 14:25 (S1-5761), Invited

The spatial footprint of biological re-organization in a demersal community

Franz J. **Mueter**[1] and Michael A. Litzow[2]

[1] School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Juneau, AK, 99801, USA. E-mail: fmueter@alaska.edu
[2] Blue World Research, 2710 East 20th Ave., Anchorage, AK, 99508, USA

Indicators of physical and biological variability have revealed important decadal-scale trends and abrupt regime shifts in the Northeast Pacific Ocean and its marginal seas. Here we first review major modes of marine environmental variability based on a re-analysis of updated time series from Hare and Mantua (2000), as well as an analysis of regional time series for the eastern Bering Sea. We found some evidence for a re-organization in fish communities and for a shift in biological productivity in 1999 both in the eastern Bering Sea and throughout the Northeast Pacific, but these changes were not accompanied by a persistent shift in the physical environment. There appears to be relatively weak coherence on decadal scales between the major modes of biological and physical variability following the 1976/77 regime shift. We hypothesize that directional changes in the productivity or abundance of multiple populations can be triggered by short-term events or thresholds in the physical environment that result in pronounced shifts in the spatial distribution of fish communities and therefore in the trophic interactions among species. We test our hypothesis for the eastern Bering Sea shelf by examining spatial anomalies in the distribution of groundfish populations. We quantify the temporal variability in these spatial anomalies to test (1) whether changes in spatial anomalies are linked to physical variability and (2) whether recurring spatial patterns of distribution are associated with periods of above or below-average productivity of trophically related species.

26 October, 14:50 (S1-5855)

Long-term fluctuations in the biomass of sardine *Sardinops melanostictus* in the western Japanese waters (Sea of Japan and East China Sea) from 1953 to 2008, in relation to climate variability

Hiroshige **Tanaka**[1], Seiji Ohshimo[1] and Yoshiaki Hiyama[2]

[1] Seikai National Fisheries Research Institute, Fisheries Research Agency, 1551-8 Taira, Nagasaki, Nagasaki, 851-2213, Japan
E-mail: tanakahs@affrc.go.jp
[2] Fisheries Research Agency, 2-3-3 Minato Mirai, Nishi-ku, Yokohama, Kanagawa, 220-6115, Japan

We analyzed long-term fluctuations in the biomass of sardine *Sardinops melanostictus* in the western Japanese waters (in the Sea of Japan and northeastern part of the East China Sea), called "Tsushima current stock", using a cohort analysis from 1953 to 2008. An age-length key was developed using age estimated from annual rings on scales. Growth of the 1980-1987 year classes, when biomass reached its maximum value, was less than growth of other year classes. Biomass of this stock has fluctuated at large scale; it increased in the 1970s and was especially high in the 1980s, and then it rapidly declined in the 1990s, following by 1 year the decline of the Japanese Pacific sardine stock. The lowest fishery catch was recorded in 2001 (*ca.* 1,000 tons), and at that time biomass was also estimated as the lowest. Recently, biomass has been recovering slightly. Long-term temporal variation in reproductive success rates, expressed by logarithmic recruitment residuals (LNRR) from an extended Ricker spawner-recruitment curve, corresponds to variation in climate indices such as the Monsoon Index (MOI, differences in air pressure at sea level between Irkutsk, Russia and Nemuro, Japan from December to February). It suggests that stock fluctuation is influenced by environmental factors, possibly through ambient water temperature, transports, and prey (plankton).

26 October, 15:10 (S1-5830)

An assessment of fisheries management strategies in Alaska relative to the goals of ecosystem approaches to management

Chang Ik Zhang[1], Jennifer Boldt[2], Angie Greig[3], Anne B. **Hollowed**[3] and Patricia Livingston[3]

[1] Department of Marine Production Management, Pukyong National University, 559-1 Daeyeon-3-dong, Nam-gu, Busan, 608-737, R Korea
[2] Pacific Biological Station, Fisheries and Oceans Canada, 3190 Hammond Bay Rd., Nanaimo, BC, V9T 6N7, Canada
[3] Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA, 98115, USA. E-mail: Anne.Hollowed@noaa.gov

In 2004, the North Pacific Fishery Management Council (NPFMC) prepared a Programmatic Supplemental Environmental Impact Statement (PSEIS) that adopted a precautionary management policy designed to promote ecosystem-based management principles. Many of the provisions of this policy adhere to goals identified by national and international panels charged with developing frameworks for implementing Ecosystem Approaches to Management (EAM). The performance of the NPFMC approach is evaluated using an Integrated Fisheries Risk Assessment Method for Ecosystems (IFRAME). The IFRAME approach synthesizes information from stock assessments and ecosystem indicators to provide a comprehensive evaluation of the status of the Bering Sea Aleutian Islands ecosystem. The IFRAME is used to assess the impacts of changes in management resulting from implementation of the American Fisheries Act, Steller sea lion protection measures, revisions to overfishing definitions and other plan amendments by comparing risk scores in 1997 to 2007.

26 October, 15:50 (S1-5778), Invited

Ecosystem approach to management: The Scotian Shelf example

Michael **Sinclair**

Bedford Institute of Oceanography, Box 231 Central, Halifax, NS, B3J 2M4, Canada. E-mail: sinclairm@mar.dfo-mpo.gc.ca

The Canadian Oceans Act (1997) states that an ecosystem approach will be implemented for the integrated management of multiple ocean use activities. The Eastern Scotian Shelf was chosen as a pilot. A pragmatic approach has been adopted, involving incorporation of a common set of high level national conservation objectives (addressing biodiversity, productivity and habitat features) within the diverse ocean use management plans.

Following broad consultation on specific conservation issues, the high level objectives are being made operational within the diverse fisheries management plans (and other ocean use planning processes). Initial priorities relative to fisheries impacts have been on by-catch and benthic disturbance. The template for the approach has been used to identify research needs. Implementation has been compromised to some degree by a lack of understanding of the causes of a regime shift in the 1990s. The relative roles of Grey seals and fishing on ecosystem structure remain controversial. Progress made to date, and the challenges, are summarized.

26 October, 16:15 (S1-5578), Invited

Major human activities affecting Norwegian coastal marine ecosystems: Present status and challenges

Erlend **Moksness**

Institute of Marine Research, Flødevigen Marine Research Station, 4817 His, Norway. E-mail: moksness@imr.no

The Norwegian coastal zone encompasses approximately 90,000 km^2 and has a coastline of 57,000 km (including islets and islands). The coastal zone with its many fjords and habitats is inhabited by numerous of species. Cod (*Gadus morhua*) is one of the key species, and each fjord has its local unique stock. The area is annually used by several abundant oceanic fish such as Norwegian spring-spawning herring (*Clupea harengus*), capelin (*Mallotus villosus*) and Arctic cod and haddock (*Mellanogrammus agelefinus*) for spawning and as nursery grounds.

Historically, the transport and fishing industries have been the major stakeholders in the coastal zone. Over the past 40 years, however, the number of stakeholders has increased and now includes new stakeholders such as aquaculture, oil and gas exploration and different forms of tourism. This development has resulted in increased user conflicts, and higher pressure and impact on the different coastal ecosystems, affecting both habitats and living resources. The increased public attention on the coastal zone in general has led to demand for better knowledge and understanding of the content and functions of the different ecosystems. This has resulted in increased mapping and research activities, and implementation of new regulations. Because there are now many stakeholders and a need to keep the monitoring cost at a low level, there is a requirement to develop management models that include environmental, social and economical components. Such models should be a significant part of a future toolbox to be applied in the management of the coastal zone.

26 October, 16:40 (S1-5975), Invited

Ecosystem approaches to managing marine systems – the human dimension

Tony **Smith**, Beth Fulton and David Smith

Marine and Atmospheric Research, CSIRO, P.O. Box 1538, Hobart, 7001, Australia. E-mail: tony.d.smith@csiro.au

The emergence of both ecosystem based management (EBM) and ecosystem based fishery management (EBFM) in the past decade has led to more focus on understanding marine ecosystems, and arguably to new insights into ecosystem dynamics. This has involved a “rediscovery” of some existing tools (ecosystem modelling) and extensions of those tools, together with the development and application of other tools such as ecological risk assessment approaches to evaluating the broader ecological impacts of fishing, and more recently of climate change. While ecosystem science may have benefited, it is less clear that this improved understanding has translated into better management or outcomes. In this presentation we briefly review some of the scientific advances that have occurred, and point to some of the tools that allow evaluation of broad based (whole of system) strategies for managing marine ecosystems. However the main argument we put forward is that there has been insufficient attention paid to the human dimensions of the problem, and that failure to attend to this issue risks a scenario where we simply have better and better scientific understanding of the gradual or sometimes rapid demise of marine ecosystems and the services they provide. We argue for a systems view of dynamics that fully incorporates humans as key actors, from the behaviour of fishers under new regulatory or incentive based measures, through to overall governance of marine systems. Ultimately, this imbeds EBM in an earth systems view of global and regional dynamics.

26 October, 17:05 (S1-5618)

Impact of human activities on marine ecosystem services

Wei **Zheng**, Zongling Wang and Mingyuan Zhu

Key Laboratory for Science and Engineering of Marine Ecology and Environment, First Institute of Oceanography, SOA, 6 Xianxialing Rd., Qingdao, 266061, PR China. E-mail: zhengwei@fio.org

In recent years, economic development of coastal areas and acceleration of urbanization processes has increased the demand for marine ecosystem services. But, some marine ecosystems have been destroyed and their capability to provide these services have decreased. Therefore, evaluating marine ecosystem services and the impact of human activities on them is important for the protection and sustainable development of marine ecosystems. Based on an analysis of marine ecosystem services, an assessment model for them has been established and applied to several marine ecosystems, including Sanggou Bay and Jiaozhou Bay. The main results are as follows:

(1) Change of ecosystem services due to mariculture activities in Sanggou Bay.
The results show, due to mariculture activities, the total value of ecosystem services in Sanggou Bay increases greatly. The value of food production increases a lot, but the value of oxygen production, climate regulation and water purification decreases. In future, improvement of the mariculture model in Sanggou Bay should not only concentrate on the production of cultured species, but also address the impact of mariculture activities on ecosystem services and trade–offs among different ecosystem services.

(2) Loss of ecosystem services value due to reclamation in Jiaozhou Bay
A model is developed to assess the loss of marine ecosystem services caused by reclamation in Jiaozhou Bay. The result indicates that the loss caused by reclamation in Jiaozhou Bay is about 5.11×10^8CNY from 2003 to 2006 and there is about 1.28×10^8CNY in loss annually.

26 October, 17:25 (S1-5721)

The pulse of the Pacific: Can science respond effectively to a changing ocean?

Peter S. **Ross**

Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, V8L 4B2, Canada. E-mail: peter.s.ross@dfo-mpo.gc.ca

The Pacific Ocean faces an onslaught of threats associated with burgeoning human impacts, including pollution, habitat destruction, climate change, and overexploitation of fisheries. As the world shrinks, the pace of change quickens, and the magnitude of change looms ever larger, can the credibility of science survive the gauntlet of a hungry public, a sensational media and an impatient politic climate? With cumulative impacts blurring traditional scientific disciplines and ever-changing technologies providing increased socio-economic complexity, the 21st century will see profound ways in which science is applied and used in support of management. A changing climate has wide-ranging implications for nutrient cycles, ocean productivity, fisheries catches, the movement of environmental contaminants, and the health of wildlife. Traditional management approaches and a division of labour among government departments will be challenged to respond to the impending needs of society. I argue here that science must strive to maintain and enhance its connections at the local level, where the vulnerable stakeholders who rely on the sea's bounty will face the full brunt of change. These stakeholders include aboriginal and artisinal fishers, whose very lives are already intimately interwoven with the fabric of the Pacific Ocean. Such a paradigm might include increased reliance on traditional ecological knowledge, social sciences, and cultural awareness. Failure to bring such issues to the forefront of science may decouple scientific observation from the people at sea level, and diminish the integrity of adaptive management in a changing environment. Effective and adaptive management means that choices will have to be made that straddle the often tenuous line between science and society. Empowering science to deliver meaningful advice in the face of environmental change will require, among other things, cross-disciplinary exchange, creative thinking, conversations, humility, and compassion.

S1 Posters

S1-5536

Environmental assessment of the rivers of Peter the Great Bay basin (Japan/East Sea)

Lidia T. Kovekovdova and Mikhail V. **Simokon**

Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia
E-mail: scheglov@tinro.ru

Bays and estuaries receive large amounts of terrestrial pollutants, and river run-off is traditionally considered the main external source of pollutants to coastal marine ecosystems. Human-caused wastes and surface wash flow into the surface water system and enter coastal areas. The main anthropogenic load in Primorsky Krai flows into Peter the Great Bay (Japan/East Sea). In this connection, the content of Al, As, Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Zn in the bottom sediments from estuaries of the Sukhodol, Artyomovka, Razdolnaya, Gladkaya and Tesnaya rivers, belonging to Peter the Great basin, were determined. Cr, Co, Ni, Cu concentrations in the bottom sediments of the Razdolnaya River were significantly higher compared to other rivers, whereas As concentration was significantly lower compared with the Artyomovka River.

It was ascertained that the concentration of As in bottom sediments of the Artyomovka River, Cr and Cu in bottom sediments of the Razdolnaya River, and Pb in bottom sediments of the Sukhodol and Razdolnaya rivers are high enough to produce negative biological effects on the organisms inhabiting bottom communities.

Concentrations of As, Hg, Pb, Cd, Zn, Cu, Ni, Se, Co, Cr, Fe were determined in organs of several fish: redfin (*Tribolodon brandtii*), Prussian carp (*Carassius gibelio*), redlip mullet (*Liza haematocheila*), and Eurasian minnow (*Phoxinus phoxinus*) collected from the estuaries of Peter the Great Bay basin. Comparative estimations of metal concentrations in the liver of redfin (*Tribolodon brandtii*) from the Artyomovka and Razdolnaya rivers indicated, that most levels of As, Co, Cr, Mn, Ni, Pb and Zn were typical for livers of fish caught in the outfall area of the Artyomovka River, while the concentrations of Fe, Cu and Se were higher in the livers of fish from the Razdolnaya River. This argues for the site-specificity of the ecological conditions existing in the estuaries concerning element composition. Our assessment of the toxic metals in the environment of each river allows for elaboration of the measures required for management of water quality in this ecosystem.

S1-5537

Biotransport of POPs by salmonids in the North Pacific

Mayuko **Tomida**, Nobuyuki Miyazaki and Masahide Kaeriyama

Faculty of Fisheries Sciences, Hokkaido University, 3-1-1, Minato, Hakodate, Hokkaido, 041-8611, Japan
E-mail: tomida@fish.hokudai.ac.jp

Pacific salmon (*Oncorhynchus* spp.) migrate to their natal river to spawn and act as “vectors”, transporting anthropogenic pollutants such as persistent organic pollutants (POPs) to the terrestrial ecosystem, despite their contribution as biotransporters of marine-derived nutrients (MDN). In general, POPs evaporate in warm regions and travel via the atmosphere as far as the Arctic and Antarctica where they are cooled and deposited. Pacific salmon are shifting their distribution area northward as a consequence of global warming, thereby increasing the opportunity for POP uptake. However, little is known about the biotransport of POPs and the possible impacts to the coastal environment. We clarified 1) the distribution of POPs in 11 organs of chum salmon (*O. keta*) before the run, and 2) the behavior of POPs in muscle, liver and gonad of masu salmon (*O. masou*) throughout various maturation stages. Our study revealed that accumulation sites of POPs and POP concentrations varied according to salmon maturation stage. Pacific salmon are at various maturation stages when entering the freshwater environment, depending on environmental factors and species-specific differences. Thus, our study will contribute to understanding the biotransport and estimating POP inputs to the Pacific coastal environment. Global warming may affect the dynamics of POP global transport. Pacific salmon could be a good indicator for evaluating POP deposition in the North Pacific and for determining the influence of POPs on the terrestrial ecosystem.

S1-5558

Environmental impact assessment in the estuarine ecosystems of Peter the Great Bay (Japan/East Sea)

Olga N. **Lukyanova**, Andrey P. Chernyaev, Nikolay V. Kolpakov and Anna S. Vazhova

Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia
E-mail: onlukyanova@tinro.ru

Estuaries are naturally stressed, highly variable ecosystems and at the same time they are exposed to high levels of anthropogenic pollution. It is necessary to determine a set of regional, domestic bioindicators, which are useful for assessing ecosystem and organism health in specific natural zones. The environmental conditions in estuarine zones of Peter the Great Bay (Japan/East Sea) were estimated using chemical analyses and bioassays. Petroleum hydrocarbon (PH) concentrations were detected in marine sediments and seawater in estuaries of 8 rivers discharging into the Bay. Maximal petroleum pollution was observed in bottom sediments and water of the Razdolnaya River, and minimal pollution in the Barabashevka, Ryazanovka and Gladkaya rivers. Bioassay experiments for measuring acute toxicity of bottom sediments were conducted using marine crustaceans (mysids) as test-organisms. The bottom sediments from the Razdolnaya, Artemovka, Sukhodol and Gladkaya rivers were acutely toxic. The highest toxicity was found in the Gladkaya estuary, where sediments were toxic both in the river and the sea. Significant positive correlation was determined between acute toxicity and PH concentrations in the bottom sediments from the river's low reaches (brackish water) only, but not in seawater of adjacent bays. Significant correlation between PH and abundance (biomass and number) of fish, benthic invertebrates and zooplankton was not found. Bioassay is an appropriate tool for environmental impact assessment in polluted estuaries.

S1-5603

Bottom-up control of multi-decadal variation of the western North Pacific ecosystem revealed by stable isotope ratio analysis

Sanae **Chiba**[1], Kazuaki Tadokoro[2], Akira Kuwata[2] and Hiroya Sugisaki[3]

[1] Environmental Biogeochemistry Research Program, JAMSTEC, 2-15 Natushima-cho, Yokosuka, Kanagawa, 237-0001, Japan
E-mail: chibas@jamstec.go.jp
[2] Tohoku National Fisheries Research Institute, Fisheries Research Agency, 3-27-5 Shinhamacho, Shiogama, 985-0001, Kanagawa, Japan
[3] National Research Institute of Fisheries Science, Fisheries Research Agency, 2-12-4 Fukuura, Yokohama, 236-8648, Kanagawa, Japan

The nitrogen stable isotope ratio ($\delta^{15}N$) of zooplankton can be a useful clue to understanding temporal changes in regional trophic conditions and food web structure. Mechanisms of multi-decadal variation of the western North Pacific ecosystem were studied based on $\delta^{15}N$ of the four major copepod species, *Neocalanus cristatus*, *N. plumchrus*, *N. flemingeri* and *E. bungi* from the Odate Collection. $\delta^{15}N$ of all four species dropped *ca.* 3‰ after 1990, indicating those copepods fed on more phytoplankton compared to the previous decades. To further understand the relationship among environmental condition, lower trophic level productivity and plankton stable isotope ratio, seasonal variation of $\delta^{15}N$ and $\delta^{13}C$ of phytoplankton and *Neocalanus* spp. were investigated based on fresh specimens taken along the A-line of the Tohoku National Fisheries Research Institute from March to July, 2007. The results showed a negative correlation between nutrient availability and $\delta^{15}N$ of phytoplankton and a positive correlation between $\delta^{15}N$ of phytoplankton and *Neocalanus* spp. In this region, retrospective studies have reported an increase in zooplankton abundance after 1990 in spite of decreases in spring and annual phytoplankton abundance associated with warming and increased stratification. We have suggested that an increase of wintertime phytoplankton availability might have enhanced survival for early populations of major zooplankton species. Results of this $\delta^{15}N$ study based on both historically collected and fresh specimens strongly support our previous speculation on the mechanism of decadal scale, bottom-up control of the lower trophic levels.

S1-5627

Temporal and spatial distribution of marine primary production in the South China Sea (SCS)

Shan **Gao**[1,2], Hui Wang[2], Guimei Liu[2] and Liyin Wan[2]

[1] College of Environmental Science and Engineering, Ocean University of China, 238 Songling Rd., Qingdao, 266100, PR China
[2] National Marine Environmental Forecasting Center, State Oceanic Administration, 8 Dahuisi, Haidian District, Beijing, 100081, PR China. E-mail: wangh@nmefc.gov.cn

Temporal and spatial distribution of marine primary production (MPP) is largely influenced by physical and biological processes, such as nutrient transport and phytoplankton growth. Analysis of SeaWiFS and *in situ* data reveal a strong chlorophyll *a* seasonality in the SCS, especially in the two upwelling regions off east coast of Vietnam and off the northwest coast of Luzon Island. We used a three-dimensional physical-biogeochemical model to investigate the temporal and spatial distribution of MPP in the SCS, for the purpose of understanding the responses of MPP to monsoon forcing, nutrient transport, phytoplankton growth and other important physical-biological processes. The Hybrid Coordinate Ocean Model (HYCOM) coupled with the NORWegian ECOlogical Model (NORWECOM) was used and run in a nested system (the Pacific Ocean). The model consisted of 10 compartments, including two phytoplankton classes (diatoms and flagellates), nitrate, silicate, phosphate, biogenic silica, detritus, oxygen, inorganic suspended particulate matter (ISPM) and yellow substances. In our study, some parameter values are adjusted to fit to the SCS ecosystem observational data, and the model was run without ISPM and yellow substances. Nutrient fields were initialized with World Ocean Atlas 2001 (WOA01) and climatological river runoff. The model revealed seasonal and geographic variations of phytoplankton and nutrients concentration, which compared well with observed and satellite data. Model sensitivity experiments were performed to assess the potential impact of river runoff that regulates nutrient transport and phytoplankton productivity.

S1-5633

Numerical simulation study on primary production in the Bohai Sea in summer, 2006

Hai Li, Jing **Yang** and Qin-Zheng Liu

National Marine Environmental Forecasting Center, Beijing, 100081, PR China. E-mail: yangj@nmefc.gov.cn

A finite volume coastal ocean model (FVCOM) was coupled with EPA's water quality model (WASP) for the Bohai Sea. The models focused on the numerical simulation and analysis of the primary production system from June to August in 2006. The simulated biological and chemical state variables included dissolved oxygen, CBOD, phytoplankton biomass, phosphate, organic nitrogen, organic phosphorus, ammonium, nitrate and nitrite. River runoff from the Haihe River, Luanhe River and Yellow River was considered in this paper. The variation and space distribution of nutrition and phytoplankton were simulated, and the primary production was estimated based on the simulated results. Results showed the basic characteristics of the primary production system during the summer in the Bohai Sea and compared well to the observed data.

S1-5638

Response of marine primary production to monsoon variations in the South China Sea

Hui **Wang**[1], Guimei Liu[1], Shan Gao[1,2] and Hua Jiang[3]

[1] National Marine Environmental Forecasting Center, State Oceanic Administration, 8 Dahuisi, Haidian District, Beijing, 100081, PR China. E-mail: wangh@nmefc.gov.cn
[2] College of Environmental Science and Engineering, Ocean University of China, 238 Songling Rd., Qingdao, 266100, PR China
[3] Chinese Academy of Meteorological Sciences, Beijing, 100081, PR China

The ecosystem in the South China Sea (SCS) exhibits strong seasonal and interannual variations, and the changing of the East Asia Monsoon System and North Pacific Decadal Oscillation (NPDO) has direct impacts on nutrients and plankton dynamics. Based on observed and satellite data, the changes of primary production associated with monsoon winds and marine environments are analyzed in the SCS. Primary production is calculated from SeaWiFS data based on the vertically generalized production model (VGPM) in the SCS. Results showed that summer southerly winds favored high primary production off the east coast of Vietnam. Conversely, northerly winds in the winter favored high primary production off the west coast of Luzon Island. Primary production is lower in 1998 than in other years in the SCS, which is highly correlated with the 1997-98 El Niño event. Biogeochemical processes were simulated for the SCS with an ecosystem model consisting of multiple nutrients and plankton functional groups. Model results and analysis provided evidence that biological productivity in the SCS respond to the Pacific-East Asia large-scale climatic variability.

S1-5753

Causal linkage among growth, survival, and intra-population interactions of Hokkaido chum salmon related to climate changes in 1945-2005

Hyunju **Seo**[1], Hideaki Kudo[2] and Masahide Kaeriyama[2]

[1] Graduate School of Fisheries Sciences, Hokkaido University, 3-1-1 Minato-cho, Hakodate, Hokkaido, 041-8611, Japan E-mail: uagiri@fish.hokudai.ac.jp
[2] Faculty of Fisheries Sciences, Hokkaido University, 3-1-1 Minato-cho, Hakodate, Hokkaido, 041-8611, Japan

To clarify the response of the chum salmon (*Oncorhynchus keta*) population to the dynamics of North Pacific ecosystems, we examined causal linkages among growth, survival, and intra-population interactions of Hokkaido chum salmon related to climate change. Variability in chum salmon growth at age-1 to -4 was estimated by the back-calculation method using scales of age-4 adults returning to the Ishikari River in Japan during 1945-2005. Chum salmon growth anomaly at age-1 had negative values in the mid 1940s and the 1970s, but positive values in the 1980-1990s. However, growth anomalies at later ages showed opposite trends to that of age-1. The Pacific Decadal Oscillation (PDO) was positively correlated with growth at age-1, and negatively with growth at later ages. The results of the path analysis indicated that growth at age-1, affecting the survival rate due to size-related mortality, was influenced directly by SST, and indirectly by ice cover area in the Okhotsk Sea, PDO, Aleutian Low Pressure, and global sea surface temperature. Subsequently, the population size, affecting growth at later ages due to population density-dependent effects, was influenced directly by survival rate, and indirectly by growth at age-1. That is to say, Hokkaido chum salmon show that an increase of survival rate linked with growth at age-1, lead to larger population size which reduce adult body size due to density-dependent intra-population competition effects.

S1-5789

An adaptive technology for Nature/Society System biocomplexity assessments

Vladimir Krapivin and Ferdenant **Mkrtchyan**

V.A. Kotelnikov's Institute of Radio Engineering and Electronics, Russian Academy of Science, Fryazino, Moscow Region, 141190, Russia
E-mail: ferd47@mail.ru, ferd@ms.ire.rssi.ru

Biocomplexity refers to phenomena that result from dynamic interactions between the physical, biological and social components of the *Nature/Society System* (NSS). The investigation of processes of interaction between *Society* and the *Biosphere* are, as a rule, targeted at understanding and estimating the consequences of such interactions. The reliability and precision of these estimations depend on criteria founded on conclusions, expertise and recommendations. At present, there is no unified methodology for selection between the set of criteria due to the absence of a common science-based approach to the ecological standardization of anthropogenic impacts on the natural environment. After all, the precision of the ecological expertise for the functioning and planning of anthropogenic systems, as well as the representativeness of the global geoinformation monitoring data, depend on these criteria. We are introducing a scale of biocomplexity ranging from the state where all interactions between the environmental subsystems are broken into the state where they correspond to natural evolution. In this case, we have an integrated indicator of the environmental state including bioavailability, biodiversity and survivability. It reflects the level of all types of interactions among the environmental subsystems. In reality, specific conditions exist where these interactions are changed and transformed. For example, under the biological interaction of the type *consumer/producer* or *competition-for-energy-resources* there exists some minimal level of food concentration where contacts between interacting components cease. In the common case, physical, chemical and other types of interactions in the environment depend upon specific critical parameters. Environmental dynamics are regulated by these parameters and the main task is in the parametrical description of them. Biocomplexity reflects these dynamics. This report is oriented to the development of biocomplexity indices based on remotely measured environmental characteristics. Microwave radiometry is used as an effective technique to assess land covers and ocean parameters. Other ranges help to form input information for the NSS Biocomplexity Model that will be developed in the framework of this work.

S1-5831

The impact of the Changjiang River plume extension on the nanoflagellate community in the East China Sea

An-Yi Tsai[1], Kuo-Ping **Chiang**[1,2], Ciou-Jyu Wang[1] and Gwo-Ching Gong[2]

[1] Institute of Environmental Biology and Fishery Science, National Taiwan Ocean University, Keelung 202-24, Taiwan, ROC
E-mail: kpchiang@mail.ntou.edu.tw
[2] Institute of Marine Environmental Chemistry and Ecology, National Taiwan Ocean University, Keelung 202-24, Taiwan, ROC

Variation in the summer nanoflagellate community on the continental shelf ecosystem of the East China Sea (ECS) is closely coupled with environmental variation due to extension of the Changjiang River plume. Spatial patterns of nanoflagellate abundance were studied in June and August 2003, June 2006 and July 2007 over the East China Sea shelf. The Changjiang River plume was smaller during the August 2003 and July 2007 cruises than during the other 2 cruises. Total nanoflagellate densities varied between 1 and 120 × 10^2 cells ml^{-1} with the highest abundances occurring within the Changjiang River plume during large plume periods. In the small plume periods, the abundance of nanoflagellates was reduced to 3 to 33 × 10^2 cells ml^{-1} and the highest abundances were observed within the Changjiang River plume or the Yellow Sea Coastal Water. During large plume periods, nanoflagellate abundances were related to salinity changes and during the small plume periods, abundance was more related to water temperature. The pigmented nanoflagellate community (PNF) within the Changjiang River plume, especially in the <3 μm size class, appears to increase in response to terrestrial or anthropogenic inorganic nutrient loading in the discharge of fresh water from the Changjiang River. The pronounced increase in PNF associated with the plume was the primary cause of ECS nanoflagellate community variation in summer. Fresh water discharge from the Changjiang River has significant ecological impacts on the microbial food web in the East China Sea.

S1-5880

The role of uncertainty in hypothetical top predator culling programs

Felipe **Hurtado-Ferro**

Laboratory of Marine Resources and Environment, Ocean Research Institute, The University of Tokyo, 1-15-1 Minamidai, Nakano-ku, Tokyo 164-8639, Japan. E-mail: felipehurtado@nenv.k.u-tokyo.ac.jp

From an ecosystem perspective, fisheries can be seen as part of a larger cycle of interactions between ecological agents where humans occupy the position of a top predator. In most ecosystems however, humans are not the only species occupying this position and thus must compete against other species for valuable food resources. As it became evident that many of the worlds fish stocks were being depleted, a controversial debate about culling competing top predators arose, garnering attention both from scientists and managers. Culling seems rational from a 'surplus-yield' reasoning but recent developments in multispecies studies have shown that such reasoning is incorrect. Complex interactions among ecosystem components (populations) may lead to unexpected outcomes as the effects of reducing a top predator species propagate across food-webs through multiple pathways, potentially bringing detrimental consequences to the fishery. Since knowledge of many food-webs is still limited, any devised culling program would have to be implemented under tremendous uncertainties, presenting great challenges and risks.

Using simple food-web models with variable number of trophic levels and eight species, two of which are top predators and three are exploited species, I explore the effects of uncertainty and incomplete knowledge when implementing a hypothetical top predator culling program. I consider three scenarios of uncertainty: culling implemented without any knowledge of the system; culling implemented with partial consideration of the system (only the exploited species considered); and culling implemented with full consideration of the system but inaccurate knowledge of its interactions. I discuss the possible benefits and risks from such program.

S1-5902

Atmosphere aerosol and marine ecosystems after Sarychev Peak volcano eruption of June 2009

Pavel A. **Salyuk**[1], Oleg A. Bukin[2], Alexander Yu. Mayor[3], Andrey N. Pavlov[3] and Konstantin A. Shmirko[3]

[1] V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: psalyuk@poi.dvo.ru
[2] G.I. Nevelskoy Maritime State University, 50a Verkhneportovaya St., 690059, Vladivostok, Russia
[3] Institute for Automation and Control Processes, FEB RAS, 5 Radio St., Vladivostok, 690041, Russia

The results of shipboard observations and satellite data analysis of atmosphere aerosol and phytoplankton communities just after the Sarychev Peak eruption are presented in the report. The strongest stage of eruption was from June 12 to 16 and the shipboard expedition was carried out from June 23 to July 3, 2009. The route of the expedition was from Korsakov city (south of the Sakhalin Island) through the open part of the Okhotsk Sea to Matua Island (the Kuril Islands), where Sarychev Peak is located, 3 days stationed near the volcano and back through the Kuril Islands to Korsakov city. Lidar sounding of atmosphere, sun photometer measurements, and flow through measurements of seawater fluorescence, temperature and salinity were carried out on the moving ship. These data jointly with ASTER, MODIS and CALLIPSO data were used for the analysis. Atmosphere aerosol layers were observed in the 2-4 km height diapason and near tropopause height (8-10 km) in the Okhotsk Sea about 200 km from the volcano. Near Iturup Island (about 500 km from the volcano) strong aerosol layers were observed at a height of 11 km. Data collected with sun photometers allowed retrieval of atmosphere aerosol parameters. Shipboard seawater biooptical and hydrology data, and satellite ocean color data were used to investigate phytoplankton communities after the Sarychev Peak eruption.

S1-5935

Long term change of phytoplankton ecology in the eastern part of the Yellow Sea

Joong Ki **Choi**[1], Jae Hoon Noh[2], Sung Hwan Cho[3], Seung Yoon Park[3] and Youngju Lee[1]

1 Plankton Laboratory, Department of Oceanography, Inha University, 253 Yonghyun-dong, Nam-gu, Incheon, 402-751, R Korea
E-mail: jkchoi@inha.ac.kr
2 Marine Environment Research Department, KORDI, Ansan P.O. Box 29, 425-600, R Korea
3 NFRDI, 408-1 Sirang-ri, Gijang-eup, Gijang-kun, Busan, 619-902, R Korea

To understand the long term change of phytoplankton ecology in the Yellow Sea, we analyzed the environmental and phytoplankton data produced in the eastern part of the Yellow Sea from 1987 to 2008. The distribution of water temperature, minimum salinity and transparency (Secchi disc depth) showed slight increases over a 20 year period. The mean concentration of DIN has increased dramatically, due to the increasing input of N from land and atmospheric deposition. The decrease of Si and the increase of N in the Yellow Sea caused changes in phytoplankton abundance and dominant species changed from diatoms to dinoflagellates and nanoflagellates. The primary productivity of phytoplankton in the Yellow Sea has increased slightly due to the increase in DIN, transparency and phytoplankton abundance.

S1-5946

Egg production of copepod *Acartia omorii* in the coastal waters of Korea

Seok-Hyun **Youn**[1], Yu-Mi Jun[2], Jae-Dong Hwang[1], Yong-Hwa Lee[2], Hyun-Gook Jin[2], Jung-Min Shim[2], Young-Suk Kim[2] and Ki-Young Kwon[2]

1 Ecology and Oceanography Division, National Fisheries Research and Development Institute, 152-1 Heaan-ro, Gijang-gun, Busan, 619-705, R Korea. E-mail: shyoun@nfrdi.go.kr
2 Fisheries Resources and Environment Division, East Sea Fisheries Research Institute, 30-6 Dongduk-ri, Yeongok-myon, Gangneung, Gangwon-do, 210-861, R Korea

The planktonic copepod *Acartia omorii* is a numerically abundant and widespread species in the coastal regions of the Korea. It occurs continuously through the year, with a maximum peak in the cold season. Egg production of *A. omorii* was estimated in the Seomjin River estuary and Gangneung coastal waters from January to June 2009. Daily egg production ranged from 3.8 to 23.5 eggs·ind^{-1}·day^{-1} with an average of 15.2 eggs·ind^{-1}·day^{-1}. Variation of egg production rates with salinity gradients (12.7~33.5 psu) showed that egg production rates were relatively constant above 20 psu in Seomjin River estuary. However, values below 13 psu decreased significantly. The salinity tolerance could explain the ecological characteristics that *A. omorii* is a euryhaline species which dominantes in zooplankton community in the estuarine waters during the dry season. The average ingestion rates of *A. omorii*, calculated using the gut fluorescence method, was 2.05 and 2.75μg C·ind^{-1}·day^{-1}, and the ratio between carbon demands determined by the egg production rates and carbon ingestion was 68 and 102% in Seomjin River estuary and Gangneung coastal waters, respectively. Our results showed that, although the overall egg production rates of A. omorii were positively related with water temperature and chlorophyll *a* concentrations, food availability was a more predominant influencing factor regulating the egg production of *A. omorii* in the Korean coastal waters.

S1-5948

Mixed layer depth in the high production region off Korea

Young-Sang **Suh**, Ki-Tack Seong, Jae-Dong Hwang, and Yeong Gong

National Fisheries Research and Development Institute, Busan, 619-705, R Korea. E-mail: yssuh@nfrdi.go.kr

It has been suggested that the western central area of the East/Japan Sea is highly productive, but related oceanographic and biological mechanisms are poorly known. We attempted to explain the high primary production in the area by comparing the mixed layer depth (MLD) and critical depth (Dcr). Because it is difficult to define the barrier or vertically-compensated layer in the Japan/East Sea, we defined the mixed layer depth (MLD) as the water depth at which water temperature becomes 1ºC less than the sea surface temperature, and evaluated its spatio-temporal variability based on NFRDI serial oceanographic observation data from 1961 to 2007. The MLD showed a seasonal cycle, ranging from 10-20 m in summer to 50-150 m in winter. Spatially, the MLD was shallow in the east coast of Korea (50 m), but deeper in the Ullung basin (up to 150 m in winter) in which an anticyclonic circulation was identified by examining the current pattern based on the dynamic topographic height (0/300db). In the East/Japan Sea, the solar radiation generally shows a zonal gradient in winter (higher in west), but a meridional gradient in summer (higher in south). The primary production during the blooming seasons, estimated from satellite imagery, was particularly higher in the western central area and frontal zones. Our estimated critical depth (Dcr) was also deeper in the western central region. Our preliminary results suggest that the deepening Dcr compared with the MLD might be a key mechanism explaining high primary production in the area.

S1-5965

A comparative study on the ecosystem risk indices of Korean waters

Jae Bong **Lee**[1], Dong Woo Lee[1], Yeong Min Choi[1], Chang Ik Zhang[2], Myoung Ho Sohn[1], Sung Il Lee[1], Young Il Seo[1], Sang Chul Yoon[1], Yoo Jung Kwon[2], Jong Hee Lee[1], Hee Won Park[2], Young Jae Shin[1], Do Hoon Kim[1], In-Ja Yeon[1], Heui Chun An[1] and Dae Soo Chang[1]

[1] National Fisheries Research and Development Institute, Busan, 619-905, R Korea. E-mail: leejb@nfrdi.go.kr
[2] Pukyong National University, Busan, 608-737, R Korea

A risk assessment of Korean fisheries in three marine ecosystems around Korean waters was done using a new approach, the Integrated Fisheries Risk Assessment Method for Ecosystems (IFRAME). Considering sustainability, biodiversity, habitat quality and socio-economic status as management objectives, the pragmatic ecosystem-based approach was employed to assess major fisheries risks from the East/Japan Sea (EJS), the Yellow Sea (YS) and the East China Sea (ECS) in Korea. The Eastern Sea Danish Seine, Coastal Gill Net, and Offshore Trap fisheries were used for the EJS ecosystem, the Anchored Gill Net, Drift Net, Trap fisheries were used for the YS ecosystem, and the Anchovy Dragnet, Korean Large Purse Seine, and Korean Large Two-Boat Trawl fisheries were used for the ECS ecosystem. The species risk index (SRI) was used to assess fisheries resources risk for the major fisheries resources. For example, sandfish (*Arctoscopus japonicus*), Korean flounder (*Glyptocephalus stelleri*) and Pacific cod (*Gadus macrocephalus*) were chosen as target species for the Eastern Sea Danish Seine; snow crab (*Chinoecetes opilio*), sandfish (*Arctoscopus japonicus*), Atka mackerel (*Pleurogrammus azonus*) and Pacific cod (*Gadus macrocephalus*) for the Coastal Gill Net, and red snow crab (*Chinoecetes japonicus*) for the Offshore Trap. Through two-tier analyses, the Species Risk Index (SRI) and Fishery Risk Index (FRI) were evaluated for marine ecosystems around Korean waters. The Yellow Sea ecosystem had relatively higher risk scores than the East Sea and East China Sea ecosystems.

S2 FIS Topic Session
Ecosystem-based approaches for the assessment of fisheries under data-limited situations

Co-Convenors: Yukimasa Ishida (Japan), Gordon H. Kruse (U.S.A.), Patricia Livingston (U.S.A.), Laura Richards (Canada), Mikhail Stepanenko (Russia) and Chang Ik Zhang (Korea)

The World Summit on the Sustainable Development recommended implementation of the ecosystem-based management by 2010. Achievement of this goal will require holistic assessment and management of fisheries resources and their associated habitat and ecosystems. Therefore, consideration must be given to ecological interactions of target species with predators, competitors, and prey species, bycatch species, interactions between fishes and their habitat, and the effects of fishing on fish stocks and their ecosystems. The challenge associated with implementation of ecosystem-based management is the design of an approach that is capable of capturing the complexity of the system, while at the same time dealing with the varying quality and quantity of available information. The Ecological Risk Assessment for the Effects of Fishing (ERAEF) approach developed by Australia and the Marine Stewardship Council's Fisheries Assessment Methodology provide two examples of pragmatic approaches. This session encourages contributions that: 1) describe the data and/or information requirements for the application of ecosystem-based assessments, 2) review existing and emerging ecosystem-based assessment methodologies, 3) describe indicators and reference points for these assessments, 4) identify research activities needed for developing an integrated framework for assessments, and 5) discuss indices for evaluating and assessing the ecosystem status and management. Selected oral and poster presentations from this session will be considered to be published in a peer-reviewed journal.

Tuesday, October 27 (9:00-18:00)

9:00 ***Introduction by Convenors***

9:05 **Tony Smith, Alistair Hobday, Shijie Zhou, David Johnson and Keith Sainsbury (Invited)**
Ecological risk assessment for fisheries: Applications in Australia and in the Marine Stewardship Council (S2-5976)

9:50 **Kozo Ishii, Atsushi Yamasaki and Yukimasa Ishida**
First Marine Stewardship Council (MSC) ecolabelling of fishery products from marine capture fisheries in Japan (S2-5696)

10:10 **Inja Yeon, Chang Ik Zhang, M.H. Shon, H.J. Whang, Kwangho Choi, J.H. Lee and Yang-Jae Im**
Ecosystem–based approach for blue crab stock assessment and management strategies in the West Sea of Korea (S2-5993)

10:30 ***Coffee / tea break***

10:50 **Masahi Nishimura, Ken Kobayashi and Yukimasa Ishida**
Marine Ecolabel Japan (MEL Japan): New ecolabelling of fishery products from marine capture fisheries in Japan (S2-5695)

11:10 **Jung Hyun Lim, Jae Bong Lee and Chang Ik Zhang**
Using size-based indicators to assess the sustainability for IFRAME (S2-5833)

11:30 **Laura Richards**
Research requirements for ecosystem-based assessments (S2-5791)

11:50 **Jong Hee Lee, Jae Bong Lee, Chang Ik Zhang, Dong Woo Lee and Dae Soo Chang**
Determining indicators and compatible reference points to assess coastal marine ecosystem risks (S2-5966)

12:10 **Chang Ik Zhang and Bernard A. Megrey**
A length-based stock assessment framework for data-deficient situations (S2-6004)

12:30 ***Lunch***

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

14:05 **Kevern Cochrane and Yimin Ye (Invited)**
Using ecological indicators in the context of an ecosystem approach to fisheries for data-limited fisheries (S2-5990)

14:50 **Paul Spencer, Olav Ormseth, Anne B. Hollowed and Patricia Livingston**
Analyzing the vulnerability of fish stocks in the North Pacific Ocean (S2-5974)

15:10 **Jon Schnute *et al.***
Ecosystem models: Can we trust ourselves? (S2-5903)

15:30 ***Coffee / tea break***

15:50 **Chang Seung and Chang Ik Zhang**
Multi-attribute utility function approach to developing socio-economic indicators for Alaska fisheries (S2-5653)

16:10 **Yongjun Tian, Hideaki Kidokoro and Tadanori Fujino**
Interannual-decadal variability of demersal fish community in the Japan Sea: Impacts of climate regime shifts and trawl fishing with recommendations for ecosystem-based management (S2-5624)

16:30 **Sukgeun Jung, Young Shil Kang, Dong-woo Lee, Young-Sang Suh, Sukyung Kang and Yeong Gong**
Climate-driven ecosystem shifts indicated in fishery catch statistics from Korean coastal waters over 1968-2008 (S2-5612)

16:50 **Dohoon Kim and Chang Ik Zhang**
Developing socioeconomic indicators for an ecosystem-based fisheries approach (S2-5630)

17:10 **Vladimir B. Darnitskiy**
Seamount ecosystems – oceanographic environment (S2-5818)

17:30 ***Discussion***

18:00 ***Session ends***

S2 Posters

S2-5553 **Saang Yoon Hyun and Rishi Sharma**
Integrated forecasts of fall Chinook salmon returns to the Columbia River

S2-5666 **Hyeok Chan Kwon, Sang Chul Yoon, Sung Il Lee, Young Yull Chun, Jong Bin Kim and Chang Ik Zhang**
An ecosystem-based fisheries resource assessment for the gillnet fishery of the Uljin marine ranch ecosystem in Korean waters

S2-5804 **Young Jae Shin, Jae Bong Lee and Chang Ik Zhang**
A systematic approach for estimating potential fishery yields of data-deficient, small-scale coastal fisheries in Korea

S2 Oral Presentations

27 October, 9:05 (S2-5976), Invited

Ecological risk assessment for fisheries: Applications in Australia and in the Marine Stewardship Council

Tony **Smith**, Alistair Hobday, Shijie Zhou, David Johnson and Keith Sainsbury

Marine and Atmospheric Research, CSIRO, P.O. Box 1538, Hobart, 7001, Australia. E-mail: tony.d.smith@csiro.au

Risk-based methods to assess the impacts of fishing have been developed and applied in several countries. Here we describe a framework (ERAEF) that was developed and applied to federally managed fisheries in Australia. A key feature of the method is its hierarchical structure, with assessments moving from basic scoping of hazards, through a qualitative (expert based) assessment, to a semi-quantitative productivity/susceptibility analysis, to fully quantitative methods (SAFE). ERAEF assesses the impacts of fishing on various components of marine ecosystems, including species, habitats and communities. The hierarchical approach provides an efficient means to be both comprehensive in considering the widest range of potential hazards, while at the same time rapidly screening out low risks and focusing time and scarce resources on higher risk impacts. The method has also been used in several other countries and regional fishery organisations, and most recently has helped form the basis for the risk-based framework used by the Marine Stewardship Council as part of its new Fishery Assessment Methodology.

27 October, 9:50 (S2-5696)

First Marine Stewardship Council (MSC) ecolabelling of fishery products from marine capture fisheries in Japan

Kozo Ishii[1], Atsushi Yamasaki[2] and Yukimasa **Ishida**[3]

[1] Marine Stewardship Council, 3rd Floor, AIG Kabuto-cho Bldg., 5-1 Nihonbashi Kabuto-cho, Chuo-ku, Tokyo, 103-0026, Japan
E-mail: Kozo.Ishii@msc.org

[2] Kyoto Prefectural Agriculture, Forestry and Fisheries Technology Center, Fisheries Technology Department, Odashukuno, Miyazu City, Kyoto Prefecture, 626-0052, Japan

[3] Tohoku National Fisheries Research Institute, 3-27-5, Shinhama-cho, Shiogama City, Miyagi Prefecture, 985-0001, Japan

Certification is one of the measures to ensure an ecosystem approach to fisheries. Fishery certification focuses the attention of consumers on the fishery and increases compliance by the fishers. At the global level, "ecolabelling" is a voluntary method of environmental performance certification and labeling. Three principles are examined in the certification process: sustainability of fish stocks, minimization of environmental impacts, and effectiveness of management. To achieve these principles, the Marine Stewardship Council (MSC) was established in England in 1997. Between 1997 and 1999 the MSC worked with individuals and organizations around the world to develop the standards and methodologies that form the basis of the MSC certification program for sustainable fishing and seafood traceability. The MSC program meets FAO guidelines that require assessments to be carried out by independent, third-party certifiers. Fisheries and seafood companies voluntarily seek certification against the standards, which meet the world's best practice guidelines for certification and ecolabelling. There are currently 47 certified fisheries in the MSC program. In Japan, two Danish seine fisheries for snow crab (*Chionoecetes opilio*) and flathead flounder (*Hippoglossoides dubius*) were certified in the Kyoto Prefecture in 2008. This first MSC ecolabelling of fishery products in Japan is described and the future prospects of the activities are discussed in relation to an ecosystem approach to fisheries under data-limited situations.

27 October, 10:10 (S2-5993)

Ecosystem–based approach for blue crab stock assessment and management strategies in the West Sea of Korea

Inja **Yeon**[1], Chang Ik Zhang[2], M.H. Shon[3], H.J. Whang[4], Kwangho Choi[4], J.H. Lee[2] and Yang-Jae Im[4]

1 South Sea Fisheries Research Institute, NFRDI, Yeosoo, 556-823, R Korea. E-mail: ijyeon@nfrdi.go.kr
2 Pukyong National University, Busan, 608-737, R Korea
3 Dokdo Fisheries Research Center, NFRDI, Pohang, 791-110, R Korea
4 West Sea Fisheries Research Institute, NFRDI, Inchon, 400-420, R Korea

Annual catches of blue crab, *Portunus trituberculatus*, declined substantially from 18,000 t in 2002 to 2,300 t in 2004 and then increased to 15,000 t in 2008. Traditional management measures, such as closed seasons during the spawning period since 1974 and a minimum size limit of 5 cm in carapace length since 1996, have been implemented. In addition, the habitat of blue crab in the west coast of Korea has been degraded due to anthropogenic activities, such as sand mining, land reclamations, and coastal pollution. Under these conditions, management was not successful to maintain the stock condition. Therefore, in 2006 a stock rebuilding program for blue crab, based on the adoption of an ecosystem approach to management, started to enhance the stock. This paper focuses on demonstrating the usefulness of Zhang *et al.*'s ecosystem-based assessment to the Korean west sea blue crab stock.

27 October, 10:50 (S2-5695)

Marine Ecolabel Japan (MEL Japan): New ecolabelling of fishery products from marine capture fisheries in Japan

Masahi **Nishimura**[1], Ken Kobayashi[1] and Yukimasa Ishida[2]

1 Marine Ecolable, Japanese Fisheries Association, Sankaido Bldg., 1-9-13 Akasaka, Minato-ku, Tokyo, 107-0052, Japan
E-mail: mnishimu@suisankai.or.jp
2 Tohoku National Fisheries Research Institute, 3-27-5, Shinhama-cho, Shiogama City, Miyagi Prefecture, 985-0001, Japan

Certification is one of the measures to ensure an ecosystem approach to fisheries. Fishery certification focuses the attention of consumers on the fishery and increases compliance by the fishers. At the global level, "ecolabelling" is a voluntary method of environmental performance certification and labelling. Three principles are examined in the certification process: sustainability of fish stocks, minimization of environmental impacts, and effectiveness of management. Considering the global ecolabelling activities and specific culture in fishery communities in Japan, the Japan Fisheries Association (JFA) established a new Japanese certification system for fishery products, the "Marine Ecolabel Japan (MEL Japan)" in line with the FAO guidelines in 2007. Three fisheries, including the red snow crab (*Chionoecetes japonicas*) fishery in Tottori Prefecture, Sakura shrimp or Stardust shrimp (*Sergia lucens*) fishery in Shizuoka Prefecture, and fresh water clam (*Corbicula japonica*) fishery in Aomori Prefecture were, were certified by 2009. These ecolabellings of fishery products in Japan are described and the future prospects of these activities are discussed in relation to an ecosystem approach to fisheries under data-limited situations.

27 October, 11:10 (S2-5833)

Using size-based indicators to assess the sustainability for IFRAME

Jung Hyun **Lim**[1], Jae Bong Lee[2] and Chang Ik Zhang[1]

1 Department of Marine Production System Management, Pukyong National University, 599-1 Daeyeon3-dong, Nam-gu, Busan, 608-737, R Korea. E-mail: ljh1113@hanmail.net
2 National Fisheries Research and Development Institute, 408-1 Sirang-ri, Gijang-eup, Gijang-gun, Busan, 619-905, R Korea

A new tool, Integrated Fisheries Risk Assessment Method for Ecosystems (IFRAME), was developed to assess fisheries resources for four management objectives: sustainability, biodiversity, habitat quality, and socio-economic benefit. In the sustainability evaluation for the Tier 1 analysis of IFRAME, eight indicators were developed for assessing ecosystem status. However, it was difficult to estimate both target and limit reference points for each indicator because these indicators required a high level of quantitative data and information. In this study, cost-

effective indicators were explored using size data, which are routinely collected. Biomass was estimated from a length-based cohort analysis by Zhang and Megrey (2009). The slope of size spectrum by species was developed as an indicator for explaining the attribute of productivity. The ratio of immature fish was used to substitute the Fish Reproduction Potential indicator. Target and limit reference points of each indicator for sustainability were developed for application to chub mackerel (*Scomber japonicus*), the main target species in the Korean large purse seine fishery.

27 October, 11:30 (S2-5791)

Research requirements for ecosystem-based assessments

Laura **Richards**

Pacific Biological Station, Fisheries and Oceans Canada, 3190 Hammond Bay Rd., Nanaimo, BC, V9T 6N7, Canada
E-mail: Laura.Richards@dfo-mpo.gc.ca

As a research manager, I am faced with making decisions on how to allocate funds towards the assessment of fisheries resources. Such decisions invariably involve trade-offs among a suite of activities such as at-sea surveys, data management, process-related research, modelling and analysis, report-writing, and consultation meetings with harvesters and fishery managers. Traditionally, most research funding was directed to short-term operational needs (*e.g.* fishery harvests for the next one or two seasons). While, we can now quantify many of the risks associated with this approach, we cannot always understand why these methods fail. Broader and longer-term questions (*e.g.* direction of climate change impacts) are addressed through higher-risk research which appears to produce fewer immediate benefits relative to the cost. Invariably, data are incomplete and additional research reveals yet more questions to be answered. Furthermore, these broader approaches have had limited success to date in providing practical advice for ecosystem-based assessment. I use examples from the Canadian context to suggest a more strategic direction for determining research priorities. In particular, I examine recent successes and failures, building on the lessons learned. I show that breakthroughs tend to be linked to new technologies (*e.g.* genomics tools) or to the inclusion of factors that are generally considered out of scope for single-species stock assessment (*e.g.* fish health, non-indigenous aquatic species).

27 October, 11:50 (S2-5966)

Determining indicators and compatible reference points to assess coastal marine ecosystem risks

Jong Hee Lee[1], Jae Bong **Lee**[1], Chang Ik Zhang[2], Dong Woo Lee[1] and Dae Soo Chang[1]

[1] National Fisheries Research and Development Institute, 408-1 Sirang-ri, Gijang-eup, Gijang-gun, Busan, 619-905, R Korea.
E-mail: leejb@nfrdi.go.kr
[2] Pukyong National University, 599-1 Daeyeon3-dong, Nam-gu, Busan, 608-737, R Korea

Due to ratification of the United Nations Convention on the Law of the Sea (UNCLOS) and escalating fuel prices, the value of coastal ecosystems has been becoming very important around Korean waters. Coastal ecosystems have higher biodiversity and provide major spawning and nursery grounds for fisheries resources. In this study, using Integrated Fisheries Risk Assessment Method for Ecosystems (IFRAME), three management objectives were developed to assess and manage fisheries resources in coastal ecosystems in Korea: sustainability, biodiversity, and habitat quality. The indicators for biodiversity and habitat quality were relatively easy to develop due to regular monitoring surveys on coastal marine environments, while those for sustainability were not due to no mandatory catch reporting from small coastal fisheries. Simple and less quantitative data and information were developed to assess sustainability of coastal ecosystems, for instance, catch-per-unit-effort and population density from fishery-independent survey. This method was applied to assess the coastal ecosystem in of the Nakdong River estuary, flowing into the East China Sea in southeastern Korea.

27 October, 12:10 (S2-6004)

A length-based stock assessment framework for data-deficient situations

Chang Ik Zhang[1] and Bernard A. **Megrey**[2]

[1] Pukyong National University, 599-1 Daeyeon3-Dong, Nam-Gu, Busan, 608-737, R Korea
[2] NOAA, National Marine Fisheries Service, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA, 98115, USA
E-mail: Bern.Megrey@noaa.gov

We developed methods to estimate management parameters of a fish stock (*e.g.*, allowable biological catch and yield per recruit) using only length and maturity data, which are usually available from the samples of standard scientific surveys or collection from fishery operations. Fish growth is an important aspect of fish population dynamics, and thus without consideration of growth, much of the process of biomass change goes undetected. The length-structured analysis described here is unique because it explicitly incorporates growth into the estimation procedure and because it uses length composition data. We evaluated these methods by applying them to the chub mackerel (*Scomber japonicus*) stock in Korean waters and the northern rock sole (*Lepidopsetta polyxystra)* stock in the eastern Bering Sea. We found that these pragmatic methods were useful for stock assessment under data-deficient situations.

27 October, 14:05 (S2-5990), Invited

Using ecological indicators in the context of an ecosystem approach to fisheries for data-limited fisheries

Kevern Cochrane and Yimin **Ye**

Fisheries Management and Conservation Service, Food and Agriculture Organization of the United Nations, Viale Delle Terme di Caracalla 1, 00153 Roma, Italy. E-mail: yimin.ye@fao.org

The poor state of many of the world fisheries and the observed impacts of fishing on marine ecosystem services have lead to the recognition that fisheries have the potential to alter the structure, biodiversity, and productivity of marine ecosystems. A holistic ecosystem approach to fisheries (EAF) is broadly accepted as crucial for effective fishery management and resource conservation and has now occupied center stage in our efforts to sustainably manage fisheries and marine ecosystems. There is a rich set of international agreements that provide principles and conceptual objectives. However, implementation of EAF in marine ecosystems remains a significant hurdle in most parts of the world and little practical experience is available to inform management authorities on how to select specific management measures to achieve EAF goals, particularly for data-limited fisheries. A number of conceptual approaches are available, such as the Australian ESD approach, the FAO EAF methodology (which draws on ESD) and integrated ecosystem assessments (IEAs). All of these share a conceptually similar process that attempts to enhance the likelihood of successful implementation of an EAF strategy by providing a framework for synthesizing and analyzing scientific information to enhance the ability of fishery managers to evaluate cumulative impacts of diverse human activities, as well as steer management efforts to achieve multiple simultaneous ecosystem objectives. However, there are still many challenges to using these approaches in data-poor fisheries. In this paper, we discuss these challenges, focusing on ecological indicators and how they can be used in an EAF context for fisheries where data are scarce.

27 October, 14:50 (S2-5974)

Analyzing the vulnerability of fish stocks in the North Pacific Ocean

Paul Spencer, Olav Ormseth, Anne B. **Hollowed** and Patricia Livingston

Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA, 98115, USA. E-mail: Anne.Hollowed@noaa.gov.

Assessing the vulnerability of target and non-target fish stocks to commercial fishing activity is critical for ecosystem-based fishery management, but it can be challenging when data are lacking for formal population assessments. Fishery biologists at the U.S. National Oceanic and Atmospheric Administration (NOAA) Fisheries division have been working on this problem in response to major changes in the federal statutes that govern commercial fishing in the U.S. As part of this effort, a working group has developed a semi-quantitative method for assessing vulnerability of fish stocks. The method is based on previous work and involves a "productivity-

susceptibility analysis" (PSA). Attributes of stock productivity (*e.g.* natural mortality rate, breeding strategy, maximum size) and susceptibility to catch in fisheries (*e.g.* geographical overlap, gear selectivity) are separately assessed for individual fish stocks. The resulting scores are averaged and graphically displayed in a scatter plot, with the mean productivity score on the x-axis and the mean susceptibility score on the y-axis. The Euclidean distance of the resulting data point from the origin is the overall vulnerability of the stock, and numerous stocks can be compared in terms of their overall vulnerability and/or their productivity and susceptibility. A separate process scores the quality of the information used to determine attribute scores to allow a complete evaluation of the results. We will describe the vulnerability analysis and present several examples of its application to fish stocks in the North Pacific Ocean.

27 October, 15:10 (S2-5903)

Ecosystem models: Can we trust ourselves?

Jon **Schnute** *et al.*

Pacific Biological Station, Fisheries and Oceans Canada, 3190 Hammond Bay Rd., Nanaimo, BC, V9T 6N7, Canada.
E-mail: Jon.Schnute@dfo-mpo.gc.ca

Fisheries models have evolved from analyses of individual species to descriptions of entire ecosystems. Although this shift in focus reflects a better awareness of the context in which fisheries take place, it poses challenging problems for the analyst. Simple combinatorial arguments show that "realistic" models rapidly outgrow the computational and memory capacity of even the most sophisticated computing systems. Complex ecological models necessarily include many hypothetical relationships, and they often require expertise that spans numerous disciplines. For example, a model with components that describe physical oceanography, primary production, invertebrates, and fish species might easily go beyond the bounds of expertise possessed by any one of its developers. Can we trust a model for which no one person understands all the technical details? The entire edifice might be deceptive, due to a single wrong line of computer code that nobody has noticed. Would it be better, for example, to use the resources required to produce an ecosystem model in making a documentary movie that the general public could understand more easily? How can ecosystem models give useful guidelines for policy development? In this talk we explore such questions, particularly in the context of data-limited situations.

27 October, 15:50 (S2-5653)

Multi-attribute utility function approach to developing socio-economic indicators for Alaska fisheries

Chang **Seung**[1] and Chang Ik Zhang[2]

[1] Alaska Fisheries Science Center, NOAA/NMFS, Seattle, WA, 98115, USA. E-mail: chang.seung@noaa.gov
[2] Pukyong National University, Busan, 608-737, R Korea

Ecosystem-based fisheries management requires a holistic assessment of status of fisheries integrating fishery eco-system indicators for several major objectives such as sustainability, biodiversity, habitat quality, and socio-economic status. Scientists have already paid much attention to the first three objectives (*i.e.*, sustainability, biodiversity, and habitat quality), and to the development of their indicators. Although there have been some efforts to develop socio-economic indicators, relatively less attention has been paid to the fourth objective, socio-economic status, and the development of its indicators. In addition, the socio-economic indicators developed so far are not firmly based on economic theory. This paper (1) discusses the problems with previous approaches to developing socio-economic indicators, (2) presents theoretical foundations of multi-attribute utility function (MAUF) approach in developing socio-economic indicators, (3) discusses the issues associated with implementation of the MAUF for fisheries in Alaska, and (4) presents, as an example, some socio-economic indicators developed using MAUF for a fishery in Alaska. Future directions along this line of research are also discussed as well as methods of, and issues associated with, integrating the socio-economic indicators with non-socioeconomic indicators (such as Zhang *et al.* 2009) developed for fisheries.

27 October, 16:10 (S2-5624)

Interannual-decadal variability of demersal fish community in the Japan Sea: Impacts of climate regime shifts and trawl fishing with recommendations for ecosystem-based management

Yongjun **Tian**, Hideaki Kidokoro and Tadanori Fujino

Japan Sea National Fisheries Research Institute, Fisheries Research Agency (FRA), Suidou-cho, Chuo-ku, Niigata, 951-8121, Japan
E-mail: yjtian@fra.affrc.go.jp

A climate regime shift was indicated by an abrupt change from a cool to warm period in the Tsushima Warm Current (TWC) and associated large changes in the TWC ecosystem in the late 1980s in the Japan Sea (JS). Variability in the demersal fish community was examined using historical trawl fishery data. Principal component analysis (PCA), applied to two fishery catch datasets, coastal pair trawlers and offshore single trawlers data in the JS, showed decadal variability patterns in the catches of target species with step changes around the late 1980s and mid 1990s. The first and second principal components (PC1 and PC2) for both datasets correspond well with winter and summer water temperatures in the JS. Detailed analysis of the demersal fish assemblage composition, abundance and distribution indicated an marked shift in the late 1980s. Cold water species decreased (increased) both abundance and distribution during warm (cold) regime. However, warm-water species increased in abundance and/or distribution during the warm 1990s. These results suggested that demersal fish community structure in the JS was largely affected by climate regime shifts. Differing response patterns between warm- and cold-water species to climate regime shifts indicated the importance of integrated assessment for trawl fishery. Impacts of trawl fishing and ecosystem-based management of the trawl fishery under the current warm regime will be discussed, as well.

27 October, 16:30 (S2-5612)

Climate-driven ecosystem shifts indicated in fishery catch statistics from Korean coastal waters over 1968-2008

Sukgeun **Jung**, Young Shil Kang, Dong-woo Lee, Young-Sang Suh, Sukyung Kang and Yeong Gong

National Fisheries Research and Development Institute, 408-1 Sirang-ri, Gijang-eup, Gijang-gun, Busan, 619-902, R Korea
E-mail: Sukgeun.jung@gmail.com

The main cause of annual fluctuations in catch by Korean fisheries is uncertain, but a prevailing view is that fisheries activity has been more critical than natural forcing. To evaluate and project influence of climate-driven oceanographic changes on Korean fisheries, we summarized changes in oceanographic conditions (1968-2007), taxonomic changes in fishery catches (1968-2008) and meso-zooplankton samples in Korean coastal waters (1978-2006) to be related with the regime-shift hypothesis. Water temperatures, averaged over all Korean marine waters, have significantly increased in the entire water column from 0 to 100-m depth. Biomass of meso-zooplankton and abundance of major zooplankton groups have increased. Although the combined annual fishery catch in Korea has been relatively stable since 1980s, annual catch of individual fish species has fluctuated greatly. Catch from shallow, inshore areas has decreased, but catch from deep, offshore areas has increased. We defined four regimes based on characteristic fish species identified by correspondence analysis: (1) saury (1968-1976), (2) pollock (1977-1982), and (3) sardine (1983-1990) and common squid (1991-2008). An additional shift in species compositions of both fisheries catch and meso-zooplankton in Korean waters was evident for 1982-1983, which was probably related with the El Niño event. The comparison between reported periods of basin-wide climate and ecosystem changes and our proposed shifts in Korean marine capture fishery suggests that climate-driven oceanic changes has been a major cause of changes in fish communities.

27 October, 16:50 (S2-5630)

Developing socioeconomic indicators for an ecosystem-based fisheries approach

Dohoon **Kim**[1] and Chang Ik Zhang[2]

[1] Management and Economic Policy Division, National Fisheries Research and Development Institute, Busan, 619705, R Korea
E-mail: delaware310@nfrdi.go.kr
[2] Pukyong National University, Busan, 608737, R Korea

As more ecosystem concerns of fisheries management have greatly increased in recent years, development and utilization an ecosystem-based fisheries approach using a variety of indicators is becoming much more important. Among indicators, in particular, developing socioeconomic indicators becomes necessary to fully measure and understanding the social and economic status of fisheries and their associated ecosystems. Although a few studies have developed socioeconomic indicators, they used almost the same attributes and evaluated their performances using a common method, the so-called traffic light system. In this study, we attempted to include other socioeconomic attributes, such as markets in addition to the productivity, revenue and cost attributes that were developed in the previous studies. Both target and limit reference points were developed for evaluating each indicator more reasonably by considering global, regional, and/or national standards and criteria. This method was applied to the Korean large purse seine fishery to demonstrate its applicability and usefulness.

27 October, 17:10 (S2-5818)

Seamount ecosystems – oceanographic environment

Vladimir B. **Darnitskiy**

Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia
E-mail: laitik@mail.ru

There are about 10,000 seamounts in the world's oceans, with more than 30,000 of heights more than 1000 m. Taken together, the system of seamounts, coral reefs, and more than 60,000 km of oceanic ridges comprise one of the largest ecosystems of World Ocean. The faunal structure depends on remoteness of seamounts from the centers of main their concentration. For example, all known plants and the animals on the Large Barrier Reef make no less than 80% of all flora and fauna of the IndoPacific, but seamounts of the Pacific Ocean may include from 50 to >200 fish species with about 30% of them representing endemics. In comparison with continental shelf areas, biological resources of seamounts are limited, but the extent depends on remoteness. Ocean current vortices form near seamounts and seamount clusters; the volumes of water flow vary and depend upon many regional features. Commercial fish catches taken from seamounts and ocean ridges vary widely by year and region. For example, Russian catches of *Coryphaenoides rupestris* from the North Atlantic Ridge varied from 35.2-36.6 t per day in 1974-75 to 14.5 t per day in 1991. In the Northern Pacific, the greatest yields were taken from the Hawaiian and Imperial Ridges combined in 1968 to 1975. Japanese troll fishery statistics indicate maximal catch rates (75-85 t per hour) of *Pentaceros* species in 1972, declining to 1-2 t per hour in 1977. Maximal annual catch of *Pentaceros* by Soviet fishing vessels was 178,300 t in 1973. In this presentation, we will summarize the biological productivity of the North Atlantic and the Imperial Ridges.

S2 Posters

S2-5553

Integrated forecasts of fall Chinook salmon returns to the Columbia River

Saang Yoon **Hyun** and Rishi Sharma

Columbia River Inter-Tribal Fish Commission, Fish Science, 729 NE Oregon St., Suite 200, Portland, 97232, OR, USA
E-mail: hyus@critfc.org

Forecasts of fall Chinook salmon (*Oncorhynchus tshawytscha*) runs to the Columbia River are a critical management component for harvest decisions and monitoring abundance trends because Columbia River fall Chinook salmon form the largest contributing fish group to ocean Chinook fisheries north of Cape Falcon, Oregon, and also they include Snake River fish at extinction risk. Preseason forecasts of fall Chinook salmon runs have been made annually using historical sibling runs. However, their accuracy has not been consistent over the years and uncertainty of preseason forecasts has not been measured. The main objective of this study is to improve the traditional forecast methods by incorporating information from fish return year, which is not currently used in the formulation of preseason forecasts. During fish return year, catch and effort data from Southeast Alaska are available on a real-time (*e.g.*, weekly) basis, as well as stock- and age-specific proportions in the ocean abundance calculated by the Pacific Salmon Commission Chinook Technical Committee ocean model. These data allow real-time forecasts of stock-and age-runs to become possible. We call forecasts made with data from fish return year "in-season forecasts". We blend the in-season forecasts of fish runs with the traditional preseason forecast to create integrated forecasts. Preliminary results show that integrated forecasts outperform the traditional preseason forecasts. We discuss variability in ocean conditions in the Northeast Pacific Ocean by contrasting the forecast performance over 10 years (1998-2007) with ocean conditions from those corresponding years.

S2-5666

An ecosystem-based fisheries resource assessment for the gillnet fishery of the Uljin marine ranch ecosystem in Korean waters

Hyeok Chan **Kwon**[1], Sang Chul Yoon[2], Sung Il Lee[2], Young Yull Chun[2], Jong Bin Kim[2] and Chang Ik Zhang[1]

[1] Pukyong National University, 559-1 Daeyeon-3-dong, Nam-gu, 608-737, R Korea. E-mail: hckwon98@pknu.ac.kr
[2] East Sea Fisheries Research Institute, NFRDI, 30-6, Dongduk-ri, Yeonkok-myeon, Gangnung, 210-861, R Korea

A pragmatic ecosystem-based approach of Zhang *et al.* (2009) was employed to assess fisheries resources for the gillnet fishery of the Uljin marine ranch ecosystem in Korean waters. Four management objectives were identified, that is, the maintenance of sustainability, biodiversity, habitat quality and socio-economic status. A number of indicators were selected for each objective. In 2008, the annual catch by the gillnet fishery at Uljin marine ranching area was 160 metric tons. In the Uljin marine ranch ecosystem, starry flounder (*Platichthys stellatus*) and bastard halibut (*Paralichthys olivaceus*) were main species targeted by the gillnet fishery. These two species were assessed by a Tier 1 analysis, since quantitative data were available for these species. A Tier 2 analysis was applied to bycatch species, such as brown sole (*Pleuronectes herzensteini*), filefish (*Stephanolepis cirrhifer*), yellow goosefish (*Lophius litulon*), Pacific cod (*Gadus macrocephalus*) and Pacific herring (*Clupea pallasii*). In this study, we estimated objectives risk index (ORI), species risk index (SRI) and fishery risk index (FRI) to evaluate the status of the gillnet fishery in the ecosystem.

S2-5804

A systematic approach for estimating potential fishery yields of data-deficient, small-scale coastal fisheries in Korea

Young Jae **Shin**[1,2], Jae Bong Lee[2] and Chang Ik Zhang[1]

[1] Pukyong National University, Busan, 608-737, R Korea. E-mail: syj5354@nfrdi.go.kr
[2] National Fisheries Research and Development Institute, Busan, 619-705, R Korea

In this study potential fishery yield (PFY) is defined as an acceptable biological catch limit of fisheries resources potentially utilized by fisheries in a designated area. A systematic approach is developed to estimate potential fishery yield using fishery-dependent and/or fishery-independent data and information available in small-scale coastal fisheries, which are typically data deficient. PFYs were estimated from a five-tier system. Tier 1 analysis is conducted based on fishery assessment models using the most reliable fishery data, such as biological parameters, length composition and fishery statistics, while Tier 5 analysis uses only fishery-dependent catch data. For a mid-western coastal fishing ground of Korea, PFYs for a total of 98 species were estimated from the five different tier analyses. PFYs for eight species were estimated using Tier 1, two species using Tier 2, three species using Tier 3, 59 species using Tier 4, and 26 species using Tier 5. The total PFY was estimated to be 26,900 metric tons on the fishing grounds. This systematic approach for estimating PFYs will be useful to develop an efficient precautionary approach to fishery resource management under data-deficient situations, which is typical for small-scale, coastal fisheries in Korea.

S3 FIS/BIO Topic Session
Early life stages of marine resources as indicators of climate variability and ecosystem resilience

Co-Sponsored by ICES

Co-Convenors: Richard D. Brodeur (U.S.A.), Douglas E. Hay (Canada), Suam Kim (Korea), Gordon H. Kruse (U.S.A.), Vladimir I. Radchenko (Russia) and Yoshiro Watanabe (Japan)

As management strategies become more ecosystem-based and climate-driven, there is a need for more information on the role of species interactions and oceanographic variability in regulating fisheries resources. The early life stage of fish and invertebrates has been shown to be critical in determining year-class success and subsequent recruitment to the fisheries. This session will examine changes in the abundance, distribution, and ecological relationships of early life stages (eggs to juveniles) of important fish and invertebrate species in relation to climate fluctuations. Studies examining these stages in relation to adult recruitment and their use as indicators of ecosystem stress or variability are invited. Examples of the uses of ichthyoplankton or juvenile surveys in the assessment or management of stocks and in forecasting future trends in fisheries are highly encouraged. The session is especially interested in papers that examine the role of early life stage work relative to ecosystem structure and vulnerability of ecosystems to climate change, with particular reference to the processes of recruitment.

Day 1, Wednesday, October 28 (9:00-12:30)

9:00 ***Introduction by Convenors***

9:10 **Mark Dickey-Collas and Jonathan A. Hare (Invited)**
Ichthyoplankton surveys, great for assessment and day to day management but are they so relevant for understanding the future? (S3-5584)

9:40 **Miriam J. Doyle (Invited)**
Responding to the call for Ecosystem Based Management of marine fisheries: Perspectives from fish early life history studies in the Northeast Pacific Ocean (S3-5712)

10:10 **Elizabeth A. Logerwell, Janet Duffy-Anderson, Matt Wilson and Denise McKelvey**
Processes affecting the productivity of capelin and pollock in the Gulf of Alaska (S3-5581)

10:30 ***Coffee / tea break***

10:50 **Sukgeun Jung, Dong-woo Lee, Yeonghye Kim, Hyung Kee Cha, Hak-jin Hwang and Jeong-yong Lee**
Contrasting recruitment of two gadoid species (*Gadus macrocephalus* vs. *Theragra chalcogramma*) to Korean coastal waters in relation to climate change (S3-5613)

11:10 **Lu Guan, John Dower and Skip McKinnell**
Quantifying long-term variability in composition of the Strait of Georgia ichthyoplankton community (S3-5651)

11:30 **Andrey Suntsov and Tony Koslow**
Nearshore ichthyoplankton communities off southern and central California (S3-5954)

11:50 **Richard D. Brodeur, Toby Auth, Elizabeth A. Daly and William T. Peterson**
Ichthyoplankton as indicators of climate change and recruitment variability of marine fishes and salmon along the northwest coast of the US (S3-5822)

12:10 **Jun Shoji, Yasuhiro Kamimura, Ken-ichiro Mizuno and Shun-ichi Toshito**
Fish production in seagrass habitat under global warming: Effects of temperature on early growth and production of a dominant species, black rockfish, in temperate waters of the western North Pacific (S3-5852)

12:30 ***Day 1 Session ends***

Day 2, Thursday, October 29 (9:00 - 12:30)

9:00 **John C. Field, Stephen Ralston and Keith Sakuma**
Rockfish (***Sebastes***) recruitment and ecosystem indicators for the Southern California Current (S3-5885)

9:20 **Chiyuki Sassa and Youichi Tsukamoto**
Distribution and growth of chub mackerel *Scomber japonicus* and spotted mackerel *S. australasicus* larvae in the southern East China Sea (ECS) in response to oceanographic conditions (S3-5636)

9:40 **David Checkley, Yoshioki Oozeki, Sam McClatchie, and Akinori Takasuka**
Comparison of spawning habitats of anchovy and sardine in the Pacific Ocean off Japan and North America (S3-5999)

10:00 **Motomitsu Takahashi (Invited)**
Contrasting responses in growth rates between anchovy and sardine to changes in water structures in the eastern and western North Pacific (S3-5939)

10:30 ***Coffee / tea break***

10:50 **Masahide Kaeriyama, Hideaki Kudo, and Hyunju Seo**
Global warming effects on the early ocean life of Hokkaido chum salmon (S3-5542)

11:10 **Igor Zhigalov, Alexander Figurkin and Svetlana Ovsyannikova**
Oceanographic conditions and the distribution of walleye pollock eggs in the southern Kuril Islands region during March – April of 2006 and 2007 (S3-5623)

11:30 **Yoshiro Watanabe**
Linear response of growth rates to ambient temperature in larval round herring *Etrumeus teres* in the Pacific coastal waters off southern Japan (S3-5684)

11:50 **Nam-Il Won, Tomohiko Kawamura, Hideki Takami and Yoshiro Watanabe**
Food web structures in crustose coralline algae bed during early life stages of abalone *Haliotis discus hannai* in relation with recruitment process (S3-5689)

12:10 **Tadanori Fujino, Hideaki Kidokoro, Tsuneo Goto and Yongjun Tian**
Effect of the oceanographic condition on the abundance of mesopelagic fish: *Maurolicus japonicus* in the Japan Sea (S3-5743)

12:30 ***Session ends***

S3 Posters

S3-5520 **Mikhail A. Zuev**
Distribution and abundance of juvenile long armed gonatid squid (*Gonatus madokai*) in the northern Sea of Okhotsk

S3-5540 **Chen-Yi Tu, Yu-heng Tseng, Tai-sheng Chiu and Chih-Hao Hsieh**
Use particle tracking simulation in hydrodynamic model to investigate spawning migration of Japanese anchovy *Engraulis japonicus* from the East China Sea to Taiwan

S3-5738 **Alexander A. Antonov, Irina Yu. Bragina and Elena M. Latkovskaya**
Nutrients transport, forage base and survival of juvenile pink salmon in Aniva Bay (south of Sakhalin Island)

S3-5768 **Ana L. Rosa, J. Yamamoto and Yasunori Sakurai**
Effects of environmental variability on the spawning areas, catch and recruitment of the Japanese common squid, *Todarodes pacificus*

S3-5806 **Heeyong Kim, D.H. Kim, Hakjin Hwang and Y.I. Seo**
Effect of Siberian High on the catch fluctuation of pacific cod, *Gadus macrocephalus*, in the Yellow Sea

S3-5814 **Yuji Okazaki, Hiroshi Kubota, Kaori Takagi, Hiroshi Itoh and Nobuhiro Saito**
Feeding ecology of larval and juvenile sardine (*Sardinops melanostictus*) and anchovy (*Engraulis japonicus*) in the western North Pacific

S3 Oral Presentations

28 October, 9:10 (S3-5584), Invited

Ichthyoplankton surveys, great for assessment and day to day management but are they so relevant for understanding the future?

Mark **Dickey-Collas**[1] and Jonathan A. Hare[2]

[1] Wageningen IMARES, P.O. Box 68, 1970 AB Ijmuiden, The Netherlands. E-mail: mark.dickeycollas@wur.nl
[2] National Marine Fisheries Service (NMFS), 28 Tarzwell Dr., Narragansett, RI02882, USA

We use examples from the ICES area to investigate the importance of ichthyoplankton surveys in the management of fish stocks. Surveys prove very useful to provide time series of proxies for spawning stock biomass (SSB) and for some species, surveys of early life stages provide valuable early warning signals for variability in recruitment. It is fairly clear how surveys that provide proxies for SSB underpin the management advice, but ichthyoplankton surveys can also be used to respond swiftly and reduce the likelihood of over exploitation in the immediate future. However the past does not necessarily reflect the future. Thus this approach does not allow management or fishers to adapt to medium to longer term changes in productivity or carrying capacity, and also does not easily enable scenarios of future exploitation to be developed. Our examples show that despite high quality proxies for spawning stock biomass and recruitment determined from ichthyoplankton surveys, process understanding of recruitment is vital when you start to consider environmental or climatic change to the ecosystem.

28 October, 9:40 (S3-5712), Invited

Responding to the call for Ecosystem Based Management of marine fisheries: Perspectives from fish early life history studies in the Northeast Pacific Ocean

Miriam J. **Doyle**

Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, P.O. Box 354925, Seattle, WA, 98195, USA
E-mail: miriam.doyle@noaa.gov

Over the last century, our understanding of recruitment in marine fish has evolved significantly from the simple concept of critical early life history periods driving annual cohort survival. The contemporary conceptual view of recruitment is that of a highly complex system of interacting biological and physical processes operating at different spatial and temporal scales. Fisheries oceanography research programs were established in ecosystems of the Northeast Pacific Ocean to provide new understanding of recruitment processes that could be used to manage fish stocks and forecast future trends in abundance. Time-series of fisheries, biological, oceanographic and climate data have been accumulated for decades and contribute substantially to our knowledge of the effects of environmental forcing on fish population abundance. In particular, there has been enormous progress made in our understanding of species early life history stages; their taxonomy, morphology, biology, ecology, and links to the physical and biological environment. Nevertheless, reliable predictions of recruitment strength remain elusive for most species. Furthermore, recognition of the potential consequences of climate change on fisheries, and the call for Ecosystem Based Management of marine fish stocks, presents ever greater intellectual and technical challenges for the development of valid recruitment prediction models. Our attitude and approach to this complexity may determine our success. In this presentation, some new ideas will be proposed for the utilization of complex biological patterns within data time-series, based on fisheries oceanographic research programs in the Gulf of Alaska and the California Current.

28 October, 10:10 (S3-5581)

Processes affecting the productivity of capelin and pollock in the Gulf of Alaska

Elizabeth A. **Logerwell**, Janet Duffy-Anderson, Matt Wilson and Denise McKelvey

Alaska Fisheries Science Center, NOAA National Marine Fisheries Service, 7600 Sand Point Way NE, Seattle, WA, 98115, USA. E-mail: libby.logerwell@noaa.gov

The over-arching goal of this project was to investigate the processes affecting the productivity of capelin and walleye pollock, important forage fishes in the Gulf of Alaska (GOA). The first objective was to investigate the key physical processes by comparing the distribution of fish with oceanographic properties and the distribution of prey. The second objective was to investigate the potential for interspecific competition by comparing measures of foraging success between capelin and juvenile pollock. The field study to address these objectives was conducted in Barnabus Trough off Kodiak Island during September 2005 on the NOAA Vessel *Miller Freeman*. The distribution of fish was assessed with fisheries acoustics and mid-water trawls. Fish were collected from the trawls for stomach contents. Physical and biological data were collected with conductivity-temperature-depth (CTD) probes and zooplankton tows. Our results support the linkage between oceanography, prey, fish diet and fish distribution. We found that age-0 pollock were distributed in cool, high-salinity waters offshore of a mid-trough front, coincident with the distribution of the bulk of their preferred prey, euphausiids. In contrast to pollock, we found that capelin were distributed throughout the trough, as was the distribution of their dominant prey, copepods. Regarding the potential for interspecific competition, we found that sympatric capelin (occurring with pollock) often had reduced foraging success compared to allopatric capelin (occurring alone). Our results also suggested that, age-0 pollock were the superior competitor of the two species and that the exclusion of capelin from foraging on euphausiids can have negative growth consequences.

28 October, 10:50 (S3-5613)

Contrasting recruitment of two gadoid species (*Gadus macrocephalus* vs. *Theragra chalcogramma*) to Korean coastal waters in relation to climate change

Sukgeun **Jung**, Dong-woo Lee, Yeonghye Kim, Hyung Kee Cha, Hak-jin Hwang and Jeong-yong Lee

National Fisheries Research and Development Institute, 408-1 Sirang-ri, Gijang-eup, Gijang-gun, Busan, 619-902, R Korea
E-mail: Sukgeun.jung@gmail.com

Two gadoid species, Pacific cod (*Gadus macrocephalus*) and Alaska pollock (*Theragra chalcogramma*), have been traditionally important commercial fish species in Korea, but their responses to climate change are contrasting. The two species are similar in that they were once major commercial fish species in Korea, and are deep-water species that spawn at cold temperatures during the winter. However, they differ in their vertical depth ranges with respect to spawning and hatching (demersal *vs.* pelagic). In Korean coastal waters, global warming has apparently increased sea surface temperatures by *ca.* 1ºC during the past 40 years whereas bottom temperatures have not significantly increased. However, since the late 1990s, bottom temperatures during the winter spawning season have significantly decreased in some areas, probably by a strengthened mixed layer, especially in the southern Korean coastal waters, favoring the recruitment of Pacific cod whose eggs are demersal and hatch at 5-12ºC. Recruitment of cod seemed to decrease from the 1950s to the 1990s, as catch levels were lower compared with the 1920-1940s. Since 1998, however, catch has continued to increase from 0.5 x 10^3 metric tons in 1998 to 7.2 x 10^3 tons in 2007, reaching a record high. In contrast to Pacific cod, catch of Alaska pollock reached a record high (166 x10^3 metric tons) in 1981, but has steadily decreased since 1990, reaching a record low in 2007 (< 0.1 x 10^3 tons). The eggs of pollock are pelagic and we speculate that increasing sea surface temperatures may inhibit spawning, and subsequently reduce recruitment and migration of adult pollock to Korean coastal waters. In addition to the temperature changes, bottom-up control by Pacific herring (*Clupea pallasii*), driven by an increased biomass of meso-zooplankton after 1998, also could have helped recruitment of the Pacific cod in Korean coastal waters.

28 October, 11:10 (S3-5651)

Quantifying long-term variability in composition of the Strait of Georgia ichthyoplankton community

Lu **Guan**[1], John Dower[1] and Skip McKinnell[2]

[1] Department of Biology, University of Victoria, P.O. Box 3020 STN CSC, Victoria, BC, V8W 3N5, Canada. E-mail: lguan@uvic.ca
[2] North Pacific Marine Science Organization (PICES), Sidney, BC, Canada

As part of the Canadian Healthy Oceans Network (CHONe), we have recently undertaken the first analysis of decadal-scale changes in the ichthyoplankton community of the Strait of Georgia (British Columbia, Canada). Despite being an important nursery ground for commercially valuable fish species, very little is known about either the community composition or the overall abundance of larval fish in the strait. Furthermore, it is not yet known whether the community composition has changed over the past 40 years in response to changes in ocean climate or other causes. We initiated our study by resurrecting archival data from two spatially intensive field surveys that were conducted in the Strait of Georgia in 1966-1967 and 1979-1981. Neither survey had previously been analyzed in depth nor reported upon in the primary literature. The first phase of our analysis compares historical patterns of relative species dominance and overall ichthyoplankton abundance in the strait with recent (2006-2009) ichthyoplankton surveys. Our next step will involve an analysis of the spatial distribution of larval fish in the strait. Results from our recent surveys will ultimately be seeded into a 3D circulation model to determine whether there exist predictable source-sink ichthyoplankton transport corridors in the strait.

28 October, 11:30 (S3-5954)

Nearshore ichthyoplankton communities off southern and central California

Andrey **Suntsov** and Tony Koslow

Scripps Institution of Oceanography, 9500 Gilman Dr., La Jolla, CA, 92093, USA. E-mail: asuntsov@ucsd.edu

The coastal ecosystems of southern California host diverse fish communities, with many species supporting significant recreational and commercial fisheries. Data from ichthyoplankton surveys can provide a solid foundation for understanding the population dynamics of both commercial and non-commercial species. Ichthyoplankton survey data can become an important component of stock assessments and ultimately lead to more efficient ecosystem-based management. Ichthyoplankton studies off California have been carried out primarily by the California Cooperative Oceanic Fisheries Investigations (CalCOFI). This sampling effort, which started in 1951, represents one of the longest ichthyoplankton time series. These time series data are uniquely suited to address issues concerning the importance of coastal areas for recruitment, the role of marine protected areas, and the influence of long-term climate variability on early stages of fishes. However, CalCOFI sampling has traditionally concentrated on areas mostly beyond the nearshore zone, following its historical focus on commercial pelagic species such as sardine and anchovy. This offshore bias significantly restricts the utility of this dataset for comprehensive assessment of the coastal ichthyoplankton assemblages. To complement and expand the CalCOFI coverage, we assembled information from several ichthyoplankton sampling programs. In this presentation we examine gradients in coastal ichthyoplankton assemblages off southern and central California onshore-offshore, alongshore, and in response to large-scale climate variability.

28 October, 11:50 (S3-5822)

Ichthyoplankton as indicators of climate change and recruitment variability of marine fishes and salmon along the northwest coast of the US

Richard D. **Brodeur**[1], Toby Auth[2], Elizabeth A. Daly[2] and William T. Peterson[1]

[1] NOAA Northwest Fisheries Science Center, Hatfield Marine Science Center, Newport, OR, 97365, USA
Email: Rick.Brodeur@noaa.gov
[2] Cooperative Institute for Marine Resources Studies, Oregon State University, Newport, OR, 97365, USA

Ecosystem indicators that are useful to managers should be practical and available early enough to allow predictions. We developed a suite of performance indicators that are capable of addressing climate impacts relevant to ecosystems. We examined the abundance patterns of larval fish collected off Oregon from 1996-2009 in relation to historical records from the 1970s and 1980s and documented recent unusual distributions and occurrences of eggs and larvae compared to the historical record. Seasonal analysis of samples showed that variations in peak abundances of the dominant fish species correlated with temperature and oceanographic regimes, and that the relative abundance of fish larvae can provide a leading indicator of subsequent adult recruitment. Previous work has shown that the majority of larvae are present during the winter months and an estimate of winter larval abundance can provide an indicator of juvenile fish abundance in summer. Parallel studies on the diets of juvenile coho and chinook salmon has indicated that the most (>60%) of their diet is made up of juvenile fishes from a limited number of prey species. A preliminary examination of the relationship between the availability of larvae in winter and subsequent salmon survival showed a highly significant relationship (r^2 = 69.5%, p = 0.0027). This index is useful because it is available earlier in the year (before May) than the indices that are presently utilized which are measured during the summer months. The addition of this winter index can greatly improve our preseason forecasts and lead to more reliable indication of salmon marine survival the following summer. Our long-term goal is to reduce the time between detecting changes in the physical environment and related changes in fish recruitment.

28 October, 12:10 (S3-5852)

Fish production in seagrass habitat under global warming: Effects of temperature on early growth and production of a dominant species, black rockfish, in temperate waters of the western North Pacific

Jun **Shoji**, Yasuhiro Kamimura, Ken-ichiro Mizuno and Shun-ichi Toshito

Takehara Fisheries Research Laboratory, Hiroshima University, 5-8-1 Minato-machi, Takehra, Hiroshima 725-0024, Japan
E-mail: jshoji@hiroshima-u.ac.jp

Seagrass beds are considered to be some of the highest areas of productivity among the world's ecosystems. Black rockfish *Sebastes inermis* is one of the most dominant components of fish fauna in vegetated habitats in temperate waters of the western North Pacific. Larval and juvenile rockfish immigrate into macroalgae (*Sargassum* spp.) beds in early March at a total length of about 20 mm and later inhabit seagrass (*Zostera* spp.) beds through summer. In order to estimate the possible effects of global warming on fish production of these vegetated habitats, growth of larval and juvenile rockfish was examined under a variety of temperature conditions. Otoliths of wild juveniles collected in northern (Senday, Miyagi) and southwestern Japan (Takehara, Hiroshima) were processed for back-calculation of growth trajectories during larval (< 20 mm) and post-settlement (20-50 mm) periods based on the Biological Intercept Method. Under laboratory conditions, effects of temperatures on growth, gastric evacuation rate and daily ration during the post-settlement period were examined at 14-18ºC. Mean growth rates during the larval period ranged from 0.2 and 0.8 mm/d and were higher at higher temperatures. Contrastingly, mean growth rates during the post-settlement period deceased to 0.1-0.4 mm/d and were higher at lower temperatures. Gastric evacuation rate of the post-settlement juvenile was high at higher temperatures. Based on the possible increase in water temperature (about 2ºC in 2095), it is plausible to expect a reduction of juvenile fish production and northward shift of the rockfish distribution.

29 October, 9:00 (S3-5885)

Rockfish (*Sebastes*) recruitment and ecosystem indicators for the Southern California Current

John C. **Field**, Stephen Ralston and Keith Sakuma

Fisheries Ecology Division, Southwest Fisheries Science Center, National Marine Fisheries Service, NOAA, 110 Shaffer Rd., Santa Cruz, CA, 95060, USA. E-mail: john.field@noaa.gov

Juvenile rockfish (*Sebastes*) have been quantitatively monitored in an annual midwater trawl survey along the Central California coast since 1983. The survey takes place in late spring (May-June), and targets pelagic stages (prior to settlement to benthic habitats) of winter-spawning species for developing indices of year class strength in stock assessments. Many of these species are typified by high variability in year-to-year recruitment, which drives consequent trends in availability, fishery landings, and population trends. Results from these ongoing efforts suggest that there is strong covariation in juvenile abundance, as well as in realized recruitment events based on stock assessments, which is linked to large-scale oceanographic processes. Moreover, the trends in abundance and productivity of many other pelagic micronekton covary (either in or out of phase) with those of juvenile rockfish, as well as with higher trophic level predators such as seabirds. However, the relationships among the survey indices and consequent recruitments based on stock assessments are not always as solid as would be ideal, leading to questions of how best to utilize these data in forecasting. We will present a synopsis of what we have learned in the nearly 30 year history of our survey, including an overview of what seem to be key forcing mechanisms for variability in juvenile rockfish abundance, how indices of juvenile abundance have been used in assessments of target species, as well as how climate forces have driven variability in the micronekton community and their dependent predators.

29 October, 9:20 (S3-5636)

Distribution and growth of chub mackerel *Scomber japonicus* and spotted mackerel *S. australasicus* larvae in the southern East China Sea (ECS) in response to oceanographic conditions

Chiyuki **Sassa** and Youichi Tsukamoto

Seikai National Fisheries Research Institute, Fisheries Research Agency, 1551-8 Taira-machi, Nagasaki 851-2213, Japan
E-mail: csassa@fra.affrc.go.jp

Scomber japonicus and *S. australasicus* are important fishery resources in the countries adjacent to the ECS, but information on their recruitment processes is limited. Extremely high abundances of *Scomber* spp. larvae were found in the shelf break region of the southern ECS south of 28°N during February to March in 2004 and 2005. Based on species identification using PCR-RFLP analysis of mtDNA, both *S. japonicus* and *S. australasicus* were found to occur there. The distribution of *S. australasicus* was in a more southern area than that of *S. japonicus*, with a higher and narrower range of habitat temperature (20–23°C versus 15–22°C), although there was also some spatial overlap. In 2004 when an intrusion of the warm Kuroshio Branch Current north of Taiwan (KBCNT) was evident, the larvae of both species were transported northeastward with growth, while this pattern was not clear in 2005 when a southward extrusion of cold shelf water was observed. Larval growth of *S. japonicus* and *S. australasicus* were 0.32–0.49 and 0.39–0.48 mm d^{-1}, respectively, and the growth in 2004 was significantly higher than that in 2005 for both species. Habitat temperature and food availability of the larvae in 2004 were much higher than those in 2005, which would relate to the between-year difference in growth. The interannual growth differences in response to differences in the habitat conditions might affect variations in recruitment of the two mackerels in the ECS, as suggested in the congener *S. scombrus* in the northwest Atlantic.

29 October, 9:40 (S3-5999)

Comparison of spawning habitats of anchovy and sardine in the Pacific Ocean off Japan and North America

David **Checkley**[1], Yoshioki Oozeki[2], Sam McClatchie[3], and Akinori Takasuka[2,3]

[1] Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA, 92092-0218, USA
E-mail: dcheckley@ucsd.edu
[2] National Research Institute of Fisheries Science, Fisheries Research Agency, 2-12-4 Fukuura, Kanazawa, Yokohama, Kanagawa, 236-8648, Japan
[3] Southwest Fisheries Science Center, National Marine Fisheries Service, NOAA, La Jolla, CA, 92037-1508, USA

Large populations of sardine (*Sardinops* spp.) and smaller populations of anchovy (*Engraulis* spp.) at times flourish in the Pacific Ocean off Japan (Kuroshio-Oyashio System, KOS) and North America (California Current System, CCS). We analyzed the temperature, salinity, and egg abundance for ichthyoplankton collections in these two regions to investigate the spawning habitats of these taxa and to infer their possible adaptive significance. The KOS (1996-2004) had 22,823 vertical ring net samples, of which 7,030 had anchovy and 1,266 had sardine eggs. The CCS (1997-2008) had 19,387 samples taken with the Continuous Underway Fish Egg Sampler, of which 1,919 had anchovy and 5,615 had sardine eggs. Most KOS samples with many sardine eggs occurred in January-March in the frontal region between the Kuroshio and coastal waters and those with many anchovy eggs in April-August in coastal waters, at times with significant freshwater influence. Most CCS samples with many sardine eggs occurred in the frontal region between the California Current and coastal waters, and with many anchovy eggs in coastal waters, also at times with significant freshwater influence. These patterns are consistent with the large sardine populations being supported by upwelling related to potential vorticity and its interaction with winter winds in the KOS and wind-stress, curl-driven upwelling in the CCS, and the smaller anchovy populations by upwelling associated with eddies interacting with the bottom inshore of the Kuroshio, coastal wind-driven upwelling inshore of the California Current, and, at times, river runoff in both systems.

29 October, 10:00 (S3-5939), Invited

Contrasting responses in growth rates between anchovy and sardine to changes in water structures in the eastern and western North Pacific

Motomitsu **Takahashi**

Seikai National Fisheries Research Institute, Fisheries Research Agency, 1551-8 Taira-machi, Nagasaki-shi, Nagasaki 851-2213, Japan
E-mail: takahamt@fra.affrc.go.jp

I examined effects of environmental conditions on growth rates during late larval and early juvenile stages for anchovy (*Engraulis* spp.) and sardine (*Sardinops* spp.) in the California Current region (CCR) and the Kuroshio-Oyashio transition region (KOTR). The recent growth rate during the 5 days prior to collection, estimated from otolith daily increments, was related to hydrographic conditions and prey concentration in waters in which fish occurred. In the CCR, the recent growth rate for *Engraulis mordax* in waters with the pycnocline at 15-25 m was faster than that with shallower or deeper pynoclines. In contrast, the growth rate for *Sardinops sagax* in waters with a pycnocline at < 15 m was faster than that with a deeper pycnocline. Thus, the extent of stratification of the upper 25 m of the water column affects the growth rate *E. mordax* and *S. sagax* differently. In the KOTR, the growth-environment analysis revealed contrasting responses in the growth rate between *Engraulis japonicus* and *Sardinops melanostictus* to a northward shift of the subtropical Kuroshio Extension into the KOTR. Increased temperature enhanced growth rate for late larval *E. japonicus*, but reduced prey concentration diminished the growth rate of early juvenile *S. melanostictus*. Vertical stratification in density intensified in the CCR and when the Kuroshio Extension shifted northward in the KOTR in the late 1980s and the early 1990s. These results suggest that during the period when growth and survival rates for *S. sagax* and *E. japonicus* were enhanced, those for *E. mordax* and *S. melanostictus* deteriorated simultaneously in the eastern and western North Pacific.

29 October, 10:50 (S3-5542)

Global warming effects on the early ocean life of Hokkaido chum salmon

Masahide **Kaeriyama**, Hideaki Kudo, and Hyunju Seo

Graduate School of Fishereis Sciences, Hokkaido University, 3-1-1 Minato-cho, Hakodate, 041-8611, Japan
E-mail: salmon@fish.hokudai.ac.jp

The potential effect of trends in the temperature increase was analyzed for the early ocean life stages of Hokkaido chum salmon (*Oncorhynchus keta*). Age-1 growth (G1) of adult chum salmon returning to the Ishikari River from 1943 to 2005 was estimated using the back-calculation method based on scale analysis. Direct and indirect effects of global anomalies of surface air temperature (SAT), Aleutian Low Pressure Index (ALPI), Pacific Decadal Oscillation (PDO), Arctic Oscillation (AO), Okhotsk high (OH), sea surface temperature during summer and autumn (SST), and rate of sea ice cover (ICE) in the Okhotsk Sea on their G1 and survival rate (SR) were examined. The multiregression analysis indicated that the SR was as a function of the G1 and the mean body weight (BW) of juvenile released from hatchery (r^2=0.744, F=16.289, P<0.001, AIC=85.80). A path analysis indicated that there was (1) a direct linkage among the G1, the SST, and the SAT, (2) an indirect linkage among the ICE, the PDO, and the ALPI, and (3) no linkage between the G1 and the ICE. These results suggest that the global warming may have had a direct affect on growth at age-1 and survival of Hokkaido chum salmon through the SST, and indirectly for the ICE through the ALPI and the PDO in the Okhotsk Sea during the last several decades.

29 October, 11:10 (S3-5623)

Oceanographic conditions and the distribution of walleye pollock eggs in the southern Kuril Islands region during March – April of 2006 and 2007

Igor Zhigalov, Alexander **Figurkin** and Svetlana Ovsyannikova

Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia
E-mail: zhigalov@tinro.ru

Oceanographic observations and ichthyoplankton sampling were conducted by the TINRO-Centre in March-April of 2006 and 2007 off the southern Kuril Islands regions, including both the Okhotsk Sea and Pacific Ocean sides that were accessable in relatively low ice conditions. In March 2007, the thermal conditions in surface layer (0-50 m) were much warmer than normal, and the water temperature was maximal in the observations since 2000. This increase of temperature in 2007 could be connected with the simultaneous increase of air temperature at the surface and the reduction of cold water outflow from the Okhotsk Sea to the Pacific Ocean. In 2006, waters of the northeast current in the Okhotsk Sea, bending around the northern part of Iturup Island, penetrated into the Pacific Ocean. Part of these waters, after the passing through the Frieze Strait, was spread along Pacific coast of Iturup Island in a southwestwardly direction. It is likely that there was a distribution at the same time of walleye pollock eggs from Prostor Bay to the Pacific Ocean through Frieze Strait.

In 2007, outflow of waters of the northeast current from the southern part of the Okhotsk Sea to the Pacific Ocean was blocked by the strengthening of Pacific waters inflow of the Oyashio Current to the northern part of Iturup Island. As result, for the first time during the entire 2000-2007 period, there were no walleye pollock eggs in Pacific waters near Island Iturup and in contrast, drift of walleye pollock eggs from the Kunashirskiy Strait and the Yuzhno-Kurilskiy Strait was more significant than usual.

The densest concentrations of the pollock eggs and spawning fish were found in the Kunashir Strait and Prostor Bay, with the egg concentrations in the Pacific Ocean, in the South-Kuril Strait, and northeastward from the Iturup Island. In 2006, spawning pollock were rarely observed in trawl catches and eggs concentrations were significantly lower. We conclude that pollock did not spawn in the Pacific waters of the southern Kuril Islands in March 2006 and 2007. In 2007, high concentrations of the pollock eggs were found in the Yuzhno-Kurilskiy Strait. So, the peculiarity of the water circulation essentially influenced pollock egg distribution and drift in this region.

29 October, 11:30 (S3-5684)

Linear response of growth rates to ambient temperature in larval round herring *Etrumeus teres* in the Pacific coastal waters off southern Japan

Yoshiro **Watanabe**

Living Marine Resources, Ocean Research Institute, University of Tokyo, 1-15-1 Minamidai, Nakano-ku, Tokyo, 164-8639, Japan
Email: ywatanab@ori.u-tokyo.ac.jp

Despite a spatial and temporal overlap of egg production in the Kuroshio waters, Japanese sardine *Sardinops melanostictus* has experienced a substantial population fluctuation in the last 3 decades, whereas round herring *Etrumeus teres* has been stable during this period. I hypothesized that the stable nature of round herring population stems from stable growth rates in early life stages. When growth rates in different larval stages of round herring were analyzed and related to temperature, they were seasonally variable but 70-90% of the variability was explained by ambient temperature. This may imply that food availability was not a determining factor of larval growth rates and probably eventual recruitment to juvenile population. In this study, a total of 451 larvae were collected in Tosa Bay on the Pacific coast of southern Japan, and were aged by otolith daily rings. They were arranged in order of hatch dates spanning from 14 September 2000 to 31 March 2002. Sixteen groups of larvae within a 2-5 hatch date range were assumed as hatch-date cohorts. The cohorts hatched in autumn, winter and spring were analyzed for their otolith daily growth increment widths, as a proxy of somatic growth rates, for one month after hatching. When the mean otolith growth increment widths of 16 cohorts were plotted on SST in the coastal waters in the Bay, coefficients of determination were 0.77 for early larval, 0.94 for middle larval, and 0.89 for late larval stages. Seasonal growth rate variability in the 3 larval stages was largely explained by variability in ambient temperature. This may imply that the contribution of environmental factors other than temperature was minimal in determining larval growth rates in the coastal waters. As 0+ recruit population of round herring was reported to be composed of cohorts from the entire spawning season in Tosa Bay, seasonal changes in temperature and larval growth rates do not seem to be factors related to recruitment variability in the coastal waters.

29 October, 11:50 (S3-5689)

Food web structures in crustose coralline algae bed during early life stages of abalone *Haliotis discus hannai* in relation with recruitment process

Nam-Il **Won**[1], Tomohiko Kawamura[1], Hideki Takami[2] and Yoshiro Watanabe[1]

[1] Ocean Research Institute, the University of Tokyo, Nakano, Tokyo, 164-8639, Japan. E-mail: niwon@ori.u-tokyo.ac.jp
[2] Tohoku National Fisheries Research Institute, Shiogama, Miyagi, 985-0001, Japan

Post-settlement processes of marine benthic invertebrates are crucial for understanding their population dynamics. Abalone larvae selectively settle and spend their early life stages on crustose coralline algae (CCA). The abalone *Haliotis discus hannai* is the only species found in the cold waters on the North Pacific coast of Japan and the most important species in abalone fisheries in Japan. The catch of this species has shown an increasing trend since the middle l990s after the long-term decrease since the 1970s. The recent increase of abalone catch has been suggested to be due to recruitment success from the low overwinter mortality of young-of-the-year (YOY) abalone during the recent warm regime in the North Pacific. Food web structures in CCA beds revealed inter-specific relations of abalone showing various competitors and predators of abalone during the early life stages. The predator-prey and competitive interactions in different size groups of abalone were suggested to be influenced by both seawater temperature and ontogenetic habitat shift. To better understand the population dynamics of abalone, predation and competition need to be quantified further in subtidal rocky shore as potential factors controlling the natural recruitment of abalone. In summary, the population dynamics of the abalone *H. discus hannai* appeared to be controlled by inter-specific relations as well as overwinter mortality during early life stages, both of which could be influenced by seawater temperatures.

29 October, 12:10 (S3-5743)

Effect of the oceanographic condition on the abundance of mesopelagic fish: *Maurolicus japonicus* in the Japan Sea

Tadanori **Fujino**, Hideaki Kidokoro, Tsuneo Goto and Yongjun Tian

Japan Sea National Fisheries Institute, Fisheries Research Agency (FRA), Suidou-cho, Chuo-ku, Niigata, 951-8121, Japan
E-mail: fnori@affrc.go.jp

In the Japan Sea (JS), a cold to warm thermal shift occurred in the late 1980s affected abundance of many marine organisms, including the mesopelagic fish: *Maurolicus japonicus*. *M. japonicus* is one of the key species in this ocean; it has a huge biomass, and is an important prey species for many commercially important species. To understand the how the abundance of *M. japonicus* fluctuates in relation to the oceanographic condition, relationships of the temperature and distribution of *M. japonicus* were examined using egg survey data (1979-1991) and acoustic survey data (2000-2002, 2009) for each habitat area in the JS. *M. japonicus* was abundantly distributed in the southwestern JS area (approximately 85% of the total biomass in JS), less abundant in the middle JS area. The ambient temperature at the adult swimming depth were 1-16°C, and the southwestern JS area was colder compared to the middle JS area at the swimming depth of *M. japonicus*. The late 1980s cold to warm thermal shift increased both southwestern and middle area abundance in 1988-1989. However, since the abundance of *M. japonicus* was higher in the colder environment, increase of the warm area doesn't seem to be the direct cause which affects the abundance of *M. japonicus*.

S3 Posters

S3-5520

Distribution and abundance of juvenile long armed gonatid squid (*Gonatus madokai*) in the northern Sea of Okhotsk

Mikhail A. **Zuev**

Laboratory for Pelagic Resources, Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia. E-mail: maiklzusqd@mail.ru

Data on the distribution of juvenile *G. madokai* were collected in the northern Sea of Okhotsk during November 2008. Juvenile and adult gonatid squids (family Gonatidae) are very common animals in the Sea of Okhotsk, and they play an important role as prey for many fish, seabirds, toothed whales and seals. *G. madokai* was one of the most commonsquid in the Sea of Okhotsk, occurring across the entire sea from the surface to as deep as 2,000 m, but was most abundant in the deep basin. Juveniles occurred over the continental shelf, which is unusual for deep-water gonatid species. Mature squid occurred deeper than 200 m. The northern Sea of Okhotsk appears to be an important feeding area for juvenile *G. madokai*. Mantle lengths of juvenile *G. madokai* ranged from 31 to 99 mm (mean 50 mm). The species abundance peaked at 45.47 thousand individuals per square km, and the average abundance of squid in the research area was 0.2 thousand individuals per square km. The number of juvenile *G. madokai* in the northern Sea of Okhotsk was estimated as 24.23 million individuals.

S3-5540

Use particle tracking simulation in hydrodynamic model to investigate spawning migration of Japanese anchovy *Engraulis japonicus* from the East China Sea to Taiwan

Chen-Yi **Tu**[1], Yu-heng Tseng[2], Tai-sheng Chiu[3] and Chih-Hao Hsieh[1]

[1] Institute of Oceanography, National Taiwan University, No.1, Sec. 4 Roosevelt Rd., Taipei, 10617, Taiwan
E-mail: tu.chenyi@gmail.com
[2] Department of Atmospheric Science, National Taiwan University, No.1, Sec. 4 Roosevelt Rd., Taipei, 10617, Taiwan
[3] Institute of Zoology, National Taiwan University, No.1, Sec. 4 Roosevelt Rd., Taipei, 10617, Taiwan

The Japanese anchovy (*Engraulis japonicus*) larval fishery is one of the important fisheries in Taiwan and the fishery catch has significantly decreased since the 1990s. The abundance of spawning adults will definitely influence the recruitment process and thus the fishery catches. However, Japanese anchovy is known as a multi-batch species with many different spawning grounds, which makes the field study of the onset of spawning migration and its possible migration routes extremely difficult. Here, we approach this problem from the perspective of physical-biological coupling. To clarify the possible spawning migration route of Japanese anchovy from the East China Sea to Taiwan, we use particle tracking to simulate the migration of a spawning group. The Dual-grid Pacific Ocean Model (DUPOM) is used to simulate the physical environment, which is based on the fourth-order accurate, collocated Arakawa-A grid DieCAST (Dietrich/Center for Air Sea Technology) model. Our simulation results suggest that the spawning migration of Japanese anchovy depends highly on the coastal ocean currents, and is therefore vulnerable to environmental changes, such as reduced inflow of the Changjiang River. The results also demonstrate that a physical model coupled with a simplified biological model can help us better understand the biological processes affecting the population level and their correlation with marine environment.

S3-5738

Nutrients transport, forage base and survival of juvenile pink salmon in Aniva Bay (south of Sakhalin Island)

Alexander A. **Antonov**, Irina Yu. Bragina and Elena M. Latkovskaya

Sakhalin Research Institute of Fisheries and Oceanography (SakhNIRO), 196 Komsomolskaya St., Yuzhno-Sakhalinsk, 693023, Russia
E-mail: latkov@sakhniro.ru

We present results of long-term research on salmon dynamics, nutrients and plankton biomass in Aniva Bay, which is an important area in Sakhalin for pink salmon reproduction and fisheries. During 1998-2008, the average number of spawners was about 18.5 million individuals. Spawning adult fish provide significant amounts of organic substances to the coastal waters. This input affects nutrient and plankton dynamics. There are two peaks of nutrient concentration in Aniva Bay coastal waters. The first peak (April-May) is related to the spring flood. The second peak varies from year to year between July-September and depends, in particular, on the timing and number of fry migrants. Juvenile pink salmon stay in Aniva Bay to feed for 2-2.5 months. The timing of their seaward migration depends on water temperature. The beginning of migration to the open waters is occurs in early July and is completed by late July. The average number of wild pink salmon juveniles in Aniva Bay is about 163 million and there is an additional 59 million hatchery-reared fish. There is a positive correlation between spawner biomass and returns in their next generation. This dependence is complicated by different environmental conditions. In particular, a status of food supply for juvenile pink salmon is determined by the spring nutrient concentration, upwelling activity (southwestern Aniva Bay), and water temperature. The recent 10-year observations show that feeding conditions for juvenile pink salmon have changed greatly, with a decline in total zooplankton biomass and a reduction in the mean size of plankters.

S3-5768

Effects of environmental variability on the spawning areas, catch and recruitment of the Japanese common squid, *Todarodes pacificus*

Ana L. Rosa[1], J. Yamamoto[2] and Yasunori **Sakurai**[1]

[1] Graduate School of Fisheries Sciences, Hokkaido University, 3-1-1 Minato-cho, Hakodate, Hokkaido, 041-8611, Japan
E-mail: sakurai@fish.hokudai.ac.jp
[2] Field Science Center for Northern Biosphere, Hokkaido University, 3-1-1 Minato-cho, Hakodate, Hokkaido, 041-8611, Japan

The Japanese common squid is one of the most important commercially exploited squid species in the world. It occurs in the North-West Pacific between 25-50ºN as it migrates along the Japanese islands and the eastern coast of the Korean peninsula. We analyzed long-term changes of environmental variables, such as SST and wind, on the distribution of spawning areas (SPA) and catch of *T. pacificus* for 27 spawning seasons (September to April, 1978 to 2006) in the Japan Sea and East China Sea. Based on previous investigations (Sakurai *et al.*, 2000; Sakurai, 2006) the SPA was defined as the area located within the rectangle of 21º-40ºN, 121º-142ºE. This geographical area is west of the mean Kuroshio axis and between the 100m and 500m isobaths. The SST limitation was set between 19.5ºC and 23ºC. The results showed that the occurrence of a gap in the continuity of the SPA distribution in the central East China Sea is significant related to the catch of the Japanese fleet occurring between October and January. Also, the environmental conditions of SPA around the Kyushu Island are important in explaining the June to September Korean catch. For the same period, the Japanese catch was found to relate not only to the SPA around Kyushu but also to the most southern part of the study area. This difference can be explained by the changes in the feeding and spawning migration. The gaps in the continuity of the SPA could be observed more often during the cold regime period before the late-1980s.

S3-5806

Effect of Siberian High on the catch fluctuation of pacific cod, *Gadus macrocephalus*, in the Yellow Sea

Heeyong **Kim**[1], D.H. Kim[2], Hakjin Hwang[3] and Y.I. Seo[1]

[1] South Sea Fisheries Research Institute, NFRDI, 347 Anpo-ri, Hwayang-myeon, Yeosu, 556-820, R Korea
E-mail: heeyongkim@nfrdi.go.kr
[2] Korea Inter-University Institute of Ocean Science, Pukyong National University, 99-1 Daeyeon-dong, Nam-gu, Busan 608-737 R Korea
[3] West Sea Fisheries Research Institute, NFRDI, 707 Eulwang-dong, Jung-gu, Incheon, 400-420, R Korea

The catch of Pacific cod in the Yellow Sea accounts for more than 50% of the total Pacific cod catches in Korean waters since 2003 when abundance started to increase. The fluctuation of Pacific cod catch in the Yellow Sea is influenced by changes in hydrographic conditions due to the Siberian High (SH). The SH dominates the cooling of sea surface waters in the Yellow Sea in the winter season. The cooled surface waters sink and then form the Yellow Sea Bottom Cold Water (YSBCW) that exists at the bottom of the Yellow Sea, even in summer. Therefore, the formation and distribution of the YSBCW is affected by the strength of the Siberian High. Hatching temperature of Pacific cod is less than 12ºC. The cooling period of sea surface waters corresponds to the main spawning season of Pacific cod in Korean waters. The effect of the SH on water temperature is an important factor for dominating an early life of the Pacific cod in the Korean waters. Furthermore, the main of the YSBCW temperature when of Pacific cod catches are made in the Yellow Sea ranged 6 to 10ºC. The YSBCW was limited to the middle area of the Yellow Sea in early 1990s when the catches of the Yellow Sea pacific cod appeared the lowest level but catches reached the highest levels when the YSBCW was distributed over the entire Yellow Sea in 2007.

S3-5814

Feeding ecology of larval and juvenile sardine (*Sardinops melanostictus*) and anchovy (*Engraulis japonicus*) in the western North Pacific

Yuji **Okazaki**[1], Hiroshi Kubota[2], Kaori Takagi[2], Hiroshi Itoh[3] and Nobuhiro Saito[3]

[1] Tohoku National Fisheries Research Institute, FRA, 3-27-5 Shinhama-cho, Shiogama, Miyagi, 985-0001, Japan
E-mail: okazakiy@affrc.go.jp
[2] National Research Institute of Fisheries Science, FRA, 2-12-4 Fukuura, Kanazawa-ku, Yokohama, 236-8648, Japan
[3] Suidosha Co. Ltd., 8-11-11 Ikuta, Tama-ku, Kawasaki, 214-0038, Japan

It is suggested that change in growth rate during the period from the late larvae to early juvenile stages in sardine (*Sardinops melanostictus*) and anchovy (*Engraulis japonicus*) is a key factor for successful or failure recruitment to adult stock. In general, growth rate is affected by ambient temperature and prey availability. Although recent study showed that the temperature for optimal growth rates in sardine and anchovy larvae was different, the effect of prey availability on their growth rate has been not well established. Thus, to better understand for effect of prey availability on the larval and juvenile growth rate, we synthesized the larval and juvenile feeding ecology of sardine and anchovy in the inshore and offshore area of western North Pacific using data from published literature and unpublished data. In the Tosa Bay (south western coast of Japan), differences in gut contents of sardine and anchovy larvae (mostly 20-30mm SL) were small. The larvae fed on adult and copepodite stages of copepods, especially adult *Paracalanus parvus* s.l., adult *Clausocalaus* spp. and adult and copepodite *Calanus sinicus*. In the Kuroshio and Oyashio transition region, larval and juvenile anchovy fed mainly on copepods smaller than 0.4 mm in body width, such as *P. parvus* s.l. and *Corycaeus* spp. Juvenile sardine also fed on small copepods. These results suggest that during the late larvae to early juvenile stages, species-specific prey selectivity of sardine and anchovy in the western North Pacific are likely to be similar for individuals of the same size classes.

S4 MEQ Topic Session
Mitigation of harmful algal blooms

Co-Convenors: Hak-Gyoon Kim (Korea) and Mark L. Wells (U.S.A.)

Mitigation includes any method that can reduce the impact or severity of harmful algal blooms (HABs). These methods involve both physical means, such as dispersal of clay to cause flocculation of cells from surface waters, and preventative means, such as better monitoring of coastal waters, allowing selective closures of shellfish beds (in contrast to coast-wide closures). The capability for mitigation and the choice of mitigative tools depend upon the bloom-forming species, the severity of the event, and the frequency and intensity of monitoring in a region. Presentations will represent the comprehensive nature of HAB mitigation within the Pacific Rim nations.

Tuesday, October 27 (9:00-13:05)

9:00 ***Introduction by Convenors***

9:05 **J.E. Jack Rensel and Nicola Haigh (Invited)**
Fish aquaculture and Harmful Algal Bloom mitigation in marine waters of North America (S4-5644)

9:35 **Hak-Gyoon Kim, Heon-Meen Bae, Chang-Kyu Lee, Yang-Soon Kang, Young-Tae Park, Wol-Ae Lim, Sook-Yang Kim, Jeong-Min Shim, Chang-Su Jung and Kyoung-Ho An (Invited)**
Recent approaches on the feasible mitigation and clay dispersal (S4-5677)

10:05 **Ichiro Imai**
Promising prevention strategies for harmful algal blooms by utilization of seaweed- and seagrass-beds as huge sources of algicidal bacteria (S4-5782)

10:25 ***Coffee / tea break***

10:45 **Donald M. Anderson**
Suppression and control of harmful algal blooms: The slow pace of progress in an important area of HAB science (S4-5895)

11:05 **Eunhye Kim, Daeuk Kim, Hyungbeen Lee, Jungyul Na, Jee Woong Choi and Donhyug Kang**
A feasibility study on the acoustic monitoring of *Cochlodinium Polykrikoides* blooms and mitigation by ship-mounted cavitation generating system (S4-5971)

11:25 **Young Baek Son, Joji Ishizaka and Young-Sang Suh (S4-5664)**
The spectral discrimination of surface harmful algal bloom in complicated coastal water conditions

11:45 **Bum Soo Park, Rose Ann Cattolico, Seung Ho Baek, Jang Seu Ki, Yang Ho Yoon and Myung-Soo Han**
Improvement of quantitative real-time PCR assay based on SYBR green for Raphydophytes: A field applicability test (S4-5952)

12:05 **Goh Onitsuka, Naoki Hirose, Kazutaka Miyahara, Shuyo Watanabe, Hitoshi Semura, Reiko Hori and Tetsuya Nishikawa**
Monitoring and modeling of *Cochlodinium polykrikoides* bloom in the southwestern Sea of Japan (S4-5659)

12:25 **Takafumi Yoshida and Hidemasa Yamamoto**
HAB Integrated Website demonstration (S4-5583)

12:45 **Dongyan Liu, John K. Keesing, Zhijun Dong, Yu Zhen, Baoping Di, Yajun Shi and Ping Shi**
Coastal *Porphyra* aquaculture as a nursery for large scale green tide events in the Yellow Sea (S4-6016)

13:05 ***Session ends***

S4 Posters

S4-5573 **Marina S. Selina, Tatiana V. Morozova and Tatiana Yu. Orlova**
Species composition and seasonal changes in epiphytic dinoflagellates in Russian coastal waters of the Sea of Japan

S4-5669 **Chunjiang Guan, Fengao Lin and Xiutang Yuan**
Causes of 2008 green tide bloom in Yellow Sea and estimation for the absorption of C, N and H

S4 Oral Presentations

27 October, 9:05 (S4-5644), Invited

Fish aquaculture and Harmful Algal Bloom mitigation in marine waters of North America

J.E. Jack **Rensel**[1] and Nicola Haigh[2]

[1] Rensel Associates Aquatic Sciences, 4209 234th Street NE, Arlington, WA, 98223, USA. E-mail: jackrensel@att.net
[2] Harmful Algae Monitoring Program, Vancouver Island University, 900 Fifth St., Nanaimo, BC, V9R 5S5, Canada

Harmful algae are responsible for episodic losses of cultured and wild fish in marine waters throughout portions of North America. Commercial aquaculture, government and other rearing programs on the north-west coast suffer losses from a variety of organisms, principally the microflagellate *Heterosigma akashiwo* and large, spiny diatoms of the genus *Chaetoceros*, subgenus *Phaeoceros*. In these areas harmful algae-caused kills may be infrequent, but can be economically and culturally devastating. Subtropical waters of North American coasts are less well studied or utilized for marine aquaculture, but dinoflagellates (*e.g. Karenia mikimotoi*) have been responsible for major fish kills and no doubt additional blooms of other species are involved in at least sublethal stress to juvenile and adult fish populations.

A variety of methods and fish cultural practices are used to mitigate effects of blooms ranging from the upwelling of deep water into cages, deeper culture nets, surrounding skirts, selection of fish stocks, and withholding of feed to reduce metabolic oxygen demand. Moving of cages to avoid bloom exposure is difficult and risky for large-scale facilities found in North America and is often prohibited by government or insurance companies. Clay flocculation has been assessed for its efficacy and environmental effects, which are species specific and site specific, respectively. Site selection for desirable physical conditions (*e.g.* vertical mixing) remains a most effective technique to avoid harmful algae, but siting of fish farms also must consider other variables. The review concludes with a discussion of trends and future options.

27 October, 9:35 (S4-5677), Invited

Recent approaches on the feasible mitigation and clay dispersal

Hak-Gyoon **Kim**[1], Heon-Meen Bae[2], Chang-Kyu Lee[2], Yang-Soon Kang[2], Young-Tae Park[2], Wol-Ae Lim[2], Sook-Yang Kim[2], Jeong-Min Shim[2], Chang-Su Jung[2] and Kyoung-Ho An[2]

[1] Department of Oceanography, Pukyong National University, Busan, R Korea. E-mail: Hgkim7592@yahoo.co.kr
[2] National Fisheries Research and Development Institute, Kijang-gun, Busan, R Korea

The impacts from harmful algal bloom (HAB), ranging from the death of humans or other marine animals to discoloration of the water, are becoming a global socio-economic concern. To minimize their impacts, a variety of mitigation strategies have been attempted and/or proposed to reduce the size of a HAB population or its impacts. According to the timeliness of management, they can be generally classified into two categories; precautionary impact preventions, and direct bloom controls. The former includes nutrient reductions, HAB monitoring, and prediction, and the latter is to kill, remove, and destroy HAB cells in the water column through chemical, physical, and biological means.

Pilot or practical bloom controls have been attempted to protect aquaculture animals, even if there have been concerns that bloom control may make matters worse. The current practical mitigations are flocculent clay dispersal, pumping bottom waters to the surface fish cages, centrifugal separation equipment to remove HAB cells in the pumped seawater, an automated HAB warning and oxygen supply system, and others. Biological control through the introduction of a predator, algicidal virus or bacteria are under feasibility studies for application. Based on decadal experience in Korea, dispersing flocculent clay, which scavenge particles from bloom water and carry them to bottom sediment, has been one of promising mitigation strategies to control fish-killing HAB in Korea since 1996.

27 October, 10:05 (S4-5782)

Promising prevention strategies for harmful algal blooms by utilization of seaweed- and seagrass-beds as huge sources of algicidal bacteria

Ichiro **Imai**

Division of Marine Bioresource and Environmental Science, Graduate School of Fisheries Sciences, Hokkaido University, 3-1-1 Minatocho, Hakodate, Hokkaido, 041-8611, Japan E-mail: imai1ro@fish.hokudai.ac.jp

There is an urgent need for bloom mitigation strategies in aquaculture areas due to huge fishery damages by HABs. Microorganisms such as bacteria appear to be promising control agents against red tides. Algicidal bacteria have actually been isolated from the coastal waters. Several studies on temporal fluctuations of algicidal bacteria and HAB species demonstrated that algicidal bacteria are specifically associated with the occurrence and crash of red tides, and also contributed to the rapid termination of red tides in the coastal waters such as the Seo Inland Sea.

New research indicates large numbers of algicidal bacteria attached onto the surface of seaweeds (maximum, 1 million cells per gram wet weight) such as *Ulva* sp. (Chlorophyta) and *Gelidium* sp. (Rhodophyta) without occurrences of any microalgal blooms. Further, we discovered higher numbers of algicidal bacteria (ten times or more), including killers for *Cochlodinium polykrikoides*, on the surface of seagrass (*Zostera marina*) and in seawater within *Zostera* beds than in seaweed beds. The presence of the large number of algicidal bacteria indicates the potential for preventing red tide occurrences. We propose here new prevention strategies for red tides by the cultivation of seaweeds in aquaculture areas (*i.e.*, poly cultures of fish and seaweeds). When we develop and restore the natural seaweed- and seagrass-beds as part of the Sato-Umi concept, these may presumably function to prevent the occurrences of HABs. Further, restored seaweed- and seagrass- beds also serve as nursery grounds for important fisheries resources.

27 October, 10:45 (S4-5895)

Suppression and control of harmful algal blooms: The slow pace of progress in an important area of HAB science

Donald M. **Anderson**

Biology Department, Woods Hole Oceanographic Institution, MS 32, 266 Woods Hole Rd., Woods Hole, 02543-1049, USA
E-mail: danderson@whoi.edu

Harmful algal blooms (HABs) are a diverse group of phenomena caused by the growth and proliferation of algae, some of which produce potent toxins. HABs take many forms, with impacts that include poisonous shellfish, dead fish, aerosolized toxins that drive tourists and residents from beach areas, and ecosystem changes such as the destruction of submerged aquatic vegetation or mortality of marine mammals and other organisms at all levels of the food web. The diversity in HAB species and their impacts presents a significant challenge to those responsible for the management of coastal resources. HABs are complex phenomena that require multidisciplinary study ranging from molecular and cell biology to large-scale field surveys, numerical modelling, and remote sensing. Our understanding of these phenomena is increasing dramatically, and with this understanding come technologies and management tools that can reduce HAB incidence and impact.

This talk will highlight some new technologies and approaches to HAB bloom control and impact mitigation. In particular, strategies for bloom suppression and control will be reviewed and discussed, emphasizing the slow pace of progress in this area of research, and the reasons for this. The HAB scientific community has been active and diverse in its exploration of the fundamental science of potential bloom control strategies, but very slow in moving these concepts to field trials on even a modest scale, with only one or two exceptions (*e.g.*, clay dispersal in Korea). Reasons for this slow pace of progress will be discussed, and strategies for moving forward presented.

27 October, 11:05 (S4-5971)

A feasibility study on the acoustic monitoring of *Cochlodinium Polykrikoides* blooms and mitigation by ship-mounted cavitation generating system

Eunhye **Kim**[1], Daeuk Kim[1], Hyungbeen Lee, Jungyul Na[1], Jee Woong Choi[1] and Donhyug Kang[2]

[1] Department of Environmental Marine Sciences, Hanyang University, Ansan, 1271, R Korea. E-mail: ehkim@hanyang.ac.kr
[2] Marine Living Resources Research Department, Korea Ocean Research and Development Institute, Ansan, 1270, R Korea

Blooms of the toxic dinoflagellate *Cochlodinium polykrikoides* are increasing annually and causing serious damage to coastal fisheries activities in Korea, especially aquaculture. Real-time monitoring and mitigation methods of *Cochlodinium* blooms need to be established to decrease their harmful effects on the surrounding ecosystems and local communities. In this paper, the acoustic backscatter measurements and the mitigation experiments from aggregation of the *C. polykrikoides* are presented as an alternative method to monitor and mitigate the Harmful Algal Blooms in real time at the sites located off the coast of Geumo island, in the southern sea of Korea. Background scattering strengths in areas of no *Cochlodinium* blooms were less than about -41 dB, however, in the bloom area, average volume backscattering strength was significantly higher than that of no-bloom by 10 dB. The cavitation bubbles generated by rapidly rotating blades were used to mitigate the harmful algae by destroying the chain-structure of the algae. By this method, density of harmful algae was changed from 2.7×10^6 cells/liter to 0.33×10^6 cells/liter within 8 min. Our results indicated that this acoustic technique and cavitation bubble generating method can be applied to real-time detection and mitigation of harmful algal blooms as environmental-friendly method compared to the current clay disposal method.

27 October, 11:25 (S4-5664)

The spectral discrimination of surface harmful algal bloom in complicated coastal water conditions

Young Baek **Son**[1], Joji Ishizaka[1] and Young-Sang Suh[2]

[1] Lab. of Satellite Biological Oceanography, Hydrospheric Atmospheric Research Center (HyARC), Nagoya University, Furo-cho, Chigusa-ku, Nagoya, Aichi, 464-8601, Japan. E-mail: sonyb@hyarc.nagoya-u.ac.jp
[2] National Fisheries Research and Development Institute, Busan, 619-902, R Korea

In Korean coastal water, red tide events by diatom or dinoflagellate blooms within enclosed and semi-enclosed bay areas were often reported after early 1990's. After 1995, the red tide condition changed to dominance of *Cochlodinium polykrikoides* blooms. Duration and coverage of the red tide has been increasing through onshore and offshore of Korea, included the east and west coast, and it was suggested that it is related to possible natural dispersal of organism, human activities and various physical variability.

To assess the increasing spatial and temporal scales of red tide in complicated coastal water conditions, we tested several simple approaches to determine the different water type and red tide using MODIS satellite-derived multi-spectral radiance. The spectral band ratio was used to separate red tide from non-red tide water using step by step spectral classification.

Analysis of MODIS ocean color imagery revealed that pixel-based classification projected into distinct clusters in the space domain, suggesting that these waters can be simply distinguished using a few spectral bands of ocean color data. This approach is promising for mapping phytoplankton blooms from different water conditions regionally based on remote sensing data.

27 October, 11:45 (S4-5952)

Improvement of quantitative real-time PCR assay based on SYBR green for Raphydophytes: A field applicability test

Bum Soo **Park**[1], Rose Ann Cattolico[2], Seung Ho Baek[3], Jang Seu Ki[4], Yang Ho Yoon[5] and Myung-Soo Han[1]

1 Department of Life Science, College of Natural Science, Hanyang University, Seoul, 133-791, R Korea
E-mail: parkbs@hanyang.ac.kr
2 Department of Biology, University of Washington, Box 355325, Seattle, WA, 98195-5325, USA
3 Department of South Sea Research, KORDI, Geoje, 656-830, R Korea
4 Department of Life Science, College of Natural Science, Sang-myung University, Seoul, 110-743, R Korea
5 Department of Fisheries and Ocean Sciences, Chun-Nam University, Yeo-su, 550-749 , R Korea

Previous study has indicated that detection and quantification of Raphydophytes by microscopy may be unreliable because of cell lysis after fixation. The Quantitative Real-Time PCR assay has been suggested as a means to overcome this problem. However, it is difficult to use for high numbers of field samples because of the high cost. Therefore, we developed qRT-PCR assay based on SYBR green for Raphydophytes in a simple and economical format. All specific primer sets were designed on the ITS2 rDNA region. The amplified length is 148 bp (*H. akashiwo*), 208 bp (integrated *Chattonella*), and 250 bp (*C. subsalsa*). The optimal reaction condition was determined by gradient PCR with annealing temperature of 62.5ºC (*H. akashiwo*) and 62ºC (integrated *Chattonella* and *C. subsalsa*). Primer specificities were confirmed by BLAST search and competitive PCR against other genomic DNA having similar sequence with target species. The specificity of all specific primers set was confirmed in that they didn't amplify all extracted DNA of target species ($r^2 > 0.99$) using qRT-PCR. We analyzed the population dynamics of Raphydophytes at Shi-Hwa Lake (total 70 samples) during 10 months, and the distribution of Raphydophytes in Korean coastal water samples (total 35 sites) using direct counting and qRT-PCR assay. Only 10 samples containing *H. akashiwo* were detected at Shi-Hwa Lake by direct counting, but 43 samples containing *H.akashiwo* and 7 samples containing integrated *Chattonella* were detected using qRT-PCR assay. In addition, 34 sites having *H. akshiwo* and 14 sites having integrated *Chattonella* were detected in Korea coastal waters using qRT-PCR assay. QRT-PCR assay based on SYBR green is available to use for rapid, accurate and sensitive quantification of Raphydophytes in the field.

27 October, 12:05 (S4-5659)

Monitoring and modeling of *Cochlodinium polykrikoides* bloom in the southwestern Sea of Japan

Goh **Onitsuka**[1], Naoki Hirose[2], Kazutaka Miyahara[3], Shuyo Watanabe[4], Hitoshi Semura[5], Reiko Hori[5] and Tetsuya Nishikawa[6]

1 National Fisheries University, 2-7-1 Nagata-Honmachi, Shimonoseki, Yamaguchi, 759-6595, Japan. E-mail: onizuka@fish-u.ac.jp
2 Research Institute for Applied Mechanics, Kyushu University, 6-1 Kasugakoen, Kasuga, Fukuoka, 816-8580, Japan
3 Fisheries Technology Institute, Hyogo Prefectural Technology Center for Agriculture, Forestry and Fisheries, 22-2 Minami-Futami, Futami, Akashi, Hyogo, 674-0093, Japan
4 Tottori Prefectural Fisheries Experimental Station 1166 Ishiwaki, Yurihama, Tohaku, Tottori, 689-0602, Japan
5 Shimane Prefectural Fisheries Technology Center, 530-10 Etomo, Kashima, Matsue, Shimane, 690-0322, Japan
6 Tajima Fisheries Technology Institute, Hyogo Prefectural Technology Center for Agriculture, Forestry and Fisheries, 1126-5 Sakai, Kasumi, Hyogo, 669-6541, Japan

Blooms of a harmful dinoflagellate, *Cochlodinium polykrikoides* Margalef, occurred in the coastal areas of the southwestern part of the Sea of Japan (San-in coast) since 2002. The blooms broke out suddenly and almost simultaneously on a larger scale in the San-in coast causing a lot of damage to coastal fisheries, suggesting a current-dependent occurrence transported by the Tsushima Warm Current. To investigate the occurrence mechanisms of the blooms, numerical experiments were conducted during 2002-2008 using a Lagrangian particle-tracking model. The results of Lagrangian simulations revealed that the source region of the blooms was located in the southeast Korean coast and they were transported by the Tsushima Warm Current over about two weeks to one month. The blooms in the San-in coast were suggested to occur only when a series of conditions were met, including 1) preceding occurrences in the upstream Tsushima Warm Current area, 2) the southwesterly wind around the Tsushima Straits, and 3) the nearshore position of the Tsushima Warm Current off the San-in coast. Effective monitoring in combination with research vessel observations, satellite images and numerical simulations is expected to prevent damages to coastal fisheries.

27 October, 12:25 (S4-5583)

HAB Integrated Website demonstration

Takafumi **Yoshida** and Hidemasa Yamamoto

CEARAC (Special Monitoring and Coastal Environmental Assessment Regional Activity Centre), NOWPAP (Northwest Pacific Action Plan), 5-5 Ushijimashin-machi, Toyama City, Toyama, 930-0856, Japan. E-mail: yoshida@npec.or.jp

NOWPAP CEARAC has implemented HAB-related activities to promote coastal environmental assessment in the NOWPAP region. In the past, CEARAC conducted various activities such as publishing the Integrated Report on HAB in the NOWPAP region and the booklet of countermeasures against HABs in order to share information among the NOWPAP member states and to promote proactive action against HABs in the member states.

In 2009, CEARAC will develop HAB Integrated Website with three contents: Publication, Database and Topic. In 'Publication', all the outputs and publications made by CEARAC will be downloadable. We expect our materials will contribute to development of countermeasures for all stakeholders, while in 'Database', various data and information on reference materials on HABs and/or HAB occurrences in the NOWPAP region will be provided. These information and data will be useful to facilitate HAB study not only in the NOWPAP region but also in other regions. 'Topic' contents will provide information on HABs, eutrophication and coastal environmental assessment in our region. This content will show the latest and interesting information for stakeholders. Other related organizations and events will be introduced in 'Events' and 'Link'.

CEARAC will demonstrate its prototype at this meeting. Official operation of the website will be started from 2010.

27 October, 12:45 (S4-6016)

Coastal *Porphyra* aquaculture as a nursery for large scale green tide events in the Yellow Sea

Dongyan **Liu**[1], John K. Keesing[2], Zhijun Dong[1], Yu Zhen[3], Baoping Di[1], Yajun Shi[1] and Ping Shi[1]

[1] Yantai Institute of Coastal Zone Research for Sustainable Development, Chinese Academy of Sciences, Yantai, Shandong, 264003, PR China. E-mail: dyliu@yic.ac.cn
[2] CSIRO Marine and Atmospheric Research, Private Bag 5, Wembley, 6913, Australia
[3] Key Laboratory of Marine Environment and Ecology, Ministry of Education, Ocean University of China, Qingdao, 266100, PR China

In late June 2008, just weeks before the opening of the Beijing Olympics, a massive green-tide of the macroalga *Enteromorpha prolifera* occurred covering about 600 km^2 along the coast of Qingdao, host city for Olympic sailing regatta. Eutrophication from pollution was quickly attributed with the blame by the international media and some scientists. However, we explored an alternative hypothesis that the source of the *Enteromorpha prolifera* was the rapid expansion of *Porphyra yezoensis* aquaculture along the Jiangsu Province coastline to the south of Qingdao. A field survey, over the December 2008-April 2009 *Porphyra yezoensis* aquaculture growing season, measured biomass accumulation of *Enteromorpha prolifera* on the aquaculture apparatus of up to 505 kg/ha which is sufficient to seed the macroalgal bloom. Moreover, morphological and phylogenetic analysis of *E. prolifera* collected from the apparatus used for *P. yezoensis* aquaculture off the Jiangsu province coast matched almost identically (99.6%) DNA sequences obtained from *E. prolifera* collected from the 2008 Qingdao green-tide. The harvest method and clean-up procedures which result in waste *E. prolifera* being deposited into the sea seem likely to be the source of the green tide algae. We propose that the industry change its current practices in favour of depositing the waste *E. prolifera* on land at the end of each harvest year to prevent the green-tide phenomena becoming an annual event.

S4 Posters

S4-5573

Species composition and seasonal changes in epiphytic dinoflagellates in Russian coastal waters of the Sea of Japan

Marina S. **Selina**, Tatiana V. Morozova and Tatiana Yu. Orlova

A.V. Zhirmunsky Institute of Marine Biology (IBM), FEB RAS, 17 Palchevskogo St., Vladivostok, 690002, Russia
E-mail: marsel@imb.dvo.ru

Epiphytic dinoflagellates have been investigated in coastal waters of Peter the Great Bay (Sea of Japan) since 2006. The seasonal dynamic of abundance was studied in 2008−2009. The biodiversity of dinoflagellates included 19 species of the genera *Adenoides*, *Amphidiniopsis*, *Amphidinium*, *Cabra*, *Ostreopsis*, *Prorocentrum, Pseudothecadinium*, *Sinophysis,* and *Thecadinium*. The epiphytic dinoflagellates were observed throughout the year. Four potentially toxic species were found: *Ampidinium carterae*, *Ostreopsis siamensis*, *Ostreopsis ovata,* and *Prorocentrum lima*. The biodiversity was 1 to 11 species, density 59 to 70,000 cells g^{-1}, dry wt of macrophytes. Biodiversity and density of epiphytic dinoflagellates were the lowest in December and the highest in August and September, respectively. *O. siamensis* and *O. ovata* were found on macroalgae from August to October at 9-24ºC and dominated at that time. The rapid increase in dinoflagellate abundance at the end of September was due to *Ostreopsis* spp. (up to 69,573 cells g^{-1} or 99% of total dinoflagellate abundance). High density of these species was also recorded in September of 2006 and 2007. Abundance of other potentially toxic species was low. *Pseudothecadinium campbellii* occurred during the whole year. Benthic dinoflagellates *Adenoides edulens*, *Amphidiniopsis uroensis*, *Sinophysis stenosoma* and *Thecadinium kofoidii* were recorded occasionally in low numbers. Most of epiphytic dinoflagellates did not show any significant preference for any algal group, although the highest abundance of *Ostreopsis* spp. occurred on the rhodophyte *Neorhodomela larix*. Due to the constant presence and high abundance of new potentially toxic dinoflagellates in summer−autumn period, monitoring of epiphytic assemblage is a necessity.

S4-5669

Causes of 2008 green tide bloom in Yellow Sea and estimation for the absorption of C, N and H

Chunjiang **Guan**, Fengao **Lin** and Xiutang **Yuan**

Department of marine ecology, National Marine Environmental Monitoring Center, 42 Linghe St., Shahekou District, Dalian, 116023 , PR China. E-mail: cjguan@nmemc.gov.cn

A bi-monthly investigation was conducted in the Yellow Sea from May to October in 2005-2008. It was found that the N/P ratios in Haizhou Bay, one of regions having early green tide blooms, were 10.08, 27.86, 40.94 and 43.58 in 2005, 2006, 2007 and 2008, respectively, with the N/P ratio in 2008 being 4 times that in 2005. Although blooms of green tide have been attributed to many causes, the hypothesis that the increase of N/P ratio in coastal water is responsible is particularly worth further testing and research. Measures such as reforestation to reduce water and soil loss, protection of wetland to avoid wetland shrinkage in area and degradation in ecosystem function, and coastal algae culturing to introduce more large-sized brown algae to suppress green algae are expected to lower the N/P ratio in Haizhou Bay, Yellow sea. One million tons of Enteromorpha prolifra (wet weight) were artificially or naturally moved inland from the green algae bloom in Yellow sea from May to July, 2008. Measurements showed that water content in Enteromorpha prolifra was 95.09% whereas the contents for C, N and H are 23.88%, 1.23% and 3.79%. It is then estimated that the absorption for C, N and H are 11,725,604 and 1861 tons, respectively.

S5 MEQ Topic Session
The role of submerged aquatic vegetation in the context of climate change

Co-Convenors: Ik-Kyo Chung (Korea) and Hiroshi Kawai (Japan)

This session will focus on the practical measures utilizing submerged aquatic vegetation (SAV) such as seaweeds and sea grasses in coping with climate change in coastal regions. Discussion is expected on immediate and practical SAV measures that mitigate and adapt against global warming and sea level rise. Participants will present papers highlighting their ideas on such practical measures against climate change and global warming as well as on other pertinent subjects.

Wednesday, October 28 (9:00-12:30)

9:00 ***Introduction by Convenors***

9:10 **Xuelei Zhang, X.J. Zhang and J.W. Wang**
Restoration of seagrass/algal beds as a measure to abate climate change (S5-5700)

9:30 **Kwang-Seok Park, Hyung-Suek Kim, Heon-Woo Park, Gun-Mok Sohn and Hyeon Park**
Climate change adaptation using seaweed bed of BioSlag in marine environment (S5-6000)

9:50 **I. Nyoman Radiarta, Sei-Ichi Saitoh and Toru Hirawake**
The impact of climate change on the development of marine aquaculture: A case study on Japanese scallop aquaculture in Funka Bay, Hokkaido, Japan (S5-5619)

10:10 **Seokjin Yoon and Michio J. Kishi**
Estimation of the role of eelgrass and associated epiphytic algae on the carbon cycle in Akkeshi Lake, Japan (S5-5637)

10:30 ***Coffee / tea break***

10:50 **Taehee Na, Ik Kyo Chung and Tongsup Lee**
Estimation of carbon sequestration by seaweed beds (S5-5589)

11:10 **Hack-Churl You, Munho Sohn and Grevo Gerung**
Red-algae pulp and paper, bio-ethanol (S5-5962)

11:30 **Eduard A. Titlyanov and Tamara Titlyanova**
Coral-algal competition on damaged reefs (S5-5688)

11:50 **Sang Yong Lee and Yong-Gun Gong**
Seasonal variation in $\delta^{13}C$ and $\delta^{15}N$ values for the temperate seagrass *Zostera marina* and its relation to leaf production (S5-6003)

12:10 **Tatyana N. Krupnova, Vladimir A. Pavlyuchkov and Vera V. Agarkova**
Resource management of sea urchin *Strongylocentrotus intermedius* on the basis of its biotic relations with brown alga *Laminaria japonica* (S5-5848)

12:30 ***Session ends***

S5 Posters

S5-5732 **Miryang Kim, Jeong Chan Kang, Jong Chul Lee and Myung Sook Kim**
Subtidal macroalgal species diversity during wintertime in Jeju Island, Korea

S5-5742 **Sang Rul Park and Kun-Seop Lee**
Growth and photosynthetic characteristics of three *Zostera* spp. (*Z. japonica, Z. marina and Z. caespitosa*) along vertical gradient: Implications for seagrass zonation

S5-5794 **Seong Cheol Kim, Mi Sook Hwang, Jae Min Baek, Seock Jung Han, Nack Joong Choi, Mi Kyung Choe and Moon Ho Yang**
Management of artificial coastal CO_2 removal belt in Korea

S5-5856 **Yoon-Seok Choi, Choonkoo Jungand Min-Woo Park**
The effect of geochemical characteristics and environmental factors on the growth of cultured ark shell *Scapharca broughtonii* at several shellfish-farming bays on the south coast of Korea

S5-6001 **Ik Kyo Chung, Kwang-Seok Park, Hyung-Suek Kim, Jin-Hwan Hwang, Jae-Young Lee and Jung Hyun Oak**
Research and development roadmap for climate change adaptation and CO_2 mitigation in the Korean maritime and fisheries sector

S5-6002 **Jin Ae Lee, Jung Hyun Oak and Siew-Moi Phang**
The Asian Network for Using Algae as a CO_2 Sink of the Asian Pacific Phycological Association

S5 Oral Presentations

28 October, 9:10 (S5-5700)

Restoration of seagrass/algal beds as a measure to abate climate change

Xuelei **Zhang**[1], X.J. Zhang[2] and J.W. Wang[2]

[1] Center for Marine Ecology Research, First Institute of Oceanography, State Oceanic Administration, 6 Xianxialing Rd., Qingdao, 266061, PR China. E-mail: zhangxl@fio.org.cn
[2] Rongcheng Fisheries Association, 140 Guanhai Rd., Rongcheng City, Weihai, 264300, PR China

Climate change and global warming present human beings with challenges, including damages to fisheries and necessitated lifestyle changes. We suggest restoration of seagrass/algal beds as a measure to abate these problems. The merits of this measure include: (1) fixing CO_2 into marine plant organics and then exporting these to higher trophic levels including food for humans, (2) long-term (at least decades-long) storage of CO_2 in material (seagrass debris) for folk house building to reduce lifestyle-connected CO_2 emissions (such folk houses are naturally cool in summer and warm in winter), (3) harboring biodiversity and protecting various valuable resources and enabling sustainable fishery production and income with less energy and materials costs, (4) protecting the coastal bank by formation of natural wave filters, and (5) removing excess nutrients, which might help further ameliorate marine environmental problems associating with climate change and global warming. A review of the historical distribution of seagrass beds in the northern waters of China, along with the current status, also is presented, followed by a call for seagrass/algal beds rehabilitation measures.

28 October, 9:30 (S5-6000)

Climate change adaptation using seaweed bed of BioSlag in marine environment

Kwang-Seok **Park**[1], Hyung-Suek Kim[1], Heon-Woo Park[1], Gun-Mok Sohn[2] and Hyeon Park[2]

[1] Energy and Environment Research Division, Research Institute of Industrial Science & Technology (RIST), Pohang 790-600, R Korea E-mail: kspark@rist.re.kr
[2] Environment and Energy Department, POSCO, Pohang, 790-600, R Korea

Recently the phenomenon of "coralline flats" has been spreading rapidly along the coastal areas surrounding the Korean Peninsula, resulting in reductions in coastal productivity. In the case of Jeju Island, about 31% of its coastal fishery was found to be influenced by the coralline flats, in which affected areas this trend was determined to be increasing. One of the main causes of coralline flats is assumed to be increased sea surface temperature due to global warming, and it is predicted that global climate change will continuously affect the coastal productivity of Korea in the future. Here, seaweed forest cultivation using BioSlag seaweed reefs made of steel-making slag would be an effective adaptation measure. By this means also, CO_2 could be mitigated in a two-step process: carbonation of steel-making slag aggregates in the BioSlag reefs, and photosynthesis by the seaweeds grown on the BioSlag reefs, creating a natural CO_2-storage site. The carbonation process of slag corresponds to that of mineral carbonation, and the application of slag seaweed reefs falls under the CCS ocean storage method reported by the IPCC (2005). Approval of this kind of seaweed-photosynthetic CO_2 storage as a CO_2 sink mechanism, by the UNFCC, is anticipated, and in fact, related research by the Asian Network for Using Algae as a CO_2 Sink (APPA) is now underway. In the future we will expand our cooperative work with the Korean Government to promote the seaweed belt and CO_2 mitigation using BioSlag reefs.

28 October, 9:50 (S5-5619)

The impact of climate change on the development of marine aquaculture: A case study on Japanese scallop aquaculture in Funka Bay, Hokkaido, Japan

I. Nyoman **Radiarta**[1,2], Sei-Ichi Saitoh[1] and Toru Hirawake[1]

[1] Laboratory of Marine Environment and Resource Sensing, Graduate School of Fisheries Sciences, Hokkaido University, 3-1-1 Minato, Hakodate, Hokkaido, 041-8611, Japan. E-mail: radiarta@salmon.fish.hokudai.ac.jp

[2] Research Center for Aquaculture, Agency for Marine and Fisheries Research, Ministry of Marine Affairs and Fisheries, Jl. Ragunan 20, Pasar Minggu, Jakarta, 12540, Indonesia

Evidence has been accumulating in recent years that suggest climate change might drive changes in aquaculture development. Sustainability of scallop production is also influenced by changes of environmental conditions. Climate change presents unquantifiable threats in the forms of increased temperatures, extreme weather and diminishing water supplies. In this study, to model the potential impact of climate change on the scallop aquaculture, we carried out a two-step analysis. First, we analyzed the suitability of sites for Japanese scallop aquaculture using an integrated remote sensing and geographic information system (GIS)-based model. Multi-criteria evaluation was adapted to the GIS models in order to rank sites on a 1 (least suitable)-to-8 (most suitable) scale. Second, in the site selection analysis, we examined the potential climate change impacts using the sea surface temperature (SST) values of 1°C, 2°C, or 4°C. These three SST values were selected based on the fourth assessment report of the IPCC. By increasing the SST values, we found that the most suitable sites (score 8) indicated slight (26.4%), significant (14%) and drastic (0.01%) changes compared with the original model (29%), respectively. These prediction models showed that climate change, by altering the physical characteristics of suitable cultivation areas, can have detectable impacts on the development of scallop aquaculture. The models also indicated that climate change might have an important impact on the future development of marine aquaculture in this region, a prospect that will need to be considered.

28 October, 10:10 (S5-5637)

Estimation of the role of eelgrass and associated epiphytic algae on the carbon cycle in Akkeshi Lake, Japan

Seokjin **Yoon** and Michio J. Kishi

Graduate School of Environmental Science, Hokkaido University, N10 W5, Sapporo, Hokkaido, 060-0810, Japan
E-mail: seokjin.yoon@ees.hokudai.ac.jp

Lake Akkeshi is located in the eastern part of Hokkaido, the northern island of Japan. It is semi-closed, being connected to Akkeshi Bay via only a narrow channel. The water depth is usually less than 2 m, and the shallow areas are covered with eelgrass, specifically *Zostera marina*. The Manila clam, *Ruditapes philippinarum*, is cultured in the intertidal sand flats near the mouth of the lake, and the oyster, *Crassostera gigas*, is cultured throughout Lake Akkeshi except for the intertidal sand flats. In order to evaluate the role of eelgrass and the other primary producers on carbon cycle in the lake, we developed an ecosystem model with seven components, which are phytoplankton, zooplankton, eelgrass, epiphytes, bottom diatoms, oysters and Manila clams. The model was coupled with a three-dimensional physical model and run for nine months, from April to December 2006. We estimated the time-dependent features of the biomass of each compartment, as well as the carbon contents and the production rates of the primary producers (*i.e.* phytoplankton, eelgrass, epiphytes and bottom diatoms). The primary producers, through their photosynthesis and respiration, have an important role to play in the coastal carbon cycle. We estimated the roles of eelgrass and associated epiphytic algae in the carbon cycle, and also calculated the outflow/inflow flux of particulate organism carbon (POC) to/from Akkeshi Bay. We concluded that the main route of POC flux from the lake is determined by the outflow of the dead leaves of eelgrass. Furthermore, we estimated the ways in which primary producers respond to climate changes such as increased temperature.

28 October, 10:50 (S5-5589)

Estimation of carbon sequestration by seaweed beds

Taehee **Na**, Ik Kyo Chung and Tongsup Lee

Division of Earth Environmental System, Pusan National University, Busan, 609-735, R Korea. E-mail: ocean95@pusan.ac.kr

Seaweed growth promoted in response to increased CO_2 concentrations could lead to enhanced photosynthetic storage of carbon. In order to estimate *in situ* the net seaweed community productivity in a small bay, dissolved inorganic carbon (DIC) and dissolved oxygen (DO) levels were monitored in seaweed beds and ambient seawater. Photosynthesis in seaweed beds leads to a conspicuous diel cycle and higher seasonal variations of DIC/DO than those for ambient seawater. The reasonably high Net Ecosystem Productivity (NEP; 0.9 ~ 4.4 gC $m^{-2}d^{-1}$) observed in the seaweed beds from winter to spring seems due mainly to light availability, as there was a strong correlation between the daily NEP and the surface irradiance. Seaweed beds absorbing prodigious amounts of DIC potentially are very effective sinks for atmospheric CO_2. Yet a rigorous NEP estimation of seaweed beds still requires an extended DIC survey to determine their quantitative significance to the global carbon cycles, along with the indirect contributions via community that algae support.

28 October, 11:10 (S5-5962)

Red-algae pulp and paper, bio-ethanol

Hack-Churl **You**[1], Munho Sohn[1] and Grevo Gerung[2]

[1] Pegasus International Inc. 7F, Platinum Bldg., 889-51, Dae-Chi Dong, Kang-Nam Ku, Seoul 135-839, R Korea
E-mail: Pegasus1@pegasushomepage.com
[2] Faculty of Fisheries and Marine Science, Sam Ratulangi University, J1. Kampus Bahu Mando, 95115, Indonesia

The manufacture of pulp and paper from Gelidiaceae red-algae was first developed by Pegasus International Inc. The advantages are; (1) rd-algae pulp and paper can replace wood pulp and paper and conserve forests, (2) agar, which is a by-product of the pulping process, can be a source of bio-ethanol, and (3) mass aquaculture of Gelidiaceae can uptake CO_2 much more efficiently than forests because of a higher per-unit growth rate. In these advantages, there is not only a high economical efficiency but also the possibility for a Clean Development Mechanism. It is well known that the manufacture of wood pulp is a high-CO_2-emission process, but red-algae pulp and paper can reduce 70-80% of such CO_2 emissions. Industrial-scale production of red-algae pulp and paper requires mass aquaculture, and so the development of mass aquaculture will signal the beginning of the red-algae pulp and paper era. Pegasus International Inc. has aquacultured Glidiaceae in Indonesia owing to the good and sustainable underwater conditions there.

28 October, 11:30 (S5-5688)

Coral-algal competition on damaged reefs

Eduard A. **Titlyanov** and Tamara Titlyanova

A.V. Zhirmunsky Institute of Marine Biology (IBM), FEB RAS, 17 Palchevskogo St., Vladivostok, 690002, Russia
E-mail: etitlyanov@mail.ru

On the basis of both our own and the literature data, it was shown that tropical and subtropical coral populations declined by about 80% or disappeared completely in some regions. Biodiversity of coral reefs, moreover, was significantly reduced. The main cause of the changes was the temperature of surface seawater, which was elevated (by 1-2ºC) in comparison with the monthly mean hot-season temperature. The recovery rate of coral reefs depends on hydrological and hydrochemical conditions, the frequency of natural catastrophes and competitive relationships between algae and corals on the damaged reef. In unpolluted waters, coral communities can recover from damage and partial mortality, but in waters polluted due to human activity coral reefs degrade. Competitive relationships patterns between algae and corals, the dynamics of the overgrowth of damaged and dead corals by different algal species, mechanisms of competitive relationships, and the influence of environmental conditions on the competitive properties of corals and algae were considered. A hypothesis of coral reef restoration via

temporary reformation into a plant reef was made. It has been supposed that in the absence of repeated natural catastrophes, damaged coral reefs can be restored to their original or changed state within several decades, but only in unpolluted waters.

28 October, 11:50 (S5-6003)

Seasonal variation in $\delta^{13}C$ and $\delta^{15}N$ values for the temperate seagrass *Zostera marina* and its relation to leaf production

Sang Yong **Lee** and Yong-Gun Gong

Seaweed Research Institute, NFRDI, 1101 Okamdong, Mokpo, 530-831, R Korea. E-mail: seagrass1@nfrdi.go.kr

The seasonal variability of the leaf production and the carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotopic rations of the leaf blades of a temperate seagrass, *Zostera marina*, were measured at two sites on the southern coast of Korea from February 2006 to February 2007. Significant differences in isotopic composition and leaf production, tested by ANOVA, were observed to be functions of both site and season. The $\delta^{13}C$ values of the seagrass leaves ranged from -8.22 to -4.70‰ for both sites, with a significantly lower at the sandy than the muddy site. There was an overall trend towards less discrimination against ^{13}C in summer than in winter. The $\delta^{15}N$ values ranged from 6.77 to 10.82‰ and decreased from summer to winter. The leaves at the sandy site showed significantly lower values than at the muddy site. Leaf production in *Z. marina* showed a clear seasonal variation; it was the highest in spring and the lowest in winter. Production at the muddy site was higher than at the sandy site. This site variation might result from differences in the geological characteristics between the sites, which possibly influence the productivity of plants and thereby their isotope ratios.

28 October, 12:10 (S5-5848)

Resource management of sea urchin *Strongylocentrotus intermedius* on the basis of its biotic relations with brown alga *Laminaria japonica*

Tatyana N. **Krupnova**, Vladimir A. Pavlyuchkov and Vera V. Agarkova

Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia
E-mail: krupnova@tinro.ru

The important prerequisite in the regulation of *Laminaria* settlements stability under sea urchin food pressure is the elucidation of their relationships at the biochemical level. Our investigations have found that sea urchins consume sporelings, old decomposed plants and algae ejections. It was revealed that sea urchins and laminaria, as shown in their respective life cycles, produce a complex of biological and biochemical protective factors for surviving in coexistence. For example, sea urchins avoid juvenile plants in spite of their attractiveness as food. Such sea urchin behavior is regulated by a fermentative system of "inhibitors – activators". Thus, zoospores' "group" sprouting is typical for laminaria, as it is connected with the peculiarities of egg cell fertilization. As a result, a great density of juvenile sprouts (up to 5 th. sp./m²) is formed, preventing each other's further growth. In this period of the sea urchin life cycle activation of feeding occurs, and they fall upon laminaria sprouts, thinning them out and providing, thereby, the required density for further favorable algae growth. Laminaria sprouts do not contain inhibitors of sea feeding. When laminaria thalli reach reproductive maturity, the inhibitors synthesize and push sea urchins away. At the same time, sea urchins are spawning and their food activity falls, which diminishes their attraction to laminaria. After zoospores' dissemination in laminaria thalli, the inhibitors are destroyed and they again become available for sea urchins. This is favorable to laminaria because it purifies the bottom of its old thalli, enabling zoospores to settle on a clean substratum. Based on the obtained results, we worked out the methods of additional foraging with specially grown *Laminaria* and the different components necessary for sea urchins.

S5 Posters

S5-5732

Subtidal macroalgal species diversity during wintertime in Jeju Island, Korea

Miryang **Kim**[1], Jeong Chan Kang[1], Jong Chul Lee[2] and Myung Sook Kim[1]

[1] Department of Biology, Jeju National University, Jeju, 690-756, R Korea. E-mail: myungskim@jejunu.ac.kr
[2] Ocean and Fisheries Research Institute, Jeju, 697-914, R Korea

Macroalgae are the dominant primary producers in coastal Jeju Island, Korea. They play a vital role in carbon fixation and provide habitat and nutrients to a myriad of associated species. Subtidal macroalgae form a large proportion of the total marine algal biomass in Jeju Island, but data is scarce on their contribution to wider marine ecosystems. The aim of this research is to understand the primary productivity potential in subtidal seaweeds and the role of species composition on ecosystem function. The collections of subtidal macroalgae by scientific SCUBA diving were made at eight sites, Udo, Hado, Oedo, Sinchang, Beophwan, Wimi, Onpyeong and Hyeongje Island of Jeju Island during February to March in 2009. The underwater surveys were conducted using quadrats on line transects at 3, 6, 10, and 15 m depth levels to assess the biomass and coverage of marine macroalgae. A total of 89 species, including 9 green, 15 brown and 65 red algae, were identified in this study. At the 6 and 10 m depth levels, comparatively high biomasses of brown algae were estimated with 2086 and 1794 g wet wt/m^2, respectively. *Ecklonia cava* and coralline spp. were the representative alga occurring at almost all sites and shore levels. The results showed that species diversity and distribution had significantly declined in the north and south coasts of Jeju Island. Furthermore, the appearance of the dominant species forming coralline algae might have been caused by the whitening event.

S5-5742

Growth and photosynthetic characteristics of three *Zostera* spp. (*Z. japonica, Z. marina and Z. caespitosa*) along vertical gradient: Implications for seagrass zonation

Sang Rul **Park** and Kun-Seop Lee

Department of Biological Sciences, Pusan National University, Geumjeong-gu, Busan, 609-735, R Korea. E-mail: srv99park@pusan.ac.kr

Seagrasses have usually distinct zonation patterns in tropical and temperate areas. In Korea, three *Zostera* spp. (*Z. japonica*, *Z. marina* and *Z. caespitosa*) are distributed at different water depths, leading to specific zonation patterns from intertidal to subtidal zones. The growth and photosynthetic characteristics of those three *Zostera* species, which show distinct vertical zonation, were examined seasonally in Koje Bay. *Zostera japonica* in the intertidal zone showed the lowest value in shoot height and blade width while *Z. caespitosa* in the subtidal zone exhibited the highest value in specific leaf area. The total chlorophyll (Chl *a*+*b*) and carotenoids concentrations were significantly higher in *Z. japonica* than *Z. marina* and *Z. caespitosa*. The carbon stable isotope ($\delta^{13}C$) values suggested that inorganic carbon forms used as photosynthetic carbon sources depend on seagrass zonation. The average $rETR_{max}$ was 17.4 ± 0.8 μmol electrons m^{-2} s^{-1} for *Z. marina*, 13.9 ± 0.7 μmol electrons m^{-2} s^{-1} for *Z. japonica* and 11.7 ± 0.5 μmol electrons m^{-2} s^{-1} for *Z. caespitosa*. The F_v/F_m values were higher for *Z caespitosa* (0.671 ± 0.011) than both *Z. japonica* (0.541 ± 0.013) and *Z. marina* (0.634 ± 0.010). According to the results of rapid light-response curve (RLC) parameters, *Z. japonica* was adapted to high light conditions, while *Z. caespitosa* was low light adapted species. After RLC, *Z. japonica* completely extinguished within 5 min, indicating that its leaf was energy-dependent quenching (qE). Dark respiration of *Z. caespitosa* showed the lowest values while *Z. japonica* had the highest values, suggesting that *Z. caespitosa* can survive with low photosynthetic activity due to low dark respiration rates. The results for the physiological and morphological characteristics were consistent with the observed zonation and differences of seagrasses, and thus variation in these characteristics among species can probably explain the zonation patterns of seagrass.

S5-5794

Management of artificial coastal CO_2 removal belt in Korea

Seong Cheol **Kim**[1], Mi Sook Hwang[2], Jae Min Baek[2], Seock Jung Han[2], Nack Joong Choi[2], Mi Kyung Choe[2] and Moon Ho Yang[2]

[1] Jeju Fisheries Research Institute, National Fisheries Research and Development Institute, 1928 Oeodo2-dong, Jeju, 690-192, R Korea
E-mail: sckim@nfrdi.go.kr
[2] Seaweed Research Institute, NFRDI, 1101 Okamdong, Mokpo, 530-831, R Korea

Seaweed production by aquaculture in Korea amounts to 764,913 tons total (MOMAF, 2006), 97% of which, 741,849 tons, represents *Porphyra, Undaria pinnatifida,* and *Laminaria japonica.* Over the past 30 years, seaweed production has decreased from about 600,000 tons in the mid-1990s to 400,000 tons in 2000. Nowadays, aquaculture production of browns *(Undaria, Laminaria)* is increasing, as they are used as a food source for abalone culture. In Korea, the harvest of cultivated seaweeds begins in December, when the seawater temperature falls below 15ºC. It reaches a peak in March when the temperature is around 9ºC, accounting for 190,000 tons, and after the water temperature goes above 15ºC in May, the algal blades disappear and production comes to an end. Carbon fixation by fronds in major aquaculture species last year (MOMAF, 2006) amounted to 24,225 tons, 8,472 tons by *Porphyra*, 9,681 tons by *Undaria*, and 6,072 tons by *Laminaria*. Their combined CO_2 removal was estimated to be 88,768 tons. Whitening occurs over an area of 7,058 ha (21.6% of the entire 82,679 ha of the inshore fishery) in Korea. The coastal area of Jeju, with the highest mean water temperature, shows the most whitening, or 4,640 ha, 31.4% of the total; Ulsan accounts for 16.9%, Kyungpuk, 14.8%, and Kangwon, with 7.6% with the Kuroshio Warm Currents. The climate change between the period 1968-2006 in Korea shows that the temperature increased by 1.3ºC and the water temperature by 1ºC. The Korean peninsula has already begun to be affected by global warming, which means that, to cope with the new environment, it is time to get to work on greenhouse gas emissions reduction using seaweed ecosystems.

S5-5856

The effect of geochemical characteristics and environmental factors on the growth of cultured ark shell *Scapharca broughtonii* at several shellfish-farming bays on the south coast of Korea

Yoon-Seok **Choi**[1], Choonkoo Jung[2] and Min-Woo Park[1]

[1] National Fisheries Research and Development Institute, Busan 619-705, R Korea. E-mail: grcys@nfrdi.go.kr
[2] South Sea Fisheries Research and Development Institute, Yeosu 556-823, R Korea

To assess the effects of environmental factors on the sustainability of cultured ark shell *Scapharca broughtonii* production, we investigated the habitat characteristics of shellfish-farming bays (Gangjin Bay, Yeoja Bay, Keoje Bay and Deukryang Bay). We measured the physiochemical parameters (temperature, salinity, dissolved oxygen, nutrients, chemical oxygen demand and chlorophyll *a*) and the geochemical characteristics (chemical oxygen demand, ignition loss, C/N ratio and C/S ratio). Surface sediments were collected from several shellfish-farming bays to examine the geochemical characteristics of both the benthic environment and heavy metal pollution. The grain sizes for Gangjin Bay, Yeoja Bay and Keoje Bay were similar, at the ratio of silt and clay in comparison with Deukryang bay of it. The C/N ratio was more than 5.9, reflecting the range arising from the mix of marine organisms and organic matter. The C/S ratio (more than 4.2) showed that the survey area had anoxic or sub-anoxic bottom conditions. The enrichment factor (Ef) and the index of accumulation rate (Igeo) of the metals showed that those research areas can be classified as heavily polluted, heavily to moderately polluted, or more or less unpolluted, respectively. We suggested that the growth of ark shell *Scapharca broughtonii* in the shellfish-farming bay was effected by the various environmental conditions, so an improvement in the culture method was needed.

S5-6001

Research and development roadmap for climate change adaptation and CO_2 mitigation in the Korean maritime and fisheries sector

Ik Kyo Chung[1], Kwang-Seok **Park**[2], Hyung-Suek Kim[2], Jin-Hwan Hwang[3], Jae-Young Lee[4] and Jung Hyun Oak[5]

1 Division of Earth Environmental System, Pusan National University, Busan, 609-735, R Korea
2 Energy and Environment Research Division, Research Institute of Industrial Science and Technology, Pohang, 790-600, R Korea
E-mail: kspark@rist.re.kr
3 Department of Civil and Environmental System Engineering, Dongguk University, Seoul, 100-715, R Korea
4 Division of Marine Environmental Policy, Ministry of Land, Transport and Maritime Affairs, Gwacheoun, 427-712, R Korea
5 Marine Research Institute, Pusan National University, Busan, 609-735, R Korea

The Korean Ministry of Land, Transport and Marine Affairs (MLTM), formerly the Ministry of Maritime Affairs and Fisheries (MOMAF), has proposed key strategies for the protection of people's livelihoods and property and to contribute to the retardation of global warming through active coping with marine environmental changes due to climate change. The five strategic topics are: 1) Adaptations in coastal environment for territorial security; 2) Adaptations in fishery resources for food control; 3) Mitigations of global warming in marine environments through reduction of greenhouse gas emissions; 4) Build-up of marine science and monitoring in climate change research; and 5) Strengthening of policy-making. The MLTM also actively cooperates with industrial sectors and NGOs.

S5-6002

The Asian Network for Using Algae as a CO_2 Sink of the Asian Pacific Phycological Association

Jin Ae **Lee**[1], Jung Hyun Oak[2] and Siew-Moi Phang[3]

1 School of Environmental Science and Engineering, Inje University, Gimhae, 621-749, R Korea. E-mail: envjal@inje.ac.kr
2 Marine Research Institute, Pusan National University, Busan, 609-735, R Korea
3 Institute of Biological Sciences, University of Malaya, Kuala Lumpur, 50603, Malaysia

In response to the commitment expressed in the Kyoto Protocol on climate change, the Asian Network for Using Algae as a CO_2 Sink, a working group of Asian Pacific Phycological Association (APPA), was established to encourage collaboration among member countries in conducting research in sustainable CO_2 removal by marine-life mechanism in November 2005. A total of 12 countries of Asia Pacific region participate in the network and the membership system entailing a single representative from each country is basically maintained. The members of the working group follow up the action on the Agenda 21 for Green Path to the future and have been working for the collaborative activities under the United Nations Framework Convention on Climate Change (UNFCCC). So far total 7 workshops and 2 meetings in the form of a side event of the Conference of the Parties, UNFCCC were convened. With the elaborative discussion of the workshop, the network identified the list of the task, related to publications, R&D and network activities to be performed by the network.

S6 MEQ/FIS Topic Session
Marine spatial planning in support of integrated management - tools, methods, and approaches

Co-Sponsored by NOWPAP

Co-Convenors: Glen Jamieson (Canada), Vladimir Shulkin (NOWPAP, Russia) and Chang-Ik Zhang (Korea)

Marine spatial planning is receiving support from a growing number of PICES member countries as a means to develop a strategic approach to offshore ocean usage and resolve spatial conflict issues. While the concepts of integrated management (IM) and supporting marine spatial planning (MSP) are now often referred to at the policy level, there is generally only a vague and patchy understanding of how they might be practically implemented. The most obvious elements of MSP include marine protected or spatially regulated areas designed to meet one or more objectives of IM. This requires identifying and mapping marine features and processes, along with human activities and associated pressures and impacts. The session aims to explore the latest thinking and developments in MSP. Contributions are therefore invited on practical examples of MSP approaches or on any of its sub-components, including: 1) role of MSP in achieving IM objectives - success stories and problem areas to avoid in practical implementation of MSP; 2) criteria for identifying, mapping and assessing (based on observations and/or predictions) cumulative impacts of multiple human activities, including theoretical developments on community sensitivity, resilience and other features of ecological significance (*e.g.*, mapping of human activities/impacts using spatially-resolved data or model predictions); and 3) criteria and guidelines used to design and locate MPAs to meet cross-sectoral IM objectives, *i.e.* not just fisheries or nature conservation objectives; included in this are theoretical considerations on interconnectivity amongst these areas. We are particularly interested in practical examples of marine planning or management systems or processes that bring together any combination of the above.

Friday, October 30 (9:00-17:40)

9:00 ***Introduction by Convenors***

9:05 **Erik Olsen and Fanny Douvere (Invited)**
Marine spatial planning: A practical approach to ecosystem-based management (S6-6009)

10:05 **Michio J. Kishi, Ayaka Sakamoto and Kenta Awa**
Basic idea on ecosystem based management for aquaculture and artificially released chum salmon (S6-5686)

10:25 ***Cofee / tea break***

10:50 **Brett R. Dumbauld**
Managing estuarine resources at the landscape scale in Willapa Bay, Washington and similar U.S. West Coast estuaries (S6-5824)

11:10 **Jong-Deuk Bang, Jung-Pyo Hong, Sang Un Park, Jung-Yeong Lee, Jae-Yeong Lee, Im-Gi Jeon and Jong-Hun Na**
Marine enhancement program in Korean Peninsula: Introduction of marine ranching programs (S6-5685)

11:30 **Hidemasa Yamamoto**
Procedures for assessment of eutrophication status developed by NOWPAP CEARAC (S6-5571)

11:50 **Ivan S. Arzamastsev**
Zoning of Far Eastern Seas for integrated nature management (S6-5527)

12:10 **Blake E. Feist, Carolina Parada, Kevin E. See and David A. Armstrong**
Using ROMS ocean circulation models to predict the range expansion of non-indigenous European green crab (*Carcinus maenas*) along the west coast of North America (S6-5959)

12:30 ***Lunch***

14:00 **Anatoly Kachur (Invited)**
Marine spatial planning in support of integrated management in North West Pacific Region – tools, methods, and approaches (S6-5766)

14:50 **David Nicolson, Natalie Ban, Julie Beaumont, Karin Bodtker, Christopher Bos, Tanya Bryan, Andrew Day, Glen Jamieson, Lynn Lee, Greg MacMillan, Glen Rasmussen, Charlie Short, Bruce Turris and Karen Topelko**
Generating information to support integrated marine planning: Advantages and challenges of a collaborative approach (S6-5960)

15:10 **Ian M. Dutton, Kerrie Wilson and Hedley Grantham**
Making marine spatial planning real: Bridging the gap from planning to action (S6-5972)

15:30 ***Coffee / tea break***

15:50 **Robinson Mugo, Sei-Ichi Saitoh, Akira Nihira and Tadaaki Kuroyama**
Spatial prediction of skipjack tuna catch rates from remote sensing and geo-statistical approaches: Some tools for fisheries spatial planning and management in the western North Pacific (S6-5764)

16:10 **Vladimir Shulkin**
Spatial zoning of the sea coastal areas by the land-based influences as a part of ICARM (S6-5521)

16:30 **Ning Lin, Nanyan Huang, Wenbin Xu and Qian Wang**
Evaluation of marine function zoning: Research and practice in China (S6-5626)

16:50 **Li-Feng Lu, Yasumasa Miyazawa, Kazuo Nadaoka, Sergey M. Varlamov and Aditya R. Kartadikaria**
Responses of surface current and temperature to the local wind and tidal forcing within Sekisei Lagoon, Japan and their application to the regional coral reef connectivity (S6-5909)

17:10 **Erik Olsen**
Marine spatial planning in Norway: Lessons learned from developing and implementing integrated management plans for the Norwegian and Barents seas (S6-6008)

17:30 ***Discussion***

17:40 ***Session ends***

S6 Oral Presentations

30 October, 9:05 (S6-6009), Invited

Marine spatial planning: A practical approach to ecosystem-based management

Erik **Olsen**[1] and Fanny Douvere[2]

[1] Institute of Marine Resarch, P.O. Box 1870 Nordnes, N-5817 Bergen, Norway. E-mail: eriko@imr.no
[2] Intergovernmental Oceanographic Commission, United Nations Educational, Scientific and Cultural Organization (UNESCO), 1 rue Miollis, Paris, France. E-mail: fanny.douvere@mac.com

Ecosystems are biological systems with a spatial boundary, therefore management of ecosystems needs to take the boundaries of the system and the components of the system into account to be successful. There is a growing awareness amongst managers and scientist that such place-based management is key to successful Ecosystem-Based Management (EBM). Systematic placed-based management such as Marine Spatial Planning (MSP) offers a practical and tangible start of implementing EBM in complex marine systems. Although demanding good data and complex analyses the spatial side of MSP makes it understandable to managers and stakeholders alike. However, the implementation requires that the governance corresponds to the need for MSP – a sometimes more difficult task than the scientific and technical side. MSP is a future-oriented activity that not only can address directly conflicts, fragmentation and spatial mismatches in current ocean management, but also facilitates efforts to adjust governance to the rhythms of human institutions and the dynamics of spatially-bounded ecosystems. UNESCO's Intergovernmental Oceanographic Commission (IOC) has recently published (June 2009) an operational guide that outlines the steps to implement ecosystem-based MSP. As part of the preparatory work, good practices of MSP in Norway, Belgium, the Netherlands, Germany, United States, United Kingdom, China, Australia, Canada and New Zealand have been analyzed and documented, providing necessary information on what is crucial and what is not in the use and application of MSP. More information available at: ioc3.unesco.org/marinesp.

30 October, 10:05 (S6-5686)

Basic idea on ecosystem based management for aquaculture and artificially released chum salmon

Michio J. **Kishi**[1,2], Ayaka Sakamoto[1,3] and Kenta Awa[1]

[1] Faculty of Fisheries Sciences, Hokkaido University, Japan
[2] Graduate School of Environmental Science, Hokkaido University, N10W5 Kita-ku, Sapporo, 060-0810, Japan
E-mail: mjkishi@nifty.com
[3] Ocean Research Institute, University of Tokyo, Japan

A basic idea for ecosystem based management (EBM) is proposed, especially for reference by young scientists. In order to manage fisheries mathematically, we need "constraints" and "cost" functions. In the case of aquaculture, constraints should be the environment of coastal waters and the cost function must be total income of fishermen. We show a simple example for yellow tail aquaculture. Constraints are COD (Chemical Oxygen Demand) concentration for water quality and DO (Dissolved Oxygen) concentration for the survival of fish. A cost function is determined as total income of fishermen. Total cost was calculated as proceeds minus the total cost of food. Return was calculated as a function of fish wet weight and the number of cultured fish, and fish weight was calculated using a bio-energetic model. The model ultimately should suggest the most suitable number of fish per unit cage of aquaculture. In the case of salmon, constraints are prey density in the Bering Sea and/or Gulf of Alaska and cost function is income of fishermen. Income is the calculated unit cost of salmon, which is a function of both wet weight and number of returning fish to Japanese rivers.

30 October, 10:50 (S6-5824)

Managing estuarine resources at the landscape scale in Willapa Bay, Washington and similar U.S. West Coast estuaries

Brett R. **Dumbauld**

USDA-ARS, Hatfield Marine Science Center, 2030 SE Marine Science Dr., Newport, OR, 97365, USA
E-mail: brett.dumbauld@ars.usda.gov

Management of estuarine resources has typically been undertaken at a single species or single activity level in the past. While historically true for terrestrial systems as well, this has remained the case in most aquatic systems due to the difficulty in visualizing and mapping underwater habitat. We report on an estuarine habitat assessment effort in Willapa Bay, Washington where 63% of the estuary is exposed at low tide making a landscape scale mapping effort more tractable and where 20% of that area is used for shellfish aquaculture which clearly modifies the habitat and provides intriguing historical context. Pacific oysters were introduced to this estuary from Japan in the early 1920's to replace the native oyster which was overharvested and now covers substantial area. The habitat formed is different due to this oyster's much larger size and physiological requirements, but more importantly the advent of aquaculture practices which also alter the habitat. We mapped the current spatial extent and distribution of both oyster habitat and submerged aquatic vegetation in this estuary, compare this with a historical estimate, and present preliminary information from an ongoing study which attempts to quantify how changes in structure influence the function of these habitats for fish and invertebrates at the estuarine landscape scale. While management continues to be dictated by societal goals and historical precedent, further research could prove useful in designing best practices for aquaculture and making sound estuarine management decisions for multiple species.

30 October, 11:10 (S6-5685)

Marine enhancement program in Korean Peninsula: Introduction of marine ranching programs

Jong-Deuk **Bang**, Jung-Pyo Hong, Sang Un Park, Jung-Yeong Lee, Jae-Yeong Lee, Im-Gi Jeon and Jong-Hun Na

National Fisheries Research and Development Institute, Busan, 619-902, R Korea. E-mail: jdbang@nfrdi.go.kr

Catches in commercial fisheries landings have been in decline since the 1980s, leading to growing global concerns about the state of fish resources. According to the FAO, 75% of fisheries are fully exploited, overexploited, severely depleted, or in recovery. The effect of such overexploitation on the marine ecosystem has come under increasing scrutiny in recent years. In addition to the new international maritime regime that is represented by the 200-nautical-mile Exclusive Economic Zones (EEZs), which was reduced the Korea's fishing grounds. So the Korean government tried to promote Marine enhancement program. From a part of the program, since 1998, marine ranching programs have been operated by the Korean government (National Fisheries Research and Development Institute in Ministry of Agriculture, Forestry, Fisheries and Food). Conversely, the demand for fishery products has continued to increase during the last decade, and ultimately, Korea has become a major importer of fishery products. To meet the ever-increasing demand for fishery products, it is essential to improve the productivity of coastal areas by properly managing coastal waters. Marine ranching is a new concept in the management of coastal waters, which improves marine habitats to produce more marine organisms for human consumption. These enhancement programs will be continued in Korean peninsula. The current marine ranching program are operated 5 places for (1) understanding the ecological properties, (2) improvement of habitat, (3) annexation of fish stock, and (4) operation and management of marine ranching.

30 October, 11:30 (S6-5571)

Procedures for assessment of eutrophication status developed by NOWPAP CEARAC

Hidemasa **Yamamoto**

CEARAC (Special Monitoring and Coastal Environmental Assessment Regional Activity Centre), NOWPAP (Northwest Pacific Action Plan), 5-5 Ushijimashin-machi,Toyama, 930-0856, Japan. E-mail: h-yamamoto@npec.or.jp

In the Northwest Pacific region, coastal areas of China, Japan and Korea are densely populated and eutrophication is often perceived as a potential threat for coastal environment, although eutrophication is rare in Russian waters. Ability to monitor their coastal systems is necessary to manage and sustain healthy coastal environments. However, the availability of continuous and synoptic water quality data, particularly in estuaries and bays is lacking, and it is difficult to characterize the response of water quality to human and natural impacts.

Thus, NOWPAP CEARAC have decided to use experience of the European countries and develop "Procedures for assessment of eutrophication status". As in 2009, CEARAC developed the Procedures, CEARAC will suggest/ lead the four NOWPAP member states (China, Japan, Korea and Russia) to implement the assessment of the eutrophication status in their sea areas during the 2010-2011 biennium. The assessment results could hopefully then be utilized by each NOWPAP member state for consideration and development of monitoring systems and countermeasures against eutrophication. The assessments results will also be utilized when designating marine protected areas, and moreover when developing land-use planning, marine parks and/or zoning in the marine and coastal areas.

Sea areas for the assessment in the current plan are not so many; however, when the number of the areas is increased in the future, the project itself will contribute to "the transboundary coastal management".

30 October, 11:50 (S6-5527)

Zoning of Far Eastern Seas for integrated nature management

Ivan S. **Arzamastsev**

The Center Landscapes and Ecological Researches, Pacific Geographical Institute, FEB RAS, 7 Radio St., Vladivostok, 690041, Russia
E-mail: arz@tig.dvo.ru

To organize more efficient renewable resource management in the Far Eastern Russia, various strategies of land and sea zoning are applied. Functional zoning of Far Eastern Seas is achieved by establishing fishery areas for fishing management, areas of bioresource data gathering for fishery efficiency forecasting, and areas with different level of navigation complexity and zoning based on analysis of hydrometeorological information or natural resources. Land zoning includes various types of socio-economical zoning, climatic and landscape zoning, zoning by presence of natural hazards, *etc*. All these types of zoning are mainly sectoral and specialized. They are singled out for achieving some clearly defined objectives for human activities. The divisions have no mutual interrelation, frequently resulting in contradictions and sometimes even violent conflicts between natural resource user groups.

Nevertheless, over the past few decades, a new worldwide trend of natural resource management has evolved, characterized by an easily traced transition of sectoral type of management to a more complex type of ecosystem-based management. The work is targeted on carrying out another zoning of Far Eastern Seas and their coastal areas with consideration of the interests of the vast majority of natural resource users, regional natural and socio-economical peculiarities and environmental problems. Such zoning will allow a more efficient organization of well-balanced and sustainable development and may serve as a basis for the realization of complex management programs for the region's coastal areas.

30 October, 12:10 (S6-5959)

Using ROMS ocean circulation models to predict the range expansion of non-indigenous European green crab (*Carcinus maenas*) along the west coast of North America

Blake E. **Feist**[1], Carolina Parada[2], Kevin E. See[3] and David A. Armstrong[2]

1 National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Fisheries Science Center, 2725 Montlake Blvd. E, Seattle, WA, 98112, USA. E-mail: Blake.Feist@noaa.gov
2 University of Washington, School of Aquatic and Fishery Sciences, 116 Fishery Sciences, Seattle, WA, 98195, USA
3 University of Washington, Department of Biology, 416 Kincaid Hall, Seattle, WA, 98195, USA

European green crab (*Carcinus maenas*), were unintentionally introduced from the east coast of the United States to San Francisco Bay, ca. 1989. Green crab are native to the northeastern Atlantic, but are considered invasive and a great ecological threat to the marine and estuarine ecosystems of the United States. Green crabs have been documented in nearly every major estuary along the west coast of the lower 48 and as far north as the southwest coast of Vancouver Island, British Columbia. There is great concern that green crab populations will continue expanding northward along coastal British Columbia and southeast Alaska. Green crab expand their range to new estuaries and embayments via larval transport. We coupled Regional Ocean Modeling System (ROMS) ocean circulation output with larval green crab life history parameters to create an individual based model (IBM) that predicted where larvae could be transported along the west coast of North America. Larvae were released from 13 sites ranging from San Francisco Bay, California up to Riou Bay, Alaska, at various times of the year from 1994 – 2004. We found that there were three general patterns of larval dispersal: offshore, alongshore and random. Of the three patterns, alongshore dispersal is most likely to transport larvae to new locations in Southeast Alaska. Finally, the model predicted that currently un-colonized areas along the coast of British Columbia and Southeast Alaska are susceptible to colonization, provided there is suitable habitat for successful recruitment.

30 October, 14:00 (S6-5766), Invited

Marine spatial planning in support of integrated management in North West Pacific Region – tools, methods, and approaches

Anatoly Kachur

Pollution Monitoring Regional Activity Center of North-Western Pacific Action Plan of UNEP (POMRAC of NOWPAP), 7 Radio St., Vladivostok, 690041, Russa. E-mail: kachur@tig.dvo.ru

The overall goal of the Northwest Pacific Action Plan of UNEP is "…development and management of the coastal and marine environment so as to obtain the utmost long-term benefits for the human populations of the region, while protecting human health, ecological integrity and the region's sustainability for future generations". The strategy for wise management of the Northwest Pacific coastal and marine environment should included integrated coastal area planning (3) and integrated coastal area management (4). The third and fourth Objectives in the initial Action Plan for the Northwest Pacific region are the follows: (3) To develop and adopt a harmonious approach towards coastal and marine environmental planning on an integrated basis and in a pre-emptive, predictive and precautionary manner; (4) To develop and adopt a harmonious approach towards the integrated management of the coastal and marine environment and its resources, in a manner which combines protection, restoration, conservation and sustainable use. POMRAC from 2006 started practical implementation of 3 from 4 elements of NOWPAP: integrated coastal area planning and integrated coastal area management (ICARM). The final objective of NOWPAP activities within ICARM can be development of strategic program of ICARM for NOWPAP Region, main part of it will be marine spatial planning as a means to develop a strategic approach to offshore ocean usage and resolve spatial conflict issues.

30 October, 14:50 (S6-5960)

Generating information to support integrated marine planning: Advantages and challenges of a collaborative approach

David **Nicolson**[1], Natalie Ban[2], Julie Beaumont[3], Karin Bodtker[4], Christopher Bos[5], Tanya Bryan[6], Andrew Day[7], Glen Jamieson[8], Lynn Lee[9], Greg MacMillan[10], Glen Rasmussen[8], Charlie Short[11], Bruce Turris[12] and Karen Topelko[13]

1 BC Marine Conservation Analysis, 4469 Annette Pl., Victoria, BC, V8N 3J6, Canada. E-mail: dnicolson@bcmca.ca
2 James Cook University, Townsville, Queensland, 4811, Australia
3 Coastal First Nations Turning Point Initiative, United Kingdom Bldg., Suite 1051 – 409 Granville St., Vancouver, BC, V6C 1T2, Canada
4 Living Oceans Society, 207 W. Hastings St., Suite 1405, Vancouver, BC, V6B 1H7, Canada
5 Sport Fish Advisory Board, Suite 156, 1591H Hillside Ave., Victoria, BC, V8T 2C1
6 Nature Conservancy of Canda – BC Region, #200-825 Broughton St., Victoria, BC, V8W 1E5, Canada
7 West Coast Vancouver Island Aquatic Management Board, P.O. Box 1042, Stn A, Port Alberni, BC, V9Y 7L9, Canada
8 Fisheries and Oceans Canada, 3190 Hammond Bay Rd., Nanaimo, BC, V9T 6N7, Canada
9 Haida Fisheries, Box 87, Massett, BC, V0T 1M0, Canada
10 Parks Canada, 300 West Georgia St., Vancouver, BC, V6B 6B4, Canada
11 BC Integrated Land Management Bureau, P.O. Box 9352, Stn. Prov. Govt., Victoria, BC, V8W 9M1, Canada
12 BC Seafood Alliance, 1100-1200 West 73rd Ave., Vancouver, B.C. V6P 6G5, Canada
13 BC Ministry of Environment, P.O. Box 9309, Stn. Prov. Govt., Victoria, BC, V8W 9N1, Canada

Transparent, integrated, and collaborative approaches are increasingly promoted to advance ecosystem-based management. The British Columbia Marine Conservation Analysis project (www.bcmca.ca) is taking such an approach, resulting in opportunities and challenges. The project is an encouraging example of proactive collaboration among federal and provincial governments, academics, environmental non-governmental organizations, and aboriginal organizations.

The inter-organization project team is assembling spatial data representing the distribution of ecological features and human uses in Canada's Pacific Ocean to inform integrated marine planning. These data are the foundation for the project's two products: an atlas of ecological and human use maps and a Marxan analyses that identify areas of high conservation value which minimize overlap with areas important to human use. User groups are being invited to review human use data and provide direction on the use of these data in analyses.

The processes of assembling information to support decisions about ecosystem-based management is crucial but challenging – disputes over origins and quality of data, and methods used to generate it, are common hurdles to advancing integrated planning for ecosystem-based management.

The project's collaborative approach has created key opportunities to develop information products that can be widely perceived as credible and deliberate on how to represent humans as ecosystem components in analyses. One challenge has been managing communication among project team members, their "constituencies", and user groups. Additional challenges and preliminary project results will be discussed.

30 October, 15:10 (S6-5972)

Making marine spatial planning real: Bridging the gap from planning to action

Ian M. **Dutton**[1], Kerrie Wilson[2] and Hedley Grantham[2]

1 Alaska SeaLife Center, Seward, AK, 99664, USA. E-mail: ian_dutton@alaskasealife.org
2 Spatial Ecology Laboratory, University of Queensland, Brisbane, QLD, AUS

In the past five years there has been a resurgence of global interest in marine spatial planning, with major efforts recently completed or now underway in the British Isles, The European Union, South Africa, parts of the United States, Indonesia and Australia. Unlike terrestrial spatial planning, which has a long tradition of formal theory and practice, marine spatial planning is a relatively new discipline. The most advanced examples developed only over the past 30 years. The largest area of application to date, the 350,000 km^2 Great Barrier Reef Marine Park, has demonstrated the importance of ensuring that the planning process (a) emphasizes stakeholder participation and fairly reflects their interests (b) incorporates sound scientific principles and (c) fosters an effective and seamless transition to implementation, typically within a well-established regulatory framework. Those plans that do not adequately reflect all three of those criteria are likely to fail. In this paper we review recent developments in

marine spatial planning and the potential for wider application of spatial prioritization software, such as Marxan and Marzone which can optimize for multiple marine tenures and resource uses such as fishing, conservation, mining and tourism. We provide case studies from throughout the Pacific that provide guidance on options for wider application of marine spatial planning in the North Pacific. We suggest that there must be a greater emphasis on trans-national marine spatial planning and international cooperation in implementation if action at the local and national scales is to ultimately be effective.

30 October, 15:50 (S6-5764)

Spatial prediction of skipjack tuna catch rates from remote sensing and geo-statistical approaches: Some tools for fisheries spatial planning and management in the western North Pacific

Robinson **Mugo**[1], Sei-Ichi Saitoh[1], Akira Nihira[2] and Tadaaki Kuroyama[2]

[1] Laboratory of Marine Environment and Resource Sensing, Graduate School of Fisheries Sciences, Hokkaido University, 3-1-1 Minato-cho, Hakodate, 041-8611, Hokkaido, Japan. E-mail: robin_mugo@salmon.fish.hokudai.ac.jp

[2] Ibaraki Prefecture Fisheries Research Station, Japan

Fishing is one of the extractive uses of the marine environment which can benefit from effective spatial planning. We present work on application of statistical models and GIS to derive important habitat information, applicable for spatial prediction of catch rates. We modeled skipjack tuna habitat from catch data and remotely sensed sea surface temperature (SST), surface chlorophyll (SSC), sea surface height anomalies (SSHA) and eddy kinetic energy (EKE) using generalized additive models (GAM) and GIS in the western North Pacific (WNP), for the period March to November, 2004. We split the period March to August to represent northern migration and September to November, the southern migration of skipjack tuna in the WNP. GAMs were fit consistent with these migration patterns, catch rate levels and step-wise addition of environmental parameters. We selected a best case scenario model using Akaike information criterion procedures and subsequently made spatial prediction of skipjack tuna catch rates from the four environmental parameters. Results indicate that skipjack tuna catch rates were high in habitats defined by 20 and 23ºC SSTs; 0 and 30 cm SSHA; 0.2 mgm^{-3} SSC and EKE 0-200 cm^2s^{-2}. SST was the most important variable for selection of fishing ground, followed by SSC. Spatially predicted catch rates ranged from 0-5 ton/boat-day, were within the range of observed catch rates and consistent with observed distribution of fishing locations. Development of dynamic spatial-based management tools such as closed areas and individual transferable quotas, using remote sensing and GIS, is explored.

30 October, 16:10 (S6-5521)

Spatial zoning of the sea coastal areas by the land-based influences as a part of ICARM

Vladimir **Shulkin**

Pacific Geographical Institute, FEBRAS, 7 Radio St., Vladivostok, 690041, Russia. E-mail: shulkin@tig.dvo.ru

Integrated Coastal and River Basin Management (ICARM) - is a scientific, economic and legal tool for the harmonization of numerous inconsistent interests of the coastal communities and stakeholders, based on the understanding of the close interrelationships of processes in the coastal sea waters and in the inputting rivers and adjacent watersheds. The spatial zoning is inevitable part of ICARM approach. The feature of ICARM projects is a necessity to describe and to analyze the influences of the land-based fluxes of the matter on the sea areas. The assessment of such influence could provide the basis and limits for the present and future human activities, could help to monitor the quality of environment, and to evaluate the efficacy of remediation measures. The bunch of methods is used, when specific sites are studied from the point of view land-based influence. At the same time there are issues where the regional and sub regional assessment of the land-based influence on the sea areas is needed. Such assessments could help to distinguish and to compare the localities from the different coastal areas with present and/or future ecological problems connected with fluxes of matter from the land. Two simple models will be presented for the regional and sub regional spatial zoning of the coastal waters of Japan/East Sea and Yellow Sea by the size of the areas with possible eutrophication due to land-based sources of nutrients, and by the coast line length-normalized river runoff of different contaminants.

30 October, 16:30 (S6-5626)

Evaluation of marine function zoning: Research and practice in China

Ning **Lin**, Nanyan Huang, Wenbin Xu and Qian Wang

National Marine Data and Information Service, No.93, Liuwei Rd., Hedong District, Tianjin, 300171, PR China
E-mail: peterlin@mail.nmdis.gov.cn

Evaluation of marine activity zoning is important prior to potential alteration of marine activity zoning. The principles of marine zoning are discussed, and evaluation procedures have been studied. It is proposed that three main aspects should be considered in establishing an evaluation index system framework. Using a method combining both quantity and quality analyses, a scientific and systematic evaluation on marine activity zoning is presented. Results can determine whether marine function zoning needs to be altered or not. Evaluation results provide an important reference basis to conclude whether a slight or great alteration is justified. Evaluation of parameters includes assessing the general situation of marine activity zones, and the degrees of implementation and public participation. Evaluation of implementation degree includes assessments of achievements and existing problems to date, notably in protecting marine resources and the environment, promoting marine economic development. Evaluation of the consequences of zoning includes assessment of changes in social and economic conditions, usage demands by marine industries, marine resource conditions and marine environmental conditions. As evaluation example is given for Shenzhen City marine activity zoning to assess the utility of this marine activity zoning evaluation index system.

30 October, 16:50 (S6-5909)

Responses of surface current and temperature to the local wind and tidal forcing within Sekisei Lagoon, Japan and their application to the regional coral reef connectivity

Li-Feng **Lu**[1], Yasumasa Miyazawa[1], Kazuo Nadaoka[2], Sergey M. Varlamov[1] and Aditya R. Kartadikaria[2]

[1] Japan Agency for Marine-Earth Science and Technology, Yokohama, Kanagawa, 236-0001, Japan. E-mail: lifeng_lu@jamstec.go.jp
[2] Department of Mechanical and Environmental Informatics, Tokyo Institute of Technology, Tokyo, 152-8552, Japan

Sekisei Lagoon contains the largest coral reef in Japan. Now the reef is confronting various environmental stresses including sedimentation, eutrophication and over-fishing. To conserve the coral reef ecosystem in this region, it is necessary for us to better understand the horizontal and vertical dispersion processes of the coral larvae, which need to clarify detailed horizontal and vertical surface flow structure. To this end, we have developed a multi-nested grid system which includes a fine-resolution (1/900 deg.) hydrodynamic model of Sekisei Lagoon. The simulated currents are characterized by reef currents driven by tidal and wind forcing inside of the lagoon and strong open ocean currents formed along the bottom slope. We investigated the larval dispersal of corals around the lagoon through particle tracking experiments. Significant sensitivities of the dispersal pattern to time, space, and model physics suggest that probability distribution of the particles should be used to exactly evaluate the dispersal of coral larvae. A 'dispersion matrix' is also obtained to show the relationships between sources-sinks of the larvae, by which we propose candidates of most effective Marine Protected Areas (MPAs) around Sekisei lagoon.

30 October, 17:10 (S6-6008)

Marine spatial planning in Norway: Lessons learned from developing and implementing integrated management plans for the Norwegian and Barents seas

Erik **Olsen**

Institute of Marine Resarch, P.O. Box 1870 Nordnes, N-5817 Bergen, Norway. E-mail: eriko@imr.no

Starting in 2002 the Norwegian government initiated the work on developing integrated ecosystem-based management plans for the Norwegian EEZ of the marine ecosystems in Norwegian waters. The Barents Sea and adjacent areas was the first area for which a plan was developed. Five ministries formed a steering group for leading the development of the plan, while the scientific work and analyses were carried out by government research institutes and directorates. The Barents Sea plan was presented to parliament in 2006 and consisted of an updated description of the system and its human use, the knowledge base and lacks in current knowledge, aims and environmental standards for existing and future human use, indicators of ecosystem health, and an area-based management framework for oil and gas activities in relation to fisheries and ecologically valuable areas. After finishing the Barents Sea plan work on the Norwegian Sea plan was initiated in 2006. A similar approach as for the Barents Sea plan was followed, but with greater focus on analyzing vulnerability and cumulative effects of human use. Traditional risk analysis was done to evaluate the vulnerability, but some of the results have been contended as uncertainties in the knowledge base propagate to the risk estimates. The Norwegian Sea plan was presented to parliament in 2009 and consisted of the same elements as the Barents Sea plan. Again a large-scale area-based management framework was put in place. Both plans call for regular revisions every four years where assessment of the knowledge base and changes in the vulnerability are central issues.

S7 MONITOR Topic Session
State of the art of real-time monitoring and its implication for the FUTURE oceanographic study

Co-Sponsored by Argo and GOOS

Co-Convenors: Jack Barth (U.S.A.), Dake Chen (China), David L. Mackas (Canada), Vyacheslav Lobanov (Russia), Young Jae Ro (Korea) and Hiroya Sugisaki (Japan)

As the technology for the Ocean Sciences and Engineering is advanced rapidly, the real-time data production will revolutionize the field investigation and laboratory analysis in many ways which will have the impact over the entire oceanographic paradigm in the end. This session will review the state of art technology for the ocean investigation on real-time and/or near real-time basis and will discuss the impact on the research and educational horizons made possible by it. Each nation will demonstrate their ocean monitoring network and their application. The exhibits from ocean monitoring companies are to occur in conjunction with this session.

Thursday, October 29 (9:00-17:20)

9:00 ***Introduction by Convenors***

9:05 **Howard J. Freeland (Invited)**
The state of the art of real-time monitoring – The Argo experience (S7-5645)

9:35 **Tsuyoshi Kitamoto, Hirotaka Hamanaka, Asako Toyozumi, Satoshi Tanaka, Hiroko Arataki, Yoichiro Ishibashi, Yukio Kishimoto, Hideaki Nakata, Satoru Futatsumachi, Joji Ishizaka, Hideaki Maki, Shuhei Nishida, Yukihiro Nojiri, Haruo Ogi, Yoshihisa Shirayama and Shinsuke Tanabe**
Has pollution of the sea around Japan become better? A discussion based on more than 10 years of monitoring at depths up to 4000m (S7-5765)

9:55 **Elena A. Shtraikhert, Sergey P. Zakharkov and Tatyana N. Gordeychuk**
Some features of the distribution chlorophyll *a* in the north-western part of the Sea of Japan based on near real-time data (S7-5593)

10:15 **Young Baek Son, Joji Ishizaka and Young-Sang Suh**
Detection of *Cochlodinium polykrikoides* blooms using spectral classification in the South Sea of Korea (SSK) (S7-5665)

10:35 ***Coffee / tea break***

10:55 **Kelly J. Benoit-Bird (Invited)**
Trophic cascades in Hawaii's nearshore ecosystem: Using observing technology to understand ecological interactions (S7-5649)

11:25 **Hiroya Sugisaki and K. Sawada**
Real-time monitoring for mesopelagic fish abundance using J-QUEST integrated system of echosounder and stereo TV cameras (S7-5611)

11:45 **Yury N. Morgunov, Yury A. Polovinka and Dmitry S. Strobykin**
Acoustic monitoring of hydrophysical processes in ocean shelf zones (S7-5740)

12:05 **Natheer M. Alabsi, Hideaki Tanoue, Teruhisa Komatsu, Isamu Mitani, Mitsuhiro Kato, Toyomitsu Horii, Ichiro Aoki and Nobuyuki Miyazaki**
Measurement of swimming behavior of alfonsino *Beryx splendens* in experimental tank using micro-data logger (S7-5929)

12:25 ***Lunch***

14:00 **Tomowo Watanabe, Manabu Shimizu, Takashi Setou, Hiroshi Kuroda, Masachika Masujima and Makoto Okazaki (Invited)**
Ocean monitoring system operated by fisheries institutes at waters around Japan (S7-5932)

14:30 **John A. Barth, Justin Brodersen, Francis Chan, Anatoli Y. Erofeev, Murray D. Levine, Kim Page-Albins, Stephen D. Pierce, Craig Risien, Laura Rubiano-Gomez, R. Kipp Shearman and B. Walton Waldorf**
An expanding observatory to monitor hypoxia off the Oregon (U.S.A.) coast (S7-5949)

14:50 **Tomoharu Senjyu, Takeshi Matsuno, Sang-Hyun Kim and Ig-Chang Pang**
Monitoring of the Changjiang Diluted Water around the Jeju and Tsushima Straits using fisheries trap-nets (S7-5894)

15:10 **Kwang-Soon Park, Dong-Young Lee, Jae-Il Kwon, Kwan Chang Lim, Sang-Ik Kim and Ki-Chun Jun**
Development of real-time coastal monitoring network and operational oceanographic system in Korea (S7-5992)

15:30 ***Coffee / tea break***

15:50 **Dong-Young Lee (Invited)**
Status of real-time data exchange and strategy for the development of regional GOOS (S7-5984)

16:20 **Gennady A. Kantakov, Viktor S. Tambovsky, Alexey O. Bobkov and Evgeny G. Lunev**
Surface currents new data collected during 2008-2009 Argo's ice/ocean drifters. Prototype trials in the Sea of Okhotsk (S7-5747)

16:40 **Yasumasa Miyazawa, Ruo Chao Zhang, Sergey M. Varlamov, Takashi Setou, Daisuke Ambe and Tomowo Watanabe**
Roles of *in situ* profile data obtained by Japanese fishery research agencies in quality of the eddy-resolving ocean reanalysis data: FRA-JCOPE2 (S7-5729)

17:00 **David G. Foley, Elizabeth A. Becker and Karin Forney**
Integrating ocean observing data to enhance protected species spatial decision support systems (S7-5953)

17:20 ***Session ends***

S7 Posters

S7-5533 **Sirajuddin M. Horaginamani and M. Ravichandran**
A study on impacts of anthropogenic CO_2 on oceans

S7-5646 **Howard J. Freeland and the Argo Steering Team**
Argo – An ocean observing system for the 21st century

S7-5699 **Xiutang Yuan, Aihua Chen, Yibing Zhou, Haiying Liu and Dazuo Yang**
The influence of cadmium on the antioxidant enzyme activities in polychaete *Perinereis aibuhitensis* Grube (Annelida: Polychaeta)

S7-5709 **Jingfeng Fan and Hongxia Ming**
Fecal coliform and typical enteric virus in representative bathing beaches of China

S7-5710 **Zhen Wang, Zhengxian Yang, Dongmei Zhao and Ziwei Yao**
Sources and deposition of heavy metals, nutrients and PAHs in the atmosphere of the North Yellow Sea

S7-5808 **Shin-ichi Ito, Yugo Shimizu, Shigeho Kakehi, Fumitake Shido, Taku Wagawa, Kazuyuki Uehara, Toshiya Nakano and Masafumi Kamachi**
A profiling mooring buoy to observe mixed layer formations in the western North Pacific and its combination with a deeper type underwater glider

S7-5865 **Koji Kakinoki, Tatsuro Watanabe, Katsumi Takayama and Osamu Katoh**
Behavior of the cold water area off the Sado Island in the Japan Sea detected from satellite altimeter data

S7-5927 **Hisashi Yamaguchi, Young Baek Son, Eko Siswanto, Joji Ishizaka, Sinjae Yoo, Yu-Hwan Ahn, Sang-Woo Kim, Junwu Tang, Hiroshi Kawamura and Yoko Kiyomoto**
Development and validation of a new satellite chlorophyll *a* algorithm in the Yellow and East China Seas with relation to suspended sediment concentration

S7-5928 **Yoshiyuki Nakano, Tetsuichi Fujiki and Shuichi Watanabe**
Development of compact drifting buoy for sea surface pCO_2 monitoring

S7 Oral Presentations

29 October, 9:05 (S7-5645), Invited

The state of the art of real-time monitoring – The Argo experience

Howard J. **Freeland**

Institute of Ocean Sciences, Fisheries and Oceans Canada, P.O. Box 6000, N. Saanich, BC, V8L 4B2, Canada
E-mail: howard.freeland@dfo-mpo.gc.ca

At the time of writing the Argo steering team is tracking more than 3300 floats. These floats are reporting data every 10 days from every ocean basin. The object is to make data freely available in near real-time and we are almost achieving this objective. Currently 90% of all profiles are available for download from the Global Argo Data Centres within 24 hours of their acquisition. So far 25 nations have deployed floats in support of Argo and this is likely to grow in the near future.

In keeping with the theme of this session I will review the experience gained by the Argo collaborators over the last 10 years as we built a global ocean climate observatory. Some mistakes have been made, but now, 10 years after OceanObs'99, we have the global array in place and use of the array is growing rapidly. Though 90% of profiles are available in near real-time it appears to be an overwhelming challenge to get the remaining 10% reporting quickly. We promised a delayed-mode quality control system, and this is working fairly well, but some substantial challenges remain. We promised global access, and while this is available in principle, in practice many scientists in developing nations have only weak access to high-speed internet and so find the challenge of downloading many 10 MByte files to be an overwhelming challenge. These are generic problems that will be familiar to any group that has tried to make large data sets uniformly available. Finally, managing and overseeing such a program remains a daunting challenge that requires substantial time and energy from a very small group of scientists.

29 October, 9:35 (S7-5765)

Has pollution of the sea around Japan become better? A discussion based on more than 10 years of monitoring at depths up to 4000m

Tsuyoshi **Kitamoto**[1], Hirotaka Hamanaka[1], Asako Toyozumi[1], Satoshi Tanaka[1], Hiroko Arataki[2], Yoichiro Ishibashi[2], Yukio Kishimoto[2], Hideaki Nakata[3], Satoru Futatsumachi[4], Joji Ishizaka[5], Hideaki Maki[6], Shuhei Nishida[7], Yukihiro Nojiri[8], Haruo Ogi[9], Yoshihisa Shirayama[10] and Shinsuke Tanabe[11]

1 Global Environmental Issues Division, Global Environmental Bureau, Ministry of the Environment, Japan, 1-2-2 Kasumigaseki, Chiyoda-ku, Tokyo, 100-8975, Japan
2 Japan NUS Co., Ltd., 3-9-15 Kaigan, Minato-ku, Tokyo, 108-0022, Japan. E-mail: ishibashi@janus.co.jp
3 Faculty of Fisheries, Nagasaki University, 1-14 Bunkyo-machi, Nagasaki, 852-8521, Japan
4 Japan Hydrographic Association, Dai-ichi Sougou Bldg. 6F, 1-6-6 Hanedakuko, Ota-ku, Tokyo, 144-0041, Japan
5 Hydrospheric Atmospheric Research Center, Nagoya University, Furo-cho, Chikusa-ku, Nagoya, Aichi, 464-8601, Japan
6 Water and Soil Environment Division, National Institute for Environmental Studies, 16-2 Onogawa, Tsukuba, Ibaraki, 305-8506, Japan
7 Ocean Research Institute, University of Tokyo, 1-15-1 Minamidai, Nakano, Tokyo, 164-8639, Japan
8 Center for Global Environmental Research, National Institute for Environmental Studies, 16-2, Onogawa, Tsukuba, Ibaraki, 305-8506, Japan
9 Yamashina Institute for Ornithology, 3-3 Enomoto-cho, Hakodate, Hokkaido, 042-0931, Japan
10 Seto Marine Biological Laboratory, Kyoto University, 459, Shirahama-cho, Nishimuro-gun, Wakayama, 649-2211, Japan
11 Center for Marine Environmental Studies, Ehime University, Bunkyo-cho 2-5, Matsuyama, 790-8577, Japan

There is a concern that even low levels of pollutants with no obvious adverse effects on human health may nonetheless have impacts on marine ecosystems. So, what is the current distribution of marine pollutants around Japan including offshore regions? Have pollutant levels decreased or increased?

To answer these questions and take appropriate measures, since 1998 the Japan Ministry of the Environment has conducted extensive Marine Environmental Monitoring Surveys extending to more than 100 miles offshore, and to depths of over 4000m. A status report was compiled using the data acquired by our 10+ year survey. We focused on the concentrations of pollutants such as PCBs, PCDD/Fs and TBT in sediments and marine organisms,

with concurrent analysis of seawater quality, community structure of meiobenthos and quality/distribution of marine debris. On the basis of the spatial and temporal trends of the pollutants, we considered whether current environmental regulations in Japan are appearing to have beneficial impacts on marine pollution here.

We found that the concentrations of dioxins in coastal sediments are higher near big cities than in offshore areas. In tissues of marine organisms, no consistent trend of decrease was evident over the past decade. In Japan, dioxin emissions to the air have been restricted by law since 1999, resulting in its rapid decrease in air, but not in the sea. As dioxins are highly persistent and bioaccumulative, the influence of past emissions may still remain. We conclude that the effects of dioxin regulation have thus far not caused any clear decline in concentrations in the marine environment, and continuous monitoring is still required.

29 October, 9:55 (S7-5593)

Some features of the distribution chlorophyll *a* in the north-western part of the Sea of Japan based on near real-time data

Elena A. **Shtraikhert**, Sergey P. Zakharkov and Tatyana N. Gordeychuk

V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: straj@poi.dvo.ru

Chlorophyll *a* concentration (Cchl-*a*) is one of the basic parameters of water bioproductivity. It can serve as an indicator of hydrological, hydrobiological, climatic, and ecological processes. Monitoring of Cchl-*a* in near real-time based on satellite data has allowed us to reveal the temporal course, including interannual anomalies, and its distribution at upwelling sites in the Peter the Great Bay and in the anticyclonic eddy in the north-western part of the Sea of Japan. Data on Cchl-*a* from the satellite SeaWiFS color scanner for 1998-2007 and MODIS-Aqua spectroradiometer for 2003-2007 were obtained from sites http://ocean.color.gsfc.nasa.gov and http://www.nowpap3.go.jp. Data from site http://ocean.color.gsfc.nasa.gov were processed by SeaDAS software. Anomaly indices were calculated from the monthly Cchl-*a* estimations obtained by averaging the MODIS-Aqua data. They were compared to the anomaly indices calculated by us for SST from MODIS-Aqua and for the quantity of atmospheric precipitation from the TRMM satellite. This data were obtained by means of the Giovanni System. To study the Cchl-*a* distribution at wind upwelling sites, the QuikScat satellite wind speed and direction from site http://www.ssmi.com/qscat were obtained. Investigations showed that in the Peter the Great Bay, the spring Cchl-*a* maximum is in April-May and the autumn maximum is in November. There is also a summer maximum, which is lesser in comparison with the first two and occurs in August. The greatest anomalies of Cchl-*a* for 5 years (from the MODIS-Aqua data) were observed for January, 2007, and April, 2003. It is noted that they are caused mostly by SST anomalies. The zone of increased Cchl-*a* caused by wind upwelling was the largest and most intense (most chlorophyll and lowest temperature) at the north-eastern bay coast. In separate years, it stretched from the coast in the open bay part more than 50 km offshore. October was most favorable for its development. The increased Cchl-*a* on the periphery of the anticyclonic eddy located by a ship survey on February 27, 2003, in a region with coordinates of 40.5-41ºN, 132.7-134ºE, were noted in October, 2002 – April, 2003.

29 October, 10:15 (S7-5665)

Detection of *Cochlodinium polykrikoides* blooms using spectral classification in the South Sea of Korea (SSK)

Young Baek **Son**[1], Joji Ishizaka[1] and Young-Sang Suh[2]

[1] Lab. of Satellite Biological Oceanography, Hydrospheric Atmospheric Research Center (HyARC), Nagoya University, Furo-cho, Chigusa-ku, Nagoya, Aichi 464-8601, Japan. E-mail: sonyb@hyarc.nagoya-u.ac.jp
[2] National Fisheries Research and Development Institute, Busan, 619-902, R Korea

For detection of *Cochlodinium polykrikoides* blooms in the South Sea of Korea (SSK), we developed a systematic method for classification of water type and red tide in complex coastal water conditions using MODIS remote sensing data. Data on radiance, chlorophyll, as well as inherent optical properties (IOPs) were processed.

Water type was tested to separate optically different water conditions using simple spectral classification. The first step for water type classification differentiated between clear/intermediate and turbid/high chlorophyll waters

using maximum radiance value of blue-to-green wavelengths. The second step used radiance values at red wavelengths to identify the turbid and high chlorophyll waters. The third step determined clear and intermediate waters using radiance values at blue and near-infrared wavelengths.

After separating different water types, red tide waters were determined from high chlorophyll water by four different criteria. Spectral information was used to determine the relationship between red tide (especially *C. polykrikoides* bloom) and non-red tide. The first step optically discriminated two different waters using relatively less/high contribution of detritus/gelbstoff to chlorophyll. The second step identified red tide water under less contribution of detritus/gelbstoff to chlorophyll. The third and fourth steps discriminated red tide water under high contribution of detritus/gelbstoff to chlorophyll.

This simple spectral classification delineates areal coverage of each water type and algal bloom in each case study. The results provide a more reliable and robust identification of water types and red tide over a wide range of oceanic environments than using chlorophyll *a* concentration, chlorophyll anomaly, or fluorescence analysis.

29 October, 10:55 (S7-5649), Invited

Trophic cascades in Hawaii's nearshore ecosystem: Using observing technology to understand ecological interactions

Kelly J. **Benoit-Bird**

College of Oceanic and Atmospheric Sciences, Oregon State University, 104 COAS Administration Bldg., Corvallis, OR, 97331, USA
E-mail: kbenoit@coas.oregonstate.edu

Moored single and multi-frequency echosounders were used to describe zooplankton, micronekton, and spinner dolphin distributions off the leeward coast of Oahu Hawaii while a moored acoustic Doppler current profiler (ADCP), thermistor chains, point current meters, and an autonomous vertical profiler provided a description of the physical circulation, and optical sensors on the autonomous profiler were used to characterize the distribution of phytoplankton. Intensive sampling with a 4-frequency echosounder, ADCP, vertical profiling package, and nets were used to examine specific ecological interactions. During the study, extremely thin, dense layers of phytoplankton were optically identified. Dense acoustic scattering layers comprised primarily of copepods were often identified just beneath phytoplankton layers, but were not found when phytoplankton were more diffusely distributed. The presence of zooplankton layers reduced the extent of the diel migration of mesopelagic micronekton leading to changes in the nocturnal behavior of spinner dolphins foraging on these micronekton. This ecosystem shows a strong, bottom-up trophic cascade where the physical environment affects the formation and persistence of thin phytoplankton layers which influence the formation of thin layers of zooplankton. The presence of zooplankton layers modifies the behavior of micronekton that serve as prey for spinner dolphins and, in turn, affects the nighttime behavior of dolphins. Sampling of these interactions was greatly facilitated by continuous observations of the physical habitat and four trophic levels as well as near real-time data on the physical and optical characteristics of the habitat that permitted intensive ship-based sampling when phytoplankton layers were detected.

29 October, 11:25 (S7-5611)

Real-time monitoring for mesopelagic fish abundance using J-QUEST integrated system of echosounder and stereo TV cameras

Hiroya **Sugisaki**[1] and K. Sawada[2]

[1] National Research Institute of Fisheries Science, Fisheries Research Agency, 2-12-4 Fukuura, Kanazawa, Yokohama, Kanagawa, 236-8648, Japan. E-mail: sugisaki@affrc.go.jp
[2] National Research Institute of Fisheries Engineering, 7620-7, Hasaki, Kamisu, Ibaraki, 314-0478, Japan

Real-time monitoring for studying deep-water ecosystems is challenging. A scientific echosounder is one of the few research items used for real-time monitoring of biomass of underwater fishes and invertebrates. However, the species shown by echosounder images cannot be identified precisely. In order to analyze both biomass and species simultaneously, an integrated system of echosounder and stereo TV cameras (J-QUEST) is developed. Using this system, real-time acoustic and visual data are able to be collected on a research vessel. For observing the abundance of deep-sea micronekton (mesopelagic fish, squids and so on), we improve the invisible lighting

system for mesopelagic fish based on the results of research on their visual acuity. We also develop a data acquisition system for micronekton abundance and their biological characteristics which can be used when we operate J-QUEST on the vessel. The data acquisition system can support species identification from TV camera images from J-QUEST. J-QUEST must become a helpful gear for *in situ* real-time observation of deep-sea organisms, and the result will contribute to the studies of not only deep-sea biology, but also the carbon cycle in the ocean. In this paper, we will introduce the design and summary of real-time underwater monitoring by the J-QUEST system and show the preliminary result of the J-QUEST monitoring cruise.

29 October, 11:45 (S7-5740)

Acoustic monitoring of hydrophysical processes in ocean shelf zones

Yury N. Morgunov, Yury A. Polovinka and Dmitry S. **Strobykin**

V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: doom46@yandex.ru

The results of theoretical and experimental studies of the formation and interaction of hydroacoustic and hydrophysical fields in shallow water area are presented. The use of multiplex phase manipulated signals enlarges the potential of remote acoustic methods for solution of reconstruction problems of water medium parameters. It allows us to measure the pulse characteristics, *i.e.* to single out, identify and measure the travel times of impulses propagating along different ray trajectories in the waveguide. By inverting the travel times, one can reconstruct temperature fields, tidal and internal wave parameters. This research direction is new and timely since it is concerned with the solution of such topical contemporary problems as climate change control and the application of environmentally balanced technologies to fisheries, bioresources regulation and replenishment.

29 October, 12:05 (S7-5929)

Measurement of swimming behavior of alfonsino *Beryx splendens* in experimental tank using micro-data logger

Natheer M. **Alabsi**[1], Hideaki Tanoue[1], Teruhisa Komatsu[1], Isamu Mitani[2], Mitsuhiro Kato[3], Toyomitsu Horii[4], Ichiro Aoki[2] and Nobuyuki Miyazaki[1]

[1] Ocean Research Institute, University of Tokyo, 1-15-1, Minamidai, Nakano-ku, Tokyo, 164-8639, Japan
E-mail: alabsinatheer@yahoo.com
[2] Department of Aquatic Bioscience, Graduate School of Agricultural and Life Sciences, University of Tokyo, Bunkyo, Tokyo, 113-8657, Japan
[3] Kanagawa Prefectural Fisheries Research Institute, Jogashima, Miura, Kanagawa, 238-0237, Japan
[4] National Research Institute of Fisheries Science, Fisheries Research Agency, 6-31-1 Nagai, Yokosuka, Kanagawa, 238-0316, Japan

Alfonsino (*Beryx splendens*) is a deep-water cosmopolitan fish species distributed around seamounts in all tropical and temperate seas excluding North-East Pacific ocean. With recent innovations in fishing technology, deep sea resources became easily accessible to fisheries and many stocks have been depleted. Other stocks will become depleted unless management measures are developed or in place. Alfonsino aggregate in schools on seamounts and this makes them an easy target to trawlers. Information about their behaviour is an important aid to management. With miniaturization of bio-logging devices, we can now successfully attach data-logger to small fishes like alfonsino, and report here results from the first use of these data-loggers to study behaviour of alfonsino. Water temperature and light environment are controlled at 13°C and dark, respectively to maintain dial natural habitat condition in the tank. We attached the acceleration data-logger D2GT (Little Leonardo Co., Tokyo) to two captive alfonsino and we collected data of surging and swaying acceleration for 3 days. We used acceleration profile to get a fish body tilt angle. We will present data demonstrating the ability of data-loggers to get tail beat, body tilt angle and other fine-scale movements of alfonsino.

29 October, 14:00 (S7-5932), Invited

Ocean monitoring system operated by fisheries institutes at waters around Japan

Tomowo **Watanabe**, Manabu Shimizu, Takashi Setou, Hiroshi Kuroda, Masachika Masujima and Makoto Okazaki

Marine Environmental Data Integrated Analysis Center, National Research Institute of Fisheries Science, Fisheries Research Agency, 2-12-4 Fukuura, Kanazawa-ku, Yokohama, 236-8648, Japan. E-mail: wattom@affrc.go.jp

The waters around Japan are among the most densely observed areas in the world ocean. Ocean monitoring by Japanese fisheries institutes has contributed oceanographic observation from the coastal area for long period. From the beginning of the monitoring program, information about relationships between oceanographic environment and fisheries has been an important concern for fisheries community. In recent years, the ocean monitoring system has been improved based on developments of internet environment and ocean numerical modeling systems, allowing real-time data distribution and integration. An ocean forecast model, FRA-JCOPE, which was developed under the cooperation of JAMSTEC, is operated by FRA for the monitoring system. The marked advantage of the system is real-time use of the oceanographic data obtained by fisheries institutes for data assimilation. While ARGO data and satellite data, SSH and SST, are important for the data assimilation, these data are less available from the coastal region which is especially important for fisheries. It is expected that the insufficiency is compensated by the fisheries institute's oceanographic data. The three-dimensional data produced by the monitoring system are provided to member institutes for diagnosing the oceanographic conditions and for providing fisheries information to local fisheries community. The data are also applied to the fisheries researches. For example, the drifts of Giant Jellyfishes in the East China Sea are calculated by using the forecasted surface currents. Transport experiments of bluefin tuna larvae near the continental shelves are performed in order to investigate the mechanisms of the recruitment of young bluefin tuna.

29 October, 14:30 (S7-5949)

An expanding observatory to monitor hypoxia off the Oregon (U.S.A.) coast

John A. **Barth**[1], Justin Brodersen[1], Francis Chan[2], Anatoli Y. Erofeev[1], Murray D. Levine[1], Kim Page-Albins[2], Stephen D. Pierce[1], Craig Risien[1], Laura Rubiano-Gomez[1], R. Kipp Shearman[1] and B. Walton Waldorf[1]

[1] College of Oceanic and Atmospheric Sciences, Oregon State University, 104 COAS Admin Bldg., Corvallis, OR, 97331-5503, USA E-mail: barth@coas.oregonstate.ed

[2] Department of Zoology, Oregon State University, 3029 Cordley Hall, Corvallis, OR, 97331, USA

Near-bottom waters over the inner shelf (< 50 m water depth) off central Oregon have been increasingly hypoxic (dissolved oxygen < 1.4 ml/l) over the last 8 years, including the appearance of anoxia in summer 2006. Near-bottom, inner-shelf hypoxia is driven by upwelling of low-oxygen, nutrient-rich sourcewater onto the continental shelf, followed by the decay of organic matter raining down from surface phytoplankton blooms. Through a combination of moorings, autonomous underwater gliders and ship sampling, we have been measuring dissolved oxygen with increasing temporal and spatial coverage. The mooring array spans the inner shelf (15 m isobath) along 60 km of Oregon coastline and includes two mid-shelf (70-80 m isobath) moorings. Two of these moorings return near-bottom dissolved oxygen, as well as temperature and salinity, in near real-time. Underwater gliders occupy an 85-km long cross-shelf section in the middle of the mooring array and return data to shore every 6 hours. Near real-time data are posted on the web (http://agate.coas.oregonstate.edu). We are coordinating the measurement of dissolved oxygen from annual National Oceanic and Atmospheric Administration (NOAA) groundfish and hake surveys which allows us to greatly expand the spatial footprint of our sampling. Accurate knowledge of the subsurface dissolved oxygen distribution provides the context for sampling to assess the impact of low oxygen on marine organisms, for example on larval and adult fish and invertebrates. Data from the observatory are used in a regression model to link observed inner-shelf, near-bottom oxygen levels with dissolved oxygen levels in offshore source water and with the wind forcing that brings offshore deep water onto the shelf.

29 October, 14:50 (S7-5894)

Monitoring of the Changjiang Diluted Water around the Jeju and Tsushima Straits using fisheries trap-nets

Tomoharu **Senjyu**[1], Takeshi Matsuno[1], Sang-Hyun Kim[2] and Ig-Chang Pang[2]

[1] Research Institute for Applied Mechanics, Kyushu University, 6-1 Kasuga-koen, Kasuga City, Fukuoka, 816-8580, Japan
E-mail: senjyu@riam.kyushu-u.ac.jp
[2] College of Ocean Science, Cheju National University, Jeju, Jeju-do, R Korea

Low salinity water originating from the Changjiang River (Changjiang Diluted Water; CDW) spreads widely over the East China Sea in summer. The CDW is considered to affect the primary production in the shelf region through effects on light and nutrient availability. In addition, it is reported that freshwater with properties similar to the Changjiang discharge flows into the Japan Sea through the Tsushima Strait. To monitor the behavior of CDW, we attached T-S sensors (with a wiper to minimize bio-fouling) to fisheries trap-nets around the Jeju and Tsushima Straits in summer 2008. Salinity measurements at the all stations showed a clear seasonal variation with a minimum in August. Sub-inertial variations with periods of 3-5 days were superimposed on the seasonal cycle. Since the sub-inertial variations in temperature and salinity at the southeastern Jeju Island lead by 1-2 days those at northwestern Jeju Island, this variation may be due to an intermittent advection of high salinity water from the south, rather than to CDW advection. Cross-correlation between variations at Jeju and Tsutsu, the entrance of the western channel of the Tsushima Strait, suggests advection arrival time lag and speed between the two straits of 60-80 hours and 0.9-1.2 ms^{-1}, respectively. Salinity measurements at some stations in the eastern channel of the Tsushima Strait showed that the CDW was advected from the west of Kyushu to San'in coast in the Japan Sea by the Tsushima Current.

29 October, 15:10 (S7-5992)

Development of real-time coastal monitoring network and operational oceanographic system in Korea

Kwang-Soon **Park**[1], Dong-Young Lee[1], Jae-Il Kwon[1], Kwan Chang Lim[2], Sang-Ik Kim[1] and Ki-Chun Jun[1]

[1] Climate Change and Coastal Disaster Research Department, Korea Ocean Research and Development Institute, 1270 Sadong, Ansan 426-744, R Korea, E-mail: kspark@kordi.re.kr
[2] Oceanographic Division, Korea Hydrographic and Oceanographic Administration, 195 Seohaero, Junggu, Incheon, 400-800, R Korea

KORDI designed the implementation plan for the integrated coastal monitoring network in Korea at the request of Ministry of Land, Transport and Maritime Affairs (MLTM) in 2000. The integrated coastal monitoring network program is aimed to integrate field monitoring, numerical modeling and remote sensing technology to provide the coastal and ocean environmental data. The proposed plan has been implementing through partnerships within government agencies such as Korea Hydrographic and Oceanographic Administration (KHOA), National Fisheries Research and Development Institute (NFRDI) and Korea Meteorological Administration (KMA) since 2001. Eighty nine real-time coastal monitoring networks are currently operating in the surrounding waters of the Korean peninsula. In Korea, marine organizations normally collect the real-time coastal/offshore observing data and distribute them to users through various websites. To develop an operational oceanographic system in Korea (KOOS), KORDI designed the ten years implementation plan for the establishment of the KOOS at the request of MLTM in 2007. KORDI has been carrying out this project based on this plan since August, 2009. The objective of KOOS is to produce and give users the nowcast and the forecast information which is needed to support ocean activities and to resolve various concerned problems such as coastal disasters, oil spill, red tide, *etc.* Additionally in this presentation, we will show the operational storm surge prediction system that developed as a part of KOOS. Establishment of real-time coastal monitoring network in Korea and KOOS will contribute to, and may be part of, the NEAR-GOOS as a sub-system for this region.

29 October, 15:50 (S7-5984), Invited

Status of real-time data exchange and strategy for the development of regional GOOS

Dong-Young **Lee**

Climate Change and Coastal Disaster Research Department, Korea Ocean Research and Development Institute, P.O. Box 29, Ansan, R Korea. E-mail: dylee@kordi.re.kr

The regional scale ocean observing system for the exchange of real-time ocean observation data among the countries sharing the same water body is important in building operational ocean forecasting system. Since the establishment of the North East Asia Regional (NEAR) GOOS as a pilot program of regional ocean observing system, many regional GOOS have been organized in many other regions of the world. The performance and development of the regional GOOS of different regions will be reviewed together with state of art in operational ocean observing and forecasting system in coastal waters. Obstacles and problems to establishment of more active ocean observing system are analyzed, focusing especially on real-time data exchange for developing countries, and on the strategies needed for development of regional ocean observing system.

29 October, 16:20 (S7-5747)

Surface currents new data collected during 2008-2009 Argo's ice/ocean drifters. Prototype trials in the Sea of Okhotsk

Gennady A. **Kantakov**[1], Viktor S. Tambovsky[2], Alexey O. Bobkov[2] and Evgeny G. Lunev[3]

[1] Far-Eastern Ecological Center Ltd.,Office 404, Mira Ave., 426 Yuzhno-Sakhalinsk, 693004, Russia. E-mail: deco@sakhalin.ru
[2] Ecological Company of Sakhalin Ltd., 63 Rozhdestvenskaya St., Yuzhno-Sakhalinsk, 693007, Russia
[3] Marine Hydrophysical Institute Academy of Sciences of the Ukraine, Marlin-Yug Ltd. 3, 2 Kapitanskaya St.,Sebastopol, 99011, Ukraine

In the Sea of Okhotsk ice floe and sea surface drift measurements with satellite markers have been done widely since the 1990s. Lagrangian drift measurements are simple, objective and effective tools for obtaining data for model verification and monitoring of ocean currents. Many maritime/fisheries/offshore tasks require sea ice drift measurement during formation and following melting. The drift data are notably important for description of hydrodynamic conditions which influence the dissipation or accumulation of larval (ichthyoplankton) stages of commercially important gadoid fish species in the Sea of Okhotsk. Regular current observations by surface drifters are especially important for research on distribution of early ontogenetic stages for locations/seasons where flow variability is weakly periodic or aperiodic.

However, use of classic drifter buoy with underwater sail is often impossible in ice fields. Marlin-Yug company during 2007-2008 developed and tested in the Sea of Okhotsk a drifter prototype, which can continue work in the ocean water after ice melting, allowing measure of drift of both ice floes and open water surface currents. 2008 and 2009 experiment conducted in the northern Sea of Okhotsk by Far-Eastern Ecological Center Ltd. (FEEC Ltd.), Ecological Company of Sakhalin (ECS Ltd.) featured field trials of this prototype drifter. In 2008, the data revealed new information about surface waters circulation in the northern part of the Sea of Okhotsk. Maximum of daily currents were obtained in the Western Kamchatka shelf (0.78 m/s, buoy ID 84893), while currents maxima near Shelikhov Bay and close to Sakhalin were weaker (0.50 m/s and 0.48 m/s, buoy IDs 84890 and 84891 respectively). Cyclonic circulation in the northern part of the Sea of Okhotsk was confirmed. Nevertheless, in contradiction to earlier views about direction of main streams in the Sea of Okhotsk, 2008 surface currents near Sakhalin (buoy ID 84891 track) were directed anticlockwise, reflecting seasonal relaxation of the East-Sakhalin Current as well tidal effects near Kashevarov Bank and Iony Isle. Similar results were obtained later. In April, 2009 three Argos drifters (IDs 89998, 89999, 90000) were installed on the pack ice in the Sakhalinsky Bay near Amur River estuary. After breakup and melting of the pack ice all three drifters drifted to the northern part of the Sea of Okhotsk after anti-cyclonic spin-up in the Sakhalinsky Bay. An algorithm to estimate and filter-out impacts of wind and waves on buoy movements is in the beginning stage of development.

29 October, 16:40 (S7-5729)

Roles of *in situ* profile data obtained by Japanese fishery research agencies in quality of the eddy-resolving ocean reanalysis data: FRA-JCOPE2

Yasumasa **Miyazawa**[1], Ruo Chao Zhang[1], Sergey M. Varlamov[1], Takashi Setou[2], Daisuke Ambe[2] and Tomowo Watanabe[2]

[1] Research Institute for Global Change, JAMSTEC, Kanazawa-ku, Yokohama, Kanagawa, 236-0001, Japan
E-mail: miyazawa@jamstec.go.jp
[2] National Research Institute for Fisheries Science, Fisheries Research Agency, Kanazawa-ku, Yokohama, Kanagawa, 236-8648, Japan

We have recently produced the reanalysis data (JCOPE2 reanalysis data) with horizontal high resolution of 1/12º to describe the oceanic variability associated with the Kuroshio-Kuroshio Extension, the Oyashio, and the mesoscale eddies. The JCOPE2 reanalysis data have been created by using an eddy-resolving ocean general circulation model (JCOPE2) for the western North Pacific (10.5º-62ºN and 108º-180ºE) with assimilation of observational data, including satellite altimetry, satellite sea surface temperature, and *in situ* temperature and salinity profiles provided from the GTSPP archive. The JCOPE2 reanalysis data have not assimilated *in situ* salinity profiles for the period from 1995 to 1999 because some data have not been contained in the present version of the GTSPP archive. We thus produced a second version of the reanalysis data (FRA-JCOPE2 reanalysis data) for the period from 1993 to 2009 assimilating *in situ* temperature and salinity profiles provided from Japanese fishery research agencies in addition to the profiles archived in the GTSPP. The ocean model and data assimilation components for the FRA-JCOPE2 reanalysis data have been updated to reduce biases of water mass properties shown in the JCOPE2 reanalysis data. Comparison of the JCOPE2 and FRA-JCOPE2 reanalysis data indicates that the addition of the profile data improved the reproduction skills for the latitude of the southern end of the Oyashio coastal branch and the size of the Oyashio water in the Kuroshio-Oyashio mixed-water region. The FRA-JCOPE2 data also skillfully represent meso-scale events such as the Tsugaru warm water and warm-core rings in this region. The JCOPE2 reanalysis data and their updated versions are available from the authors by request. Our website: http://www.jamstec.go.jp/frcgc/jcope/ provides detailed information for data users.

29 October, 17:00 (S7-5953)

Integrating ocean observing data to enhance protected species spatial decision support systems

David G. **Foley**[1,2], Elizabeth A. Becker[2] and Karin Forney[2]

[1] Joint Institute for Marine and Atmospheric Research, University of Hawaii, 1000 Pope Rd., Honolulu, HI, USA
[2] NOAA-Fisheries, Southwest Fisheries Science Center, La Jolla, CA, 97365, USA. E-mail: dave.foley@noaa.gov

This presentation describes ongoing efforts to provide spatially explicit, quantitative predictions of marine mammal habitat (probability of occurrence) and species density. This project provides support for environmental planners to estimate and avoid potentially adverse interactions with protected marine species (*e.g.*, ship strikes, oil drilling noise, Navy exercises). We have prepared a suite of oceanographic parameters derived from satellite observations in order to test their effectiveness at predicting Cetacean abundance. Complementary *in situ* data fields acquired during survey cruises in 1991, 1993, 1996, 2001, 2005, and 2008 provide critical "ground truth" of the satellite-derived data sets. The *in situ* measurements are especially important for resolving subsurface features that cannot be directly observed by satellite and must, instead, be derived by proxy. It is anticipated that in the near future, information related to marine ecosystems will be provided in the form of 4-dimensional fields produced by numerical models simulating the physical and ecological dynamics of regional marine systems. With this eventuality in mind, we have tested the utility of numerical forecasts (and retrospective fields) for predicting Cetacean habitat, and have found very encouraging results.

S7 Posters

S7-5533

A study on impacts of anthropogenic CO_2 on oceans

Sirajuddin M. **Horaginamani** and M. Ravichandran

Deptartment of Environmental Management, Bhararathidasan University, Palkaliperur, Tiruchirappalli, 620 024, India
E-mail: ecosirajuddin@yahoo.com

The global oceans are the largest natural reservoir for this excess carbon dioxide, absorbing approximately one-third of the carbon dioxide added to the atmosphere by human activities each year, and over the next millennium, is expected to absorb approximately 90% of the CO_2 emitted to the atmosphere. It is now well established that there is a strong possibility that dissolved CO_2 in the ocean surface will double over its pre-industrial value by the middle of this century, with accompanying surface ocean acidity (pH) and carbonate ion (CO32-) decreases that are greater than those experienced during the transition from ice ages to warm ages. Estimates of future atmospheric and oceanic CO_2 concentrations, based on the IPCC emission scenarios and general circulation models that include the biogeochemical cycles of carbon and nutrients, indicate that by middle of this century atmospheric CO_2 levels could be reach over 500 ppm, and near the end of the century they could be over 800 ppm. Corresponding models for the oceans indicate that surface water acidity (pH) drop would be approximately 0.4 pH units, and the carbonate ion concentration would decrease almost 50 % by the end of the century. This surface ocean pH drop would be lower than it has been for more than twenty million years. A pH reduction of approximately 0.1 unit in surface waters has occurred already due to oceanic uptake of anthropogenic CO_2.

S7-5646

Argo – An ocean observing system for the 21st century

Howard J. **Freeland** and the Argo Steering Team

Institute of Ocean Sciences, Fisheries and Oceans Canada, P.O. Box 6000, Sidney, BC, V8L 4B2, Canada
E-mail: howard.freeland@dfo-mpo.gc.ca

This poster is designed to describe the progress of the international Argo array.

Argo is an international venture designed to install a global array of profiling floats in all oceans of the world, with deployments starting in 2001 and continuing. This poster will summarize progress towards full implementation of a globally homogeneous array of devices. At the time of writing Argo is tracking more than 3300 floats reporting data every 10 days from every ocean basin on the planet. The object is to make data freely available in near real-time and we are almost achieving this objective. Currently 90% of all profiles are available for download from the Global Argo Data Centres within 24 hours of their acquisition. So far 25 nations have deployed floats in support of Argo and this is likely to grow in the near future.

Argo now permits mapping of the physical oceanography of the top 2000 decibars of the ocean in near real-time. This should be of particular interest to scientists attempting an ecosystem approach to the management of ocean resources. To date Argo has focused on its primary mission of describing the distribution of heat and fresh water in the oceans and the advection of those. However, in rapidly increasing numbers floats are being deployed with sensors designed to observe dissolved oxygen. This opens the way to a wide area of new applications.

S7-5699

The influence of cadmium on the antioxidant enzyme activities in polychaete *Perinereis aibuhitensis* Grube (Annelida: Polychaeta)

Xiutang **Yuan**[1,2], Aihua Chen[1], Yibing Zhou[1], Haiying Liu[1] and Dazuo Yang[1]

[1] Dalian Fisheries University, Dalian, 116023, PR China. E-mail: xtyuan@nmemc.gov.cn
[2] Department of Marine Environmental Ecology, National Marine Environmental Monitoring Center, State Oceanic Administration (SOA), P.O. Box 303, Dalian, 116023, PR China

The infaunal polychaete *Perinereis aibuhitensis* Grube, widely abundant along Asian coasts and estuaries, is considered a useful animal model in ecotoxicological tests and a promising candidate in biomonitoring programs. This paper deals with the change in the activity of antioxidant enzymes including superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidases (GSH-Px) in this species exposed to a series of sublethal water-bound cadmium concentrations (0, 0.34, 1.72, 3.44, 6.89, and 17.22 $mg.L^{-1}$) under a short-term exposure (1-8d). The results indicate that the SOD and GSH-Px activities in *P. aibuhitensis* are stimulated first and then renewed to the original level. The CAT activity of worms decreases at an earlier exposure time but increases to the control values at a later exposure time. Our study suggests that cadmium (Cd) can interfere with the antioxidant defense system of the polychaete *P. aibuhitensis*. However, the activity changes of antioxidant enzymes in *P. aibuhitensis* do not show the best promise as biomarkers in Cd biomonitoring of estuarine and coastal zones because weak or non-dose-effect relationships between the antioxidant enzymes activities and Cd levels are found.

S7-5709

Fecal coliform and typical enteric virus in representative bathing beaches of China

Jingfeng **Fan** and Hongxia Ming

National Marine Environmental Monitoring Center, Dalian, 116023, PR China. E-mail: jffan@nmemc.gov.cn

Ten representative bathing beaches in China were investigated to study the incidence of fecal coliform and typical enteric viruses and their association by traditional microbiological and modern biological methods. One hundred surface seawater samples were assayed for fecal coliform detection and 20 samples were analyzed for human enteric viruses (hepatitis A viruses, rotaviruses, polioviruses). The result showed that fecal coliform in 7 bathing beaches exceeded the normal value with the concentration ranging from 2 to more than 2400 cfu/100mL in all these specimens (100 samples from 10 bathing beaches) and the ensemble average being 576 cfu/100mL. The virus incidence in water samples from 300 meters beyond the seashore was found to be correlated with those from 30 meters and 100 meters beyond the seashore. These viruses concentrated by Millipore virus concentration device (Centricon Plus-70) were detected by RT-PCR method. The Positive rate of hepatitis A viruses, rotaviruses, polioviruses were 5%, 40%, 40%, respectively. It was found that bacterial and viral contaminations were not correlated with each other. It is recommended that both bacterial and viral indicators are needed to reevaluate our current recreational water quality standards.

S7-5710

Sources and deposition of heavy metals, nutrients and PAHs in the atmosphere of the North Yellow Sea

Zhen **Wang**, Zhengxian Yang, Dongmei Zhao and Ziwei Yao

National Marine Environmental Monitoring Center, Dalian, 116023, PR China. E-mail: zwyao@nmemc.gov.cn)

Continuous emissions of polycyclic aromatic hydrocarbons (PAHs), trace metals and nutrients can lead to significant atmospheric deposition to coastal regions. Atmospheric deposition of these contaminants represents an important and dominant source of contaminants to aquatic ecosystems. To capture the *regional* atmospheric signal, sampling sites can be located in background areas away from local sources. Moreover, because many urban/industrial centers are located on or near the Yellow Sea coastal areas, emissions of contaminants into the urban atmosphere being reflected in elevated local and regional pollutant concentrations and localized intense atmospheric deposition should be addressed, and thus sites can be selected near an urban area. The results obtained

from this research and monitoring network provide estimates of the importance of atmospheric delivery processes to the Yellow Sea surface waters. The evaluation of the potential impact of atmospheric deposition to aquatic ecosystems and the identification of local and regional sources of atmospheric contaminants were implemented. The current concentrations and deposition fluxes of Cu, Pb, Zn, Cd, Fe, Hg, nitrate, ammonium salt and PAHs were quantified, and their spatial and seasonal trends were assessed. Furthermore, the importance of atmospheric deposition of their pollutants relative to other inputs was determined. The results are important to established baseline levels of the organic contaminants in the gas, particle and precipitation phases and of the metals and nutrients in the particle and precipitation phase.

S7-5808

A profiling mooring buoy to observe mixed layer formations in the western North Pacific and its combination with a deeper type underwater glider

Shin-ichi **Ito**[1], Yugo Shimizu[1], Shigeho Kakehi[1], Fumitake Shido[1], Taku Wagawa[1], Kazuyuki Uehara[2], Toshiya Nakano[3] and Masafumi Kamachi[4]

[1] Tohoku National Fisheries Research Institute, FRA, 3-27-5 Shinhama-cho, Shiogama, Miyagi, 985-0001, Japan
E-mail: goito@affrc.go.jp
[2] Tokai University, 3-20-1 Orito, Shimizu-ku, Shizuoka, Shizuoka, 424-8610, Japan
[3] Japan Meteorological Agency, 1-3-4 Ootemachi, Chiyoda-ku, Tokyo, 100-8122, Japan
[4] Meteorological Research Institute, 1-1 Nagamine, Tsukuba, Ibaraki, 305-0052, Japan

From climatological analysis, the deepest mixed layer was found in the region 40-42N and 152-160E in the North Pacific. In this region, weak stratified thick layer was found from summer hydrographic observations and the thick layer was referred to as Transition Region Mode Water (TRMW). For the formation of TRMW, supply of saltier water by quasi-steady warm streamers is considered to play an important role. However, the observations in this region have been limited to summer season because of rough sea condition in other seasons. Accompanied with the deep mixed layer formation, a large nutrient supply is expected and the existence of TRMW is considered to intensify the formation of the mixed layer. Indeed, recently, a large nursery ground for mackerel, anchovy and sardine was found near the TRMW region. Therefore, it is important to observe the actual mixed layer formation process in the TRMW region. We deployed a profiling mooring buoy in the TRMW region. An underwater winch was mounted on the mooring (at a depth of 250m to avoid hazards from purse seining), and a CTD sensor buoy moves up and down from the winch. The profiling mooring buoy can make high-resolution time-series observations at a specific location, but the horizontal spatial coverage is limited. Underwater gliders have possibility to overcome this weak point. A deeper type underwater glider, equipped with CTD, DO-sensor and fluorometer, is now on test in the TRMW region.

S7-5865

Behavior of the cold water area off the Sado Island in the Japan Sea detected from satellite altimeter data

Koji **Kakinoki**, Tatsuro Watanabe, Katsumi Takayama and Osamu Katoh

Japan Sea National Fisheries Research Institute, Fisheries Research Agency, 1-5939-22, Suido-cho, Niigata, 951-8121, Japan
E-mail: kakinoki@affrc.go.jp

Because the location and spatial extent of cold water affects distributions of demersal fishes, knowledge of subsurface temperature patterns and their variability is very important for fisheries. In the Japan Sea, we have been analyzing the behaviors of some cold water areas off the Japanese Islands using long-time series of temperature at 100 m depth from 1964-2008. The temperature that is characteristic of a particular cold water area is different among places and also changes with season. We have therefore attempted to develop a new index based on sea surface dynamic height data which can be used throughout the year. Composite sea surface dynamic heights (CSSDHs) are estimated from satellite altimeter (Jason-1) data combined with the mean sea surface derived by numerical assimilation model data. The distances between the cold water area and the Sado Island (cold water distances) are obtained from the distribution of the temperature at 100 m depth. Using 5-season running mean, interannual variations of the CSSDH and the cold water distance are extracted. We compare the cold water

distances with the CSSDHs and look for the value of the CSSDH with high correlation coefficient. Fluctuations of the cold water distance agree well with those of the CSSDH which is 0 cm. Therefore the CSSDH is useful to detect behavior of the cold water area off the Sado Island.

S7-5927

Development and validation of a new satellite chlorophyll *a* algorithm in the Yellow and East China Seas with relation to suspended sediment concentration

Hisashi **Yamaguchi**[1], Young Baek Son[2], Eko Siswanto[2], Joji Ishizaka[2], Sinjae Yoo[3], Yu-Hwan Ahn[3], Sang-Woo Kim[4], Junwu Tang[5], Hiroshi Kawamura[6] and Yoko Kiyomoto[7,8]

1 Graduate School of Environmental study, Nagoya University, Furo-cho, Chikusa-ku, Nagoya, Aichi, 464-8601, Japan
E-mail: yamaguchi.hisashi@d.mbox.nagoya-u.ac.jp
2 Hydrospheric Atmospheric Research Center, Nagoya University, Furo-cho, Chikusa-ku, Nagoya, Aichi, 464-8601, Japan
3 Korean Ocean Research and Development Institute, Ansan 425-600, R Korea
4 National Fisheries Research and Development Institute, Busan, R Korea
5 National Satellite Ocean Application Service, 100010 Beijing, PR China
6 Graduated School of Science, Tohoku University, Sendai, 980-8578, Japan
7 Seikai National Fisheries Research Institute, 1551-8 Taira-machi, Nagasaki, 851-2213, Japan
8 Graduate School of Science and Technology, Nagasaki University, 1-14 Bunkyo, Nagasaki, Nagasaki, Japan

Accuracy of standard ocean color (SeaWiFS) chlorophyll *a* (Chl-*a*) (OC) is expected to be low in the Yellow and East China Seas. Recently, researchers from Japan, China and Korea shared the sea surface *in situ* Chl-*a* and bio-optical data from the Yellow and East China Seas. This has enabled development and validation of a local satellite algorithm for Chl-*a*. Satellite Chl-*a* was calculated from SeaWiFS normalized water leaving radiances with empirical local algorithms, which are based on OC4v4 and Tassan models. High suspended sediment areas are defined by normalized water-leaving radiance at 555 nm (nLw555) greater than 2 mW cm^{-2} um^{-1} sr^{-1}. Correlation between *in situ* Chl-*a* and OC Chl-*a* was relatively good; however OC Chl-*a* varied widely and was overestimated for the area with high nLw555. Chl-*a* from Tassan-model based algorithm with *in situ* Chl-*a* and SeaWiFS bio-optical data with nLw555 over 2 (TS2) was poorly correlated with *in situ* Chl-*a*. However, accuracy of TS2 Chl-*a* was better than OC Chl-*a* within the area of high nLw555. When OC Chl-*a* for low, estimates based on nLw555 and on TS2 Chl-*a* for high nLw555 were combined, and accuracy of the Chl-*a* was improved. This result indicated that accuracy of satellite Chl-*a* derived by combination of the different type of algorithms with different suspended sediment concentration expressed by nLw555 is better than standard algorithm, regardless of season and area. Chl-*a* data estimated by this new algorithm is expected to estimate more precisely the seasonal and interannual variability of phytoplankton biomass in the Yellow and East China Seas.

S7-5928

Development of compact drifting buoy for sea surface pCO_2 monitoring

Yoshiyuki Nakano[1], Tetsuichi **Fujiki**[2] and Shuichi Watanabe[2]

1 Marine Technology Center, Japan Agency for Marine-Earth Science and Technology, 2-15 Natsushima, Yokosuka, 237-0061, Japan
E-mail: ynakano@jamstec.go.jp
2 Mutsu Institute for Oceanography, Japan Agency for Marine-Earth Science and Technology, 690 Kitasekine, Sekine, Mutsu, 035-0022, Japan

To monitor the spatial and temporal variations of surface pCO_2 in the global ocean, there is an emerging need for new automated pCO_2 sensors which can be used in platform systems such as drifting buoys or moorings.. We have been developing the compact drifting buoy system (diameter 250-340 mm, length 470 mm, weight 15 kg) for pCO_2 measurement. The measurement principle for the pCO_2 sensor is based on spectrophotometry. The pCO_2 is calculated from the optical absorbance of a pH indicator solution equilibrated with CO_2 in seawater through a gas permeable membrane. The measured data were transmitted to the laboratory by Argos system. In the laboratory experiment, the buoy system obtained a precision within 3 µatm. We are improving the sensor components (*e.g.* pump, valves and light sauce) to increase the precision and accuracy. In order to reduce the effects of biofouling on the sensors, we tried the antifouling tests with some paints at our port facility (Aomori, Japan) for 18.5 months. Following successful tests, the silicon type paint was adapted as an anti-biofouling paint for drifting buoy. The drifting buoy system is practical for *in situ* long term observation. To test the long-term durability and effect of

anti-biofouling, the buoy systems have been moored with TRITON buoy in the western tropical Pacific Ocean (2ºN, 156ºE). The moored buoy systems are measuring sea-surface pCO_2 four times per day at three days intervals. We also deployed the two drifting buoys in Antarctic Ocean in January 2009. The expected lifetime of the pCO_2 measurement systems is about 1 year.

S8 POC/BIO Topic Session
Anthropogenic perturbations of the carbon cycle and their impacts in the North Pacific

Co-Convenors: James Christian (Canada) and Toshiro Saino (Japan)

Accumulation of anthropogenic carbon and associated changes in ocean chemistry ("ocean acidification") affect all of the world's oceans. Anthropogenic CO_2 has multiple feedbacks to ocean chemistry and biology, such as reduction of calcification, shifts in phytoplankton species composition, and dissolution of particulate or sedimentary carbonates. The carbon system can also be affected by other anthropogenic factors such as changes in river flow and aeolian dust deposition. Carbon and nutrient biogeochemistry will be affected both directly and indirectly by ocean acidification. This session invites papers that address the biogeochemistry of anthropogenic carbon (processes controlling its distribution, processes by which it alters ocean chemistry), other anthropogenic impacts on carbon and nutrient cycles, acidification impacts on marine biota, and feedbacks among these.

Tuesday, October 27 (9:00-17:10)

9:00 ***Introduction by Convenors***

9:05 **Richard E. Zeebe (Invited)**
The future ocean: More acid, less calcifying, and more transparent to sound? (S8-5658)

9:50 **Shu Saito and Akihiko Murata**
Decadal changes in $CaCO_3$ saturation state along 179°E in the Pacific Ocean (S8-5842)

10:10 **Christopher L. Sabine, Richard A. Feely, François M.M. Morel, Eric S. Egleston and Dana Greeley**
Past and present trends in ocean carbon uptake and storage in the North Pacific (S8-5888)

10:30 ***Coffee / tea break***

10:50 **Andrey G. Andreev**
Inorganic carbon parameters change in the surface waters of the subarctic North Pacific (S8-5826)

11:10 **Tsuneo Ono and A-line monitoring team**
Interannual variation of DIC in the Oyashio region along the A-line transect (S8-5625)

11:30 **Lauren W. Juranek, Richard A. Feely, William T. Peterson, Simone R. Alin, Jay Peterson, Kitack Lee, Christopher L. Sabine and Burke Hales**
A novel method for determining seasonal variations in aragonite saturation state in the eastern North Pacific continental shelf using multi-parameter analysis (S8-5883)

11:50 **James R. Christian**
The future ocean carbon cycle: Projections with the Canadian Earth System Model CanESM1 (S8-5775)

12:10 **Keith B. Rodgers, Laurent Bopp, Olivier Aumont, Daniele Iudicone, Jorge L. Sarmiento, Anand Gnanadesikan and John Dunne**
Changes in North Pacific ΔpCO_2 and air-sea CO_2 fluxes over the 21st century in coupled models (S8-5904)

12:30 ***Lunch***

14:20 **Steven S. Rumrill, Alicia R. Helms and Adam S. DeMarzo**
Long-term pH shift in a Pacific Northwest estuary: Potential relationship between ocean acidification and alkalinity within the South Slough (Coos Bay, Oregon, USA) (S8-5950)

14:40 **Tae-Wook Kim, Kitack Lee, Richard A. Feely, Christopher L. Sabine, Hae Jin Jeong and Kwang Young Kim**
Prediction of East/Japan Sea acidification over the past 40 years using a multiple-parameter regression model (S8-5780)

15:00 **Contributed poster presentations**

15:20 ***Coffee / tea break***

15:40 **Ryo Kimura, Hideki Takami, Tsuneo Ono, Toshihiro Onitsuka and Yukihiro Nojiri**
Effects of elevated pCO_2 on early development of the Ezo abalone *Haliotis discus hannai* (S8-5784)

16:00 **Shinya Fukuda, Iwane Suzuki, Takeo Hama and Yoshihiro Shiraiwa**
Control of seawater pH by the coccolithophorid, *Emiliania huxleyi* (Haptophyceae) (S8-5841)

16:20 **Takeo Hama, Shoko Kawashima, Yuhi Satoh, Koich Shimotori, Yuko Omori, Taiki Adachi, Shun Hasegawa, Hiroko Endoh, Takeshi Nakayama, Isao Inoue, Takashi Midorikawa, Masao Ishii, Shu Saitoh and Daisuke Sasano**
Experimental study on the effect of ocean acidification on microbial structure and bioelemental cycles (S8-5693)

16:40 ***Discussion***

17:10 ***Session ends***

S8 Posters

S8-5620 **Jae Hoon Noh, Dong Han Choi, Charity Lee and E.J. Carpenter**
Spatio-temporal variations of N_2 fixation rates and abundance of N_2-fixers in the northwestern Pacific

S8-5670 **Guimei Liu, Fei Chai, Huijie Xue and Lei Shi**
Primary productivity and pCO_2 variations in the China seas during 1990-2004: A three-dimensional physical-biogeochemical modeling study

S8-5714 **Zhongyong Gao, Liqi Chen and Heng Sun**
Transport of the Bering Slope Current and its effects on the carbon cycle in the Bering Sea and the western Arctic Ocean

S8-5770 **Toshiya Nakano, Kazuhiko Hayashi, Yuichi Sasaki, Masao Ishii and Takashi Midorikawa**
Estimation of the dissolved inorganic carbon inventory in the western North Pacific

S8-5871 **Jeong-Hee Shim, Dong-Jin Kang, Chun Ok Jo, Young-Keun Jin, Pavel Ya. Tishchenko, Anatoly Obzhirov and Kyung-Ryul Kim**
Distribution of surface pCO_2 and its controlling factors at the eastern shelf of the Sakhalin Island in the Sea of Okhotsk

S8-5911 **Hyung Chul Kim, Yiming Wang, Seong Heo and Pyoung Joong Kim**
Long-term variations and autumn distribution of inorganic nutrients in the Yellow Sea

S8-5912 **Yukihiro Nojiri, Shin-ichiro Nakaoka, Chihiro Miyazaki, Andrew G. Dickson and Inter-comparison Participants**
Indoor seawater pool inter-comparison of ocean surface pCO_2 systems developed for underway and buoy operation

S8 Oral Presentations

27 October, 9:05 (S8-5658), Invited

The future ocean: More acid, less calcifying, and more transparent to sound?

Richard E. **Zeebe**

School of Ocean and Earth Science and Technology, Department of Oceanography, University of Hawaii at Manoa, 1000 Pope Rd., MSB 504, Honolulu, HI, 96822, USA. E-mail: zeebe@soest.hawaii.edu

The oceans have absorbed about 40% of the carbon dioxide emitted by humans over the past two centuries. This equates to nearly 500 billion metric tons of carbon dioxide, equivalent in weight to about 28 inches of water (ca. 70 cm) across the whole State of Texas. As a result, surface ocean pH has already dropped by 0.1 units relative to preindustrial levels and is expected to drop by 0.3 units by 2100 under business as usual scenarios. This acidification process is expected to have detrimental consequences for a variety of marine organisms. I will present projections of ocean chemistry changes for various CO_2 emission scenarios and discuss changes in parameters relevant to marine organisms such as pH and calcium carbonate saturation state. If alterations of ocean chemistry beyond certain threshold values are to be avoided in the future, specific CO_2 emission targets will be required. I will suggest values for those emission targets based on results from carbon cycle modeling efforts. I will also review several implications of ocean acidification for marine organisms. Finally, I will call attention to a surprising and hitherto largely unknown consequence of declining pH in the ocean: its effect on underwater sound absorption.

27 October, 9:50 (S8-5842)

Decadal changes in $CaCO_3$ saturation state along 179°E in the Pacific Ocean

Shu **Saito** and Akihiko Murata

Ocean Climate Change Research Program, Japan Agency for Marine-Earth Science and Technology, 2-15 Natsushima-cho, Yokosuka, Kanagawa, 237-0061, Japan. E-mail: ssaito@jamstec.go.jp

The ocean absorbs approximately one third of anthropogenic CO_2 released to the atmosphere. Consequently, one can expect that the ocean would be acidified. To investigate acidification in the Pacific, we calculated the degree of saturation of seawater with respect to aragonite (Ω_{arg}) and calcite (Ω_{cal}) using data obtained on the cruise MR0706 of the R/V *Mirai* (179°E meridian). The data were compared with WOCE P14N data obtained in 1993.

From the distribution of saturation states based on 2007 observation, it was found that the saturation depth of aragonite ($\Omega_{arg} = 1$) was located at around 200 m to the north of 50°N. The saturation depth deepened southward to 600 m at 30°N. From there, it shoaled gradually to approximately 200 m near 10°N and then deepened to 1000 m south of 20°S. For the calcite saturation depth, almost the same pattern was observed, but at greater depths than for aragonite, particularly in the Southern Hemisphere. Changes in the aragonite saturation state between the two time periods (values in 2007 minus those in 1993) ranged from +0.38 to -0.44, which were mostly found above 600m depth. The positive changes in the top 100 – 200 m were probably influenced by seasonal changes. The maximum decreases of the saturation states were found at 300 ± 100m, where mode waters exist. The degrees of saturation decrease estimated from increased anthropogenic CO_2 were somewhat smaller than the observed. Other factors such as changes in water temperature, salinity, circulation, biological productivity, *etc.* probably caused the differences.

27 October, 10:10 (S8-5888)

Past and present trends in ocean carbon uptake and storage in the North Pacific

Christopher L. **Sabine**[1], Richard A. Feely[1], François M.M. Morel[2], Eric S. Egleston[2] and Dana Greeley[1]

[1] Ocean Climate Research Division, NOAA/PMEL, 7600 Sand Point Way NE, Seattle, WA , 98115; USA
E-mail: Chris.Sabine@noaa.gov
[2] Department of Geosciences, Guyot Hall, Princeton University, Princeton, NJ, 08544, USA

Recent papers have suggested that CO_2 uptake in the Southern Ocean is decreasing due to changes in regional wind patterns. Is there any evidence that the North Pacific sink for CO_2 is also changing with time? While the Hawaii Ocean Time-series data indicate significant inter-annual variability, the 20 year record of surface pCO_2 appears to closely track the atmospheric CO_2 record. Repeat hydrographic sections along 152ºW, however, indicate that there are significant changes in the ocean storage of anthropogenic CO_2 over decadal time scales. Here we examine a number of recent repeat hydrographic transect data sets of carbon changes in the North Pacific to show that the efficiency of the North Pacific sink has decreased slightly. These changes can be related to changes in the ocean buffer factor, which can be further used to examine likely changes in the efficiency of the North Pacific sink in the future.

27 October, 10:50 (S8-5826)

Inorganic carbon parameters change in the surface waters of the subarctic North Pacific

Andrey G. **Andreev**

V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: andreev@poi.dvo.ru

The growth of carbon dioxide content in the atmosphere impacts the parameters of the seawater carbonate system. This study aims to elaborate an approach to detecting changes in dissolved inorganic carbon (DIC), total alkalinity (TA) and pH in the surface waters of the subarctic North Pacific during last three decades as a result of the atmospheric CO_2 concentration increase.

To eliminate strong seasonal variability, the winter remnant water layers in the western (depth interval 50-100 m) and eastern (depth interval 25-75 m) subarctic Pacific are examined. Our results demonstrate that in the surface waters of the subarctic North Pacific, TA-DIC and pH corrected for biological activity are decreasing at approximately 1 μmol kg^{-1} yr^{-1} and 0.003 pH unit yr^{-1}. This estimate is consistent with predicted rates of oceanic carbon dioxide accumulation in response to rising CO_2 in the atmosphere.

Seawater acidification could not lead to the excess TA and DIC production in the subarctic North Pacific, Bering and Okhotsk Seas due to the low carbonate content of the sediments. One of the main sources of the high TA and DIC surface waters in the western subarctic Pacific is the Bering Sea shelf. The salinification of the river water influenced seawater due to brine production in winter produced high nTA, nCa, and nDIC* waters with a salinity of 31-34 in the shelf areas of the Bering Sea. High nTA, nCa, and nDIC* waters are transported into the western subarctic Pacific by the Bering Slope Current, which are modified by mixing with the northern Bering Sea shelf waters, and by the East Kamchatka Current.

27 October, 11:10 (S8-5625)

Interannual variation of DIC in the Oyashio region along the A-line transect

Tsuneo **Ono**[1] and A-line monitoring team

[1] Hokkaido National Fisheries Research Institute, Fisheries Research Agency, 116 Katsurakoi, Kushiro, 085-0802, Japan

The Japan Fisheries Research Agency (FRA) has maintained DIC measurements in the Oyashio region, at the western edge of the western North Pacific Subarctic Gyre, along the hydrographic monitoring line *"A-line"* since 1996. Water sampling is conducted basically on a seasonal basis, and 12-year interannual variations of mixed layer DIC concentration in each season and its annual amplitude are analyzed and presented here. DIC concentration in the summer mixed layer was ~1950 μmol/kg and was almost constant throughout the observation period, while

winter concentrations showed significant interannual variations reflecting year-to-year differences of mixed layer water mass formation. In the western subarctic North Pacific region, a trend toward surface stratification and a corresponding decrease of winter mixed-layer nutrient concentration were observed, possibly due to global warming. In this DIC time series, however, no statistically significant trend is observed, possibly due to large variations with shorter time scales (*e.g.*, interannual).

27 October, 11:30 (S8-5883)

A novel method for determining seasonal variations in aragonite saturation state in the eastern North Pacific continental shelf using multi-parameter analysis

Lauren W. Juranek[1], Richard A. **Feely**[1], William T. Peterson[2], Simone R. Alin[1], Jay Peterson[2], Kitack Lee[3], Christopher L. Sabine[1] and Burke Hales[4]

[1] Ocean Climate Research Division, Pacific Marine environmental Laboratory/NOAA, 7600 Sand Point Way NE, Seattle, WA, 98115, USA. E-mail: Richard.A.Feely@noaa.gov
[2] National Marine Fisheries Service, Northwest Fisheries Science Center, Hatfield Marine Science Center, Newport, OR, USA
[3] School of Environmental Science and Engineering, Pohang University of Science and Technology, Pohang, R Korea
[4] College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR, USA

The continental shelf region off central Oregon is seasonally exposed to water with a low aragonite saturation state (Ω_{arag}) by coastal upwelling of deep waters. However, the magnitude of Ω_{arag} and its seasonal evolution have been largely unknown. We developed a multiple linear regression model to robustly determine Ω_{arag} from observations of temperature and oxygen (R^2 = 0.987, RMS error 0.05), using chemical and hydrographic data collected in the Pacific Northwest region in late May 2007. The seasonal evolution of Ω_{arag} near Newport was subsequently evaluated by applying the regression model to a monthly (winter) / bi-weekly (summer) water-column hydrographic time-series collected over the shelf and slope in 2007. The Ω_{arag} predicted by the regression model was less than 1, the thermodynamic calcification/dissolution threshold, over the shelf/slope bottom waters throughout the entire 2007 upwelling season (May–November), with the Ω_{arag}=1 isoline shoaling to 30 m by late summer. The persistence of water with Ω_{arag} <1 on the continental shelf has not been previously noted and could have profound ecological consequences for benthic and pelagic calcifying organisms such as mussels, oysters, abalone, echinoderms, and pteropods.

27 October, 11:50 (S8-5775)

The future ocean carbon cycle: Projections with the Canadian Earth System Model CanESM1

James R. **Christian**[1,2]

[1] Institute of Ocean Sciences, Fisheries and Oceans Canada, P.O. Box 6000, Sidney, BC, V8L 4B2, Canada
[2] Canadian Centre for Climate Modelling and Analysis, Environment Canada, University of Victoria, P.O. Box 3065, STN CSC, Victoria, BC, V8W 3V6, Canada. E-mail: jim.christian@ec.gc.ca

Global climate change and accumulation of anthropogenic CO_2 are superimposed on a large background of natural interannual and interdecadal variability. Understanding variability requires consideration of anthropogenically induced changes that have occurred throughout the modern era of ocean observation. The Canadian Centre for Climate Modelling and Analysis Earth System Model CanESM1 is a global climate model with fully interactive ocean and terrestrial ecosystem and carbon cycle models. Simulations with CanESM1 illustrate trends in ocean anthropogenic CO_2 accumulation and carbonate undersaturation under anthropogenic forcing including projections of future climate according to IPCC emission scenarios. Substantial shoaling of the calcite and aragonite saturation horizons has already occurred and is likely to accelerate. Global extratropical ocean export production is projected to decline by 5-10% by 2100. Ocean uptake of anthropogenic CO_2 in the future will be affected by changes in physical and biological processes due to climate change and ocean acidification. Natural CO_2 sinks in the North Pacific Ocean are vulnerable to anthropogenic impacts including dust mobilization and ocean acidification.

27 October, 12:10 (S8-5904)

Changes in North Pacific ΔpCO_2 and air-sea CO_2 fluxes over the 21st century in coupled models

Keith B. **Rodgers**[1], Laurent Bopp[2], Olivier Aumont[3], Daniele Iudicone[4], Jorge L. Sarmiento[1], Anand Gnanadesikan[5] and John Dunne[5]

1 Princeton University, AOS Program, 300 Forrestal Rd., Princeton, NJ, 08540-0710, USA. E-mail: krodgers@princeton.edu
2 Institut Pierre Simon Laplace, CE/Saclay, Orme des Merisiers, Bât 709, FR-91191 Gif-sur-Yvette Cedex, France
3 IRD, Centre IRD de Bretagne, BP 70, 29280 Plouzané, France
4 Stazione Zoologica Anto Dohrn, Naples, Italy
5 Geophysical Fluid Dynamics Laboratory, Princeton, NJ, 08540-6649, USA

Here we test the hypothesis that changes in the seasonal cycle will make a first-order contribution to the ocean uptake of CO_2 over the 21st century. This is tested using global three-dimensional climate models that include the ocean carbon cycle. The main result of this study is that while increased seasonal variability in carbon fluxes is characteristic of the extra-tropics for all of the major ocean basins, this effect is most pronounced over the North Pacific. Mechanistic analyses reveal that many of the changes over the North Pacific are driven by secular change in the physical state of the ocean, and in particular by modulation of the seasonal cycle in the physical state of the ocean.

27 October, 14:20 (S8-5950)

Long-term pH shift in a Pacific Northwest estuary: Potential relationship between ocean acidification and alkalinity within the South Slough (Coos Bay, Oregon, USA)

Steven S. **Rumrill**[1,2], Alicia R. Helms[2] and Adam S. DeMarzo[2]

1 University of Oregon – Oregon Institute of Marine Biology, 63466 Boat Basin Dr., Charleston, OR, 97420, USA
E-mail: Steve.Rumrill@state.or.us
2 South Slough National Estuarine Research Reserve, P.O. Box 5417, Charleston, OR, 97420, USA

Recent observations of elevated pCO_2 in ocean waters along the west coast of North America provide an opportunity to investigate the relationship between ocean acidification and pH values in Pacific Northwest estuaries. We examined time-series measurements of water column parameters recorded by a YSI-6600 multi-parameter datalogger deployed within the tidal channel of the South Slough estuary (Coos Bay, Oregon, USA). The datalogger operated continuously over the period of 2000-2008, and recorded about 210200 measurements of estuary pH values (YSI 6565 pH/ORP sealed gel probe; resolution 0.01 pH unit; accuracy ± 0.2 pH unit). Estuary pH values typically ranged between 7.7 and 8.3 throughout each day, and we observed a strong diel cycle with lowest pH in mid-morning and highest pH in mid-afternoon. The daily pH cycle appears to be driven by photosynthesis and respiration of phytoplankton, macroalgae, and submerged aquatic vegetation within the estuary. The time-series dataset also revealed a long-term shift in estuary pH values from a low mean value of 7.9 in 2001-02 to a higher mean value of 8.1 in 2007-08. Although the apparent shift toward increased alkalinity falls within the reported accuracy of the datalogger probe, the trend is supported by over 200000 data points and suggests that increased alkalinity may be real rather than an artifact. The long-term trend toward increased alkalinity of the marine-dominated South Slough estuary is unexpected, and provides evidence that the relationship between ocean acidification and pH values in Pacific Northwest estuaries may not be straightforward.

27 October, 14:40 (S8-5780)

Prediction of East/Japan Sea acidification over the past 40 years using a multiple-parameter regression model

Tae-Wook **Kim**[1], Kitack Lee[1], Richard A. Feely[2], Christopher L. Sabine[2], Hae Jin Jeong[3] and Kwang Young Kim[4]

[1] School of Environmental Science and Engineering, Pohang University of Science and Technology, Pohang, 790-784, R Korea
E-mail: ktl@postech.ac.kr
[2] Pacific Marine Environmental Laboratory/National Oceanic and Atmospheric Administration, 7600 Sand Point Way NE, Seattle, WA, 98115-6349, USA
[3] School of Earth and Environmental Sciences, College of Natural Sciences, Seoul National University, Seoul, 151-747, R Korea
[4] Faculty of Earth Systems and Environmental Sciences, College of Natural Sciences, Chonnam National University, Gwangju, 500-757, R Korea

A multi-parameter linear model of aragonite saturation state (Ω_{ARG}) as a function of temperature, pressure and oxygen for the upper 1000 m of the East/Japan Sea (EJS) was derived with an uncertainty of ±0.020 (1s). The Ω_{ARG} data (n=1482) used to derive the basin-wide Ω_{ARG} prediction model were collected during a comprehensive field survey conducted in 1999. Validation of the model against datasets obtained in 1992 and 2007 yielded Ω_{ARG} errors of -0.038 for 1992 and 0.0001 for 2007. The good correlation between measurements and predictions suggests that the model can be used to estimate the distribution of Ω_{ARG} in the EJS on varying time scales, when observations of T, P and O_2 are available. Application of the model to historical measurements of the EJS indicated that interdecadal variability (2s) in Ω_{ARG} in the EJS was generally high in the upper water column (<200 m), ranging from 0.1 to 0.7, and decreased with depth to 0.05-0.2 for deeper water (>500 m). Our analysis also indicated that the interdecadal variability was predominantly controlled by variations in the intensity of water column ventilation. Superimposed on this natural variability, anthropogenic CO_2 has acidified the upper waters, and thereby moved the aragonite saturation horizon upward by 50–250 m. This impact will increase in the future. The present study clearly indicates a multi-parameter model, in combination with easily measurable parameters, can be a useful tool for predicting the temporal variability of Ω_{ARG} in the ocean, including coastal waters that are most likely to be vulnerable to ocean acidification in the future.

27 October, 15:40 (S8-5784)

Effects of elevated pCO_2 on early development of the Ezo abalone *Haliotis discus hannai*

Ryo **Kimura**[1], Hideki Takami[2], Tsuneo Ono[3], Toshihiro Onitsuka[1] and Yukihiro Nojiri[4]

[1] National Research Institute of Fisheries Science (Yokosuka Station), Fisheries Research Agency, 6-31-1 Nagai, Yokosuka, Kanagawa, 238-0316, Japan. E-mail: rkim@affrc.go.jp
[2] Tohoku National Fisheries Research Institute, Fisheries Research Agency, 3-27-5 Shinhama, Shiogama, Miyagi, 985-0001, Japan
[3] Hokkaido National Fisheries Research Institute, Fisheries Research Agency, 116 Katsurakoi, Kushiro, Hokkaido, 085-0802, Japan
[4] Center for Global Environment Research, National Institute for Environmental Study, 16-2 Onogawa, Tsukuba, Ibaraki, 305-8506, Japan

The impact of ocean acidification will be more serious for calcifiers with calcium carbonate skeletons than for other organisms. We used an up to date CO_2 manipulation system with high accuracy to investigate organisms sensitive to CO_2 acidification, and reared marine calcifiers under elevated CO_2 in running water. We evaluated the effects of elevated partial pressure of carbon dioxide (pCO_2) in seawater on marine gastropods which have high commercial value. In larvae of the Ezo abalone *Haliotis discus hannai*, there is no effect of by exposure to <1100 ppm pCO_2 seawater observed in fertilization, malformation, or mortality rates until 15 hr after fertilization. However, fertilization and hatching rates decreased with exposure to seawater with 1650 and 2150 ppm pCO_2 15 hr after fertilization, the malformation rate increased significantly, and the larval shell diameter was smaller 75 hr after hatching, compared to those in control seawater (450 and 500 ppm pCO_2). This may be the first report on an economically important gastropod from the viewpoint of ocean acidification, and the results suggest that ocean acidification will potentially impact marine populations as a human food source in the future.

27 October, 16:00 (S8-5841)

Control of seawater pH by the coccolithophorid, *Emiliania huxleyi* (Haptophyceae)

Shinya Fukuda, Iwane Suzuki, Takeo Hama and Yoshihiro **Shiraiwa**

Graduate School of Life and Environmental Sciences, University of Tsukuba, 1-1-1 Tennoudai, Tsukuba, 305-8572, Japan
E-mail: emilhux@biol.tsukuba.ac.jp

Unicellular calcifying algae, coccolithophorids (Haptophyta), are widely distributed in the world's oceans. The most abundant coccolithophorid, *Emiliania huxleyi,* frequently forms huge blooms that cover over 100000 km^2 of the ocean surface. During such blooms, the alga produces massive amounts of organic and inorganic particulate carbon by photosynthesis and calcification, which induce change in ocean pH, and part of this production sinks to the bottom of the ocean. Thus, *E. huxleyi* has a great impact on the oceanic environment. Calcification is known as an acidifying process and therefore thought to promote oceanic acidification. On the other hand, photosynthetic fixation of CO_2 by microalgae is known to alkalize the medium. Therefore both reactions, acidification and alkalization, compete during growth of *E. huxleyi*. In this study, we studied how the pH of seawater is regulated by the coccolithophorid and how its growth, photosynthesis and respiration are affected by oceanic pH change, especially acidification. For this purpose, we set up a measuring system equipped with an oxygen electrode and pH-stat system to simultaneously determine photosynthetic activity and pH change during photosynthesis and respiration. Our experimental results show that the medium was alkalized by photosynthesis in the light and acidified by mitochondrial respiration in the dark. These are due to the reduction and production of H^+ by photosynthetic removal and respiratory generation of CO_2, respectively. We will also present quantitative data on relationships among pH change, calcification, respiration and photosynthesis and to show that *E. huxleyi* has the ability to control ocean pH.

27 October, 16:20 (S8-5693)

Experimental study on the effect of ocean acidification on microbial structure and bioelemental cycles

Takeo **Hama**[1], Shoko Kawashima[1], Yuhi Satoh[1], Koich Shimotori[1], Yuko Omori[1], Taiki Adachi[1], Shun Hasegawa[1], Hiroko Endoh[1], Takeshi Nakayama[1], Isao Inoue[1], Takashi Midorikawa[2], Masao Ishii[2], Shu Saitoh[2] and Daisuke Sasano[2]

[1] Graduate School of Life and Environmental Sciences, University of Tsukuba, Tsukuba, Ibaraki 305-8572, Japan
E-mail: thama@biol.tsukuba.ac.jp
[2] Geochemical Research Department, Meteorological Research Institute, Tsukuba, Ibaraki, 305-0052, Japan

Ocean acidification caused by uptake of atmospheric CO_2 has recently been recognized as "another CO_2 problem" and possible serious effects on calcifying organisms have been recognized. Little attention, on the other hand, has been given to the effect on non-calcifying organisms. In the present study, we carried out culture experiments (15 days) using coastal microbial populations under different pCO_2 conditions controlled by bubbling air with 400, 800, and 1200 ppm CO_2. Acidification was observed to depend on pCO_2, and pH varied with ranges of 8.02-8.10, 7.76-7.85 and 7.61-7.70 in the 400, 800 and 1200 ppm culture vessels, respectively. Although macronutrients such as nitrogen, phosphorus and silicate were added at the start of the experiment, the concentration of chlorophyll *a* was low (< 0.1 µg/L) in all vessels until Day 9, probably due to low temperature. The concentration of chlorophyll *a* tended to increase from Day 9 and the highest concentration was found on Day 15. This increase was obvious in the 400 ppm vessel, and concentrations in the 800 and 1200 ppm treatments on Day 15 were only 0.12 and 0.05 of that in the 400 ppm treatment. The results of the pigment analysis using a flow cytometer and microscopic observation showed that the growth of the prasinophycean alga, *Chrysochromulina* sp. occurred from Day 9. The fact that declining growth of *Chrysochromulina* sp. was more serious as pH decreased strongly suggests that ocean acidification results in changes in microbial community structure and accompanying bioelemental cycles.

S8 Posters

S8-5620

Spatio-temporal variations of N_2 fixation rates and abundance of N_2-fixers in the northwestern Pacific

Jae Hoon **Noh**[1], Dong Han Choi[1], Charity Lee[1] and E.J. Carpenter[2]

[1] Korea Ocean Research and Development Institute, 1270 Sandong, Sangnokgu, Ansan, Kyunggido, 426-744, R Korea
E-mail: jhnoh@kordi.re.kr
[2] Romberg Tiburon Center for Environmental Studies, 3152 Paradise Dr., San Francisco State University, Tiburon, CA, 94920, USA

The availability of nitrogen is important in regulating biological productivity and deepwater nitrate has long been considered the major source of new nitrogen supporting primary production in oligotrophic regions of the open ocean. Recent studies have shown that biological N_2-fixation has a critical role in supporting oceanic new production. However, limited information is available to help understand the nitrogen cycle in the NW Pacific. To help understand characteristics of N_2-fixation, N_2-fixation rates, abundance and diversity of nitrogen fixers in the different water masses of the NW Pacific were examined during October 2007 and June 2008 cruises. N_2-fixation rates were 49.1~2,156.6 μmolN $m^{-2}d^{-1}$ in June and 20.9~171.7 μmolN m^{-2} d^{-1} in October showing much variation among different water masses. The average rates for the warm pool, Kuroshio, and East China Sea were 913.8, 403.8, and 105.9 μmolN $m^{-2}d^{-1}$ in June and 107.8, 38.9, 40.9 μmolN $m^{-2}d^{-1}$ in October. Relatively high N_2-fixation rates observed in June for the warm pool were mostly due to high concentrations of *Crocosphaera* (up to $3.5x10^3$ cells/ml). However, *Crocosphaera* abundances in the warm pool were relatively low in October, and unobserved in the East China Sea in both cruises. For the Kuroshio currents in June, the high N_2-fixation rates were mainly affected by *Trichodesimum* and dinoflagellates with nitrogen fixing endosymbionts. The results showed that N_2-fixation rates in the warm pool are very high, and the main contributor is *Crocosphaera*. The analyses also reflected variation of N_2-fixation rates, diazotroph diversity and abundance in different water masses of the NW Pacific.

S8-5670

Primary productivity and pCO_2 variations in the China seas during 1990-2004: A three-dimensional physical-biogeochemical modeling study

Guimei **Liu**[1,2], Fei Chai[2], Huijie Xue[2] and Lei Shi[2]

[1] National Marine Environmental Forecasting Center, State Oceanic Administration, 8 Dahuisi, Haidian District, Beijing, 100081, PR China. E-mail: liugm.us@gmail.com
[2] University of Maine, School of Marine Sciences, 5706 Aubert Hall, Orono, ME, 04469, USA

In this study, a Pacific basin-wide physical-biogeochemical model driven by daily air-sea fluxes derived from the NCEP reanalysis is used to estimate physical-biogeochemical impacts on the carbon cycle in the China seas between 1990 and 2004. The similarities and discrepancies in simulated primary productivity and partial pressure of carbon dioxide (pCO_2) across scenarios are identified, particularly analyzing the uncertainties arising from regional-scale biogeochemical processes. Over the period 1990-2004 modeled climatologic carbon balance in the China seas ranged from a sink in winter (Dec-Feb) to a source in summer (Jun-Aug). The China seas' carbon cycle is very dynamic and heterogeneous, and characterized by strong spatial (mesoscale and sub-mesoscale) and high temporal variability. The ecosystems switch from a source of atmospheric CO_2 in the low latitudes of the South China Sea (SCS) to sinks in the Yellow Sea (YS) and East China Sea (ECS), with the strongest seasonal variation in the YS and the weakest in the SCS. Our results suggest that SST change in the China seas dominates the spatial and temporal variations of pCO_2. The biological pump plays a compensating role in modulating the variability of pCO_2 and determining its magnitude in the sub-regions. pCO_2 generally increases throughout the China seas between 1990 and 2004 in response to the anthropogenic increase of atmospheric CO_2. The rates of anthropogenic CO_2 increase in the YS, ECS, and SCS are 1.74 μatm /yr, 1.86 μatm /yr, and 2.04 μatm /yr, respectively.

S8-5714

Transport of the Bering Slope Current and its effects on the carbon cycle in the Bering Sea and the western Arctic Ocean

Zhongyong **Gao**, Liqi Chen and Heng Sun

Key Lab of Global Change and Marine-Atmospheric Chemistry, State Oceanic Administration, Xiamen, 361005, PR China
E-mail: zgao@263.net

The Bering Slope Current (BSC) is one of the most important currents in the Bering Sea, one of the two branches of which could flow northward and affect the carbon cycle in the Western Arctic Ocean. The Chinese National Arctic research expedition (CHINARE) has gone through the Bering Sea, crossing the Bering abyssal plain, Bering Slope and North Bering Sea shelf, Bering Strait and up to the 169/170ºW sections. Underway pCO_2 (partial pressure of CO_2 in surface water) observations and station sampling for CO_2 system parameters (pH, total alkalinity, DIC) and nutrients, and chlorophyll measurements were analyzed for the effects of BSC, using data collected on three cruises. Characteristics of the pCO_2 distribution in the Bering Basin and their relationships with the ambient hydrographic conditions are discussed using variations of the pCO_2 distribution along the section crossing the Bering Basin, Bering Slope, North Bering Sea shelf and the Chukchi Sea. The results show that the BSC has sharply affected the distribution of pCO_2 in the Bering Sea and the carbon cycle in the Western Arctic Ocean. The Bering abyssal plain was a High-Nutrient Low-Chlorophyll (HNLC) area, compared to the high productivity of the Bering continental shelf; much lower levels of chlorophyll *a* were observed over the Bering abyssal plain. It was found that the BSC could transport nutrients from the HNLC Bering abyssal plain through Bering Strait and up to the western Arctic Ocean where local nutrients were almost depleted in the surface water during summer. Resupplying nutrients would stimulate the growth of phytoplankton and enhance the capacity of the surface water to absorb atmospheric CO_2, which would implicate the western Arctic Ocean in global change.

S8-5770

Estimation of the dissolved inorganic carbon inventory in the western North Pacific

Toshiya **Nakano**[1], Kazuhiko Hayashi[1], Yuichi Sasaki[1], Masao Ishii[2] and Takashi Midorikawa[2]

[1] Global Environment and Marine Department, Japan Meteorological Agency, Tokyo, 100-8122, Japan
E-mail: nakano_t@met.kishou.go.jp
[2] Geochemical Research Department, Meteorological Research Institute, Tsukuba, 305-0052, Japan

We estimated the inventory of anthropogenic CO_2 in the western North Pacific along 137°E (WHP-P09) using the extended multiple linear regression (eMLR) method. Data from two cruises conducted by the JMA R/V Ryofu Maru II and III, RY9407 cruise as a WOCE one-time cruise in July-August 1994 and RF0406 cruise in June-July 2004, were used. Following Sabine *et al.* (2008, JGR), observed dissolved inorganic carbon (DIC) was fitted to a function of potential density, potential temperature, salinity, silicic acid and phosphate for each cruise. The standard deviation of observed DIC from the fitted function was about ±5 μmol kg^{-1} on both sections. The significant difference between DIC measured in 2004 and that predicted using coefficients estimated from 1994 data and applied to 2004 data was presumed to be the anthropogenic CO_2 increase, and was found in the subsurface layer (100-400 m, >10 μmol kg^{-1}) and in the North Pacific Intermediate Water (800-1200 m, ~6 μmol kg^{-1}). The anthropogenic CO_2 inventory increase averaged along 137°E was about 0.5 mol m^{-2} y^{-1}, comparable to that along the P02 line (Sabine *et al.*, 2008).

S8-5871

Distribution of surface pCO_2 and its controlling factors at the eastern shelf of the Sakhalin Island in the Sea of Okhotsk

Jeong-Hee **Shim**[1], Dong-Jin Kang[2], Chun Ok Jo[2], Young-Keun Jin[3], Pavel Ya. Tishchenko[4], Anatoly Obzhirov[4] and Kyung-Ryul Kim[2]

[1] Environment Research Division, National Fisheries Research and Development Institute, 408-1 Sirang-ri, Gijang-eup gun, Busan, 619-705, R Korea. E-mail: jshim@nfrdi.go.kr
[2] School of Earth and Environment Sciences (BK21), Seoul National University, Seoul, 151-742, R Korea
[3] Korea Polar Research Institute, KORDI, Incheon, 406-840, R Korea
[4] V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia

To understand the carbonate chemistry and sea-air CO_2 flux at the eastern shelf of Sakhalin Island in the Sea of Okhotsk, surface temperature, salinity and carbonate parameters were measured along about 144°E from 46 to 55°N in June 2006 and October 2007. Surface temperature was lower in June 2006 (0.5-3.8°C) than in October 2007 (3-12°C), while surface salinity showed similar distributions with a range of 31-33 and the lowest values around 48-50°N. Surface pCO_2 showed a much lower and wider range of 30-480 µatm (average 256 µatm) in June 2006 than that (a range of 280-380 µatm, average 339 µatm) of October 2007. A negative correlation (r^2=0.57) existed between surface pCO_2 and fluorescence in June 2006, suggesting that biological production is the major factor controlling surface pCO_2 distribution. In October 2007, however, a negative correlation between surface pCO_2 and temperature (r^2=0.74) and a positive correlation between surface pCO_2 and salinity (r^2=0.49) suggest that freshwater input and/or mixing between water masses might be the important processes controlling surface pCO_2 levels in that season. Especially, the lowest values of surface pCO_2 and salinity around 48-50°N for both months suggest that freshwater input from Sakhalin Island might be the main factor controlling surface pCO_2 distribution in that area. Sea-air CO_2 fluxes were -29 to +5 mmol m^{-2} d^{-1} and -22 to 0 mmol m^{-2} d^{-1} in June 2006 and October 2007, respectively. Therefore, the eastern shelf of Sakhalin Island in the Sea of Okhotsk acted as an effective CO_2 sink during the study periods.

S8-5911

Long-term variations and autumn distribution of inorganic nutrients in the Yellow Sea

Hyung Chul **Kim**[1], Yiming Wang[2], Seong Heo[1] and Pyoung Joong Kim[1]

[1] Environment Research Division, National Fisheries Research and Development Institute, Busan, 400-420, R Korea
E-mail: hckim@nfrdi.go.kr
[2] Offshore Environmental Monitoring Center Station, National Environmental Monitoring Center, PR China

Within the framework of a Korea-China Joint Research Program on the Yellow Sea, cruises were carried out once a year during September to January since 1997, to understand the dynamics of environmental parameters such as nutrients in the Yellow Sea. Nutrient concentrations display short-term variability and seasonal change, with higher levels in shallow coastal waters than in the central Yellow Sea. Nutrient concentrations in relation to autumn (October-November) physical parameters in the Yellow Sea were investigated during the last four autumn surveys. Three major water masses, the Yellow Sea Bottom Cold Water (YSBCW), Coastal Current Water (CCW) and Changjiang River Diluted Water (CRDW), prevailed in the study area. The influence of riverine discharge on nutrient levels can be seen from salinity isopleths and nutrient distribution. Near-bottom waters have much higher nutrient concentration than surface waters, whereas the distribution at 20 m depth was very similar to that of surface waters. Temperature and salinity distribution shows that stratification takes place at 20 to 30 m depth. Low nutrient concentrations in surface and 20 m depth waters of the central Yellow Sea were associated with stratification, which inhibits the supply of nutrients from bottom waters by vertical mixing. YSBCW, which is characterized by low temperature and high salinity, occupied the central part of the study area, expanding southward at 50 m depth. Influenced by runoff and tidally-induced vertical mixing, CCW has high nutrient concentrations and is probably associated with high nutrient concentrations in Korean and Chinese coastal waters. Relatively high phytoplankton biomass was observed in the coastal areas during the study periods. Overall, the autumn nutrient distribution pattern in the Yellow Sea appeared to be affected by: (1) Large-scale influx of YSBCW with high nutrient concentration and CCW with high nutrient concentration influenced by Korean and Chinese coastal waters; (2) stratification and vertical mixing of water masses; and (3) phytoplankton distribution. The results of this Joint Research between Korea and China indicates that concentrations of nitrate and silicate increased, whereas phosphate, ammonium and nitrite decreased in the study area over the last 10

years. This potentially has an important influence on the health of ecosystem in the Yellow Sea, such as food web and community structure, although further intensive studies are required with respect to the inshore areas affected by effluents from both Korea and China.

S8-5912

Indoor seawater pool inter-comparison of ocean surface pCO_2 systems developed for underway and buoy operation

Yukihiro **Nojiri**[1], Shin-ichiro Nakaoka[1], Chihiro Miyazaki[1], Andrew G. Dickson[2] and Inter-comparison Participants

[1] Center for Global Environmental Research, National Institute for Environmental Studies, 16-2 Onogawa, Tsukuba, Ibaraki, 305-8506, Japan. E-mail: nojiri@nies.go.jp

[2] Scripps Institution of Oceanography, University of California, San Diego, 9500 Gilman Dr., La Jolla, CA, 92093-0244, USA

An international ocean pCO_2 instrument inter-comparison including underway and autonomous buoy systems was held at the National Research Institute of Fishery Engineering, Japan using an indoor seawater pool on 27 February to 4 March, 2009. The pCO_2 buoy project was supported by JAMSTEC and the pCO_2 data analysis project by NIES. Seven underway systems and seven buoy systems were gathered for the campaign. The pool has a nominal volume of 170 m^3 and can be kept at a stable pCO_2 overnight because of the small temperature change. The pool water was well circulated by submersible pumps. The main water line (300 L/min flow rate) was installed at poolside and water was supplied for underway systems. Because water in the line was warmed by heat from the water line pump, underway pCO_2 was corrected for the measured difference of line and pool water temperatures, which was 0.04-0.06 K during the inter-comparison period. Five overnight comparisons were run. The inter-comparison was very successful and we confirmed that well designed NDIR pCO_2 systems will give very tight agreement for a wide pCO_2 range even for underway and buoy application. However, colorimetric buoys showed less agreement against the standard underway system and may need much more improvement in stability and accuracy.

S9 POC/FUTURE Topic Session
Outlooks and forecasts of marine ecosystems from an earth system science perspective: Challenges and opportunities

Co-Sponsored by IMBER

Co-Convenors: Harold P. Batchelder (U.S.A.), Michael Foreman (Canada), Anne B. Hollowed (U.S.A.) and Hiroaki Saito (Japan)

The prediction of responses of marine ecosystems to future climate scenarios is an important objective of PICES' new science program, FUTURE (**F**orecasting and **U**nderstanding **T**rends, **U**ncertainty and **R**esponses of North Pacific Marine **E**cosystems). However, the marine ecosystem is part of the earth system and its prediction needs integrated knowledge from physical, chemical, and biological perspectives. Earth system science is an interdisciplinary approach that integrates anthropology, atmospheric science, biology, oceanography, geophysics and policy to provide predictions of ecosystem response to climate change. The earth system is complex with non-linear feedbacks, threshold responses, and, in some cases, irreversible change. Understanding the mechanisms controlling these system properties is critical to accurately forecasting future states of nature in a changing climate. Moreover, conducting large-scale experiments on the earth system is impossible. Therefore, regional marine ecosystem models should include the earth system science links that are essential for producing better predictions of marine ecosystem response to future climate scenarios. This session will focus on multi-disciplinary coupled models and theoretical, observational and experimental studies designed to provide outlooks and/or forecasts of marine ecosystems. Outlooks and forecasts differ in that outlooks are qualitative with (often) unbounded uncertainties, while forecasts are often quantitative, but must have bounded certainties. Presentations that focus on both long-term and short-term predictions, and that link two or more disciplines (such as physical oceanography, climate, ecosystem dynamics, marine resource management, or socio-economic systems) are welcome. Presentations that explore what additional information or data are needed to provide outlooks and forecasts, and especially to transition from providing outlooks to providing forecasts are desired.

Day 1, Wednesday, October 28 (9:00-12:30)

9:00 **Takeshi Okunishi, Shin-ichi Ito, Atsushi Kawabata, Hiroshi Kubota, Taketo Hashioka, Hiroshi Sumata and Yasuhiro Yamanaka (Invited)**
A multi-trophic level ecosystem model for understanding mechanisms of small pelagic fish species alternation (S9-5745)

9:25 **Fei Chai, Francisco Chavez, Yi Chao, Lei Shi, Hongchun Zhang and Richard Barber**
Using remote sensing and modeling in operational forecasting of fisheries (S9-5934)

9:45 **Keiji Kiyomatsu, Takuji Waseda and Yasumasa Miyazawa**
Reconstruction of high-resolution historical February SST in the northwestern Pacific and its application to larval dispersion (S9-5898)

10:05 **Yury I. Zuenko**
How trends, shifts, and interdecadal fluctuations in climate reconstruct the ecosystem of the Japan/East Sea (S9-5549)

10:25 ***Cofee / tea break***

10:45 **Raghu Murtugudde (Invited)**
Marine ecosystem forecasting with an Earth System Prediction model (S9-5980)

11:10 **V.S. Labay**
Evolution of a benthos of coastal lagoons of Sakhalin Island: Causes and consequences (S9-5958)

11:30 **Yumiko Yara, Masahiko Fujii, Yasuhiro Yamanaka, Naosuke Okada, Hiroya Yamano and Kazuhiro Oshima**
Projected effects of global warming on coral reefs in seas close to Japan (S9-5798)

11:50 **Hiroaki Saito**
Modeling of organic matter dynamics in the mesopelagic zone: A perspective on modeling and ecosystem studies (S9-5692)

12:10 **Enrique N. Curchitser, Kenneth A. Rose, Kate Hedstrom, Jerome Fiechter, Shin-ichi Ito, Salvador Lluch-Cota and Bernard A. Megrey**
Development of a climate-to-fish-to-fishers model: Progress, issues, and some solutions (S9-5979)

12:30 ***Day 1 Session ends***

Day 2, Thursday, October 29 (14:00-17:50)

14:00 **Manuel Barange, Icarus Allen, Eddie Allison, Marie-Caroline Badjeck, Julia Blanchard, James Harle, Robert Holmes, Jason Holt, Simon Jennings, Gorka Merino, Christian Mullon and Emma Tompkins (Invited)**
Predicting the impacts and socio-economic consequences of climate change on global marine ecosystems and fisheries: The QUEST_Fish framework (S9-5834)

14:25 **Anne B. Hollowed, Nicholas A. Bond, James E. Overland and Thomas Wilderbuer**
Future conditions in the Bering Sea: Applications to walleye pollock and flatfish (S9-5973)

14:45 **Akihiko Yatsu, Sanae Chiba, Yasuhiro Yamanaka, Shin-ichi Ito, Yugo Shimizu, Masahide Kaeriyama and Yoshiro Watanabe**
Future of Kuroshio/Oyashio ecosystems: An outcome of the CFAME Task Team and WG20 (S9-5600)

15:05 **William T. Peterson, Edmundo Casillas, Hongsheng Bi and Cheryl A. Morgan**
Forecasting returns of coho and Chinook salmon: Presentation of a mechanism that links the PDO with ocean circulation, ecosystem structure and salmon returns in the coastal northern California Current (S9-5985)

15:25 ***Coffee / tea break***

15:45 **Michael Dalton (Invited)**
Climate change and marine ecosystems: Demographic and economic implications under IPCC scenarios (S9-5994)

16:10 **Harold P. Batchelder, Enrique N. Curchitser and Kate Hedstrom**
Modeling physical processes in the Northeast Pacific: model-data comparisons for assessing when model skill is sufficient as a basis for ecosystem simulation (S9-5969)

16:30 **Jie Shi, Hao Wei and Liang Zhao**
Numerical study of the aquaculture carrying capacity in a typical raft culture bay of China (S9-5787)

16:50 **Licheng Feng, Baochao Liu, Yi Cai, Zhanggui Wang, Jiping Chao and Jianping Li**
Numerical simulation of the Changjiang estuary ecosystem (S9-5773)

17:10 **Hernan Garcia, Sydney Levitus, Tim Boyer, Ricardo Locarnini, John Antonov, Daphne Johnson, Olga Baranova, Alexey Mishonov, Dan Seidov, Igor Smolyar, Melisa Zweng and Evgeney Yarosh**
The World Ocean Database and Atlas 2009 (S9-6005)

17:30 **Steven J. Bograd, Bryan A. Black, William J. Sydeman, Isaac Schroeder and Peter Lawson**
Wintertime ocean conditions synchronize rockfish growth and seabird reproduction in the California Current (S9-5889)

17:50 ***Session ends***

S9 Oral Presentations

28 October, 9:00 (S9-5745), Invited

A multi-trophic level ecosystem model for understanding mechanisms of small pelagic fish species alternation

Takeshi **Okunishi**[1], Shin-ichi Ito[2], Atsushi Kawabata[1], Hiroshi Kubota[1], Taketo Hashioka[3,4], Hiroshi Sumata[5] and Yasuhiro Yamanaka[3,4,5]

1 National Research Institute of Fisheries Science, Fisheries Research Agency, 2-12-4 Fukuura, Kanazawa, Yokohama, Kanagawa, 236-8648, Japan. E-mail: okunishi@affrc.go.jp
2 Tohoku National Fisheries Research Institute, Fisheries Research Agency, 3-27-5 Shinhama-cho, Shiogama, Miyagi, 985-0001, Japan
3 Creation of technological seeds responding to social demands (CREST), Japan Science and Technology Agency (JST), Sanbancho 5, Tokyo, 102-0075, Japan
4 Japan Agency for Marine-Earth Science and Technology, Yokohama, 236-0001, Japan
5 Graduate School of Environmental Earth Science, Hokkaido University, N10W5 Kita-ku, Sapporo, 060-0810, Japan

A multi-trophic level ecosystem model including Japanese sardine (*Sardinops melanostictus*) that couples physical, biochemical-plankton and fish models was developed to elucidate the mechanism of fish species alternation (*e.g.*, between sardine and anchovy) associated with climate regime shifts. An oceanic general circulation model was coupled with a lower trophic level ecosystem model (NEMURO: North Pacific Ecosystem Model for Understanding Regional Oceanography) and a fish model, and then applied to the western North Pacific. An individual-based modeling technique, which has many advantages for the spatially explicit modeling of marine fish life history, was used in the fish model. As environmental factors such as sea temperature, food availability and predation risk may affect the stock fluctuation and show large spatial-temporal variations, a model representing a realistic fish distribution is expected to provide a valuable tool for the comprehensive understanding of climate change effects on ecosystem dynamics. In this study, we focus on how environmental factors affect the geographical distribution of sardines. In the model, fish movement is assumed to be controlled by feeding and spawning migrations with passive transport by simulated ocean currents. Feeding migration is assumed to be governed by searching for local optimal habitats and escaping predation by the skipjack tuna (*Katsuwonus pelamis*). The local optimal habitats are estimated by the spatial distribution of net growth rate of a sardine bioenergetics sub-model. We demonstrate how predation risk affects the geographical distribution of sardines.

28 October, 9:25 (S9-5934)

Using remote sensing and modeling in operational forecasting of fisheries

Fei **Chai**[1], Francisco Chavez[2], Yi Chao[3], Lei Shi[1], Hongchun Zhang[3] and Richard Barber[4]

1 School of Marine Sciences, University of Maine, Orono, ME, 04401, USA. E-mail: fchai@maine.edu
2 Monterey Bay Aquarium Research Institute, Moss Landing, CA, USA
3 Jet Propulsion Laboratory/California Institute of Technology, Pasadena, CA, USA
4 Duke Marine Lab, Duke University, Beaufort, NC, USA

Recent advances in observing systems, computational power and understanding of ecosystem function offer evidence that the variability of the ocean ecosystem and its impact on fishery yield can be forecast with enough lead time to be useful to society. In this contribution we present efforts to enhance the current decision support system for the small pelagic fishery and upwelling ecosystem in the coastal ocean off Peru. In order to link climate variability with nutrients and plankton dynamics to Peruvian anchovy growth, distribution, and abundance, a Peru upwelling ecosystem model has been developed, which consists of three components. First, a Pacific basin-wide circulation model based on the Regional Ocean Model System (ROMS) is forced with daily air-sea fluxes derived from the NCEP reanalysis. Second, biogeochemical processes are simulated with Carbon, $Si(OH)_4$, Nitrogen Ecosystem (CoSiNE) model containing multiple plankton groups. The Pacific ROMS-CoSiNE model is integrated synchronously, and produces 3-day averaged outputs of three-dimensional temperature, current, nutrient and plankton distributions. The third component is an anchovy dynamical model using an individual based model (IBM) approach. The IBM anchovy model takes the ROMS-CoSiNE model outputs for the Peruvian coast, and links each life-stage of the anchovy growth and reproduction with environmental conditions. Our analyses focuses on each sub-model system performance, their connections, and how these processes along the

coast of Peru respond to ENSO and PDO. Also, we discuss how to integrate ENSO predictions into the physical-ecosystem modeling system to produce forecasts with 9 month lead time, which is useful for improving fishery management.

28 October, 9:45 (S9-5898)

Reconstruction of high-resolution historical February SST in the northwestern Pacific and its application to larval dispersion

Keiji **Kiyomatsu**[1], Takuji Waseda[1,2] and Yasumasa Miyazawa[2]

[1] Department of Ocean Technology, Policy and Environment, Graduate School of Frontier Sciences, the University of Tokyo, 5-1-5 Kashiwanoha, Kashiwa, Chiba, 277-8561, Japan. E-mail: kiyomatsu@orca.k.u-tokyo.ac.jp
[2] Research Institute for Global Change, Japan Agency for Marine-Earth Science and Technology, 3173-25 Showa-cho, Kanazawa-ku, Yokohama-shi, Kanagawa, Japan

We developed a new technique to reconstruct the sea surface temperature (SST hereafter) in the past. In the proposed method, high-resolution ocean reanalysis (JCOPE), reproducing meso-scale variability with high accuracy, is combined with the decadal-scale SST variability pattern obtained from an empirical orthogonal function analysis of the OFES ocean hindcast. A numerical model reproducing transport, survival and growth of the individual Japanese sardine was developed and the reconstructed historical SSTs were used. Simulation results suggest that negative SST anomalies lead to successful migration of sardine to the nursery ground because of the suitable SST off the southern coast of Japan. The success rate is closely related with the mortality rate of the post-larvae to age one sardine. Our approach, that effectively combines the long-term slow normal mode and the high-resolution fast normal mode, may be useful in assessing the impact of global warming on the Japanese sardine biomass.

28 October, 10:05 (S9-5549)

How trends, shifts, and interdecadal fluctuations in climate reconstruct the ecosystem of the Japan/East Sea

Yury I. **Zuenko**

Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia
E-mail: zuenko_yury@hotmail.com

Variability in the meteorological and oceanographic conditions of the Japan/East Sea is considered for the last 30-50 years with special interest given to trends, regime shifts, and inter-decadal fluctuations. Few parameters have significant trends: winter monsoon indices (weakening); air temperature in any season (warming); water temperature in any area, layer, and season (warming); oxygen content in deep and bottom layers (depleting). However significant trends are not revealed for other features (summer monsoon indices, mixed layer depth, Polar front position, ice cover) though some parameters have controversial trends in different layers (salinity). The main external factor driving these climatic trends is the weakening of the Siberian High. Its most important consequence for the oceanography of the Japan/East Sea is convective weakening, with slope convection cessation. Interdecadal fluctuations are revealed for all parameters; they corresponded to cooling in the 1980s, warming in the 1990s, and slight cooling again in the 2000s. Coincidently, two tendencies arising from different dynamics, a climate scale trend and interdecadal fluctuations, produced the regime shift in 1988-1990.

These observed tendencies in the environment have lowered the productivity of Japan/East Sea waters, mainly because their dynamics are weakening. However, these tendencies are favorable for the reproduction of zooplankton and many fish and squid species. Impacts of the interdecadal fluctuations are considered. Generally, the ecosystem of the Japan/East Sea is changing from a high-productive, low-effective state usual for Subarctic waters to a low-productive, high-effective state peculiar to Subtropic waters.

28 October, 10:45 (S9-5980), Invited

Marine ecosystem forecasting with an Earth System Prediction model

Raghu **Murtugudde**

ESSIC-AOSC, University of Maryland, College Park, MD, 20740, USA. E-mail: ragu@essic.umd.edu

As the anthropogenic impacts become evident in each component of the Earth System, the need for macro-scale projections for global governance and micro-scale predictions for adaptive management of resources has become urgent. Even though the resolution of the IPCC-class models continues to be enhanced, dynamical and statistical downscaling is the only avenue for driving policy and management decisions at meter-scales. A regional Earth System Prediction model has been implemented for the Chesapeake Bay to provide routine nowcasts-forecasts and projections from days to decades that include air and water quality, temperatures, winds, currents, humidity, rainfall, *etc*. with linked products such as harmful algal blooms, pathogens, dissolved oxygen, fisheries, and sea nettles. The regional Earth System prediction will be placed in the context of a global model for multi-species tuna prediction and projection with a focus on the North Pacific. The need to go from physics to fish to fishermen is being met with the global model while the ultimate feasibility of predictive models for microbes-to-man will depend on driving the data needs for validation, uncertainties, and skill assessment. Data assimilative methods are being employed to conduct observational system simulation experiments to optimize data gathering efforts. A number of user groups have been engaged to directly insert the Earth System forecasts into decision-making and an interactive tool provided to carry out what-if scenarios for management options. Global modeling needs for driving regional Earth System predictions are discussed in the context of marine ecosystem predictions.

28 October, 11:10 (S9-5958)

Evolution of a benthos of coastal lagoons of Sakhalin Island: Causes and consequences

V.S. **Labay**

Hidrobiological Laboratory, Sakhalin Research Institute of Fisheries and Oceanography (SakhNIRO), 196 Komsomolskaya St., Yuzhno-Sakhalinsk, 693023, Russia. E-mail: labay@sakhniro.ru

Benthos of lagoons is physically supervised, *i.e.* the structure and dynamics of the bottom population are under the control of external factors of environment. Evolution of the benthos of coastal lagoons of Sakhalin Island is defined by two principal causes: 1) change of communication with the sea and 2) invasion / acclimatization of new species.

1). Change of connection with the sea can be caused as the natural reasons (increase or sea level fall, formation of alluvial plaits *etc.*), and anthropogenous activity. The basic evolutionary factors are salinity, tidal dynamic and temperature. Defining modes of salinity: sea – till 22-26$^{o}/_{oo}$ (β-horogalinicum zone), brackish - from 22-26$^{o}/_{oo}$ to 5-7$^{o}/_{oo}$ (α-horogalinicum zone), oligosaline - from 5-7$^{o}/_{oo}$ till 0.1-0.01$^{o}/_{oo}$, fresh-water. Evolution of a benthos of lagoons in process of loss of connection with the sea (on bivalva prevailing in a sublitoral) forms a row: ostrea-pecten lagoons (sea salinity) → macoma type (brackish) → corbicula type (oligosaline) → kunashiria type (fresh-water). The type of tidal littoral communities (with prevalence of mollusks) is replaced by lake type of communities of wave littoral (with a dominant of an amphipoda *Eogammarus* and an isopoda *Gnorimosphaeroma*) in process of reduction of connection with the sea and easing of tidal dynamics. On a littoral a falling of an average biomass from sea lagoons to fresh-water lagoon lakes is noted. In a sublittoral the maximum biomass is observed in brackish lagoons. Easing of connection with the sea leads to extinction cold-water elements and to a prevalence of warm-water species both on a total quantity, and on a biomass.

2). Installation of new species leads to change of a benthos structure, and, as consequence, to change of the general biomass of a benthos and the trophic status of a lagoon.

To evolution of a sea lagoons benthos of Sakhalin Island 2 principles are applicable: 1) identity of final results at long-term and fast (catastrophic) influences; 2) convertibility of process.

28 October, 11:30 (S9-5798)

Projected effects of global warming on coral reefs in seas close to Japan

Yumiko Yara[1], Masahiko **Fujii**[1], Yasuhiro Yamanaka[1], Naosuke Okada[1], Hiroya Yamano[2] and Kazuhiro Oshima[1]

[1] Faculty of Environmental Earth Science, Hokkaido University, N10 W5, Kita-ku, Sapporo, 060-0810, Japan
E-mail: yara@ees.hokudai.ac.jp

[2] Center for Global Environmental Research, National Institute for Environmental Studies, 16-2 Onogawa, Tsukuba, Ibaraki, 305-8506, Japan

Global warming and associated increases in water temperature is considered to be a crucial factor for future corals, by inducing coral habitat migration toward higher latitudes and intensifying chances for coral bleaching and death. Using projected monthly-mean sea surface temperature in the 21st century, we quantitatively evaluate the potential effects of global warming on corals in seas close to Japan. Our result shows that the temperature-determined northern limit of coral habitat, which is currently located in Niigata and Chiba Prefectures, is expected to migrate northward, up to Aomori and Iwate Prefectures, and that the northern limit of subtropical coral reefs, currently located in the southern Kyushu, is estimated to go up to the northern Kyushu, by the end of the 21st century. In the Ryukyu Islands, on the other hand, both frequency and area of coral bleaching or death are expected to be intensified. Particularly, intermittently experienced high water temperatures which result in bleaching or death of present-day corals, will appear perpetually in the latter half of the 21st century.

28 October, 11:50 (S9-5692)

Modeling of organic matter dynamics in the mesopelagic zone: A perspective on modeling and ecosystem studies

Hiroaki **Saito**

Biological Oceanography Section, Tohoku National Fisheries Research Institute, FRA, 3-27-5 Shinhama-cho, Shiogama, 985-0001, Japan
E-mail: hsaito@affrc.go.jp

Most organic matter exported from the euphotic zone is remineralized in the dimlit mesopelagic zone, also called the "*twilight zone*". Organic matter flux from the euphotic zone (F_{EZ}) and the remineralization depth are essential issues to understand marine ecosystem dynamics and biogeochemical cycles. They are also crucial for assessing ocean responses to natural and anthropogenic perturbations and the feedback of the ocean system to the atmosphere, especially for the time scale of years to decades. The ratio of F_{EZ} to the net primary production (*Ez-ratio*) is quite variable in time and space, and episodic export events contribute a significant fraction of the F_{EZ}. Large variability is also observed in the vertical profile of sinking flux in the mesopelagic zone, and high F_{EZ} does not guarantee high flux to the bathypelagic zone. Variations of the strength and efficiency of the biological pump are induced by the food web components as well as surrounding physical and chemical environments. Although the simplification of food-web structure in a mathematical model is essential to reduce the uncertainty, oversimplifications in past models caused a failure in the reproduction of the F_{EZ} variability and the vertical attenuation profile of organic matter, especially in the upper mesopelagic zone. I review past model studies representing the biological pump and draw a perspective on future ecosystem studies to improve the biogeochemical model.

28 October, 12:10 (S9-5979)

Development of a climate-to-fish-to-fishers model: Progress, issues, and some solutions

Enrique N. **Curchitser**[1], Kenneth A. Rose[2], Kate Hedstrom[3], Jerome Fiechter[4], Shin-ichi Ito[5], Salvador Lluch-Cota[6] and Bernard A. Megrey[7]

1 Institute of Marine and Coastal Sciences, Rutgers University, 71 Dudley Rd., New Brunswick, NJ, 08901, USA
Email: enrique@marine.rutgers.edu
2 Department of Oceanography and Coastal Sciences, Louisiana State University, Baton Rouge, LA, 70803, USA
3 Arctic Region Super Computing Center, University of Alaska Fairbanks, 909 Koyukuk Dr., Suite 105, Fairbanks, AK, 99775, USA
4 Department of Ocean Sciences, University of California, Santa Cruz, CA, 95064, USA
5 Tohoku National Fisheries Research Institute, Fisheries Research Agency 3-27-5, Shinhama-cho, Shiogama-city, Miyagi, 985-0001, Japan
6 Centro de Investigaciones Biológicas del Noroeste, S.C. (CIBNOR), Mar Bermejo # 195 Col. Playa Palo de Santa Rita, La Paz B.C.S., 23090, Mexico
7 NOAA Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA, 98115, USA

An ecosystem approach to understanding large-scale patterns in exploited systems caused by both climate change and human activity increasingly relies on the use of numerical models. In the past, physical, lower and higher trophic level models were developed, tested, and implemented independently of each other. Recently, the advances in physics and biology have created the needed pieces for a comprehensive (end-to-end) ecosystem model, including humans as a dynamical component. The challenge is to integrate all the components, and examples of fully-coupled end-to-end models are relatively rare. This is partly due to the perception that blending separate yet complex sub-models is impractical because of demanding computational requirements and partly due to the respective communities working independently. In this presentation, we present our progress to date on the development of an end-to-end modeling framework within the widely-used ROMS (Regional Ocean Modeling System) circulation model. The NEMURO Nutrient-Phytoplankton-Zooplankton (NPZ) submodel provides the lower trophic level dynamics, and a multi-species individual-based submodel simulates fish population and community dynamics, including fishing fleets as one of the predator species. All of these models exist in various forms, but the individual sub-models have never been harmonized together into one integrated analysis tool useful for synthesis, integration, and prediction. This model framework was designed to investigate the effects of climate and fishing on marine ecosystems within one model that includes dynamical feedbacks among the different systems. We describe the conceptual and technical challenges involved in assembling and implementing such a model and we will present some early results of a test-bed (proof of principle) application developed to study the low-frequency fluctuations of sardine and anchovy.

29 October, 14:00 (S9-5834), Invited

Predicting the impacts and socio-economic consequences of climate change on global marine ecosystems and fisheries: The QUEST_Fish framework

Manuel **Barange**[1], Icarus Allen[1], Eddie Allison[2], Marie-Caroline Badjeck[2,3], Julia Blanchard[4], James Harle[5], Robert Holmes[1], Jason Holt[5], Simon Jennings[4], Gorka Merino[1,6], Christian Mullon[7] and Emma Tompkins[8]

1 Plymouth Marine Laboratory, Prospect Place, Plymouth, PL13DH, UK. E-mail: m.barange@pml.ac.uk
2 The WorldFish Center, P.O. Box 500, GPO, 10670, Penang, Malaysia
3 School of Development Studies, University of East Anglia, Norwich, NR4 7TJ, UK
4 Centre for the Environment, Fisheries and Aquatic Science, Lowestoft Laboratory, Pakefield Rd., Lowestoft NR33 0HT, UK
5 Proudman Oceanographic Laboratory, Joseph Proudman Bldg., 6 Brownlow St., Liverpool, L3 5DA, UK
6 School of Earth, Ocean and Environmental Sciences, University of Plymouth, Drake Circus, Plymouth, PL4 8AA, UK
7 Unité de recherche Ecosystèmes d'Upwelling, Centre de Recherches Halieutiques, Avenue Jean Monnet, 34200, Sète, France
8 School of Earth and Environment, University of Leeds, Leeds, LS2 9JT, UK

Climate change is accelerating and is already affecting marine ecosystems and the services they provide. Models and ocean observations indicate that the world's oceans are warming and patterns in atmospheric variability are changing, resulting in changes in oceanic stratification, circulation patterns, sea ice and light supply to the surface ocean. Biological responses to these effects are visible but uncertain. The quantification of direct climate impacts on the production of fish resources is hampered by: a) difficulties of downscaling Global Climate Models to the scales of biological relevance, b) lack of adequate global ecosystem models capable of scaling up from biological primary production processes to predict fish population dynamics, c) uncertainties over future global aquatic net primary production (NPP), and the transfer of this production through the food chain, and d) difficulties in

separating the multiple additional biological and socio-ecological stressors affecting fish production, including differential geographical and temporal exploitation patterns and economic policies. QUEST_Fish, a research consortium between leading UK and international institutions, is addressing some of these challenges through an innovative, multi-scale, multi-disciplinary approach focused on estimating the added impacts that climate change is likely to cause, and on the subsequent additional risks and vulnerabilities of these effects to human societies. The project is anchored on coupled shelf seas biophysical ecosystem models forced by Global Climate Model forecasts to predict ecosystem functioning in pre-industrial, present, near future (2050) and distant future (2100) time slices. For each time period we estimate plankton production in 20 Large Marine Ecosystem units around the world. Plankton production is linked to fish production through models based on macroecological theory, thus bypassing much of the species-based complexity of marine food webs in favor of expressing fish production by body size classes. We then develop improved ways of assessing vulnerability of fisheries to future climate change, in the context of other drivers of change, and specifically investigate the consequences of the results on the markets for major fish-based global commodities, such as fishmeal and fish oil. This presentation will describe the framework and provide initial results of QUEST_Fish. The results are useful to discuss the dual exposure of natural resources to both climate and markets, providing new insight into the complex interactions between humans and nature.

29 October, 14:25 (S9-5973)

Future conditions in the Bering Sea: Applications to walleye pollock and flatfish

Anne B. **Hollowed**[1], Nicholas A. Bond[2], James E. Overland[3] and Thomas Wilderbuer[1]

[1] Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA, 98115, USA. E-mail: Anne.Hollowed@noaa.gov.
[2] Joint Institute for the Study of Atnosphere and Ocean, Box 354925, University of Washington, Seattle, WA, 98195, USA
[3] National Oceanic and Atmospheric Administration, Pacific Marine Environmental Laboratory, 7600 Sand Point Way NE, Seattle, WA, 98115, USA

We present a framework to statistically downscale Bering Sea climate indices to time series of environmental variables required to project future recruitment of specific species. This framework enables stock assessment authors to make quantitative forecasts of the impact of climate change on the production and distribution of major fish resources in the Bering Sea. Previous research showed that output from some IPCC model runs can replicate the basin-scale variability of the North Pacific that was observed during the 20th century. This finding suggested that IPCC model output could be used to project future oceanographic conditions. The validity of these projections is dependent on: a) the analyst's ability to correctly model the functional relationships between production and the environment; and b) the analyst's ability to simulate future states of nature. We present statistical techniques to downscale the past climate forcing, as specified by the National Center for Environmental Prediction (NCEP) Reanalysis, to past observations of local environmental factors. The statistical relationships that are developed will be applied to climate forecasts from the IPCC models to produce time trajectories of local environmental factors that have the greatest impacts on the fish populations of interest. Some key factors linked to recruitment of marine fish cannot be projected directly from IPCC model simulations, principally because of the coarse resolution of the IPCC models or other limitations. In these situations, proxies must be developed to link the parameter of interest to the broad-scale variables that can be forecast with some reliability.

29 October, 14:45 (S9-5600)

Future of Kuroshio/Oyashio ecosystems: An outcome of the CFAME Task Team and WG20

Akihiko **Yatsu**[1], Sanae Chiba[2], Yasuhiro Yamanaka[3], Shin-ichi Ito[4], Yugo Shimizu[4], Masahide Kaeriyama[5] and Yoshiro Watanabe[6]

[1] Seikai National Fisheries Research Institute, Fisheries Research Agency, Taira-machi, Nagasaki, 851-2213, Japan
E-mail: yatsua@fra.affrc.go.jp
[2] Ecosystem Change Research Program, JAMSTEC, 3173-25 Showa-machi, Kanazawa-ku, Yokohama, 236-0001, Japan
[3] Faculty of Environmental Earth Science, Hokkaido University, N10W5 Kita-ku, Sapporo, Hokkaido, 060-0810, Japan
[4] Tohoku National Fisheries Research Institute, Fisheries Research Agency, 3-27-5 Shinhama-cho, Shiogama, Miyagi, 985-0001, Japan
[5] Graduate School of Fisheries Science, Hokkaido University, 3-1-1 Minato-cho, Hakodate, 041-8611, Japan
[6] Ocean Research Institute, University of Tokyo, 1-15-1 Minamidai, Nakanoku, Tokyo, 164-8639, Japan

The Kuroshio and Oyashio western boundary currents in the North Pacific greatly influence climate, ecosystems and fisheries in the western North Pacific and its adjacent waters. The Kuroshio/Oyashio system is also known to have decadal variability including regime shifts. Under the CFAME (Climate Forcing and Marine Ecosystem Response) Task Team of the CCCC Program in collaboration with WG20 (Evaluations of Climate Change Projections) of PICES, we analyzed the observed time series of physics, nutrients, zooplankton abundance and phenology, and productivity and biomass of commercially important fishes, as well as large-scale forcing such as the Aleutian Low. Based on the available knowledge of mechanistic linkages among them, we constructed conceptual models of stock fluctuations of chum salmon (*Oncorhynchus keta*), walleye pollock (*Theragra chalcogramma*), Japanese sardine (*Sardinops melanostictus*), Japanese anchovy (*Engraulis japonicus*), Pacific saury (*Cololabiss saira*), chub mackerel (*Scomber japonicus*), and Japanese common squid (*Todarodes pacificus*). Although, there are great uncertainties in applying results from the IPCC AR4 AOGCMs (atmosphere-ocean coupled general circulation models) to the Kuroshio/Oyashio region, we reviewed projections in the physical conditions of the target ecosystems. Finally, outlooks for selected commercial species were speculated upon using available qualitative knowledge about future physics and lower trophics in this region.

29 October, 15:05 (S9-5985)

Forecasting returns of coho and Chinook salmon: Presentation of a mechanism that links the PDO with ocean circulation, ecosystem structure and salmon returns in the coastal northern California Current

William T. **Peterson**[1], Edmundo Casillas[1], Hongsheng Bi[2,3] and Cheryl A. Morgan[2]

[1] NOAA-Fisheries, Northwest Fisheries Science Center, Hatfield Marine Science Center, Newport, OR, 97365, USA
E-mail: bill.peterson@noaa.gov
[2] Cooperative Institute for Marine Resources Studies, Hatfield Marine Science Center, Oregon State University, Newport, OR, 97365, USA
[3] University of Maryland, Chesapeake Biological Laboratory, Solomons, MD, USA

Successful prediction of fishery yields will require a modicum of knowledge of where in the ocean the target species lives during its life cycle, and of processes that impact survival. Towards this end, we have monitored hydrography, plankton and juvenile salmonid abundance in coastal waters off Washington and Oregon for 11 years, and hydrography, zooplankton and krill along off Newport Oregon for 14 years. Coho and fall Chinook live in shelf waters off the Pacific Northwest thus recruitment depends on processes in these waters. Although the rates at which salmon return to their natal streams are clearly a function of the phase of the PDO (negative phase, good returns; positive phase, poor returns), returns are best predicted by local biological factors: the date of biological spring transition, biomass anomalies of northern lipid-rich copepods, copepod community structure, and catches of juvenile salmon during summer surveys. We hypothesize that the link between the PDO and salmon is through changes in ocean circulation patterns: negative phase of the PDO results in more water entering the California Current from the north, bringing lipid-rich plankton to coastal waters; positive phase implies more water entering from offshore, bringing subtropical species with low lipid content to the coast. We use altimeter data to test the hypothesis that changes in phase of the PDO are accompanied by changes in coastal circulation patterns. Combinations of satellite data, models and ecosystem observations may be required to understand how variations in physical climate forcing will affect fisheries in FUTURE programs.

29 October, 15:45 (S9-5994), Invited

Climate change and marine ecosystems: Demographic and economic implications under IPCC scenarios

Michael **Dalton**

NOAA Fisheries, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA, 98115, USA. Email: michael.dalton@noaa.gov

Implications of key demographic trends in a dynamic global model of economic growth, trade, and food consumption, will be presented. This model has sufficient detail in its energy production sectors to be calibrated to international data on primary and secondary energy use, and utilizing that feature, a model tuning procedure was developed to harmonize assumptions about technical change and population growth with numerical results for emissions and other variables in multiple IPCC scenarios. The treatment of demographic change is a noted weakness of energy-economic models that were used in the development of past IPCC scenarios because many of these models essentially treat population as a scale factor. The model here incorporates effects, on economic variables such as labor supply and consumption patterns, of compositional changes in population age structure, household size, and levels of urbanization in different parts of the world. This model has sufficient detail in its consumption sectors to quantify effects on food demand (and seafood in particular) that are consistent with the IPCC scenarios which are being used to project fish and shellfish responses to climate change. The main conclusion here is that the social and economic assumptions that form different scenarios can imply disparate impacts on marine ecosystems over the next several decades, even if the climate outcomes are similar across scenarios during that same time period. This point highlights a need to develop Integrated Assessment Models that explicitly represent within each scenario interactions between anticipated climate outcomes and changes in human uses of marine ecosystems.

29 October, 16:10 (S9-5969)

Modeling physical processes in the Northeast Pacific: model-data comparisons for assessing when model skill is sufficient as a basis for ecosystem simulation

Harold P. **Batchelder**[1], Enrique N. Curchitser[2] and Kate Hedstrom[3]

[1] Oregon State University, College of Ocean and Atmospheric Science, 104 COAS Admin Bldg., Corvallis, OR, 97331-5503, USA. E-mail: hbatchelder@coas.oregonstate.edu
[2] Institute of Marine and Coastal Science, Rutgers University, 71 Dudley Rd., New Brunswick, NJ, 08901, USA
[3] School of Fisheries and Ocean Sciences, University of Alaska, P.O. Box 757222, 129 O'Neill Bldg., Fairbanks, AK, 99775-7220, USA

Ecosystem models coupled to physical models have become routine tools in exploring complex interdisciplinary dynamics. Worldwide, coupled physical-ecosystem models are being used to examine how present climate variability and future scenarios of climate change may impact ocean physics and ecosystem function. However, biological and ecological processes and rates that provide pattern in the oceans are very sensitive to the finescale details of the physical domain. If the physical domain of a model is not accurately representing "ocean truth", it is unlikely that ecological processes that are sensitive to the physics will be accurately simulated. For instance, slight inaccuracies in stratification intensity, mixed-layer depth (MLD), or timing of seasonal mixed layer development can have significant impacts on the timing of spring blooms, and the availability and replenishment of nutrients to surface phytoplankton. All of these in turn, significantly impact phytoplankton-grazer interactions, reproductive rates and secondary production, and ultimately higher trophic level predator-prey dynamics. We evaluate how well a 10 km horizontal resolution ROMS regional model reproduces spatial patterns, and seasonal and interannual signals known from observation. We use approaches that range from the "eyeball" norm to quantitative skill assessment. Evaluation of physical model fields should include both strong constraint subsurface and gradient features (*e.g.*, stratification intensity) as well as weaker constraint surface features such as sea surface height anomaly and sea surface temperature anomaly patterns, as ecosystem processes are strongly influenced by the subsurface and gradient features.

29 October, 16:30 (S9-5787)

Numerical study of the aquaculture carrying capacity in a typical raft culture bay of China

Jie **Shi**[1], Hao Wei[2] and Liang Zhao[1]

[1] Physical Oceanography Lab, Ocean University of China, Qingdao, 266003, PR, China. E-mail: shijie@ouc.edu.cn
[2] College of Marine Science and Engineering, Tianjin University of Science and Technology, Tianjin, 300222, PR China

Based on observations, the Princeton Ocean Model (POM) has been modified to simulate the current structure in a typical aquaculture semi-enclosed bay of China, Sungo Bay, by adding parameterizations for the frictional effects of both the infrastructure and kelp at the surface and the upper water column. A three-dimensional coupled physical-ecosystem-kelp model, called the Sungo Bay Kelp Capacity Model, is established to simulate the annual cycle and seasonal distribution of DIN concentration and phytoplankton biomass, the nutrient budget and the production of kelp. Model results indicate that the annual production of kelp is $7.01*10^4$ t dry weight, and the distribution of kelp production is mainly controlled by the supply of nutrients from the open sea. Production near the mouth of the bay is much larger than the inner part where DIN is deficient due to poor water exchange. Using the Sungo Bay Kelp Capacity Model, a series of numerical experiments are implemented to study the influence of different processes on kelp production. The polyculture of kelp and bivalves is a scientific aquaculture scenario for the growth of kelp. Model results under different kelp culture densities suggest that when the culture density is 0.9 times the present culture density, kelp production reaches a peak. It is also shown that decreasing the kelp density at the mouth could give a higher annual production in the whole bay due to more nutrients being supplied to the inner area.

29 October, 16:50 (S9-5773)

Numerical simulation of the Changjiang estuary ecosystem

Licheng **Feng**[1], Baochao Liu[2], Yi Cai[1], Zhanggui Wang[1], Jiping Chao[1] and Jianping Li[2]

[1] National Marine Environmental Forecasting Center, State Oceanic Administration, Beijing, 100081, PR China
E-mail: fenglichg@163.com.cn
[2] LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, 100029, PR China

In this study, the Changjiang estuary (120°-125°E, 29°-33.5°N) was divided into more than ten thousands curvilinear and orthogonal cells in the horizontal plane, with a maximum resolution of about 200 meters. Then we adopted the EFDC (Environmental Fluid Dynamic Code, which is a public domain surface water modeling system incorporating fully integrated hydrodynamic, water quality and sediment-contaminant simulation capabilities) to study the tide, ocean current, water temperature, salinity and some water quality variables in the Changjiang estuary. The model can simulate the tide very well, and reappearance ocean currents in the open sea, which are southward in winter along the coast and northeastward as the form of Changjiang dilution water in summer. The simulated monthly water temperature and salt distributions compare well with climatological observations. As for the water quality variables such as dissolved oxygen and nutrients, the concentration is low in summer due to a bloom of zooplankton, but high in winter along the coast. We have made some model experiments and found that when suspended sediment is taken into consideration, the chlorophyll *a* concentration is higher in the open sea compared to that along the coast. However, without suspended sediment, chlorophyll *a* concentration is higher along the coast in winter. This tells us that suspended sediment is very important in the simulation of chlorophyll *a* in the Changjiang estuary.

29 October, 17:10 (S9-6005)

The World Ocean Database and Atlas 2009

Hernan **Garcia**, Sydney Levitus, Tim Boyer, Ricardo Locarnini, John Antonov, Daphne Johnson, Olga Baranova, Alexey Mishonov, Dan Seidov, Igor Smolyar, Melisa Zweng and Evgeney Yarosh

NOAA, National Oceanographic data Center, Silver Spring, MD, USA. Email: Hernan.Garcia@noaa.gov

The World Ocean Database (WOD) is the largest collection of quality-controlled ocean profile data available online without restriction. WOD is constructed and maintained by the U.S. National Oceanographic Data Center. The WOD contains data for 25 different variables including temperature, salinity, oxygen, inorganic nutrients, and geochemical tracers among others. These data have been collected and measured with several different types of instrument systems including water bottle samplers, reversing thermometers, CTDs, XBTs, MBTs, profiling floats, gliders, moored buoys, and drifting buoys. The data in WOD and products based on WOD such as the World Ocean Atlas (WOA) climatologies have proven to be of great value to the oceanographic, climate, and geodetic communities. These products are used in ocean climate diagnostic studies, as boundary conditions in ocean circulation models, for ocean data assimilation studies, and as "sea-truth" for satellite altimetry studies among others. The effect of WOD and WOA can be quantified by a count of citations in the peer-reviewed scientific literature of the WOD and WOA atlases and their predecessor "Climatological Atlas of the World Ocean". Since 1982 these products have been cited more than 5,900 times. It is clear that global compilations of oceanographic data and analyses of these compilations are of great value to the science community. The scientific community is advising governments about global climate variability and global climate change. Thus the community needs to have access to the most comprehensive and quality controlled ocean profile databases possible. All data from ocean observing systems need to be permanently archived, preserved, documented with appropriate metadata and made available without restrictions.

29 October, 17:30 (S9-5889)

Wintertime ocean conditions synchronize rockfish growth and seabird reproduction in the California Current

Steven J. **Bograd**[1], Bryan A. Black[2], William J. Sydeman[3], Isaac Schroeder[1,3] and Peter Lawson[4]

[1] NOAA, Southwest Fisheries Science Center, Environmental Research Division, Pacific Grove, CA, 93950, USA
E-mail: steven.bograd@noaa.gov
[2] Oregon State University, Hatfield Marine Science Center, Newport, OR, 97365, USA
[3] Farallon Institute for Advanced Ecosystem Research, P.O. Box 750756, Petaluma, CA, 94975, USA
[4] NOAA, Northwest Fisheries Science Center, Newport, OR, 97365, USA

Growth-increment chronologies developed from otoliths of splitnose rockfish (*Sebastes pinniger*) and yelloweye rockfish (*Sebastes ruberrimus*) are compared with time series of lay date and fledgling success for the common murre (*Uria aalge*) and Cassin's auklet (*Ptychoramphus aleuticus*) in the central California Current. All time series are annually resolved and span 1972 through 1994. The leading principal component (PC1bio) accounted for 64% of the variance in the data set and all six measurement time series significantly loaded against it. When compared to monthly-resolved climate indices of upwelling, the Northern Oscillation Index, sea surface temperatures, and the Multivariate ENSO Index, PC1bio most strongly correlated with records from January, February, and March. These correlations were also stronger than that between PC1bio and an estimate of spring transition date. As upper-trophic predators, rockfish and seabirds independently corroborate that wintertime ocean conditions are critical for productivity in the California Current Ecosystem. Overall, PC1bio serves as an annually resolved, multidecadal indicator of ecosystem function that underscores the importance of ocean conditions prior to the peak of upwelling season during the spring and summer.

BIO Paper Session

Co-Convenors: Michael J. Dagg (U.S.A.) and Sinjae Yoo (Korea)

Oral and poster presentations on biological aspects of the Annual Meeting theme are welcome, as well as papers on all aspects of biological oceanography in the North Pacific and its marginal seas (except those related to the BIO-sponsored Topic Sessions S3 and S8). Early career scientists are especially encouraged to submit papers to this session.

Friday, October 30 (9:00-17:50)

9:00 ***Introduction by Convenors***

9:05 **David Mackas, Sonia Batten, Ken Coyle and Russ Hopcroft**
Perspectives on a decade of change in the Alaska Gyre: A comparison of three Northeast Pacific zooplankton time series (BIO-P-5937)

9:25 **Bryan A. Black**
Growth-increment chronologies reflect ecosystem responses to climate variability in the northeastern Pacific (BIO-P-5884)

9:45 **Seung-Hyun Son, Meng-Hua Wang and Jae Hoon Noh**
Satellite-observed chlorophyll *a* data in the dump site of the Yellow Sea (BIO-P-5703)

10:05 **Shinji Shimode and Atsushi Tsuda**
Geographical distribution and ontogenetic migration of *Eucalanus californicus* (Johnson) in the western North Pacific Ocean (BIO-P-5851)

10:25 ***Coffee / tea break***

10:50 **Mi Hee Chung and Won Duk Yoon**
Variation of the epiphytic community and biomass on *Zostera marina* (eelgrass) related to the host plant and environmental factors (BIO-P-5863)

11:10 **Tatyana N. Krupnova and Yury I. Zuenko**
Development *Laminaria japonica* early stages in the coastal waters of Primorye caused by climate change (BIO-P-5810)

11:30 **Hongyan Bao, Ying Wu, Lixin Tian, Jing Zhang and Guiling Zhang**
Sources and distributions of terrigenous organic matter in a mangrove-dominant small tropical estuary, South China (BIO-P-5867)

11:50 **Evgenia E. Vekhova, Michael I. Kusaykin and Konstantin V. Kiselev**
The phytoplankton contribution to the common mussel diet (Bivalvia: Mytilidae) of the Sea of Japan (BIO-P-5835)

12:10 **Anastasia Dolganova**
Modern condition of fauna of *Polychaeta* in the Amur Bay (Peter the Great Bay, Sea of Japan) (BIO-P-5565)

12:30 ***Lunch***

13:50 **Toru Kobari, Haruko Mori and Hitomi Tokushige**
Nucleic acid and protein contents of ontogenetically migrating copepods in the subarctic Pacific Ocean as influenced by development stage and depth (BIO-P-5561)

14:10 **Young-Ok Kim, Pung-Guk Jang, Eun-Jin Yang, Seung-Won Jeong and Kyoungsoon Shin**
Tintinnid species as biological sensors for monitoring the Kuroshio Extension in Korean coastal waters (BIO-P-5897)

14:30 **Yuichiro Nishibe, Shuhei Nishida and Atsushi Yamaguchi**
Vertical distribution, population dynamics and lipid storage of the cyclopoid copepod *Oithona similis* in the Oyashio region, western subarctic Pacific (BIO-P-5813)

14:50 **Julie E. Keister, Emanuele Di Lorenzo, Cheryl A. Morgan, William T. Peterson, Vincent Combes and Neri Mariani**
Zooplankton species composition is linked to ocean transport in the Northern California Current (BIO-P-5850)

15:10 **Elena Dulepova and Anatoly Volkov**
East-west contrasts in production of zooplankton communities in the Bering Sea (BIO-P-5546)

15:30 **Naoki Tojo, Ryuichi Matsukura, Hiroki Yasuma, Kenji Minami, Akira Nishmura, Orio Yamamura, Tetsuichiro Funamoto, Satoshi Honda and Kazushi Miyashita**
Environmentally driven seasonal distribution of zooplankton along the Pacific coast off eastern Hokkaido, Japan (BIO-P-5701)

15:50 ***Coffee break***

16:10 **Yugo Shimizu, Kazutaka Takahashi, Shin-ichi Ito, Shigeho Kakehi, Hiroaki Tatebe, Ichiro Yasuda, Akira Kusaka and Tomoharu Nakayama**
Transport of large subarctic copepods from the Oyashio area to the mixed water region by the coastal Oyashio intrusion (BIO-P-5577)

16:30 **C. Tracy Shaw, Leah R. Feinberg and William T. Peterson**
Population dynamics of the euphausiids *Euphausia pacifica* and *Thysanoessa spinifera* off Newport, OR, USA in relation to environmental conditions (BIO-P-5523)

16:50 **Andrey Suntsov, Richard D. Brodeur and Jason Phillips**
Interannual variability and spatio-temporal characteristics in populations of three dominant myctophid species in the northern California Current System (BIO-P-5955)

17:10 **Olga Yu. Tyurneva, Yuri M. Yakovlev and Vladimir V. Vertyankin**
Photographic identification of the Korean-Okhotsk gray whale (*Eschrichtius Robustus*) offshore northeast Sakhalin Island and southeast Kamchatka Peninsula (Russia), 2008 (BIO-P-5641)

17:30 **Tabitha C.Y. Hui, Rowenna Flinn, Edward J. Gregr, Ruth Joy and Andrew W. Trites**
Are Steller sea lions (*Eumetopias jubatus*) affected by prey availability in the western Gulf of Alaska and Aleutian Islands? (BIO-P-5667)

17:50 ***Session ends***

BIO-Paper Posters

BIO-P-5510 **Andrey P. Chernyaev and Alexandra S. Petrova**
Determination of n-nonylphenol in the coastal waters of Vladivostok

BIO-P-5519 **Chun-Yi Chang, Pei-Chi Ho, Akash R. Sastri and Chih-Hao Hsieh**
Development and application of an automatic mesozooplankton image classification system in the East China Sea, a region of complicated hydrography

BIO-P-5525 **Evgeniya A. Tikhomirova**
Distribution of biogenic substances in waters of Amursky Bay (Peter the Great Bay, Japan/East Sea)

BIO-P-5538 **You-Ree Jun, Akash R. Sastri and Chih-Hao Hsieh**
Field estimates of size-based ingestion rate of zooplankton using FlowCAM in the subtropical western Pacific

BIO-P-5539 **Wei-Hsuan Teng, Akash R. Sastri and Chih-Hao Hsieh**
Investigation of size-trophic level relationships of zooplankton in different ocean environments - A stable isotope approach

BIO-P-5556 **Atsushi Tsuda, Hiroaki Saito and Hiromi Kasai**
Vertical distribution of large suspension feeding copepods in the Oyashio region during the growing period

BIO-P-5557 **Atsushi Yamaguchi and Yoshimi Matsumoto**
Life history and production of the chaetognath *Eukrohnia hamata* in the Oyashio region, western subarctic Pacific

BIO-P-5569 **Guo Ying Du and Ik Kyo Chung**
Estimating areal production of intertidal microphytobenthos based on spatio-temporal community dynamics and laboratory measurements

BIO-P-5579 **Seung Ho Baek, Kyoungsoon Shin, Shinji Shimode, Myung-Soo Han and Tomohiko Kikuchi**
The role of vertical migration and cell division on dinoflagellates *Ceratium furca* and *C. fusus*

BIO-P-5580 **Hong-Bo Li and Fengao Lin**
Relationships between bacterioplankton and virioplankton in coastal areas of Hebei, China

BIO-P-5592 **Min-Chul Jang, Kyoungsoon Shin, Woo-Jin Lee and Ok-Myung Hwang**
Grazing impact of calanoid copepods on phytoplankton size-fractions in Jangmok Bay, South Coast Korea

BIO-P-5594 **Pung-Guk Jang, Kyoungsoon Shin, Min-Chul Jang, Woo-Jin Lee and Hyun-Su Kim**
The succession of phytoplankton assemblage by nutrient property on summer in the coastal area

BIO-P-5599 **Masato Minowa, Toru Kobari, Hiroyasu Akamatsu and Toshihiro Ichikawa**
Impacts of small copepods on sinking particles in a semi-enclosed and deep embayment

BIO-P-5601 **Evgeniy A. Sigida, Svetlana S. Musko, Lidia I. Titova and Alexandra A. Dvornik**
Sakhalin's shelf pelagic marine bacteria *Pseudoalteromonas* sp. and *Pseudomonas* sp. as prospective destructors of ocean oil pollution

BIO-P-5607 **Bonggil Hyun, Kyoungsoon Shin, Min-Chul Jang, Woo-Jin Lee, Jeongmi Song and Seung Ho Baek**
The survival possibility of introducing phytoplankton via ships ballast water

BIO-P-5609 **Yulia V. Zavertanova, Larisa E. Vasilyeva, Olesya A. Sharova and Vladimir A. Rakov**
Species composition of ichthyoplankton in Alekseeva Bay (Peter the Great Bay, Japanese Sea) in 2006 – 2009

BIO-P-5614 **Bo-Bae Lee, Jae-Suk Choi, Yu-Mi Ha, Kee Hun Do and In Soon Choi**
Inhibitory effects of seaweed extracts on *Helicobacter pylori* growth and urease activity

BIO-P-5616 **Yu-Mi Ha, Jae-Suk Choi, Kee Hun Do, Bo-Bae Lee, Su Hwa Shin and In Soon Choi**
Inhibitory effects of *Sargassum sagamianum* extracts on the growth of several oral pathogens and collagenase activity

BIO-P-5650 **Zhisong Cui, Li Zheng, Li Tian, Ping Han, Xiaoying Zhang, Qian Liu, Xiaoru Wang and Frank S.C. Lee**
Characterization of polycyclic aromatic hydrocarbons-degrading *Cycloclasticus* strains isolated from Yellow Sea sediment of China and their syntrophic effects with crude oil degraders *Alcanivorax* strains

BIO-P-5660 **Goh Onitsuka, Masatoshi Moku, Toru Kobari, Tetsutaro Takikawa, Akihiko Morimoto, Atsushi Watanabe, Yutaka Yoshikawa and Tetsuo Yanagi**
Distribution of nutrients and plankton around the lee eddy of the Tsushima Islands

BIO-P-5663 **Li Zheng, Baijuan Yang, Junhui Chen, Jiaye Zang and Xiaoru Wang**
Primary source identification of the invasive *Enteromorpha prolifera* in Qingdao based on hierarchical cluster analysis of fatty acids

BIO-P-5683 **Takeshi Terui and Michio J. Kishi**
A Lagrangian ensemble model of Copepoda (*Neocalanus cristatus*) in the northwestern subarctic Pacific

BIO-P-5704 **Seung-Hyun Son and Meng-Hua Wang**
Marine environmental responses to the Saemangeum Reclamation Project in South Korea

BIO-P-5705 **Seung-Hyun Son and Meng-Hua Wang**
Temporal and spatial variability of water turbidity derived from satellite ocean color in the Yellow Sea and East China Sea

BIO-P-5717 **Natalia P. Fadeeva, Marina S. Selina, Elena V. Smirnova and Inna L. Stonik**
Communities of sandy beaches: What factors influence their diversity and zonation patterns in shallow subtidal environments of the northwestern part of the Sea of Japan?

BIO-P-5734 **Kanako Toge, Masaaki Fukuwaka, Orio Yamamura and Yutaka Watanuki**
Biennial change of pink salmon biomass and the body condition of a pelagic shearwater: Evidence of competition between fish and bird

BIO-P-5790 **Hiroshi Koshikawa, Hironori Higashi, Masanobu Kawachi, Toru Hasegawa, Kazumaro Okamura, Yoko Kiyomoto, Kou Nishiuchi, Hideki Akiyama, Kunio Kohata and Shogo Murakami**
Dominance of the dinoflagellate *Prorocentrum dentatum* on the central continental shelf of the East China Sea in early summer, 2007

BIO-P-5815 **Yuji Okazaki and Kazuaki Tadokoro**
Comparison of sampling gear (MOHT *vs.* BONGO net): Implication for euphausiid abundance

BIO-P-5825 **Evgeniya A. Tikhomirova**
Spatial and temporal variability of primary production in Amursky and Ussuriysky Bays (Japan/East Sea) from modelling results

BIO-P-5869 **Tetsuichi Fujiki, Kazuhiko Matsumoto, Shuichi Watanabe, Takuji Hosaka and Toshiro Saino**
Time-series observation of phytoplankton productivity in the western subarctic gyre of the North Pacific

BIO-P-5873 **Keiko Yamada, Sang-Woo Kim and Ji-Suk Ahn**
Interannual variability of primary production in the East/Japan Sea estimated by satellite data, in consideration of influence of atmospheric aerosol

BIO-P-5878 **Yuya Yamamoto, Yasuyuki Kishi, Hirotada Moki and Kisaburo Nakata**
A model study to predict zooplankton biomass in intermediate and deep water

BIO-P-5900 **Jiyeon Kim, Chaewoo Ma and Wongyu Park**
Spatio-temporal variability of epifaunal distributions caused by the Hebei Spirit oil spill in the surf zone on the Hakampo beach on the west coast of Korea

BIO-P-5906 **Toshikazu Suzuki, Hisako Mori and Daisuke Nakatsugawa**
Spatial distribution of filamentous cyanobacteria, *Trichodesmium* spp., in spring in the East China Sea

BIO-P-5915 **Hye Seon Kim, Ah-Ra Ko and Se-Jong Ju**
A comparative study of the lipid dynamics of the euphausiid, *Euphausia pacifica*, from Korean seas (East/Japan Sea, South Sea, and Yellow Sea)

BIO-P-5917 **In Joon Hwang and Hea Ja Baek**
Acute exposure of waterborne polycyclic aromatic hydrocarbon, benzo[a]pyrene during ovarian recrudescence in a marine fish, *Chasmichthys dolichognathus*

BIO-P-5925 **Oh Youn Kwon, Jung-Hoon Kang, Yong Hwan Cha and Man Chang**
Environmental factors affecting dynamics of the phytoplankton community in port baseline surveys in Korea

BIO-P-5926 **Joji Ishizaka, Hisashi Yamaguchi, Sarat Tripathy, Takashi Makino, Takeshi Matsuno and Takahiro Endoh**
Short term variability of primary production in the Changjiang River Plume in the East China Sea observed in summer 2008

BIO-P-5941 **Soo-Jung Chang, Donghyun Lim, Won Duk Yoon and Suam Kim**
A phylogenetic study of Medusozoa (Scyphozoa, Hydrozoa) in Korean waters

BIO-P-5951 **Young Shil Kang, Weol Ae Lim, Young Sik Lee and Yang-Soon Kang**
Ecosystem consequence of a *Noctiluca scintillans* bloom in the southern coast of the Korean Peninsula

BIO-P-5981 **Ji-Woong Ko, M. Sidharthan, Sung Hwan Cho, Seock Jung Han and Hyun Woung Shin**
Climate change triggered fecundity of the solitary ascidian, *Herdmania momus* in the Jeju coast, Korea: Implications for benthic community structure and artificial reef function

BIO-Paper Sessio Oral Presentations

30 October, 9:05 (BIO-P-5937)

Perspectives on a decade of change in the Alaska Gyre: A comparison of three Northeast Pacific zooplankton time series

David **Mackas**[1], Sonia Batten[2], Ken Coyle[3] and Russ Hopcroft[3]

[1] Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, V8L 4B2, Canada. E-mail: Dave.Mackas@dfo-mpo.gc.ca
[2] c/o Sir Alister Hardy Foundation for Ocean Science, 4737 Vista View Crescent, Nanaimo, BC, V9V 1N8, Canada
[3] Institute of Marine Science, University of Alaska, Fairbanks, AK, 99775-7220, USA

Numerous GLOBEC-era analyses have demonstrated that zooplankton time series can be very useful for detecting multi-year fluctuations and trends in pelagic ecosystems, and for interpreting their association with various modes of ocean climate variability (*e.g.* ENSO, PDO, NAO, NPGO, boundary current strength, upwelling intensity and timing, …). To separate interannual variability from spatial patchiness and seasonal fluctuations, the ideal zooplankton sampling 'grid' is dense in both time and space. One consequence is that the majority of zooplankton time series come from relatively nearshore locations; open-ocean time series are rare and valuable. One of the earliest and longest open-ocean zooplankton time series was collected from Canadian ships assigned to Ocean Weather Station P in the Alaska Gyre (50ºN 145ºW). But the weathership program ended in 1980, and the majority of its samples were analyzed only for total biomass. Our Alaska gyre zooplankton time series sampling resumed in 1997 after an unfortunately long break. For the past decade, we have taxonomically-resolved data from 3 'new' programs – the North Pacific Continuous Plankton Recorder (6-9 surface layer transects per year), seasonal Line-P research vessel cruises (0-150m vertical net tows at 6 standard stations, 3 times per year), and the Seward Line time series across the Alaskan continental margin (1998-present, a combination of vertically-integrated and depth-stratified net tows). These records have all now become long enough to allow quantification of both climatologic norms and interannual anomalies. Despite the differences in sampling design and depth, our data sets reveal very similar patterns of seasonal and interannual variability, which we will summarize in this presentation. Zooplankton seasonality in the Alaska Gyre is very strong, with the abundance and biomass maxima occurring late spring to early summer (May to early July depending on location and year; earliest timing in warm years and toward the southern and eastern=coastal margins of our survey lines). Along and seaward of the shelf break, both abundance and biomass are strongly dominated by copepods, especially large ontogenetic migrators such as *Neocalanus* spp., *Calanus pacificus*, and *Eucalanus bungii*. Other dominant taxa include chaetognaths, pteropods, hyperiid amphipods, euphausiids and medusae. Similar to our 'northern California Current' continental margin time series, the Alaska Gyre time series can be divided between cool and warm periods, each with characteristic anomalies in zooplankton community composition and phenology (seasonal timing). Cool episodes were 1999-2002 and 2007-2008 (with 2008 the 'coolest' in terms of zooplankton response); warm episodes 1997-98 and 2003-2006 (with 2005 the 'warmest'). In the cool years, the abundance and biomass peak of *Neocalanus* spp. is later and broader. Warm years often show negative anomalies of subarctic taxa (especially *N. flemingeri* and *N. cristatus*), and invariably show strongly positive anomalies of subtropical-origin copepods such as *Mesocalanus* and *Clausocalanus*.

30 October, 9:25 (BIO-P-5884)

Growth-increment chronologies reflect ecosystem responses to climate variability in the northeastern Pacific

Bryan A. **Black**

Hatfield Marine Science Center, Oregon State University, Newport, OR, 97365, USA. E-mail: bryan.black@oregonstate.edu

In recent years, traditional tree-ring techniques (dendrochronology) have been increasingly applied to growth increments that occur in long-lived fish and bivalve species in the northeastern Pacific. Resulting chronologies are annually resolved, span from decades to centuries, and can be used to i) establish the effects of climate on growth and recruitment, ii) reconstruct climate prior to the start of instrumental records, and iii) establish climate-driven linkages across diverse species and ecosystems. For example, rockfish (*Sebastes* spp.) growth-increment chronologies in the California Current Ecosystem (CCE) positively relate with climatic indicators of cool, upwelling-favorable conditions during the winter months. On a broader spatial scale, these CCE chronologies

inversely relate with rockfish chronologies above Vancouver Island, consistent with an inverse productivity regime between the CCE and Gulf of Alaska. Moreover, chronologies from Pacific geoduck (*Panopea abrupta*) along the British Columbia coast also relate to rockfish chronologies as well as high-elevation tree-ring chronologies, illustrating climate-driven synchrony from the continental shelf to alpine forests. With respect to describing past climate variability, combinations of tree-ring and geoduck chronologies can be used to reconstruct up to 70% of the variance in regional sea surface temperatures, more than doubling the length of the existing instrumental record. Ultimately, methods from dendrochronology could be applied in a variety of systems to address biological response to climate, develop high-resolution climate reconstructions, and inform estimates of ecosystem response to future climate change.

30 October, 9:45 (BIO-P-5703)

Satellite-observed chlorophyll *a* data in the dump site of the Yellow Sea

Seung-Hyun **Son**[1,2], Meng-Hua Wang[1] and Jae Hoon Noh[3]

[1] NOAA/NESDIS/STAR, NOAA Science Center, Camp Springs, MD, USA. E-mail: seunghyun.son@noaa.gov
[2] I.M. System Group, Rockville, MD, USA
[3] Korea Ocean Research and Development Institute, Ansan, R Korea

With NASA's standard ocean color data processing, a high chlorophyll *a* patch has been consistently observed from the ocean color satellite sensors in the middle of the Yellow Sea during the spring (end-March to early-May). A location corresponding to this patch has been used as a Korean dumpsite since 1995. Previous studies reported that the phenomenon was caused by waste organic matter dumped in the area. However, the feature was not observed from the MODIS-Aqua chlorophyll *a* images that were derived using the shortwave infrared (SWIR) atmospheric correction algorithm for ocean color data processing. The SWIR algorithm has been developed for processing satellite data of turbid coastal waters. Thus, the high chlorophyll *a* patch in the region is in fact an overestimation of chlorophyll *a* values due to the failure of the standard atmospheric correction algorithm.

In this presentation, we compare the MODIS-Aqua ocean color products, including the normalized water-leaving radiance spectra, chlorophyll *a* concentration, and diffuse attenuation coefficient, which were derived using the SWIR and standard algorithms from 2002 to 2008 for the dumpsite location. A regional chlorophyll *a* algorithm applicable to the Yellow Sea and the East Chin Sea has been implemented in the MODIS-Aqua data processing for retrieval of chlorophyll *a* in the region. We validate the SWIR results by comparing chlorophyll *a* from MODIS-Aqua and *in situ* measurements that were obtained around the dumpsite region by the National Fisheries Research and Development Institute.

30 October, 10:05 (BIO-P-5851)

Geographical distribution and ontogenetic migration of *Eucalanus californicus* (Johnson) in the western North Pacific Ocean

Shinji **Shimode** and Atsushi Tsuda

Ocean Research Institute, University of Tokyo, 1-15-1 Minamidai, Nakano, Tokyo, 164-8639, Japan
E-mail: shimode@ori.u-tokyo.ac.jp

Eucalanus californicus is one of the dominant large mesozooplankton and performs a seasonal ontogenetic vertical migration (OVM) in the California Current System (CCS) region of the NE Pacific. Thus, this species functions as a trophic link between epi- and mesopelagic layers in the region. In contrast to the populations of the NE Pacific, little is known about the geographical distribution and life history of *E. californicus* in the NW Pacific. We collected samples from the NW Pacific (15–48ºN) using a VMPS net. Although *E. californicus* was widely distributed between 20º and 45ºN, the maximum (1026.7 inds. m^{-2}) and high abundances (> 400 inds. m^{-2}) were restricted to an area between 30º and 35ºN. These populations mainly consisted of C5 stages inhabiting depths > 500 m, except for the samples collected from February to March. During the early spring, C5 stages were also collected in the surface layers. These results indicate dormancy in the deep layers and seasonal OVM as reported in the NE Pacific. However, the geographical distribution and OVM pattern of *E. californicus* in the NW Pacific were distinct from the eastern population, *i.e.*, 1) the latitudinal range of distribution is narrower,

2) dormant populations are distributed in deeper layers (500 – 2,000 m), and 3) seasonal upward migration occurs earlier (early spring). These differences are considered to be adaptations to the local hydrographic environments and to phytoplankton bloom events.

30 October, 10:50 (BIO-P-5863)

Variation of the epiphytic community and biomass on *Zostera marina* (eelgrass) related to the host plant and environmental factors

Mi Hee **Chung** and Won Duk Yoon

National Fisheries Research and Development Institute, 152-1 Haean-ro, Gijang-eup, Gijang-gun, Busan, 619-705, R Korea
E-mail: aloisia@nfrdi.go.kr

Temporal variation of the epiphytic algae biomass with growth of *Zostera marina* (eelgrass) and water column environmental factors was investigated at two locations in Dolsan Is., located in the South Coast of the Korean peninsula, from July 1998 to July 1999. Epiphytic diatoms on eelgrass leaves were observed from July to December 1998. At Yulim, a very calm bay in the eastern part of Dolsan Is., there were 48-61 diatom species and abundance was 33-985×10^6cells cm^{-2} LA. At Yekyo, in the western area of Dolsan Is, there were 42-61 diatom species and abundance was 3.6- 42.1×10^6cells cm^{-2} LA. Biomass of eelgrass in DW and AFDW was positively related to the water temperature while negatively related to total nitrogen concentration (TN), indicating growth of eelgrass was closely related with the relatively low TN and high water temperature. On the contrary, the biomass of epiphytes in DW and AFDW was positively related to TN, leaf area and length of eelgrass, which implies that the growth of the epiphytic algae is enhanced in high concentrations of TN and is negatively related with the growth of eelgrass. The autotrophic index (AI) calculated from AFDW and Chl. *A* of epiphytes varied from 151 to 375, suggesting the alternating appearance of heterotrophic and autotrophic communities of epiphytes in that eelgrass ecosystem. The results show that different environmental factors affect growth of eelgrass and its epiphytic community, and the alternating succession of micro-organism types on the eelgrass leaves.

30 October, 11:10 (BIO-P-5810)

Development *Laminaria japonica* early stages in the coastal waters of Primorye caused by climate change

Tatyana N. **Krupnova** and Yury I. Zuenko

Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia
E-mail: krupnova@tinro.ru

The coast of Primorye was famous for its rich fields of kelp, *Laminaria japonica,* with stock estimated from 400 to 700 thousand tons. It was important commercially and also the best food for sea urchins. In the 1980s, this stock fell drastically and in 1990 was only 4-25 thousand tons. Instead of kelp, the bottom began to be covered by weeds belonging to the algal family Colallinaceae, (the phenomenon known as barren ground or "isoyake" in Japan). The "isoyake" captured 10% of the former *Laminaria* grounds by 2000, 35% by 2003, and 80% by 2008. Climate changes in the Primorye Cold Current system are proposed as the main reason of this catastrophe. There are two main mechanisms by which the water conditions influence *Laminaria* reproduction. First, advection of warm, low-productive water from the open sea to the coastal zone, induced by the summer monsoon, shrinks the alongshore cold-water belt and prevents turbulent mixing from providing nutrients from deeper layers to the upper shelf. Also, the on-shore surge (downwelling) increases the surface layer depth. As a result, growth of kelp and formation of its sporogeneous tissue are limited by lack of nitrogen. The proportion of *Laminaria* blades covered by sporogeneous tissue decreases from 0.5-0.8 to 0.2-0.3, so a lower number of zoospores is produced. The low-productivity waters are characterized by temperatures > 16°C, so the duration of the period with SST > 16°C is a good index of conditions unfavorable for sporogenesis. The second mechanism is connected with the survival rate of *Laminaria* zoospores, which are capable of free living and maturity under temperature conditions of 8-15°. So, early cooling in October, frequent in the recent years with strong winter monsoons, is unfavorable for the survival of early stages.

30 October, 11:30 (BIO-P-5867)

Sources and distributions of terrigenous organic matter in a mangrove-dominant small tropical estuary, South China

Hongyan **Bao**, Ying Wu, Lixin Tian, Jing Zhang and Guiling Zhang

State Key Laboratory of Estuary and Coast, East China Normal University, 3663 North Zhongshan Rd., Shanghai, PR China
E-mail: shinybao1986@163.com

Small tropical rivers have received more attention recently because of their high yield of sediment load and POC. Plants, particles and surface sediments were collected in the Wenchang River, a small tropical river with a drainage basin area < 400 km^2, located on Hainan Island, South China. The goal was to study the distribution and transportation of terrestrial organic matter along the river system, especially to evaluate the role of the dominant mangrove system. Bulk properties (OC%, $\delta^{13}C$ and grain size) were measured. The OC% of plants was 43.44±2.07%, which is similar to other studies of mangrove plants. The OC% of sediments ranged from 0.07% to 1.42% and had a good linear relationship with distance to the estuary ($r=0.96$, $P<0.0001$), except for an extremely high value near the estuary, which might be the depot center for fine sediment. Lignin phenols in the sediment were between 5.16 mg/100mg OC up river to 0.51 mg/100mg OC in the estuary. Lignin and $\delta^{13}C$ were used to evaluate the contribution of mangrove to the organic matter in the river. In the low and middle salinity region, mangroves contributed more than 40% of the organic carbon, which is more than 3 times the riverine organic matter. This indicates that in a mangrove dominant small tropical estuary, mangroves can be a more important source of terrigenous organic carbon. The Ad/Al ratio suggested that terrestrial organic carbon in the particles was more degraded than in the sediments.

30 October, 11:50 (BIO-P-5835)

The phytoplankton contribution to the common mussel diet (Bivalvia: Mytilidae) of the Sea of Japan

Evgenia E. **Vekhova**[1], Michael I. Kusaykin[2] and Konstantin V. Kiselev[3]

[1] Laboratory of Invertebrates Ecology, A.V. Zhirmunsky Institute of Marine Biology (IBM), FEB RAS, 17 Palchevskogo St., Vladivostok, 690041, Russia. E-mail: evechova@mail.ru
[2] Laboratory of Enzyme Chemistry, Pacific Institute of BioOrganic Chemistry, FEB RAS, Pr. 100-letiya Vladivostoka 159, Vladivostok, 690022, Russia
[3] Biotechnology Department, Institute of Biology and Soil Science, FEB RAS, Vladivostok, 690022, Russia

Bivalve mollusks of the family Mytilidae are the main component of coastal marine benthic communities in the Sea of Japan. At the present time, estimation of the mytilid's role as a consumer of seston is required for understanding the trophic structure of the marine coastal communities, especially in those areas where Mytilidae are abundant. Unfortunately, there are insufficient data on the portion of each food type in the mussel's diet, in the literature to date. We present results from an investigation of diet of the common mussel using two methods. The level of specific activity of the digestive enzymes 1,3-β-D-glucanases and sequence analysis of the glucanase gene were studied in Grayan's mussels, *Crenomytilus grayanus,* collected from the mussel assemblages in different parts of Peter the Great Bay (northwestern part of the Sea of Japan). Both methods showed the same results: the share of phytoplankton in the nutrition of the mussels in different parts of Peter the Great Bay varies. The highest levels of specific activity of 1→3-β-D-glucanases and the glucanase expression were detected in mussels from Amursky Bay: the numbers were significantly higher ($p < 0.05$) compared with those in mussels from Vostok Bay and Ussuriisky Bay. As they develop, the mussels consume different amounts of phytoplankton. Our study showed that the techniques can be successfully used as new methods to determine the extent to which phytoplankton is used as a nutritional source in other marine invertebrates.

30 October, 12:10 (BIO-P-5565)

Modern condition of fauna of *Polychaeta* in the Amur Bay (Peter the Great Bay, Sea of Japan)

Anastasia **Dolganova**

Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia
E-mail: acdolganova@yandex.ru

Amur Bay is an area of ship navigation and many settlements, including the port of Vladivostok, are situated on its coast. The Razdolnaya River flows into the northern part of the Bay carrying runoff and discharge from the surrounding territories. Therefore, Amur Bay has organic, oil and chemical pollution. Some scientists believe there has been major restructuring in the composition of benthic communities in Amur Bay over the past 30-40 years. This can be tested by analysis of polychaete samples. *Polychaeta* - is one of the main components of most benthic communities. Quantitative samples (154) were collected in summer of 2003 and 2007 by the bottom sampler "Okean-50" (0,25 m^2), in the depth range of 2-50 m.

Polychaeta in Amur Bay accounted for 10% of the total biomass of benthos and they were the third most abundant group of benthic animals after the *Bivalvia* and *Cirripedia*. The total biomass of polychaetes varied from 0.5 to 1267.1 g/m^2, with an average 46,1 ± 16,7 g/m^2. There were 85 species of *Polychaeta* identified. The largest contribution to the total biomass (about 65%) was made by *Maldane sars*, *Dipolydora cardalia* and *Pseudopotamilla reniformis*.

Comparison of our results with those of previous researchers did not show any noticeable changes in species composition or biomass of polychaetes. Variation in the quantitative estimates of polychaetes among different authors is likely not due to pollution but to differences in sampling gear and density of the grid stations.

30 October, 13:50 (BIO-P-5561)

Nucleic acid and protein contents of ontogenetically migrating copepods in the subarctic Pacific Ocean as influenced by development stage and depth

Toru **Kobari**, Haruko Mori and Hitomi Tokushige

Fisheries Biology and Oceanography Section, Faculty of Fisheries, Kagoshima University, 4-50-20 Shimoarata, Kagoshima, 890-0056, Japan. E-mail: kobari@fish.kagoshima-u.ac.jp

We compared nucleic acid and protein contents of the ontogenetically migrating copepods *Neocalanus cristatus*, *N. plumchrus* and *Eucalanus bungii* collected from surface layers during the spring phytoplankton bloom and mesopelagic depths during winter in the Oyashio region, western subarctic Pacific Ocean. *Neocalanus* copepods collected from surface layers showed that individual DNA, RNA and protein (PRO) contents increased with development stage, but this pattern was not seen for *E. bungii* at the surface due to mixing of populations undergoing active development and those emerging from dormancy. Dormant stages residing at mesopelagic depths exhibited significantly lower RNA:DNA and RNA:PRO ratios than those at the surface. While copepods in both layers exhibited positive correlations of log-transformed RNA to log-transformed DNA and log-transformed PRO to log-transformed RNA, much lower RNA:DNA and PRO:RNA ratios were evident for copepods at depth. This indicates that protein synthesis in these ontogenetically migrating copepods is dependent on nucleic acid content and RNA and protein syntheses are decreased in dormant animals. We propose these biochemical ratios are useful as indicators of dormancy in these ontogenetically migrating copepods.

30 October, 14:10 (BIO-P-5897)

Tintinnid species as biological sensors for monitoring the Kuroshio Extension in Korean coastal waters

Young-Ok **Kim**[1], Pung-Guk Jang[1], Eun-Jin Yang[2], Seung-Won Jeong[1] and Kyoungsoon Shin[1]

[1] Southern Coastal Environmental Research Department, Korea Ocean Research and Development Institute, Geoje, 656-830, R Korea
E-mail: yokim@kordi.re.kr
[2] Deep-Sea and Marine Georesources Research Department, Korea Ocean Research and Development Institute, Ansan, P.O. Box 29, R Korea

Tintinnids are the best planktonic group to use as indicators of water mass movements. Tintinnid biogeographic distributions in relation to hydrography are well known in the front between the Oyashio and Kuroshio Currents. In order to clarify the temporal influence of the Kuroshio intrusion into Korean coastal waters, tintinnids were sampled biweekly or monthly from the western channel of the Korea/Tsushima Strait and waters shoreward from the Strait over the past 4 years. The number of Kuroshio indicator species peaked in early November 2006 and September 2007 and 2008. Annual maxima of neritic species were recorded from shoreward waters in August, but there were no clear peak times from the Korea Strait. Tintinnid species were also analyzed to spatially track the Kuroshio Current from the Northwest Pacific central zone to the Korea Strait. Endemic tintinnid species were distributed in the central and marginal zone of the Northwest Pacific. *Petalotrichia ampulla* was found in the stenochoric Kuroshio while *Salpingella acuminata* was found in the eurychoric Kuroshio. It is now considered that *Epiplocyloides ralumensis* reported previously as a Kuroshio indicator species, originates from the East China Sea not from the Kuroshio Current because this species was not detected in the Northwest Pacific central zone but in the East China Sea. Tintinnid species can be used as biological sensors to identify mixtures of different water masses. Further investigations are needed to use species specific distributions to identify highly detailed water mass movements.

30 October, 14:30 (BIO-P-5813)

Vertical distribution, population dynamics and lipid storage of the cyclopoid copepod *Oithona similis* in the Oyashio region, western subarctic Pacific

Yuichiro **Nishibe**[1], Shuhei Nishida[1] and Atsushi Yamaguchi[2]

[1] Ocean Research Institute, University of Tokyo, 1-15-1 Minamidai, Nakano, Tokyo, 164-8639, Japan
E-mail: nishibe@sci.ehime-u.ac.jp
[2] Graduate School of Fisheries Sciences, Hokkaido University, 3–1–1 Minatocho, Hakodate, 041–8611, Japan

Oithona similis is one of the most numerous copepod species throughout the subarctic Pacific, but our present knowledge of its life history is still rather limited. The present study investigates the seasonal changes in vertical distribution, population structure and lipid storage of *O. similis* at an oceanic site in the Oyashio region. Samples were collected with 0.060 mm mesh nets from five discrete layers between the surface and 2,000 m depth on eight occasions (March, May, June, July, August, October 2002, December 2003 and February 2004). The bulk of the *O. similis* population was concentrated in the top 250 m of the water column throughout the study period. The C4 stage had a deeper distribution than other copepodite stages during summer-winter. Abundance of *O. similis* showed a marked seasonal variation, with a peak in midsummer. The lack of a clear seasonal trend of copepodite stage composition makes it difficult to trace the developmental sequences of *O. similis*. The year-round occurrence of ovigerous females suggests continuous reproduction of *O. similis* in the region. However, seasonal variations in abundance of *O. similis* egg sacs and clutch size indicate that major reproduction of this copepod took place during late spring-summer. Lipid accumulation was observed as early as the C2 stage, and the proportion of individuals having oil sacs increased with developmental stage, from C2 to C5. A much lower proportion of adult females had oil sacs than males, suggesting that females utilize stored lipids as energy for reproduction.

30 October, 14:50 (BIO-P-5850)

Zooplankton species composition is linked to ocean transport in the Northern California Current

Julie E. **Keister**[1], Emanuele Di Lorenzo[2], Cheryl A. Morgan[3], William T. Peterson[4], Vincent Combes[2] and Neri Mariani[2]

[1] School of Oceanography, University of Washington, Box 357940, Seattle, WA, 98195, USA. E-mail: jkeister@u.washington.edu
[2] School of Earth and Atmospheric Sciences, Georgia Institute of Technology, Atlanta, GA, 30332, USA
[3] Cooperative Institute for Marine Resource Studies, Hatfield Marine Science Center, Newport, OR, 97365, USA
[4] NOAA-Fisheries, Northwest Fisheries Science Center, Hatfield Marine Science Center, Newport, OR, 97365, USA

In the Northern California Current, copepod communities show interannual and multi-year shifts in the dominance of species that relate to survival of fish populations. These copepod community changes are correlated with the Pacific Decadal Oscillation (PDO). A "warm-water" copepod species group is more abundant during warm (positive) phases of the PDO and less abundant during cold (negative) phases; the reverse occurs for a "cold-water" species group. We tested the hypothesis that these changes in communities are related to changes in horizontal advection paths of surface water over different phases of the PDO using a Regional Ocean Modeling System (ROMS) and passive tracer simulations. Results of the simulations were compared to observations of the species composition of zooplankton collected bi-weekly at a coastal station off Newport, Oregon, USA from 1996 to 2008. We show that horizontal surface water movements change with the phase of the PDO and are related to the regional changes in copepod species dominance. The surface current anomalies during the positive phase of the PDO show more downwelling and stronger northward currents at the coast. These anomalies transport warmer waters and the associated warm-water copepod species into the region. During the negative phase of the PDO, an increase in surface currents from the north enter the study area, and intrusion from the south and west declines. Overall, the modeled transport anomalies explained a significant part of the variation in copepod species composition, so furthers our understanding of the physical controls on ecosystem processes in the Northern California Current.

30 October, 15:10 (BIO-P-5546)

East-west contrasts in production of zooplankton communities in the Bering Sea

Elena **Dulepova** and Anatoly Volkov

Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia
E-mail: dep@tinro.ru

The production characteristics of zooplankton were calculated for the eastern and western Bering Sea from plankton data obtained in autumn of 2002-2006 under the international research program BASIS (Bering-Aleutian Salmon International Survey). The taxonomy, size and trophic structure of zooplankton were analyzed in shallow (Bristol-shallow, Bristol-shelf, Nunivak–area, Anadyrsky Bay) and deep-water (Western Bering- area, South Bering- area) zones of the Bering Sea. The structural characteristics of zooplankton in the shallow areas were different for western and eastern parts of the Bering Sea. For this reason in shallow areas of the western Bering Sea production of non-predatory zooplankton was higher than in the eastern Bering Sea. Predatory zooplankton biomass and production were higher in the deep- water areas compared to the shallow areas. The information on production of predatory and non- predatory zooplankton has been used further for calculation of "real" production of the zooplankton community, *i.e.* production available for pelagic fishes.

30 October, 15:30 (BIO-P-5701)

Environmentally driven seasonal distribution of zooplankton along the Pacific coast off eastern Hokkaido, Japan

Naoki **Tojo**[1], Ryuichi Matsukura[1], Hiroki Yasuma[2], Kenji Minami[1], Akira Nishmura[2], Orio Yamamura[2], Tetsuichiro Funamoto[3], Satoshi Honda[4] and Kazushi Miyashita[2]

1 Laboratory of Marine Ecosystem Change Analysis, Graduate School of Environmental Science, Hokkaido University, 3-1-1 Minato, Hakodate, Hokkaido, 041-8611, Japan. E-mail: ntojo@ees.hokudai.ac.jp
2 Laboratory of Marine Ecosystem Change Analysis, Hokkaido University, 3-1-1 Minato, Hakodate, Hokkaido, 041-8611, Japan
3 Hokkaido National Fisheries Research Institute,Fisheries Research Agency, 116 Katsurakoi, Kushiro, Hokkaido, 085-0802, Japan
4 National Research Institute of Fisheries Science,Fisheries Research Agency, 2-12-4 Fukura, Kanazawa ku, Yokohama, Kanagawa, 236-8648, Japan

The coastal sea off eastern Hokkaido, the Doto area, belongs to the Oyashio ecosystem, characterized by high primary productivity and interactions among the diverse higher trophic levels. Seasonal variation in the oceanography has been thought of as the key to zooplankton abundance and connections among trophic levels in the Doto area. However, quantitative studies of zooplankton abundance are limited, and year-round analyses of spatial distributions have not been conducted. We aimed to quantify the zooplankton abundance over the Doto area and analyze the spatial relationship between zooplankton distribution and the marine environment. Hydroacoustic surveys with BONGO net sampling were conducted in summer, fall, and winter in 2003 and 2004. Using the DWBA model, target strengths of specimens were calculated for quantification of the zooplankton. The ΔMVBS method was used to locate each type of zooplankton. Zooplankton abundance was estimated using the best-fit two-stage kriging model. Temperature and salinity from CTD casts were compared with vertical and horizontal distribution of zooplankton. Satellite imagery (aqua MODIS, 4-km resolution) was also used for the integrated analyses. Diel vertical distribution patterns were seasonally different. Abundance was minimum in winter, but dense aggregations were stochastically observed over the area. More even distribution of zooplankton was observed in summer, probably due to intruded offshore water. Zooplankton showed high abundance in fall, presumably due to recruited euphausiids. In winter and fall, the coastal current acts as a hydrographic barrier that limits zooplankton distribution and probably influences the food availability for higher trophic levels in the Doto area.

30 October, 16:10 (BIO-P-5577)

Transport of large subarctic copepods from the Oyashio area to the mixed water region by the coastal Oyashio intrusion

Yugo **Shimizu**[1], Kazutaka Takahashi[1], Shin-ichi Ito[1], Shigeho Kakehi[1], Hiroaki Tatebe[2], Ichiro Yasuda[3], Akira Kusaka[4] and Tomoharu Nakayama[5]

1 Tohoku National Fisheries Research Institute, Shinhama 3-27-5 Shiogama, Miyagi, 985-0001, Japan. E-mail: yugo@affrc.go.jp
2 Research Institute for Global Change, JAMSTEC, 3173-25 Showa-machi, Kanazawa-ku Yokohama City, Kanagawa, 236-0001, Japan
3 Ocean Research Institute, University of Tokyo, 1-15-1 Minamidai, Nakanoku, Tokyo, 164-8639, Japan
4 Hokkaido National Fisheries Research Institute, 116 Katsurakoi, Kushiro, Hokkaido, 085-0802, Japan
5 Japan Marine Science Foundation, 4-24 Minatocho, Mutsu, Aomori, 035-0064, Japan

The lateral transport of organic carbon in large grazing copepods (*Neocalanus cristatus*, *N. flemingeri*, *N. plumchrus* and *Eucalanus bungii*) from the Oyashio area to the mixed water region (MWR) by the coastal Oyashio intrusion was estimated by using data from a VMPS (vertical multiple plankton sampler) and the 1500 dbar referenced geostrophic transport from CTD (conductivity temperature depth sensor) data for five cruises during June 2001 to April 2002. Data were collected on a repeat observation section of the OICE (Oyashio Intensive observation line off Cape Erimo), which extends southeastward from Hokkaido Island, Japan. Transport to the MWR by the coastal Oyashio intrusion was estimated to be 5.3×10^{11} g C for the four species. Data from profiling floats indicated that the copepods were advected from the OICE to the MWR by the coastal Oyashio intrusion within about two months. This transport is considered to be one of the significant organic carbon sources for the MWR and it is larger than the amount of large zooplankton consumed by one of the dominant copepod predators, Pacific saury (*Cololabis saira*), in the MWR.

30 October, 16:30 (BIO-P-5523)

Population dynamics of the euphausiids *Euphausia pacifica* and *Thysanoessa spinifera* off Newport, OR, USA in relation to environmental conditions

C. Tracy **Shaw**[1], Leah R. Feinberg[1] and William T. Peterson[2]

[1] Cooperative Institute for Marine Resources Studies, Oregon State University, 2030 SE Marine Science Dr., Newport, OR, 97365, USA. E-mail: tracy.shaw@oregonstate.edu
[2] Northwest Fisheries Science Center, NOAA Fisheries, 2030 SE Marine Science Dr., Newport, OR, 97365, USA

The euphausiids *Euphausia pacifica* and *Thysanoessa spinifera* are the two most common species of euphausiids off the Oregon Coast. We have conducted biweekly sampling at night for adult euphausiids off Newport, OR since 2001. Our data set includes abundance of all life stages of euphausiids, species composition, density and biomass. The time period of this sampling encompasses a range of ocean conditions including cool and warm phases of the Pacific Decadal Oscillation (PDO) and variations in the timing and strength of upwelling. In samples from the shelf-break (296 m water depth) *E. pacifica* biomass was never zero and was frequently in the range of 5-50 mgC m^{-3}. The maximum *E. pacifica* biomass was 275 mgC m^{-3}. *T. spinifera* biomass was often zero at this location. The maximum *T. spinifera* biomass was 21 mgC m^{-3}. *T. spinifera* biomass has been below 5 mgC m^{-3} since 2004. We will look at cross-shelf distribution of life stages from egg to adult for both species and examine these data in the context of environmental conditions to investigate the effects of variations in ocean conditions on euphausiid distribution and biomass.

BIO PAPER

30 October, 16:50 (BIO-P-5955)

Interannual variability and spatio-temporal characteristics in populations of three dominant myctophid species in the northern California Current System

Andrey **Suntsov**[1], Richard D. Brodeur[2] and Jason Phillips[3]

[1] Scripps Institution of Oceanography, 9500 Gilman Dr., La Jolla, CA, 92093, USA. E-mail: asuntsov@ucsd.edu
[2] National Marine Fisheries Service, Northwest Fisheries Science Center, 2030 SE Marine Science Dr., Newport, OR, 97365, USA
[3] Cooperative Institute for Marine Resources Studies, Oregon State University, 2030 SE Marine Science Dr., Newport, OR, 97365, USA

The fish component of a diverse micronekton community occurring at night at epipelagic levels off Oregon and Washington is dominated by three lanternfishes – *Diaphus theta*, *Stenobrachius leucopsarus* and *Tarletonbeania crenularis*, with minor contribution from two *Nannobrachium* species and *Symbolophorus californensis*. The exact ecosystem significance of these small ubiquitous fishes remains equivocal, despite their long–term recognition as intermediate trophic links, potential competitors of commercial species as well as conduits of organic matter from surface waters to deeper levels. As we move towards an ecosystem-based fishery, a better ecological knowledge of non-commercial species such as lanternfishes, as well as other abundant mesopelagics from the mid-trophic levels, will clearly be required. During 2004-2006, we collected total 142333 myctophids during Stock Assessment Improvement Program (SAIP) cruises on four repeated transects with stations ranging between 20 and 100 km offshore. In this presentation we report detailed information on size composition, interannual variability and spatio-temporal dynamics of myctophid species in the northern California Current upwelling ecosystem.

30 October, 17:10 (BIO-P-5641)

Photographic identification of the Korean-Okhotsk gray whale (*Eschrichtius Robustus*) offshore northeast Sakhalin Island and southeast Kamchatka Peninsula (Russia), 2008

Olga Yu. **Tyurneva**, Yuri M. Yakovlev and Vladimir V. Vertyankin

A.V. Zhirmunsky Institute of Marine Biology (IBM), FEB RAS, 17 Palchevskogo St., Vladivostok, 690041, Russia
E-mail: olga-tyurneva@yandex.ru

There are two primary gray whale feeding areas offshore northeast Sakhalin Island in the Sea of Okhotsk: the first, “Piltun” feeding area is a shallow area located along the coast adjacent to Piltun Bay; whales predominantly feed in this area in water depths <20 m. The second, Offshore feeding area is located at a distance of about 30-40 km southeast of Chayvo Bay with water depths of about 35-60 m. Both areas have abundant potential prey for gray

whales. Photo-ID studies of gray whales conducted in the Piltun and Offshore feeding areas in the period 2002-2008 confirmed the exchange of individuals between the two areas between and within feeding seasons. During the seven years of photo-ID effort, use of the Offshore feeding area by gray whales varied in intensity.

Over the past few decades, researchers have become aware of the presence of gray whales in the coastal waters offshore southeast Kamchatka during the summer-autumn and early winter months. Photo-ID studies conducted offshore Kamchatka in 2004, 2006, 2007 and 2008 substantiate these observations. Results from these studies demonstrate that the western gray whale population is not confined to its feeding grounds offshore Sakhalin during their summer-to-fall feeding season. In 2008, photo-ID studies were conducted in the two Sakhalin feeding areas and in Olga Bay, located on the southeast coast of the Kamchatka Peninsula. Results from the 2008 photo-ID effort show that 97 individuals from the Sakhalin catalogue were seen only offshore Sakhalin, 24 were seen only offshore Kamchatka, and one was seen at both locations; thus, a total of 122 whales from the Sakhalin catalogue were observed in 2008. An additional 25 gray whales were seen offshore southeast Kamchatka that have not been seen previously offshore Sakhalin, and therefore are not recorded in the Sakhalin catalogue.

30 October, 17:30 (BIO-P-5667)

Are Steller sea lions (*Eumetopias jubatus*) affected by prey availability in the western Gulf of Alaska and Aleutian Islands?

Tabitha C.Y. **Hui**[1,2], Rowenna Flinn[1], Edward J. Gregr[3], Ruth Joy[1] and Andrew W. Trites[1,2]

[1] Marine Mammal Research Unit, Fisheries Centre, 2202 Main Mall, Vancouver, BC, V6T 1Z4, Canada
E-mail: t.hui@fisheries.ubc.ca
[2] Department of Zoology, University of British Columbia, 6270 University Blvd., Vancouver, BC, V6T 1Z4, Canada
[3] IRES, University of British Columbia, 2202 Main Mall, Vancouver, BC, V6T 1Z4, Canada

A leading hypothesis to explain the decline of Steller sea lions (SSL) in the western Gulf of Alaska (GOA) and Aleutian Islands (AI) is the reduction of prey abundance and/or change in prey distribution caused by commercial fisheries. We analyzed the potential impacts on SSL populations of the availability of walleye pollock, Pacific cod and Atka mackerel - commercially important species which form a significant proportion of the SSL's diet - throughout the GOA and AI during the summer breeding season from 2000-2008. Since SSL concentrate their foraging closest to their rookeries and resting sites, the positive half of a normal density function was used to calculate the expected probabilities of SSL foraging at varying distances from the rookeries. This accessibility model was combined with predicted prey biomass surfaces to estimate the total pollock/cod/mackerel biomass accessible to SSL from each of the rookeries considered. For each rookery, accessible pollock/cod/mackerel biomass was compared to its population trends using multiple regression models. Four oceanographically distinct regions were considered. Significant negative relationships were found between pollock/mackerel biomass and SSL population change in the AI, with rookeries west of Amchitka pass showing a more pronounced change with prey biomass. Significant negative relationships were also found between pollock/cod biomass and SSL population change in the GOA, with rookeries west of Uminak pass showing a more pronounced change with prey biomass. The relatively low energy content of pollock/cod/mackerel combined with these negative relationships suggest that SSL in Alaska may be affected by prey quality and/or availability.

BIO-Paper Session Posters

BIO-P-5510

Determination of n-nonylphenol in the coastal waters of Vladivostok

Andrey P. **Chernyaev**[1] and Alexandra S. Petrova[2]

[1] Lab. of Applied Ecology and Ecotoxicology, Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia. E-mail: chernyaev@tinro.ru

[2] Far Eastern National University (FENU), 27 Oktyabrskaya St., Vladivostok, 690950, Russia

Nonylphenol is an endocrine disrupting compound (EDC) because of its similarity in structure to hormones in living organisms. EDCs can disturb endocrine functions of marine organisms by binding to estrogen receptors and mimicing natural hormones. Derivates of nonylphenol (in the form of ethoxylates) are surfactants used worldwide. The USA alone markets 120,000 tons per year. Some European countries have restricted or banned the use of nonylphenols surfactants. Its discharge into the marine environment is prohibited by the MARPOL 73/78 Convention. The aim of this work was to determine the content of n-nonylphenol in the coastal waters of Vladivostok by high-performance liquid chromatography. Water samples were taken in spring and fall in 2008 at seven sites. The highest concentration was observed in the waters of the Ob'yasneniya River (1,24 µg/L). The content of n-nonylphenol in Amursky Bay waters ranged from the minimal detection limit (1 ng/L) to 0,44 µg/L. A relatively high concentration of n-nonylphenol was detected in Zolotoy Rog Bay (1,22 µg/L) which is a critical level. Generally, the concentration of n-nonylphenol in the waters of Amursky Bay do not have a negative impact on marine organisms. Knowledge of n-nonylphenol concentrations will permit us to control emissions and to correctly assess the risks.

BIO-P-5519

Development and application of an automatic mesozooplankton image classification system in the East China Sea, a region of complicated hydrography

Chun-Yi Chang, Pei-Chi Ho, Akash R. Sastri and Chih-Hao **Hsieh**

Institute of Oceanography, National Taiwan University, No. 1, Sec. 4 Roosevelt Rd., Taipei, 10617, Taiwan. E-mail: chsieh@ntu.edu.tw

We developed an automatic classification system for mesozooplankton in the East China Sea, a region with complicated environmental variations, ranging from coastal areas affected by river runoff to the shelf break influenced by the Kuroshio. Considering the large variation of water masses, we test the hypothesis that a water-mass specific training set (WTS) would perform better than a regional training set (RTS, constructed from randomly selected images from all stations). To test the water-mass specificity, we evaluated pair-wise cross predictions for all stations. We found that cross-prediction accuracy decreased with an increase in environmental dissimilarity; for example, mutual predictions between coastal stations performed better than those using coastal stations to predict Kuroshio stations. Furthermore, the cross-prediction matrix is significant correlated with the similarity matrix derived from environmental variables. These results suggest clear water-mass specificity in training sets. However surprisingly, the prediction accuracy (with an average of 75%) of RTS performs no worse than the best WTS results for each station. This suggests the benefit of WTS may be limited for the coarse taxonomic resolution (order or higher) employed here if the goal is to achieve a high overall accuracy. However, the overall accuracy from RTS is largely determined by the contribution of dominant categories, and rare categories are not well predicted under this scheme.

BIO-P-5525

Distribution of biogenic substances in waters of Amursky Bay (Peter the Great Bay, Japan/East Sea)

Evgeniya A. **Tikhomirova**

V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: tikhomirova@poi.dvo.ru

Biogenic substances are useful for understanding processes in marine ecosystems, and for studying questions of physical oceanography because they provide additional characteristics of water masses. The distribution and variability of nitrates, phosphates, and silicates in waters of Amursky Bay are analyzed using long-term data from 1990–2005 from stations of the standard network of the Nationwide System of Supervision. Analysis of the vertical structure, seasonal variability and distribution of biogenic substances is presented. According to the vertical distribution of biogenic substances, Amursky Bay waters are subdivided into three districts: northern, central and southern. A characteristic feature of seasonal changes of biogenic substances in bay waters is alternation of local extremes. On a surface there is seasonal cycle of phosphates in the central part of the bay, and also nitrates and silicates in the northern part of Amursky Bay. Their maximal concentrations are correlated with river discharge and atmospheric precipitation. Maximal surface concentrations of biogenic substances in Amursky Bay are in coastal areas throughout the year. At a depth of 10 and 20 m, the basic features in the spatial distribution of biogenic substances noted for surficial waters, are not seen all year. Their distribution has the features which are correlated with advection and intensity of phytoplankton development.

BIO-P-5538

Field estimates of size-based ingestion rate of zooplankton using FlowCAM in the subtropical western Pacific

You-Ree **Jun**, Akash R. Sastri and Chih-Hao Hsieh

Institute of Oceanography, National Taiwan University, No. 1, Sec. 4, Roosevelt Rd., Taipei, 10617, Taiwan. E-mail: ksyr83@hotmail.com

Traditionally, zooplankton ingestion rate has focused on species-specific estimates. Here, we propose to estimate *in situ* size-specific ingestion rates of zooplankton. The motivation is based on metabolic theory, which indicates that size plays an important role in determining predator-prey interactions. Since aquatic food webs are strongly size structured and many marine species will grow in mass by 5 or more orders of magnitude during their life cycle, we adopt size rather than species. Moreover, our estimates provide information to evaluate community-level impacts rather than those of any particular target species. As such, we can investigate how much nutrition is needed for growth of zooplankton at the ecosystem level. In this study, zooplankton are sorted into 50-80um and 100-150um size classes, the size classes that dominate somatic production in subtropical and tropical seas, and *in situ* incubations are carried out to calculate ingestion rates. Ingestion rates are calculated from I=CF, where C is mean food concentration, and F is clearance rates. The food concentration and numbers of zooplankton are analyzed using FlowCAM, a rapid plankton image analyzer. This study's focus is on investigating the effects of different predator-prey mass ratios on ingestion of phytoplankton under various environmental conditions, ranging from coastal eutrophic to offshore oligotrophic regions.

BIO-P-5539

Investigation of size-trophic level relationships of zooplankton in different ocean environments - A stable isotope approach

Wei-Hsuan **Teng**, Akash R. Sastri and Chih-Hao Hsieh

Institute of Oceanography, National Taiwan University, No. 1, Section 4, Roosevelt Rd., Taipei, 10617, Taiwan
E-mail: r97241201@ntu.edu.tw

"The big" eat "the small". There is evidence suggesting a positive linear relationship between log(size) and trophic level. As such, size-based foodweb analysis has gained in popularity. However, for marine zooplankton, several studies did not indicate such a positive relationship. But, for these studies only a small subset of the

zooplankton community was selected for analysis. Thus, whether such a pattern exists for zooplankton or not remains unclear. To test the generality of this pattern, we carried out stable isotope (δN^{15} and δC^{13}) analyses of a full zooplankton community in order to investigate predator-prey interactions under different trophic conditions, from eutrophic coastal to oligotrophic open ocean environments. In our research, we focused on zooplankton with a size range from 50 to 2000 um, across several trophic levels. Within each size class, we measured taxon-specific isotope values to determine the trophic level. We found that the size-trophic level relationship varied among different communities, which might result from the omnivorous feeding behavior of zooplankton. Furthermore, we analyzed how the size-trophic level relationship changes in response to different physical and chemical environments.

BIO-P-5556

Vertical distribution of large suspension feeding copepods in the Oyashio region during the growing period

Atsushi **Tsuda**[1], Hiroaki Saito[2] and Hiromi Kasai[3]

[1] Ocean Research Institute, University of Tokyo, Nakano, Tokyo, 164-8639, Japan. E-mail: tsuda@ori.u-tokyo.ac.jp
[2] Tohoku National Fisheries Research Institute, Shiogama, Miyagi, 985-0001, Japan
[3] Hokkaido National Fisheries Research Institute, Kushiro, Hokkaido, 085-0802, Japan

Neocalanus flemingeri, *N. plumchrus*, *N. cristatus* and *Eucalanus bungii* are large and dominant mesozooplankton throughout the subarctic Pacific. They are an important trophic link and they transport organic matter to mesoplegic depths. Vertical distributions of these copepods were investigated from March to October 2000 in the Oyashio region of the western subarctic Pacific. Roughly, *N. plumchrus* and *N. flemingeri* showed a shallow distribution (0-30 m) and *N. cristatus* and *E. bungii* showed a deeper one (40-100 m). However in detail, the young copepodites of *N. flemingeri*, *N. cristatus* and *E. bungii* were distributed much deeper than the productive layer in March. From late April to the end of July, *N. plumchrus* was concentrated in the top 20 m, and *N. flemingeri* showed a little deeper distribution from May to July. *N. cristatus* showed a deeper distribution than that of grazing *E. bungii* from April to early July, but grazing *E. bungii* (C3 to C6) showed a deeper distribution than that of *N. cristatus* from the end of July to October. Early copepodites (C1 and 2) of *E. bungii* were distributed much shallower than those of late copepodite stages and overlapped with those of *N. plumchrus* and *N. flemingeri*. These vertical distribution patterns were similar to those in the Alaskan gyre but very different from those in the Sea of Okhotsk. We will discuss the reasons for the difference in the three regions of the North Pacific.

BIO-P-5557

Life history and production of the chaetognath *Eukrohnia hamata* in the Oyashio region, western subarctic Pacific

Atsushi **Yamaguchi** and Yoshimi Matsumoto

Laboratory of Marine Biology, Graduate School of Fisheries Sciences, Hokkaido University, 3-1-1, Minato, Hakodate, Hokkaido, 041-8611, Japan. E-mail: a-yama@fish.hokudai.ac.jp

Chaetognaths are the second dominant component of macrozooplankton biomass in the world oceans, and provide a vital link between small zooplankton and fishes. While their importance in marine ecosystems is understood, little information is available on their life history and production. This study aims to evaluate the life history and production of the chaetognath *Eukrohnia hamata* in the Oyashio region. Zooplankton samples were collected by Bongo-net from 0-1000 m at several month intervals during March 2003-February 2004. Eleven chaetognath species belonging to three genera were observed, and *E. hamata* was the most dominant species (39-62% of total abundance), followed by *Sagitta elegans* and *E. bathypelagica*. For *E. hamata*, total length (TL) and gonad development (juvenile, stage I-IV) were determined on each specimen. Recruitment of juveniles was observed during spring-summer. This cohort developed to 8 mm TL by the end of the year, then overwintered. In the next year, they grew during June-October, and reached 15 mm TL by the end of the year. This cohort again overwintered, then spawned during the next spring-summer. Thus, a two-year generation length is estimated for *E. hamata*. Seasonal abundance of major prey (the copepod *Pseudocalanus minutus*) is considered to be the cause of seasonal variation in growth rate, which was fast in summer. Production of *E. hamata* was estimated to be 5-10

mg C m^{-2} d^{-1}. In the Oyashio region, the major food chain is considered to be: phytoplankton (diatoms)–large copepods (*Neocalanus* spp.)–fishes. Since chaetognaths feed on small copepods, they function as a mediator and vital link in the food web in the Oyashio region.

BIO-P-5569

Estimating areal production of intertidal microphytobenthos based on spatio-temporal community dynamics and laboratory measurements

Guo Ying **Du**[1,2] and Ik Kyo Chung[1]

[1] Division of Earth Environmental System, Pusan National University, Busan, 609-735, R Korea
[2] Department of Biological Engineering, Ocean University of China, Qingdao, 266003, PR China. E-mail: dgydou@gmail.com

Field investigations of community dynamics of microphytobenthos (MPB) in intertidal sand flats of the Nakdong River estuary, Korea, were conducted from August 2006 to August 2007. Biomass varied between 0.47 and 16.58 μg cm^{-3}, with two dominant diatom species, *Amphora coffeaeformis* and *Navicula* sp., occupying an average of 77.2% of total MPB abundance. There was an exponential decline of biomass within the upper 1 cm of sediment, and the biomass proportion in the upper 3 mm was 57.6% and 37.8% with and without the presence of biofilm, respectively. The two dominant species were cultured in the laboratory, and their photosynthetic parameters, ETR_{max} (maximum electron transport rate), α (light utilization coefficient) and E_k (light saturation parameter) were derived from ETR-irradiance curves by Imaging-PAM (pulse amplitude modulated) fluorometry. The ETR-irradiance curves showed no significant difference in photosynthetic capacity between the two species. The estimated total primary production of our study area ranged from 0.32 to 1.00 g C m^{-2} d^{-1} with bimodal peaks (winter and early summer) reflecting biomass variation. This study combined a field survey with laboratory production estimates of the predominant species to evaluate the variability of areal primary production.

BIO-P-5579

The role of vertical migration and cell division on dinoflagellates *Ceratium furca* and *C. fusus*

Seung Ho **Baek**[1], Kyoungsoon Shin[1], Shinji Shimode[2], Myung-Soo Han[3] and Tomohiko Kikuchi[4]

[1] Korea Ocean Research and Development Institute/ South Sea Institute, Geoje, 656-830, R Korea. E-mail: baeksh@kordi.re.kr
[2] Ocean Research Institute, University of Tokyo, 1-15-1 Minamidai, Nakano, Tokyo, 164-8639, Japan
[3] Department of Life Science, Hanyang University, 17 Haengdang, Seongdong, Seoul, 133-791, R Korea
[4] Graduate School of Environmental and Information Sciences, Yokohama National University, 79-2 Tokiwadai, Hodogaya, Yokohama, 240-8501, Japan

To better understand the mechanism underlying blooms of the dinoflagellates, *Ceratium furca,* and *Ceratium fusus*, we investigated the diel changes of vertical migration, swimming speed, cell volume, and cell division. Diel vertical migration (DVM) of *C. furca* was observed in the laboratory but *C. fusus* did not show DVM. *C. furca* demonstrated a constant DVM rhythm, *i.e.*, their cells began to descend from the surface before the light was extinguished, and ascended into the surface before the light was turned on. The downward and upward migrations of the cells occurred three hours before turning the light on and off, suggesting that the DVM pattern was independent of nutrient concentration. The swimming speeds of *C. furca* (avg. 250 μm s^{-1}) were always faster than those of *C. fusus* (avg. 75 μm s^{-1}). In addition, the speeds of *C. furca* during light periods were faster than those during dark periods, whereas the speeds of *C. fusus* remained relatively constant. A higher proportion of dividing cells was recorded near dawn (05:00 - 07:00 hr). Cell volumes of *C. furca* and *C. fusus* did not markedly change between 12:00 hr and 21:00 hr, but gradually increased until 03:00 hr and then sharply decreased. Furthermore, the cell volume of the two *Ceratium* species was closely tied to the temporal pattern of cell division. Combining the DVM behavior of the two *Ceratium* species and cell division timing, showed that only *C. furca* divided at the bottom, and then moved toward the surface shortly before the dark to light transition. Based on our observations, *C. furca* would have an ecological advantage due to their DVM activity, since nutrients can be obtained well in the near bottom layers at night, while during the daytime, light present in the nutrient–depleted surface water can be obtained using their high swimming speed. On the other hand, *C. fusus*, which has no DVM, may be stimulated by low salinity conditions and might be dependent on external environmental conditions such as additional nutrients following freshwater discharge by heavy rainfall.

BIO-P-5580

Relationships between bacterioplankton and virioplankton in coastal areas of Hebei, China

Hong-Bo **Li**[1,2] and Fengao Lin[2]

[1] Laboratory of Marine Ecosystem and Biogeochemistry, SOA, Second Institute of Oceanography, SOA, HangZhou, 310012, PR China. E-mail: marinepico@126.com
[2] National Marine Environment Monitoring Center, Dalian, 116023, PR China

Virioplankton are considered to be an abundant and dynamic component of aquatic systems where they can regulate the biomass, production and species composition of heterotrophic bacteria. Virioplankton and bacterioplankton were stained with SYBR Green I and their abundance was measured by direct counts with epifluorescence microscopy (EM). Virioplankton abundance was much higher than bacterioplankton abundance. The abundance ratio of viruses to bacteria (VBR) ranged between 1.75~26.51, and averaged 6.22. Bacteria were harvested directly onto Fomvarcoated, 200-mesh electron-microscope grids by ultracentrifugation and the frequency of visibly infected cells (FVIC) was determined by transmission electron microscopy (TEM). FVIC ranged from 3 to 5% for samples in Spring 2007, and estimated viral mortality of bacteria (VMB) was on average 41.5% (28%~55%), indicating that viruses could be significant contributors to bacterial losses in coastal areas of Hebei province.

BIO-P-5592

Grazing impact of calanoid copepods on phytoplankton size-fractions in Jangmok Bay, South Coast Korea

Min-Chul **Jang**, Kyoungsoon Shin, Woo-Jin Lee and Ok-Myung Hwang

Korea Ocean Research and Development Institute/South Sea Institute, Geoje, 656-830, R Korea. E-mail: mcjang@kordi.re.kr

Grazing impacts of calanoid copepods on size-fractionated phytoplankton biomass (Chl-*a*) were measured in the Jangmok Bay of Geoje island monthly from November 2004 to October 2005. The ingestion rate of calanoid copepods on total phytoplankton biomass ranged between >1 and 215 ng chl copepod^{-1} day^{-1} during bottle incubations. In grazing experiments on 3 phytoplankton size categories (<3, 3-20 and >20 mm), our result indicated microphytoplankton (>20mm) was the primary food source for calanoid copepods. The ingestion rate on microphytoplankton showed a significant increase (r=0.93, p<0.01) with Chl-*a* concentration. Nanophytoplankton (3-20 mm) showed negative ingestion rate from June to October 2005 because calanoid copepods consumed their microzooplanktic predators (specially, ciliates). Calanoid copepods were unable to feed efficiently on picophytoplankton (<3 mm) due to unfavorable size. Between >0.1-27.7% (average 3.6±15.8%) of phytoplankton biomass was removed daily by calanoid copepods during grazing experiments. High grazing pressure was found in January (27.7%), February (27.4%) and March (15.6%) 2005, but values in other months were low (<5%). Our result suggests calanoid copepods play an important role in controlling the biomass and size structure of phytoplankton in winter and early spring.

BIO-P-5594

The succession of phytoplankton assemblage by nutrient property on summer in the coastal area

Pung-Guk **Jang**, Kyoungsoon Shin, Min-Chul Jang, Woo-Jin Lee and Hyun-Su Kim

Korea Ocean Research and Development Institute/South Sea Institute, Geoje, 656-830, R Korea. E-mail: pgjang@kordi.re.kr

The production of phytoplankton is affected by various physical and chemical parameters. However, the most critical factor for controlling primary production of phytoplankton is nutrients. Recently, it has been shown that nutrient limitation and ratios can affect the succession of phytoplankton groups and species. Nutrient supply in Jangmok Bay may be mainly controlled by rainfall for silicate and nitrate and by wind stress for phosphate and ammonia. Typhoons provide both factors, rainfall and strong wind stress, so typhoons passing in the South Sea lead to phytoplankton blooms. Nutrient limitation changes phytoplankton community structure in coastal areas.

The proportion of flagellates increased during low nutrient conditions, but diatoms increased during high nutrient conditions after rainfall and typhoons in Jangmok Bay. *Leptocylindrus danicus* predominated during conditions of phosphate and nitrate limitation in June when there was little rainfall and no typhoon. *S. costatum* predominated when high concentrations of phosphate and ammonia were supplied by strong wind stress, and silicate and nitrate were also supplied by heavy rainfall. The competition between *S. costatum* and *Chaetoceros* spp. may be regulated by silicate concentration. *S. costatum* may prefer high silicate, but *Chaetoceros* spp. may be acclimated to low silicate. In coastal ecosystems, the supply pattern of each nutrient, controlled by precipitation and wind stress, will play an important role in the succession and species composition of the phytoplankton community.

BIO-P-5599

Impacts of small copepods on sinking particles in a semi-enclosed and deep embayment

Masato **Minowa**[1], Toru Kobari[1], Hiroyasu Akamatsu[1] and Toshihiro Ichikawa[2]

[1] Fisheries Biology and Oceanography, Faculty of Fisheries, Kagoshima University, 4-5-20 Shimoarata, Kagoshima, 890-0056, Japan
E-mail: k8092136@kadai.jp

[2] Earth and Environmental Science, Faculty of Science, Kagoshima University, 21-35 Korimoto 1, Kagoshima, 890-0065, Japan

We compared seasonal changes in sinking particles collected by sediment trap and community structure of mesozooplankton in the water column in Kagoshima Bay, a semi-enclosed and deep embayment. Particulate carbon (PC) flux was low in March (55.8 mgC m^{-2} day^{-1}) and reached a maximum in August (171.5 mgC m^{-2} day^{-1}) when chlorophyll *a* concentrations were the lowest and a thermocline was developed at 30 m. Fecal pellet flux decreased toward summer and comrised less than 2% of PC flux in August when poecilostmatoid copepods dominated zooplankton abundance and biomass. Cylindrical pellets, typically egested from copepods, were predominant among sinking fecal pellets over the study period. The cylindrical pellets at 150 m were smaller than those at 50 m, indicating coprorhexy by mesozooplankton during sinking. A box model showed that fecal pellet production was dependent on zooplankton biomass in the fraction of 0.2-0.5 mm above 50 m and supported carbon demands of particle-feeding metazoans in the underlying layers. We suggest that small cylindrical pellets produced by poecilostmatoid copepods contribute to PC flux but are largely fragmented by mesozooplankton in surface layers.

BIO-P-5601

Sakhalin's shelf pelagic marine bacteria *Pseudoalteromonas* sp. and *Pseudomonas* sp. as prospective destructors of ocean oil pollution

Evgeniy A. **Sigida**, Svetlana S. Musko, Lidia I. Titova and Alexandra A. Dvornik

Far Eastern National University, 8 Sukhanova St., Vladivostok, 690950, Russia. E-mail: el-lobo@yandex.ru

In 2005, 67 pure cultures of microorganisms isolated from the coastal zone of a southern part of Sakhalin were incubated in oil-containing media. Action of 7 strains in media with crude oil as the single hydrocarbon source was investigated in the present research. All of the studied microorganisms were capable of recycling naphtha products: gasoline, kerosene, bitumen, residual fractions of oil, *etc*. Experiments showed that the marine bacteria *Pseudoalteromonas sp*. and *Pseudomonas sp*. were most active in using petroleum hydrocarbons (PH). Analysis of the degradation dynamics of different naphtha products in these bacteria showed that aromatic hydrocarbons are the intermediate degradation stage, as a result of activity of the microorganisms. Degradation dynamics of gasoline hydrocarbons in synthetic sea water by these microorganisms was investigated by static vapor-phase analysis with subsequent gas chromatographic separation. These strains were observed to influence alkanes, cycloalkanes and pyrobitumen. Results show that both strains adept at PH-destruction, but *Pseudomonas sp.* was the most active. During 8 days, pyrobitumen components were decreased to 80% relative to the control sample.

BIO-P-5607

The survival possibility of introducing phytoplankton via ships ballast water

Bonggil **Hyun**, Kyoungsoon Shin, Min-Chul Jang, Woo-Jin Lee, Jeongmi Song and Seung Ho Baek

Korea Ocean Research and Development Institute/South Sea Institute, Geoje, 656-830, R Korea. E-mail: bghyun@kordi.re.kr

Ballast water has been widely recognized as a serious environmental problem due to the risk of introducing non-indigenous species. Ballast water samples were collected from three commercial vessels in their ports; ASASHIO MARU in Ulsan, SUN ACE in Pusan and SNK LUCKY in Pohang, Korea. Sub-samples of water were analyzed for environmental factors including phytoplankton community composition and were also examined to assess species survival under a range of laboratory conditions. A total of 29 phytoplankton species were observed in the ballast water from the 3 voyages. Among them, potential harmful species such as *Pseudo-nitzschia pungens* and *Pseudo-nitzschia delicatissima* were observed in SNK LUCKY and SUN ACE. The most abundant species consisted of centric diatom species such as *Skeletonema coatatum*, *Eucampia zodiacus* and *Chaetoceros* spp., which are commonly recorded in Korean coastal water and adjacent areas. In the survivability and adaptability experiments, phytoplankton species collected from the three vessels did not grow in the typical ballast water samples (as control; without nutrients) even if they are provided with favorable light intensity, whereas these species gradually increased in nutrient rich medium even at low temperature (around 10°C). In particular, phytoplankton species in SNK LUCKY increased more quickly than species of ASASHIO MARU and SUN ACE under high temperature conditions. This implies that they would be able to survive if the ballast water of SNK LUCKY was discharged in nutrient rich water in high temperature areas.

BIO PAPER

BIO-P-5609

Species composition of ichthyoplankton in Alekseeva Bay (Peter the Great Bay, Japanese Sea) in 2006 – 2009

Yulia V. **Zavertanova**, Larisa E. Vasilyeva, Olesya A. Sharova and Vladimir A. Rakov

Laboratory of Marine Biotoxicology, V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia. E-mail: zavertanova@poi.dvo.ru

The ichthyoplankton of Alekseeva Bay contained 27 fish species, belonging to 15 families among which 6 are commercial ones. Dominant species of larvae (40.7%) were Stichaeidae and Hexagrammidae. Eggs of Japanese anchovy (*Engraulis japonicus*) were the most widely distributed. Herring larvae were most abundant (from 25.7 up to 97.2%) among the commercial species, Based on data from publications on the spawning ecology of fishes encountered within ichthyoplankton of Alekseeva Bay, the species were divided by regional-ecology groups (Davydova, 1998). Groups were characterized by spawning strategy and distribution of eggs and larva. Eight species of fishes were represented in group I, whereas 10 species of fishes were discovered in samples from group II, and 9 species were related to group III. This shows that the spawning ecology of fish species encountered within the ichthyoplankton of Alekseeva Bay is highly variable. Along with pelagic species (14.9%) and the species that shed bottom-dwelling (demersal) eggs (62.9%), we found fish that shed eggs onto underwater vegetation (18.5%), and also one viviparous species (3.7%). Seasonal changes in the qualitative and quantitative characteristics of ichthyoplankton are related to the spawning ecology of fishes dwelling in Alekseeva Bay, and the appearance of thermophilic migrants of E. japonicus during the aestival-autumnal period. The largest species diversity of ichthyoplankton in shallow zones of the bay was recorded in April and May.

BIO-P-5614

Inhibitory effects of seaweed extracts on *Helicobacter pylori* growth and urease activity

Bo-Bae **Lee**[1], Jae-Suk Choi[1], Yu-Mi Ha[1], Kee Hun Do[1] and In Soon Choi[1,2]

[1] RIS, Industry-Academic Cooperation Foundation, Silla University, Busan, 617-736, R Korea. E-mail: sg3ym@hanmail.net
[2] Department of Biological Science, Silla University, Busan, 617-736, R Korea

Seaweeds produce a great variety of secondary metabolites with different activities, making them a good source of bioactive compounds. Numerous studies have reported on the biological activities of compounds from seaweeds against human pathogens, fungi, and yeasts, but only a few reports contain data on their effects against *Helicobacter pylori*, an important etiological agent of chronic gastritis, peptic ulcers, and gastric cancer. Therefore, this study examined the anti-*Helicobacter pylori* activity of seaweed extracts from 27 species of marine macroalgae found along the coast of Korea.

Of the species screened for potential antimicrobial activity, seven (25.9%) showed strong inhibitory activity in the agar diffusion method. The strongest activity was for ethanol extracts from *Ishige okamurae*. At 1 mg/disc, the inhibition zone of *I. okamurae* extract was 9.0 mm and the minimum inhibitory concentration (MIC) was 12 μg/ml in the broth microdilution assay. Urease hydrolyzes urea in gastric juice to produce ammonia and carbon dioxide and plays a critical role in the survival of *H. pylori* in the gastric mucosa and in the pathogenesis of the diseases caused by this organism. In the free urease assay system, the ethanol extracts of *I. okamurae* inhibited more than 25.8% at 1 mg/ml.

We evaluated the ethanol extract of *I. okamurae* for acute toxicity in BALB/c mice (8–10 weeks old; 20–25 g body weight). Over the 2-week observation period, no death occurred in any mouse given a dose of 5 g/kg body weight. These results suggest that *I. okamurae* extract is valuable for developing therapeutic agents for chronic gastritis and peptic ulceration. Isolation of these active compounds is now in progress.

BIO-P-5616

Inhibitory effects of *Sargassum sagamianum* extracts on the growth of several oral pathogens and collagenase activity

Yu-Mi **Ha**[1], Jae-Suk Choi[1], Kee Hun Do[1], Bo-Bae Lee[1], Su Hwa Shin[1] and In Soon Choi[1,2]

[1] RIS, Industry-Academic Cooperation Foundation, Silla University, Busan, 617-736, R Korea. E-mail: sg3ym@hanmail.net
[2] Department of Biological Science, Silla University, Busan, 617-736, R Korea

As a source of bioactive compounds, seaweeds produce a great variety of secondary metabolites with different activities. Previously, we demonstrated that an ethanol extract of *Sargassum sagamianum* had antimicrobial activity against *Prevotella intermedia* and *Porphyromonas gingivalis*. To identify the main active compound in the seaweed extract, *S. sagamianum* powder was successively fractionated into five classes of constituents according to their polarity: saccharides, lipids, phenolics, alkaloids, and nitrogen compounds. Of these classes, the phenolics (a moderately polar extract) of *S. sagamianum* had the strongest activity. The minimum inhibitory concentrations (MICs) of phenolics against *P. intermedia*, *P. gingivalis*, *Candida albicans*, *Fusobacterium nucleatum* subsp. *vincenti*, *Haemophilus actinomycetemcomitans*, and *Streptococcus mutans* were 49, 49, 195, 195, 391, and 195 μg/ml, respectively.

As collagenase is an important pathogenic factor in the development of periodontal disease, we tested the possible influence of phenolics from *S. sagamianum* on it. In the MMP-13 (collagenase 3) assay system (ECM487; Chemicon, Temecula, CA, USA), the phenolics fraction from *S. sagamianum* inhibited more than 71.2% at 100 μg/ml.

We evaluated acute toxicity of the phenolics fraction of *S. sagamianum* might in BALB/c mice (8–10 weeks old; 20–25 g body weight). Over the 2-week observation period, no death occurred in any mouse given a dose of 5 g/kg body weight. These results suggest that *S. sagamianum* extract is valuable for developing therapeutic agents in periodontitis. Isolation of these active compounds is now in progress.

BIO-P-5650

Characterization of polycyclic aromatic hydrocarbons-degrading *Cycloclasticus* strains isolated from Yellow Sea sediment of China and their syntrophic effects with crude oil degraders *Alcanivorax* strains

Zhisong **Cui**, Li Zheng, Li Tian, Ping Han, Xiaoying Zhang, Qian Liu, Xiaoru Wang and Frank S.C. Lee

Marine Ecology Research Center, First Institute of Oceanography, State Oceanic Administration, Room 409, Research Bldg., 6 Xianxialing Rd, Qingdao, 266061, PR China. E-mail: czs@fio.org.cn

Thirteen bacterial strains were isolated from two PAHs-degrading consortia NY093 and PY097 enriched from Yellow Sea sediments. Three degraders NY93E, PY97M and PY97S were found to be *Cycloclasticus* strains by 16S rRNA analysis. The biodegradability of thirteen kinds of PAHs were evaluated using these strains, and their PAH utilization ranges were found to be identical. When used as the sole source of carbon and energy, PAHs including naphthalene, 2,6-dimethylnaphthalene, biphenyl, phenanthrene, anthracene, dibenzothiophene, pyrene and fluoanthene could be steadily degraded. No growth, however, was observed on 2-methylnaphthalene, fluorene, acenaphthene, dibenzofuran or benzo[α]pyrene. The morphology of these strains was determined by negative staining electron microscopy. They were shown to be short rods without flagellum. The degradation efficiency of 0.2 g/L phenanthrene after ten days of incubation determined by GC-MS ranged from 97% to 99%. In addition, the bacterial structure of the phenanthrene-degrading consortium PY097 was analyzed by DGGE, and the profile revealed that two bacteria *Cycloclasticus* and *Sphingomonas* were the dominant members in the community. Syntrophic effects between *Cycloclasticus* and *Alcanivorax* strains were observed during the crude oil degradation process. The degradation efficiency of 10 g/L crude oil determined by a weighting method was enhanced to as high as 86.89% compared with the oil-degrader only treatment. GC-FID and GC-MS analyses showed that the aromatic portions in the crude oil were better degraded by the co-culture treatment. The *Cycloclasticus* strains with new characteristics are promising bio-materials for applications in the bioremediation of PAHs and oil contaminated marine environments.

BIO-P-5660

Distribution of nutrients and plankton around the lee eddy of the Tsushima Islands

Goh **Onitsuka**[1], Masatoshi Moku[2], Toru Kobari[3], Tetsutaro Takikawa[1], Akihiko Morimoto[4], Atsushi Watanabe[5], Yutaka Yoshikawa[6] and Tetsuo Yanagi[6]

1 National Fisheries University, 2-7-1 Nagata-Honmachi, Shimonoseki, Yamaguchi, 759-6595, Japan. E-mail: onizuka@fish-u.ac.jp
2 Ocean Research Institute, University of Tokyo, Nakano, Tokyo, 164-8639, Japan
3 Fisheries Biology and Oceanography Section, Faculty of Fisheries, Kagoshima University, 4-50-20 Shimoarata, Kagoshima, 890-0056, Japan
4 Hydrospheric Atmospheric Research Center, Nagoya University, Furo-cho, Chikusa-ku, Nagoya, 464-8601, Japan
5 Graduate School of Information Science and Engineering, Tokyo Institute of Technology, 2-12-1-W8-13, O-okayama, Meguro-ku, Tokyo, 152-8552, Japan
6 Research Institute for Applied Mechanics, Kyushu University, 6-1 Kasugakoen, Kasuga, Fukuoka, 816-8580, Japan

The Tsushima Warm Current flows northeastward through the Tsushima Straits, and a cyclonic (or counterclockwise) eddy downstream of the Tsushima Islands was found by research vessel and HF radar observations in the eastern channel of the straits in November 2007. The horizontal scale of the eddy was about 30 km, and the baroclinic current accompanying the counterclockwise eddy was over 15 cm s^{-1} at the edge of the eddy. The maximum chlorophyll *a* concentration was observed in the subsurface layer in the vicinity of the eddy core, where the thermocline became shallow. In contrast, zooplankton biomass was rather low in the eddy core, but high concentrations were observed in the northwestern region of the eddy. The difference in horizontal distributions between phytoplankton and zooplankton may be caused by the difference in their growth rates. Larval Japanese anchovy had relatively high abundance in the lee region of the Tsushima Islands in agreement with previous observations when an eddy was not present. This implies that the lee region of the Tsushima Islands is selected as a spawning ground by Japanese anchovy.

BIO-P-5663

Primary source identification of the invasive *Enteromorpha prolifera* in Qingdao based on hierarchical cluster analysis of fatty acids

Li **Zheng**, Baijuan Yang, Junhui Chen, Jiaye Zang and Xiaoru Wang

Research Center for Marine Ecology, The First Institute of Oceanography, SOA, QingDao, 266061, PR China. E-mail: zhengli@fio.org.cn

A serious green tide caused by *Enteromorpha prolifera* broke out in Qingdao city during June, 2008. This marine disaster brought huge losses to tourism and aquaculture. In order to identify the source of the *Enteromorpha prolifera* rapidly, one chemical tracing method based on fatty acids analysis was carried out. Twenty samples of *Enteromorpha prolifera* were collected along the seashore of the Yellow Sea and the Bohai Sea. The fatty acid composition of these 20 samples were determined by GC-MS. The results indicate that C_{16} are the predominant fatty acids in *Enteromorpha prolifera*, and the content of C_{16} ranged from 27.82 to 43.27%. C 18:2 (cis,cis-9,12) (n-6), C 18:3 (gamma) (all cis-6,9,12)(n-6), C 18:3 (alpha) (all cis-9,12,15)(n-3) and EPA are the main polyunsaturated fatty acids (PUFAs) in *Enteromorpha prolifera*. A numerical classification of *Enteromorpha prolifera* is derived from their fatty acids by using Squared Euclidean distance as a similarity measure and a Between-groups linkage method as the clustering algorithm. Cluster analysis of the twenty samples of microalgae classified them into four groups: Group I are the floating *Enteromorpha prolifera*, and Groups II and III are native to Qingdao and Lianyungang. The floating *Enteromorpha prolifera* of the Qingdao coastal area did not come from the native groups of Qingdao, but came from the open sea. The first cluster result indicated that *Enteromorpha prolifera* in Qingdao had invaded from the South China Sea.

BIO-P-5683

A Lagrangian ensemble model of Copepoda (*Neocalanus cristatus*) in the northwestern subarctic Pacific

Takeshi **Terui**[1,2] and Michio J. Kishi[1,3,4]

1 Graduate School of Environmental Science, Hokkaido University, N10W5 Kita-ku, Sapporo, Hokkaido, 060-0810, Japan
E-mail: tk4terui@ees.hokudai.ac.jp
2 Core Research for Evolutional Science and Technology, Japan Science and Technology Agency, 5 Sanbancho, Chiyoda-ku, Tokyo, 102-0075, Japan
3 Graduate School of Fisheries Sciences, Hokkaido University, 3-1-1 Minato-cho, Hakodate, Hokkaido, 041-8611, Japan
4 The Research Institute for Global Change JAMSTEC, Yokohama, 236-0001, Japan

A Lagrangian ensemble model which can describe the population dynamics of *Neocalanus cristatus* was developed to simulate the northwestern Pacific lower trophic ecosystem. This model includes development stages, vertical migration, and NEMURO for other compartments. Each particle of the Lagrangian model represents copepods of the same cohort age, which means one particle represents a set of copepods of the same birthday. Each particle also has variables that represent age, development-time, growth-rate, structural weight, and food satiation. This model was coupled with a lower trophic level ecosystem model of NEMURO as an interactive copepod component. The model can simulate the annual cycle of *Neocalanus cristatus*. Most of copepodite stages begin during the spring bloom, followed by a decrease in biomass during summer, then by migration of *Neocalanus* to deep water where they diapause during autumn and winter, and finally ends with egg production in winter. The model simulation successfully described the annual life cycle of the copepods in the Northwestern subarctic Pacific. By analyzing the simulated results of vertical trajectories of particles, individual growth, and stage development, we can conclude that during the spring bloom they graze large-phytoplankton without starvation and in summer they begin to prey on small-zooplankton (ZooS) to maintain their weight. These results support observations of their food selection corresponding to the seasonal food supply. Moreover we are applying this model to vertical 1-D NEMURO, so that we will be able to represent the vertical variations of seasonal abundance, depth dependent features of stage development, and patterns of reproduction caused by ontogenetic vertical migration.

BIO-P-5704

Marine environmental responses to the Saemangeum Reclamation Project in South Korea

Seung-Hyun **Son**[1,2] and Meng-Hua Wang[1]

[1] NOAA/NESDIS/STAR, NOAA Science Center, Camp Springs, MD, USA. E-mail: seunghyun.son@noaa.gov
[2] I.M. System Group, Rockville, MD, USA

The Saemangeum Reclamation Project, the biggest reclamation project in South Korea, has been carried out since 1991. The northern reclamation dike was constructed in June 2003, and the southern dike was completed in April 2006. The reclamation project is scheduled to be completed around 2030.

A time series of water property observations from MODIS-Aqua between 2002 and 2008 is used to study the marine environmental changes to the Saemangeum Reclamation Project. In particular, for this study we use the MODIS-Aqua derived normalized water-leaving radiance spectra, the diffuse attenuation coefficient, and chlorophyll *a* concentration data. The MODIS-Aqua ocean color products were derived using the shortwave infrared (SWIR) atmospheric correction algorithm, which was developed for satellite data processing of turbid coastal waters.

Results show that, after closure of the dikes, there was a drastic increase of water transparency in the region, demonstrating marine environmental responses to human activities. Some other effects and changes in response to the project will also be discussed, including seasonal variations of water optical and biological properties. We show that satellite-derived imagery can be a useful monitoring and management tool, providing improved understanding of optical, biological and ecological processes and phenomena in coastal waters.

BIO PAPER

BIO-P-5705

Temporal and spatial variability of water turbidity derived from satellite ocean color in the Yellow Sea and East China Sea

Seung-Hyun **Son**[1,2] and Meng-Hua Wang[1]

[1] NOAA/NESDIS/STAR, NOAA Science Center, Camp Springs, MD, USA. E-mail: seunghyun.son@noaa.gov
[2] I.M. System Group, Rockville, MD, USA

In aquatic systems, the diffuse attenuation coefficient is an important property related to light penetration and availability in the aquatic system, which are critical for understanding physical processes such as the heat transfer in the upper layer of the ocean, and biological processes such as phytoplankton photosynthesis within the water column. Satellite observation of the diffuse attenuation coefficient at the wavelength 490 nm, Kd(490), is the only effective method of providing large scale maps of Kd(490) over basin and global scales with high spatial and temporal resolution. In particular, Kd(490) can be directly related to water turbidity. Although there are several models of Kd(490) that are commonly in use to derive the Kd(490) maps from ocean color satellite sensors, those models are generally applicable for clear open-ocean waters. Recently, new Kd(490) models for turbid coastal waters have been developed for providing more accurate Kd(490) estimation. In this presentation, seven years (2002 to 2009) of MODIS-Aqua Kd(490) data, which were derived from the near-infrared (NIR) and shortwave infrared (SWIR) combined atmospheric correction algorithm for ocean color data processing with the new Kd(490) model for turbid coastal waters, are used to quantify temporal (seasonal/interannual) and spatial variability of the diffuse attenuation coefficient in the Yellow Sea and East China Sea. In addition, *in situ* water quality data are compared with the satellite observations to investigate influences of environmental change on the interannual variability.

BIO-P-5717

Communities of sandy beaches: What factors influence their diversity and zonation patterns in shallow subtidal environments of the northwestern part of the Sea of Japan?

Natalia P. **Fadeeva**[1], Marina S. Selina[2], Elena V. Smirnova[3] and Inna L. Stonik[2]

[1] Far Eastern State University, 27 Oktyabr'skaya St., Room 404, Vladivostok, 690600, Russia. E-mail: nfadeeva@mail.primorye.ru
[2] A.V. Zhirmunsky Institute of Marine Biology (IBM), FEB RAS, 17 Palchevskogo St., Vladivostok, 690041, Russia
[3] Far Eastern Fisheries and Technical University (Dalrybvtuz), 52 Lugovaya St., Vladivostok, Russia

Sandy shallow subtidal coastal habitats are examples of simple ecosystems, driven principally by the interacting physical forces of waves and sediment movements. Spatial and temporal variations of the interstitial composition of benthic microalgae and meiobenthos were analyzed on four oligotrophic beaches in a shallow subtidal environment of the Russian coastline of the northwestern part of the Sea of Japan. Generally, 5 taxa (dinoflagellates, diatoms, chrysophytes, eugleophytes, cryptophytes) of microphytobenthos and 11 taxa (nematodes, harpacticoid copepods, osracodes, turbellaria, nemertini, halacarides, amphipods, bivalvia, priapilida, polychaetes, foraminifera) of meiofauna represented the resident biota of this community throughout 2006-2008. The sandflat communities are characterized by low species dominance, high species diversity and high species endemism. Multivariate analyses indicated the diversity patterns were different among the four beach types. The hypothesis that physical factors are the driving force controlling the dynamics of sandy beach community was examined. Sediment type, hydrodynamics and food availability are identified as the principle factors determining the observed patterns. The study deals with the possibility of trophic linkage between the microphytobenthos and meiobenthos in sandy sediments. The benthos in shallow subtidal coastal habitats typically receives a variety of carbon and energy inputs.

BIO-P-5734

Biennial change of pink salmon biomass and the body condition of a pelagic shearwater: Evidence of competition between fish and bird

Kanako Toge[1], Masaaki Fukuwaka[2], Orio Yamamura[2] and Yutaka **Watanuki**[1]

[1] Graduate School of Fisheries Sciences, Hokkaido University, 3-1-1 Minatocho, Hakodate, Japan. E-mail: ywata@fish.hokudai.ac.jp
[2] Hokkaido National Fisheries Research Institute, Fisheries Research Agency, Kushiro, Japan

Predatory fish and seabirds are two important top predator groups in marine ecosystems. In addition to their top-down effects on lower trophic levels, there could be interactions between them, competition for example, though there is a little evidence. Using samples collected during research gill-net fishing, the impacts of the biennial change of pink salmon (*Oncorhynchus gorbuscha*) biomass in the central Bering Sea on short-tailed shearwaters (*Puffinus tenuirostris*) wintering there were investigated in late-June to mid-July during 2003 - 2008. Both species fed on krill, fish and small squids in the pelagic layer. In odd-numbered years, CPUE of pink salmon was greater (8 – 45 times) and the shearwater decreased liver mass (by 14%) and subcutaneous fat, compared to even-numbered years. This study provides new evidence suggesting exploitative competition between predatory fish and seabirds under food-limited conditions.

BIO-P-5790

Dominance of the dinoflagellate *Prorocentrum dentatum* on the central continental shelf of the East China Sea in early summer, 2007

Hiroshi **Koshikawa**[1], Hironori Higashi[1], Masanobu Kawachi[1], Toru Hasegawa[2], Kazumaro Okamura[2], Yoko Kiyomoto[2], Kou Nishiuchi[2], Hideki Akiyama[2], Kunio Kohata[1] and Shogo Murakami[1]

[1] Asian Environmental Research Group, National Institutes for Environmental Studies, 16-2 Onogawa, Tsukuba, Ibaraki, 305-8506, Japan. E-mail: koshikaw@nies.go.jp

[2] East China Sea Fisheries Oceanography Division, Seikai National Fisheries Research Institute, 1551-8 Taira-machi, Nagasaki, 851-2213, Japan

We found the dinoflagellate *Prorocentrum* cf. *dentatum* dominated at 7 out of 16 research stations on the central shelf of the East China Sea (29º30′E–31º45′E, 124º30′E–128º00′E) in June 2007. Stations dominated by *P. dentatum* mostly corresponded to areas with low salinity surface-water (*i.e.* Changjiang Diluted Water). Vertically, the *P. dentatum* assemblages mainly existed near the pycnocline and often formed high and sharp Chl-*a* peaks. The observed maximum Chl-*a* concentration among *P. dentatum* dominant stations was about 56 $\mu g \cdot l^{-1}$ at a depth of 14 m at station #31 (31º30′N, 125º00′E). Since nitrate and phosphate were almost exhausted in the surface mixed layer and fairly rich beneath the pycnocline, the *P. dentatum* assemblages were likely using nutrients supplied by bottom water masses and not by Changjiang Diluted Water. To estimate the potential contribution of dinoflagellates to primary production, we quantified phytoplankton class abundances within the euphotic zone using algal pigment analysis and CHEMTAX. This showed the contributions of dinoflagellates (mainly *P. dentatum*), diatoms, and haptophytes to Chl-*a* were 60%, 21%, 6.8%, respectively. This result is a mere snapshot of continuous algal species succession on the central shelf of East China Sea. However, to our knowledge, there are few reports of *P. dentatum* blooms on the central shelf, unlike the Changjiang estuary and the adjacent sea area. We should give continuing attention to signs of changing algal composition on the central shelf of the East China Sea.

BIO-P-5815

Comparison of sampling gear (MOHT *vs.* BONGO net): Implication for euphausiid abundance

Yuji **Okazaki** and Kazuaki Tadokoro

Tohoku National Fisheries Research Institute, FRA, 3-27-5 Shinhama-cho, Shiogama, Miyagi, 985-0001, Japan
E-mail: okazakiy@affrc.go.jp

Quantitative estimation of euphausiid abundance is a key requirement for modern ecological and modeling studies. Thus, abundance (biomass) estimation is an old and new problem. However, previous sampling methods were not sufficient for the quantitative estimation of euphausiids because of net avoidance. In this regard, we quantitatively sampled for euphausiid abundance and compared two sampling gears (MOHT and BONGO net). We obtained seasonal data (May, July, November and March) at five stations along the A-line (a fixed transect from the Oyashio to the Kuroshio-Oyashio transition region) using the MOHT (1.59mm mesh size with a mouth area of $5m^2$) and a BONGO net (0.33mm mesh size with 0.6m diameter) in 2006-2007. The MOHT and BONGO net were towed from a depth of ca. 500m to the surface. Net tows were conducted both day and night at the each station. We mainly analyzed juvenile and adult *Euphausia pacifica*. For *E. pacifica* greater than 7mm TL (adults and large juveniles), abundances from the MOHT tended to be several times higher than those from the BONGO net. However, for *E. pacifica* less than 7mm TL (juveniles), abundances of from the MOHT tended to be lower than those from the BONGO net because small juveniles were not retained by the large mesh size of the MOHT. In future, we will need to compare with acoustic methods.

BIO-P-5825

Spatial and temporal variability of primary production in Amursky and Ussuriysky Bays (Japan/East Sea) from modelling results

Evgeniya A. **Tikhomirova**

V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: tikhomirova@poi.dvo.ru

Estimation of primary production in Amursky and Ussuriysky Bays based on the average long-term monthly data for the period of 1990-2005 is made using the advanced model of V.V. Menshutkin (1993). This model considers vertical structure, seasonal variability and spatial distribution of primary production in the studied area. In the present model, the absorption of light by ice in winter months is used in addition to previously used data on water temperature, concentration of biogenic substances, irradiance and dependence of photosynthesis intensity on depth. Modelling results showed that primary production decreased with depth in all investigated areas. For the majority of stations in Amursky and Ussuriysky Bays at the depth of 10 m and in the bottom layer, the seasonal maximum is delayed. Primary production in Amursky and Ussuriysky Bays has a strongly pronounced seasonal pattern with two maxima on a surface: June-July and September-October. The peaks are caused by increased concentrations of biogenic substances, atmospheric precipitation and variability in river discharge. Spatial distribution of primary production was well coordinated with the distribution of biogenic substances, meteorological conditions, river discharge variability and the current systems in the bays. The general spatial distribution at the surface showed high primary production in the coastal parts of both bays. Estimations of primary production, obtained on the basis of this model, gave results comparable to other models and on-site data.

BIO-P-5869

Time-series observation of phytoplankton productivity in the western subarctic gyre of the North Pacific

Tetsuichi **Fujiki**[1], Kazuhiko Matsumoto[1], Shuichi Watanabe[1], Takuji Hosaka[2] and Toshiro Saino[3]

[1] Mutsu Institute for Oceanography, Japan Agency for Marine-Earth Science and Technology, 690 Kitasekine, Sekine, Mutsu, Aomori, 035-0022, Japan. E-mail: tfujiki@jamstec.go.jp
[2] Japan Science and Technology Agency, Kawaguchi Center Bldg., 4-1-8 Hon-cho, Kawaguchi, Saitama, 332-0012, Japan
[3] Institute of Observational Research for Global Change, Japan Agency for Marine-Earth Science and Technology, 2-15 Natsushima-cho, Yokosuka, Kanagawa, 237-0061, Japan

The western subarctic Pacific plays a role as a sink of anthropogenic carbon dioxide (CO_2) from the atmosphere. Phytoplankton can contribute to the efficient uptake of atmospheric CO_2 in this ocean. Thus, knowledge of the variability in phytoplankton productivity is needed to understand the carbon cycle dynamics in the western subarctic Pacific. However, in ship-based studies of the open ocean, the time-series observations for understanding of variability in primary productivity have been restricted. In the previous study (Fujiki *et al.* 2008), we developed an underwater profiling buoy system that uses a fast repetition rate fluorometer. The profiling buoy system can estimate *in situ* primary productivity at high vertical and temporal resolutions. In this study, we deployed the profiling buoy system at the time-series station K2 (47ºN, 160ºE) in the western subarctic gyre of the North Pacific during the early summer (June-July) of 2006 and succeeded in observing day-to-day variations in primary productivity for about 40 days. Here, we show the results of observations and also discuss the relationship between primary productivity and organic carbon flux.

BIO-P-5873

Interannual variability of primary production in the East/Japan Sea estimated by satellite data, in consideration of influence of atmospheric aerosol

Keiko **Yamada**[1], Sang-Woo Kim[2] and Ji-Suk Ahn[1]

[1] Ecology and Oceanography Division, National Fisheries Research and Development Institute, 152-1 Haean-ro, Gijang-eup, Gijang-gun, Busan, 619-705, R Korea. E-mail: keiko@nfrdi.go.kr
[2] Fisheries Resources and Environmental Division, East Sea Fisheries Research Institute, Gangneung, Gangwon-do, 210-861, R Korea

The East/Japan Sea is affected by several kinds of atmospheric aerosols such as Asian dust, smoke from forest/agricultural burning and NOx and SOx from industry. It is said that the existence of atmospheric aerosols may affect the value of satellite ocean color and lead to the overestimation of satellite chlorophyll *a*. In this study, the influence of atmospheric aerosols on satellite ocean color was evaluated using SeaWiFS monthly standard mapped image products. The atmospheric optical thickness (AOT) increased in spring and summer, and it showed a strong positive correlation with remote sensing reflectance (normalized water leaving radiance/solar irradiance) at 555 nm (Rrs555) which is a component of the satellite chlorophyll estimation. The chlorophyll *a* of pixels that had high AOT and high Rrs555 was possibly overestimated in spring, especially in the area which showed large phytoplankton absorption, which is expressed by low remote sensing reflectance at 443, 490 and 510 nm (Rrs 443, Rrs490 and Rrs510). For this presentation, we recalculate the monthly chlorophyll *a* concentration in spring in consideration of the influence of atmospheric aerosols, and calculate the spring primary production in the East/Japan Sea using a vertical generalized production model. Calculated primary production will be compared with the satellite-estimated primary production in the East/Japan Sea that Yamada *et al.* (2005) calculated with the standard product.

BIO-P-5878

A model study to predict zooplankton biomass in intermediate and deep water

Yuya Yamamoto[1], Yasuyuki Kishi[1], Hirotada **Moki**[2] and Kisaburo Nakata[2]

[1] The General Environmental Technos Co.,Ltd.(KANSO Technos), 1-3-5 Azuchimachi, Chuo-ku, Osaka, 541-0052, Japan
[2] School of Science and Technology, University of Tokai, 3-20-1 Shimizu-Orido, Shizuoka, 424-8610, Japan
E-mail: 8atgd004@mail.tokai-u.jp

To estimate primary production of the global ocean, a global carbon cycle model based on an ecosystem model has been developed. This type model is focused on the surface euphotic layer. In environmental assessments of ocean mining such as manganese nodule mining and thermal vent deposit mining, impacts on the ecosystems in intermediate and deep water could be important. By using a global carbon cycle model, we computed the ecosystem in these environments and found the model predicted less zooplankton biomass by 2-3 orders of magnitude than the observed results. To improve the model performance, we introduced a vertical diurnal migration of carnivorous and omnivorous zooplankton into the global ecosystem model and re-examined the parameter values related to zooplankton grazing such as the Ivelev coefficient. The improved model can predict reasonable zooplankton biomass in deep water. The model results showed that the vertical migration of zooplankton plays an important role in the export of detritus to the intermediate and deep zones.

BIO-P-5900

Spatio-temporal variability of epifaunal distributions caused by the Hebei Spirit oil spill in the surf zone on the Hakampo beach on the west coast of Korea

Jiyeon **Kim**, Chaewoo Ma and Wongyu Park

Department of Marine Biotechnology, Soonchunhyang University, 646 Eupnae-ri, Asan-si, Chungcheongnam-do, 336-745, R Korea
E-mail: kjy8122@naver.com

Effects of the Hebei Spirit oil spill, which occurred in December 2007, on epifaunal densities and distributions were investigated in the surf zone on the Hakampo beach on the west coast of Korea. Epifauna were captured every two hours for 24 hours on the day of the highest tidal range in June 2007 and 2008. A sled equipped with a net 45 cm wide, 10 cm high and 0.5 mm mesh was towed for 100 m parallel to the coastline. After the oil spill, the number of species increased while density decreased. The number of species was highest at 1 AM in both years. Density was highest at 3 AM in June 2007 while it was highest 1 PM in June 2008. The dominant species during the entire sampling period was *Calanus sinicus*. Other abundant species in June 2007 were *Archaeomysis vulgaris*, *Monoculodes koreanus, Cirolana harfordi japonica, Allorchestes angusta* and hyperiids. Among these species, densities of *M. koreanus,* and *A. angusta*, which were less mobile, were significantly decreased while those of *C. harfordi japonica*, inhabiting the upper intertidal area, increased after the oil spill. *C. calanus* decreased approximately 50% after the oil spill while hyperiids increased dramatically. Oil spill effects might have been fatal to the less mobile epifauna inhabiting intermediate and low intertidal areas while it was less fatal to the species inhabiting the upper intertidal area. Planktonic species occurring in the surf zone may be less impacted by the oil spill.

BIO-P-5906

Spatial distribution of filamentous cyanobacteria, *Trichodesmium* spp., in spring in the East China Sea

Toshikazu **Suzuki**, Hisako Mori and Daisuke Nakatsugawa

Faculty of Fisheries, Nagasaki University, 1-14 Bunkyo-machi, Nagasaki, 852-8521, Japan. E-mail: tsuzuki@nagasaki-u.ac.jp

Marine filamentous cyanobacteria, *Trichodesmium* spp., occur generally in the tropical and subtropical oligotrophic oceans. Their complicated structures in the fasciculated colonial form frequently prevent us from accurately estimating their standing crop. In this study, to get basic ecological information on this phytoplankton, the standing crop of *Trichodesmium* and its spatial distribution were closely investigated in spring in the eastern part of the East China Sea. Vertical profiles of *Trichodesmium* biomass showed a surface-biased pattern and the maximum layer (0 to 30 m depth) tended to be shallower than that of phytoplankton chlorophyll *a* (30 to 75 m depth) and that of coccoid cyanobacteria (10 to 40 m depth). *Trichodesmium* biomass in the surface layer ranged from 0.0001 to 0.043 μg/L in chlorophyll *a* concentration and it contributed up to 17 % of phytoplankton chlorophyll *a*. Higher biomass occurred in the area of higher water temperature as well as higher salinity. The separate filamentous form was sometimes predominant in continental shelf water, while the large-sized colonial (fasciculated) form was more or less abundant in the Kuroishio water. *Trichodesmium* biomass showed a positive relationship with nauplius abundance of *Macrosetella gracilis* (a harpacticoid copepod), though it had no relation with adult abundance of *M. gracilis* and had a negative relation with net-zooplankton biomass. A prey-predator relationship might be exclusively tight between *Trichodesmium* spp. and nauplius of *M. gracilis* in the eastern part of the East China Sea.

BIO-P-5915

A comparative study of the lipid dynamics of the euphausiid, *Euphausia pacifica*, from Korean seas (East/Japan Sea, South Sea, and Yellow Sea)

Hye Seon **Kim**[1], Ah-Ra Ko[2] and Se-Jong Ju[2]

[1] Deep-Sea and Marine Georesources Research Department, Korea Ocean and Research Development Institute, Ansan, P.O. Box 29, Seoul, 425-600, R Korea. E-mail: khs99@kordi.re.kr
[2] Marine Resources Research Department, Korea Ocean and Research Development Institute, Ansan, P.O. Box 29, Seoul, 425-600, R Korea

The euphausiid, *Euphausia pacifica*, is a cosmopolitan species in the North Pacific Ocean and is also widely distributed in all Korean seas including the East/Japan Sea, South Sea and Yellow Sea. It is assumed that they have different life strategies in order to live under various environmental/oceanographic conditions. Although they are one of the key species in marine ecosystems of Korean seas, little information on their biology and ecology is available. Therefore, this study was conducted to understand and compare the ecological/physiological characters (*i.e.* food availability, reproduction and mechanism for energy storage) of *E. pacifica* from three geographically and environmentally different Korean seas by examining lipid biomarkers including total lipids and lipid class composition. According to the preliminary results, *E. pacifica* from the East/Japan Sea have the same level of lipid content (about 10% of dry weight) and composition (phospholipids as a dominant lipid class – more than 50% of total lipids) found in *E. pacifica* from the eastern North Pacific Ocean (California Current System). These preliminary results suggest that the lipid dynamics (*i.e.* lipid contents and class composition) of *E. pacifica* may not be so different among regions in the North Pacific Ocean having similar environmental conditions (temperature, salinity, upwelling, *etc.*) to East/Japan Sea. However, currently we are investigating samples from the other seas (South Sea and Yellow Sea) having distinctly different oceanographic conditions to determine if there are regional differences of lipid dynamics with regard to their living strategies and life cycle features.

BIO-P-5917

Acute exposure of waterborne polycyclic aromatic hydrocarbon, benzo[a]pyrene during ovarian recrudescence in a marine fish, *Chasmichthys dolichognathus*

In Joon **Hwang** and Hea Ja Baek

Department of Marine Biology, Pukyong National University, Busan, 608-737, R Korea. E-mail: hjbaek@pknu.ac.kr

Polycyclic aromatic hydrocarbons (PAHs) are toxic compounds, generally formed as the result of incomplete combustion of organic material or crude oil. The purpose of this study was to assess the effects of benzo[a]pyrene (B[a]P), a representative PAH, on the ovarian recrudescence, following a period of regression, which can be sensitive to chemical contaminants. Adult *C. dolichognathus* were kept at 21ºC and a 14h light/10h dark regime to induce ovarian recrudescence. They were then exposed to 10 and 100 nM of B[a]P for 72 hours. After chemical exposure, effects on sex steroid hormone (testosterone (T), estradiol-17β (E2) and 17α,20β-dihydroxy-4-pregnen-3-one (17α20βP)) production from the ovaries were quantified by radioimmunoassay (RIA). Additionally, the effects on gonadosomatic index (GSI), hepatosomatic index (HSI) and condition factor (CF) were investigated. There were no significant differences in the GSI, HSI and CF of exposed and non-exposed groups during the experimental period. B[a]P exposure resulted in no significant differences in each steroid level. However, in the ratio of E2/T and E2/17α20βOHP, indices for endocrine disruption, 100 nM of B[a]P decreased the E2/T ratio significantly whereas there were no significant effects in the E2/17α20βOHP ratio. These results suggested that B[a]P exposure is sensitive to estrogenic activity and can disrupt steroid production during ovarian recrudescence.

BIO-P-5925

Environmental factors affecting dynamics of the phytoplankton community in port baseline surveys in Korea

Oh Youn **Kwon**[1], Jung-Hoon Kang[1], Yong Hwan Cha[1] and Man Chang[2]

[1] South Sea Coastal Environment Research Department, South Sea Institute, KORDI, 391, Jangmok-myeon Geoje-si, 656-830, R Korea. E-mail: koy00@kordi.re.kr
[2] Marine Resources Research Division, KORDI, Ansan, P.O. Box 29, Seoul, 425-600, R Korea

To understand the environmental factors affecting dynamics of phytoplankton communities at the busiest ports (Pusan, Ulsan, Incheon and Gwangyang) of Korea, we seasonally investigated the physico-chemical factors and phytoplankton assemblages from February 2007 to November 2008. Diatoms were the majority in the phytoplankton communities (78%). Maximum abundance of diatoms was observed at Pusan in summer 2007, and at Ulsan in spring 2007. During each period, over 60% diatoms at Pusan were *Chaetoceros debilis* and *Ch. pseudocrinitus*, and *Detonula pumilia* dominated at Ulsan. At the Incheon and Gwangyang ports, characterized as eutrophic and semi-enclosed environments, the abundance of diatoms peaked in winter when *Skeletonema costatum* dominated. It corresponded to conditions of lower salinity, higher concentration of chemical oxygen demand and total suspended solids compared to Pusan and Ulsan. When diatoms bloomed at the ports investigated, there were very low concentration of silicate and nitrate ($p<0.001$), indicating strong nutrient uptake by the dominating diatoms. Dinoflagellates, the next most abundant group, occurred frequently at the Pusan, Ulsan and Gwangyang ports in summer, when their abundance was significantly correlated with increasing temperature and decreasing salinity ($p<0.05$). Also, the concentration of phosphate was high (>1 μM) at the four ports in summer. In contrast, low abundances of dinoflagellates occurred during the study period at Incheon. At all ports, the predominant diatoms characterized waters with low concentrations of nutrients such as silicate and nitrate, while dinoflagellates mainly occurred in summer, with increasing temperature, low salinity and high phosphate concentration.

BIO-P-5926

Short term variability of primary production in the Changjiang River Plume in the East China Sea observed in summer 2008

Joji **Ishizaka**[1], Hisashi Yamaguchi[2], Sarat Tripathy[2], Takashi Makino[3], Takeshi Matsuno[4] and Takahiro Endoh[4]

[1] Hydrospheric Atmospheric Research Center (HyARC), Nagoya University, Furo-cho, Chikusa-ku, Nagoya, 464-8601, Japan E-mail: jishizak@hyarc.nagoya-u.ac.jp
[2] Graduate School of Environmental Study Nagoya University Japan
[3] Graduate School of Science and Technology, Nagasaki University, Japan
[4] Research Institute for Applied Mechanics, Kyushu University, Japan

The Changjiang River Plume is expected to influence the biological production in the East China Sea. Ocean color remote sensing showed the high chlorophyll *a* plume of the Changjiang River takes about two months to transit from the Changjiang mouth to the east of Jeju Island to the Tsushima Strait. However, little is know about the short term variability of biological responses in the Changjiang River Plume. We conducted time series observations in the Changjiang River Plume south of Jeju Island to track the plume with surface drifting buoys during summer 2008. Ocean color satellite imagery indicated switching of the Changjiang River Plume from southeastward to eastward before the time series observations. We will discuss the changes in primary production and other environmental parameters observed during the experiment.

BIO-P-5941

A phylogenetic study of Medusozoa (Scyphozoa, Hydrozoa) in Korean waters

Soo-Jung **Chang**[1], Donghyun Lim[1], Won Duk Yoon[1] and Suam Kim[2]

[1] Ecology and Oceanography Division, National Fisheries Research and Development Institute, 152-1 Haean-ro, Kijang, Pusan, R Korea. E-mail: sjchang@nfrdi.go.kr
[2] Department of Marine Biology, Pukyong National University, R Korea

To investigate the evolution of Medusozoa, molecular sequence data from the small subunit (SSU) and large subunit (LSU) of the ribosome were analyzed (Medina *et al*., 2001; Collins *et al*., 2006). Previous studies supported the monophyly of Bilateria, Cnidaria, Ctenophora, and Metazoa. We studied the 16S mitochondrial DNA of 10 Scyphozoa and 15 Hydrozoa for maximum likelihood (ML) and maximum parsimony (MP) using PAUP. The result shows that the Classes Scyphozoa and Hydrozoa are monophyletic and Orders Pelagiidae, Rhizostomatidae and Cyaneidae are sister groups under the Class Scyphozoa. Our phylogenetic study supports the original phylogenetic relationships within the medusazoa and we also found that 16S mitochondrial DNA was highly informative for identifying the medusozoan phylogenetic relationships.

BIO PAPER

BIO-P-5951

Ecosystem consequence of a *Noctiluca scintillans* bloom in the southern coast of the Korean Peninsula

Young Shil **Kang**[1], Weol Ae Lim[2], Young Sik Lee[2] and Yang-Soon Kang[1]

[1] National Fisheries Research and Development Institute (NFRDI), 408-1 Shirang-ri, Kijang-up, Kijang-gun, Busan, 619-705, R Korea. E-mail: yskang@nfrdi.go.kr
[2] Aquaculture Environment Institute, NFRDI, Tongyeong-si, 650-943, R Korea

Noctiluca scintillans blooms occur every year and large blooms often occur off the southern coast of the Korean Peninsula, These can have adverse effects on fisheries and the ecosystem. In the present study, environmental factors associated with *N. scintillans* occurrences, and bloom impacts on marine ecosystems, were investigated.

Bloom and non-bloom areas were compared before and after bloom periods. *N. scintillans* blooms were positively associated with high concentrations of DIN (Dissolved Inorganic Nitrogen) before the bloom. High NH_4 and DIN, and low Chl-*a* concentration were observed after the bloom. *N. scintillans* blooms are likely to have adverse impacts on copepods, appendicularians and fish eggs, while anchovy eggs and euphausiids occurred at high densities in *N. scintillans* blooms.

BIO-P-5981

Climate change triggered fecundity of the solitary ascidian, *Herdmania momus* in the Jeju coast, Korea: Implications for benthic community structure and artificial reef function

Ji-Woong **Ko**[1,2], M. Sidharthan[2], Sung Hwan Cho[1], Seock Jung Han[1] and Hyun Woung Shin[2]

[1] Jeju Fisheries Research Institute, National Fisheries Research and Development Institute, 1928 Wedo 2-Dong, Jeju City, 690 191, R Korea. E-mail: nyhc555@naver.com
[2] Department of Marine Biotechnology, Soonchunhyang University, 646 Shinchang-Myun, Eupnae-Ri, Asan City, 336 745, R Korea

An intensive underwater survey (SCUBA/CPCe) was carried out in selected coastal zones along the Jeju Island to assess the biodiversity of benthic fauna in 2008 - 2009. During the survey we encountered the solitary ascidian, *Herdmania momus* in high frequencies with unusual densities. In general, *H. momus* has enormous reproductive potential and thrives well in 'tropical waters'. Once rarely encountered, *H. momus* has increased in both the areal extent and vertically (3 – 40 m) along the Jeju coast. In quadrat samples collected from 27 locations on both natural and artificial reef surfaces, *H. momus* densities ranged from 5 to 2997 m^{-2}. A maximum of 832 individuals m^{-2} corresponding to 1438.503 g wet biomass m^{-2} was estimated from Haengwon (northern coast). Lower biomass levels were estimated from the eastern and southern coasts. Horn-triangle, turtle and bungalow type artificial reef modules attracted relatively high densities of *H. momus.* Analysis of mean annual temperature profiles on the Jeju coast suggested the distribution of *H. momus* has possiblly been affected by temperature induced fecundity.

Even though there is no direct evidence of allelochemical cues or inhibitory effects established from this species so far, the recent substantial impact of this opportunistic species is recognized. Ascendance of *H. momus* can lead to drastic changes in benthic community structure and composition, with cascading shifts in species diversity of natural as well as artificial reefs off the Jeju coast. Its impacts on native benthic species of commercial interest, inshore aquaculture and artificial reef function are discussed.

FIS Paper Session

Co-Convenors: Gordon H. Kruse (U.S.A.) and Mikhail Stepanenko (Russia)

Papers addressing general topics in fishery science and fisheries oceanography in the North Pacific and its marginal seas are invited (except S2, S3 and S6 topics).

Thursday, October 29 (9:00-18:00)

9:00 ***Introduction by Convenors***

9:10 **Chul-Woong Oh, Jong-Hun Na and Hye-Min Park**
Reproductive biology of *Exopalaemon carinicauda* (Decapoda, Palaemonidae) in the Hampyong Bay of Korea (FIS-P-5676)

9:30 **Hyunjung Kang, Yeonghye Kim, Jinkoo Kim, Sungyeon Kim, Sukgeun Jung, Dong-woo Lee and Dae Soo Chang**
Maturity and spawning of small yellow croaker, *Larimichthys polyactis* (FIS-P-5859)

9:50 **Eunhui Lee, Yeonghye Kim, Hyunjung Kang, Haekyoung Kim, Sukgeun Jung, Dong-woo Lee and Dae Soo Chang**
Reproduction and growth of shotted halibut, *Eopsetta grigorjewi*, in southern coastal areas of Korea (FIS-P-5861)

10:10 **Hyunju Seo, Kohei Matsuda and Masahide Kaeriyama**
Long-term variations in body size and relative abundance of Pacific salmon during 1943-2007 (FIS-P-5754)

10:30 ***Coffee / tea break***

10:50 **Yasuhiro Kamimura and Jun Shoji**
Estimation of cohort-specific mortality of larval and juvenile black rockfish in a macro-algae habitat in the central Seto Inland Sea (FIS-P-5854)

11:10 **Sukgeun Jung**
Generalized size-dependent formulation for natural mortality of fish based on their fecundity (FIS-P-5615)

11:30 **Hee Won Park, Young Il Seo, Jae Bong Lee and Chang Ik Zhang**
Developing indicators and reference points for assessing fisheries in marine ranching ecosystems (FIS-P-5832)

11:50 **Oleg Bulatov and Georgiy Moiseenko**
The experience of using GIS technology for stock assessments of marine fishes (FIS-P-5534)

12:10 **Elizabeth A. Logerwell, Kimberly Rand, Sandra Parker-Stetter, John Horne and Tom Weingartner**
Beaufort Sea survey: Oceanographic linkages and climate change impacts (FIS-P-5587)

12:30 ***Lunch***

14:00 **Oleg N. Katugin, Gennady A. Shevtsov and Mikhail A. Zuev**
Patterns of spatial, bathymetric and seasonal distribution of the schoolmaster gonate squid *Berryteuthis magister* (Berry, 1913) in the Sea of Okhotsk and adjacent waters of the northwestern Pacific Ocean (FIS-P-5524)

14:20 **Aymen Charef, Seiji Ohshimo and Ichiro Aoki**
Vertical distribution patterns of acoustically classified fish schooling aggregations (FIS-P-5606)

14:40 **Sukyung Kang, Suam Kim, Ki Baik Seong and Hyung Kee Cha**
Effects of biological and oceanographic variability on migration timing of Korean chum salmon (FIS-P-5956)

15:00 **Fumitake Shido, Shin-ichi Ito, Taizo Morioka, Naoto Murakami, Takashi Ichikawa, Norio Shirafuji, Tadashi Andoh, Yasuhiro Ueno and Yasuhiro Yamanaka**
Influence of temperature on cruising speed of Pacific saury: Laboratory experiments with simple video techniques (FIS-P-5809)

15:20 ***Coffee / tea break***

15:40 **Yurii P. Diakov**
Generation stock abundance dynamics of flounders in the eastern Okhotsk Sea in view of inner and outer population factors (FIS-P-5514)

16:00 **William R. Bechtol and Gordon H. Kruse**
Factors leading to stock collapse of Kodiak red king crabs and their failure to recover (FIS-P-5530)

16:20 **Anatoliy Ya. Velikanov and Kim Sen Tok**
Peculiarities of climatic and oceanological influence on the long-term changes in species composition and abundance of pelagic and bottom fishes in Tatar Strait (FIS-P-5548)

16:40 **Eugene V. Samko and Alexander V. Kapshiter**
Using the satellite altimetry data to reveal perspective areas of the Japanese flying squid fishery in the Japan Sea (FIS-P-5722)

17:00 **Gottfried Pestal and Tatiana Tunon**
Statistical and practical performance of Bayesian decision-support tools for terminal fisheries targeting Atnarko River, British Columbia, Chinook salmon (*Oncorhynchus tshawytscha*) (FIS-P-5919)

17:20 **You Jung Kwon, Jae Bong Lee, Do Hoon Kim, Hyeok Chan Kwon and Chang Ik Zhang**
Ecosystem-based risk assessment and forecasting for the Korean large purse seine fishery (FIS-P-5797)

17:40 **Minling Pan and Chin-Hwa (Jenny) Sun**
Structural breaks and price linkage between Hawaiian and Japanese tuna sashimi markets (FIS-P-5890)

18:00 ***Session ends***

FIS-P Posters

FIS-P-5515 **Victor F. Bugaev, A.V. Bugaev and V.A. Dubynin**
Biological characteristics of commercial stocks of sockeye salmon *Oncorhynchus nerka* in East Kamchatka, Koryak Plateau and some adjacent areas

FIS-P-5517 **Elena V. Gritsay**
Seasonal and interannual variations in the age structure of walleye pollock in commercial catches in the western Bering Sea

FIS-P-5528 **Tetsuichiro Funamoto**
Effects of spawning stock biomass and environmental conditions on walleye pollock (*Theragra chalcogramma*) recruitment in the northern Japan Sea

FIS-P-5545 **Margarita D. Boyarova and Olga N. Lukyanova**
Organochlorine pesticides in marine and freshwater organisms from the Russian Far East

FIS-P-5570 **Réka Domokos**
Environmental effects on forage and longline fishery performance for albacore (*Thunnus alalunga*) in the American Samoa Exclusive Economic Zone

FIS-P-5572 **Kevin Thompson, Grant Thompson and OSU Qualitative Analysis Group**
Precautionary management may destabilize a fishery: Examples using loop analysis

FIS-P-5575 **Liudmila S. Dolmatova and Olga A. Zaika**
Seasonal- and age-dependent activities of antioxidant enzymes in holothurian *Eupentacta fraudatrix*

FIS-P-5590 **Yugo Shimizu and Yoji Narimatsu**
Relationship in temporal variability between temperature and recruitment of Pacific cod (*Gadus macrocephalus*) off the northeast coast of Japan

FIS-P-5597 **Alexei M. Orlov, Eugeny F. Kulish, Alexander O. Shubin and Ilyas N. Mukhametov**
New data on age and growth of spiny dogfish *Squalus acanthias* in the northwestern Pacific Ocean

FIS-P-5675 **Galina S. Borisenko**
The artificial radionuclides Sr-90 and Cs-137 in commercial fishes and sea water of Japan Sea

FIS-P-5678 **Chul-Woong Oh and Jong-Hun Na**
Population biology of Korean pomfret *Pampus echinogaster* (Basilewsky, 1855) (Perciformes: Stromateidae) on the Western Coast of Korea, Yellow Sea

FIS-P-5687 **Alexei M. Orlov, Vadim F. Savinykh, Dmitry V. Pelenev and Eugeny F. Kulish**
Distribution and size composition of spiny dogfish in the North Pacific

FIS-P-5702 **Naoki Tojo, Akira Nishmura, Tetsuichiro Funamoto, Orio Yamamura, Hiroki Yasuma and Kazushi Miyashita**
Ecologically driven spatial dynamics in pre-wintering juvenile walleye pollock (*Theragra charcogramma*) in the coastal sea off northeastern Hokkaido, Japan

FIS-P-5726 **Svetlana A. Ireykina**
Biotransformation and oxidative stress biomarkers as useful tools in assessment of pollution effects in estuaries of Peter the Great Bay (Japan/East Sea)

FIS-P-5807 **Seock-Woo Jang, Seong-Gil Kim, Ok-In Choi, Seong-Soo Kim and Zang-Geun Kim**
Concentration of trace metals in the tissues of common dolphins (*Delphinus delphis*) on the east coast of Korea

FIS-P-5847 **Nadezhda L. Aseeva**
Myxozoa parasites in fishes of the northwest Japan Sea

FIS-P-5857 **Wongyu Park, Chaewoo Ma, Miyoung Song, Myoung-Ho Sohn, Hakjin Hwang, Jong-Bin Kim, Kwangho Choi and In-Ja Yeon**
Seasonal occurrence and distribution of Japanese mantis shrimp *Oratosquilla oratoria* larvae off Yeonpyeong-do near the Korean coast in the Yellow Sea

FIS-P-5858 **Myoung-Ho Sohn, Miyoung Song, Hakjin Hwang, Yang-Jae Im, In-Ja Yeon, Wongyu Park, Chaewoo Ma and Jae-Won Kim**
Larval occurrence and distribution of swimming crab *Charybdis japonica* (Milne Edwards, 1860) off Yeonpyeong-do near Korean coast in the Yellow Sea

FIS-P-5872 **Jong Hee Lee, Jae Bong Lee, Jung Nyun Kim, Dong Woo Lee and Dae Soo Chang**
Seasonal species composition of marine organisms collected by a shrimp beam trawl in the Nakdong River estuary, Korea

FIS-P-5916 **Hyoungsum Han, Chaewoo Ma and Wongyu Park**
Differences of growth and density in *Ruditapes philippinarum* in the intertidal area in Tae-an on the west coast of South Korea

FIS-P-5918 **Hae-Won Lee, Byung-Kyu Hong, Young-Min Choi and Dong-Woo Lee**
Gonadal maturation and spawning in the Pacific herring, *Clupea pallasii*, in the East/Japan Sea of Korea

FIS-P-5920 **Tatiana Tunon and Gottfried Pestal**
Using classification trees to capture a manager's interpretation of Bayesian projections

FIS-P-5957 **Jung Hwa Choi, Bong Jun Sung, Jung Nyun Kim, Taeg-Yun Oh, Dae Soo Chang and Hyung Kee Cha**
Feeding habits of yellow goosefish, *Lophius litulon*, and John Dory, *Zeus faber* in the northern part of the East China Sea

FIS-P-5988 **Wen-Bin Huang**
Comparisons of spatiotemporal variations in abundance and size composition of Pacific saury between the high-seas and coastal fishing grounds in the Northwestern Pacific

FIS-Paper Session Oral Presentations

29 October, 9:10 (FIS-P-5676)

Reproductive biology of *Exopalaemon carinicauda* (Decapoda, Palaemonidae) in the Hampyong Bay of Korea

Chul-Woong Oh[1], Jong-Hun Na[2] and Hye-Min **Park**[1]

[1] Department of Marine Biology, Pukyung National University, Busan, 608-737, R Korea. E-mail: srimppark@gmail.com
[2] Fisheries Resources Research Team, National Fisheries Research and Development Institute, Busan, 619-705, R Korea

Investigations on reproductive aspects of the ridgetail prawn, *Exopalaemon carinicauda*, were made in the Hampyong Bay of Korea from January 2003 to December 2004. Males and females comprised 31.6% and 68.4% of the total sample, respectively. There was a predominance of females in the sex ratio. Females progressively dominated the larger size classes. Female maturity was determined by the size of ovigerous females and of females with maturing ovaries. The size at which 50% of females are mature is estimated as 14.97±4.63 mm CL. The main breeding season, from June to August, coincided with higher gonadosomatic indices. A significant difference in ovarian weight between females with non-eyed and with eyed egg stages was found. In this season, ovaries rematured during embryonic development, indicating a potential for multiple ovulations. Based on the incubation time of the embryos, females seemed to have at least two broods per year. Brood size showed a positive allometry to female body size with no apparent egg loss during incubation. The egg volume increased by 91% from 0.78±0.17 mm^3 at non-eyed eggs to 1.50±0.34 mm^3 at eyed eggs. Based on dry weight, an egg batch averaged 14% of female weight, indicating an investment in egg production similar to that in other marine shrimps, but lower than that of freshwater shrimps.

29 October, 9:30 (FIS-P-5859)

Maturity and spawning of small yellow croaker, *Larimichthys polyactis*

Hyunjung **Kang**[1], Yeonghye Kim[1], Jinkoo Kim[2], Sungyeon Kim[3], Sukgeun Jung[1], Dong-woo Lee[1] and Dae Soo Chang[1]

[1] Fisheries Resource Research Department, National Fisheries Research and Development Institute, Busan, 619-705, R Korea
E-mail: khj0214@nfrdi.go.kr
[2] Pukyong National University, Department of Marine Biology, Busan, 608-737, R Korea
[3] Aquaculture Environment Research Center, South Sea Fisheries Research Institute, NFRDI, Tongyoung, 650-943, R Korea

The small yellow croaker, *Larimichthys polyactis*, is a commercially important fish species in the Yellow and East China Seas. It is actively targeted by both Chinese and Korean fishing vessels. Past studies suggested that overfishing has led to a decline in its maturation size (norms of reaction), but catches of this species have dramatically rebounded since 2006. To obtain recent estimates of growth and maturity parameters and to re-evaluate the long-term change in its reproductive biology, we investigated monthly changes in maturity, gonadosomatic index, gonad weight, mean length at maturity, and sex ratio based on croaker samples caught by trawl, lift and gill nets from January 2006 to December 2008. We compare our estimates of these parameters to those previously reported to evaluate long-term changes in maturity of small yellow croaker.

29 October, 9:50 (FIS-P-5861)

Reproduction and growth of shotted halibut, *Eopsetta grigorjewi*, in southern coastal areas of Korea

Eunhui **Lee**, Yeonghye Kim, Hyunjung Kang, Haekyoung Kim, Sukgeun Jung, Dong-woo Lee and Dae Soo Chang

Fisheries Resource Research Department, National Fisheries Research and Development Institute, Busan, 619-705, R Korea
E-mail: ehlee83@nfrdi.go.kr

Shotted halibut, *E. grigorjewi*, is distributed throughout the Yellow, East and East China Seas. Their annual catch in Korean sea waters decreased since 2000, but their population biology is poorly known. To support the development of fishery management plans, we studied their reproduction and growth based on samples caught by trawls from 2004 to 2008 in southern coastal areas of Korea. We estimated maturity and fecundity by inspecting the gonad. We derived a von Bertalanffy growth curve for each sex by examining a thin sagittal plane of otoliths with transmitted and reflected–light microscopes to count the number of opaque zones. Then, we evaluate and project long-term changes in the population of shotted halibut in Korean sea waters by developing and applying an age-structured model.

29 October, 10:10 (FIS-P-5754)

Long-term variations in body size and relative abundance of Pacific salmon during 1943-2007

Hyunju **Seo**[1], Kohei Matsuda[2] and Masahide Kaeriyama[2]

[1] Graduate School of Fisheries Sciences, Hokkaido University, 3-1-1 Minato-cho, Hakodate, Hokkaido, 041-8611, Japan
E-mail: uagiri@fish.hokudai.ac.jp
[2] Faculty of Fisheries Sciences, Hokkaido University, 3-1-1 Minato-cho, Hakodate, Hokkaido, 041-8611, Japan

Pacific salmon, *Oncorhynchus* spp., play an important role as keystone species and providers of ecosystem services in the North Pacific. The most abundant species is pink salmon (*O. gorbusha*), followed by chum (*O. keta*) and sockeye salmon (*O. nerka*). To clarify the relationship between abundance and biological characteristics of Pacific salmon, we analyzed long-term spatiotemporal changes in fork length (FL) and catch per unit effort (CPUE) of pink, chum, and sockeye salmon collected by research gillnets from the T/V Oshoro-maru and the T/V Hokusei-maru of Hokkaido University in the North Pacific during 1943-2007. Populations of each species were distributed throughout the western Bering Sea (WBS), eastern Bering Sea (EBS), western North Pacific (WNP), central North Pacific (CNP), and east North Pacific (ENP). Since 1970, the average FL of chum salmon showed a significant declining trend in 6 of 48 populations (age-0.3 and -0.4 female in WNP, age-0.3 female and age-0.2-0.4 male in CNP). Average FL of sockeye and pink salmon did not show temporal changes. However, for pink salmon the odd-year group was shown to be larger than the even-year group in FL. In 10 of 48 populations, significant correlations were observed between CPUE and FL. Sockeye salmon showed negative correlations for four populations in the ENP and the EBS. Chum salmon showed a negative correlation for a population in the CNP, and positive correlations for two populations in the ENP and EBS. Pink salmon showed negative correlations for two populations in the WNP and ENP.

29 October, 10:50 (FIS-P-5854)

Estimation of cohort-specific mortality of larval and juvenile black rockfish in a macro-algae habitat in the central Seto Inland Sea

Yasuhiro **Kamimura** and Jun Shoji

Takehara Marine Research station, Graduate School of Biosphere Science, Hiroshima University, 5-8-1 Minato-machi, Takehara, Hiroshima, 725-0024, Japan. E-mail: m080161@hiroshima-u.ac.jp

Three species of black rockfish *Sebastes inermis, S. ventricosus and S. cheni* are most dominant in fish fauna of vegetated habitats (macro-algae: *Sargassum* spp. and seagrass: *Zostera marina*) in the Seto Inland Sea, southwestern Japan. The larvae and early juveniles immigrate into macro-algae habitats in late February at a total length of about 20 mm. Macro-algae, the dominant flora in the vegetated coastal waters of the Seto Inland Sea,

is replaced with seagrass after May. Rockfish larvae and juveniles were collected with a seine net (5 mm mesh) at one- or two-week intervals from February to May 2008. Surveys on environmental conditions (temperature, salinity, vegetation and prey abundance) were also conducted. Rockfish (three species combined) were most abundant on March 24 (479 ind./100 m^2). Extrusion dates estimated from otolith microstructures ranged from mid December to mid March. Larval and juvenile rockfish were divided into ten cohorts (each cohort covering a 10 days extrusion period). Immigration of January cohorts contributed to the seasonal peak in abundance observed in late March. Mortality rates estimated for five cohorts (early January to middle February), based on the decrease in cohort abundance, were higher in the later cohorts. Seasonal change in prey availability at the sampling site did not explain fluctuations in mortality rate, while abundance of vegetation (macro-algae) inversely correlated with the mortality rate. It is concluded that macro-algae habitat serves as predation refuge especially for the earlier cohorts of rockfish and that later cohorts are tend to be exposed to higher mortality (vulnerability to predation) due to decrease in the macro-algae abundance.

29 October, 11:10 (FIS-P-5615)

Generalized size-dependent formulation for natural mortality of fish based on their fecundity

Sukgeun **Jung**

National Fisheries Research and Development Institute, 408-1 Sirang-ri, Gijang-eup, Gijang-gun, Busan, 619-902, R Korea
E-mail: Sukgeun.jung@gmail.com

Natural mortality of fish is a major source of uncertainty in stock assessment for fishery management. As the mortality rate of fish larvae and juveniles is known to decrease with increasing body size, various generalized size-dependent formulations of mortality have been proposed. However, derived mortality rates differ greatly among the proposed formulations, requiring a way to validate the formulations. As fisheries scientists have often ignored implications of fecundity in estimating natural mortality of fish, I have developed and proposed an approach to validate size-dependent mortality rates based on fecundity for both of batch and total spawners. For bay anchovy (*Anchoa mitchilli*) and Pacific anchovy (*Engraulis japonica*), examples of heterochronal species, my central assumption for deriving their mortality rates was that, at equilibrium, approximately two of the eggs produced by an average female anchovy during the spawning period would survive after a year, because the life cycle of anchovy is mostly complete in a year. I recently developed a matrix projection method to estimate size-dependent natural mortality for isochronal fishes by providing an example of the application to Pacific cod (*Gadus macrocephalus*). Comparisons with results from field surveys suggested that my theoretically-derived natural mortality rates based on fish fecundity are reliable enough for the purpose of stock assessment. My approach of estimating and validating size-dependent natural mortality based on fecundity can be applied and extended to other freshwater and marine fish species, improving reliability of stock assessments for fisheries management.

29 October, 11:30 (FIS-P-5832)

Developing indicators and reference points for assessing fisheries in marine ranching ecosystems

Hee Won **Park**[1], Young Il Seo[2], Jae Bong Lee[3] and Chang Ik Zhang[1]

[1] Division of Marine Production System and Management, Pukyong National University, Busan, 608-737, R Korea
E-mail: hwpark@pkn u.ac.kr
[2] South Sea fisheries Research Institute, NFRDI, Yeosu, 556-820, R Korea
[3] Department of Fisheries Resources Research, National Fisheries Research and Development Institute, Busan, 619-905, R Korea

In marine ranching ecosystems we developed management objectives, indicators and reference points for assessing fisheries and their resources. Four management objectives were identified, such as the maintenance of sustainability, biodiversity, habitat quality and socio-economic benefits. Several indicators for each objective were developed according to data availability. In this study, we applied this approach to the Jeonnam marine ranching ecosystem. We carried out risk analyses for the three coastal fisheries, that is, gillnet, set net, and traps in the marine ecosystem. Based on the evaluation of 26 indicators for four objectives, we estimated species risk

index (SRI), fishery risk index (FRI) and ecosystem risk index (ERI) for the three coastal fisheries in the marine ecosystem. Finally, fisheries management recommendations were made to prevent significant and potentially irreversible changes in the marine ranching ecosystem.

29 October, 11:50 (FIS-P-5534)

The experience of using GIS technology for stock assessments of marine fishes

Oleg **Bulatov** and Georgiy Moiseenko

Russian Federal Research Institute of Fisheries and Oceanography (VNIRO), 17 V. Krasnoselskaya St., Moscow, 107140, Russia
E-mail: obulatov@vniro.ru, georgem@vniro.ru

During 2004-2009 years we have done on stock assessments of important targeted fishes in the Pacific and Atlantic oceans: walleye pollock (*Theragra chalcogramma),* North-east Arctic cod *(Gadus morhua morhua),* and Greenland halibut *(Reinhardtius hippoglossoides).* Daily reports of fishing vessels were used as a data source and GIS technology as a processing tool. Two versions of stock assessment were created. One of them takes into account the differential catchability of trawls and seems to be more precise. The results of this research showed that stock assessments by method presented here are superior to the XSA or other analytical approach methods.

29 October, 12:10 (FIS-P-5587)

Beaufort Sea survey: Oceanographic linkages and climate change impacts

Elizabeth A. **Logerwell**[1], Kimberly Rand[1], Sandra Parker-Stetter[2], John Horne[1,2] and Tom Weingartner[3]

[1] Alaska Fisheries Science Center (NOAA-NMFS), 7600 Sand Point Way NE, Seattle, WA, USA
E-mail: Libby.Logerwell@noaa.gov
[2] School of Aquatic and Fisheries Science, University of Washington, Box 355020, Seattle, WA, 98195, USA
[3] School of Fisheries and Ocean Sciences, 905 N. Koyukuk Dr., 245 O'Neill Bldg., P.O. Box 757220, Fairbanks, AK, 99775-7220, USA

During August 2008 the first survey of marine fishes in offshore waters of the Beaufort Sea since 1977 was conducted. The primary objective was to establish a baseline against which the effects of oil and gas development and climate change could be measured. The F/V *Ocean Explorer* was chartered for the survey. Benthic fish and invertebrate species composition, distribution and abundance were assessed with bottom trawls. Pelagic fish were surveyed with hydroacoustics and mid-water net tows. Physical oceanographic data were collected with conductivity-temperature-depth instruments. Fish made up 6% of the bottom trawl catch, and invertebrates made up the remaining 94%. A total of 38 species of fish and 174 species of invertebrates were identified at sea. The four most abundant benthic fish species were Arctic cod *(Arctogadus glacialis)*, eelpouts, Bering flounder *(Hippoglossoides robustus)* and walleye pollock *(Theragra chalcogramma)*. The most abundant invertebrates were brittle stars, snow crab (*Chionoecetes opilio*), a mollusk (*Musculus niger*) and a seastar (*Ctenodiscus crispatus*). The pelagic community was dominated by age-0 and age-1+ Arctic cod, sculpin and eelblennies. Synthesis of the fish survey and oceanographic data shows that water emanating from the Chukchi Sea through Beaufort canyon appears to be important habitat for pelagic and benthic fish. Comparison of our results with historic data suggests that climate change has resulted in northward expansion of some species' ranges, including commercially valuable species, such as pollock and Pacific cod *(Gadus macrocephalus)*. Our survey was also the first to document commercial-sized snow crab in the North American Arctic.

29 October, 14:00 (FIS-P-5524)

Patterns of spatial, bathymetric and seasonal distribution of the schoolmaster gonate squid *Berryteuthis magister* (Berry, 1913) in the Sea of Okhotsk and adjacent waters of the northwestern Pacific Ocean

Oleg N. **Katugin**, Gennady A. Shevtsov and Mikhail A. Zuev

Laboratory for Pelagic Resources, Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia. E-mail: katugin@tinro.ru; okatugin@mail.ru

The schoolmaster gonate squid *Berryteuthis magister* (Berry, 1913) is widely distributed in the boreal North Pacific, and is a common demersal cephalopod on the continental slope. There is a large body of scientific information about this species. However, many issues related to its distribution and life cycle patterns are unknown. We have analyzed an extensive database on the occurrence and biology of *B. magister*, from 33 research expeditions of TINRO-Centre into the Sea of Okhotsk and adjacent waters of the northwestern Pacific Ocean, during 1977-2003. Young squid were captured both in the pelagic zone and near the bottom, and were more frequent in the Sea of Okhotsk than in the Pacific Ocean. Adult squid were rarely caught in the pelagic zone, were distributed almost exclusively near the bottom, and occurred over the entire research area on the slope in the Sea of Okhotsk and northwestern Pacific Ocean. The densest concentrations of *B. magister* were found on slope off the north Kuril Islands in the Pacific Ocean and off west Kamchatka in the Sea of Okhotsk. Distribution patterns of different ontogenetic stages of this squid suggested that life cycle of the species is associated with the bottom.

Size distribution was bimodal (juveniles and adults) practically every month in the course of the year, and sexually mature squid were present almost all year round, with a peak abundance in the late summer and early fall. These observations suggest that successive generations of this semelparous species spawn throughout the year, and life cycle of *B. magister* lasts about two years.

FIS PAPER

29 October, 14:20 (FIS-P-5606)

Vertical distribution patterns of acoustically classified fish schooling aggregations

Aymen **Charef**[1], Seiji Ohshimo[2] and Ichiro Aoki[1]

[1] Graduate School of Agriculture and Life Science, University of Tokyo, Bunkyo ku, Tokyo, 113-8657, Japan
E-mail: aymen_charef@yahoo.com
[2] Seikai National Fisheries Research Institute, Fisheries Research Agency, Nagasaki, 851-2213, Japan

We studied the influence of environmental factors patterns on the vertical distribution of pelagic fish schools by examining individual school characteristics. Acoustic data were recorded using a quantitative echosounder Simrad EK 505 during summer acoustic surveys conducted form 2002 to 2006. We identified multispecies fish assemblages that included five commercially exploited fish species: sardine, round herring, anchovy, chub mackerel and Jack mackerel. These species were classified into three groups based on their acoustic descriptors.

Generalized additive models (GAMs) were applied to provide a statistically quantitative description of the relationship between vertical distribution and environmental covariates (surface and bottom temperature, surface and bottom salinity and depth). The results showed that the thermocline played an effective thermal barrier in limiting sardine, anchovy and round herring in the upper water column layer. Other species occurred in deeper waters below the thermocline and preferred lower temperature. Salinity and bottom depth had no significant effect on vertical distribution of fishes. Results were fairly consistent between from 2002 to 2006. These findings are essential for a better understanding of fish-ecosystem interactions and will provide leading indicators for more efficient fish stock monitoring.

29 October, 14:40 (FIS-P-5956)

Effects of biological and oceanographic variability on migration timing of Korean chum salmon

Sukyung **Kang**[1], Suam Kim[2], Ki Baik Seong[1] and Hyung Kee Cha[1]

1 National Fisheries Research and Development Institute, 152-1 Haean-ro, Gijang-gun, Busan, 619-705, R Korea
Email: kangsk@nfrdi.go.kr
2 Department of Marine Biology, Pukyong National University, 599-1 Daeyeon3-dong, Nam-gu, Busan, 608-737, R Korea

Korea is located at the southern range of the chum salmon (*Oncorhynchus keta*) distribution, an area where Pacific salmon production is known to be negatively impacted by climate change. Therefore, despite hatchery production, catches of chum salmon declined from 553 t in 1997 to less than 200 t at present. To improve run timing forecasts for Korean chum salmon, we examined relationships among regional ocean climate indices, in-river environmental conditions, age and size data of chum salmon and full run migration timing. It appears that larger chum salmon return earlier; timing of return in 2003 was about two weeks earlier than it was 20 years ago. Results indicated that Korean chum salmon arrived earlier in years with high river discharge and arrived later in years of low precipitation. However, there was no significant relationship between run timing and water temperatures in the coastal area and river. An ability to capture and identify maturing chum salmon in the open ocean, combined with the promising contributions from genomics, may begin to unravel the mysteries of how and why salmon decide to return to spawn, and will improve forecasting of chum salmon migration timing.

29 October, 15:00 (FIS-P-5809)

Influence of temperature on cruising speed of Pacific saury: Laboratory experiments with simple video techniques

Fumitake Shido[1,2], Shin-ichi **Ito**[1], Taizo Morioka[3], Naoto Murakami[3], Takashi Ichikawa[3], Norio Shirafuji[3], Tadashi Andoh[3], Yasuhiro Ueno[4] and Yasuhiro Yamanaka[2,5]

1 Tohoku National Fisheries Research Institute, FRA, 3-27-5 Shinhama-cho, Shiogama, Miyagi, 985-0001, Japan
E-mail:shido@affrc.go.jp
2 Graduate School of Environmental Science, Hokkaido University, Kita-10, Nishi-5, Kita-ku, Sapporo, Hokkaido, 060-0810, Japan
3 Akkeshi Station, Hokkaido National Fisheries Research Institute, FRA, 2-1 Tsukushikoi, Akkeshi, Hokkaido, 088-1108, Japan
4 Hachinohe branch, Tohoku National Fisheries Research Institute, FRA, 25-259 Shimomekurakubo, Same, Hachinohe, Aomori, 031-0841, Japan
5 Frontier Research Center for Global Change (FRCGC), Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 3173-25 Showa-machi, Kanazawa-ku, Yokohama, Kanagawa, 236-0001, Japan

Recently, a fish bioenergetics model coupled to a lower trophic ecosystem model, named NEMURO.FISH, was developed to investigate climate impacts on the growth of Pacific saury and herring. Regarding saury, whereas consumption parameters were relatively well established by field studies, other bioenergetics parameters were not determined by either field observations or laboratory experiments. This is mainly due to the long-standing difficulty to rear saury. However, saury rearing techniques were developed recently. The leading term of the bioenergetics model is consumption and the second is respiration. Respiration is a nonlinear function of temperature, body size and swimming activity. Therefore, as a first step to improve the bioenergetics model, we measured cruising speeds with a video camera fixed above a rearing tank under various water temperatures. As a result, we estimated a bell-shaped response function of cruising speed against temperature for both adult and young saury. While adults showed maximum cruising speeds at 11.3°C, the speed of young it was greatest at 14.9°C. This temperature dependency is quite different from that represented in NEMURO.FISH. Therefore, the next step is to determine how these new parameterization influences the growth calculations of NEMURO.FISH.

29 October, 15:40 (FIS-P-5514)

Generation stock abundance dynamics of flounders in the eastern Okhotsk Sea in view of inner and outer population factors

Yurii P. **Diakov**

Kamchatka Research Institute of Fisheries and Oceanography (KamchatNIRO), 18 Naberedzhnaya St., Petropavlovsk-Kamchatski, 683000, Russia. E-mail: diakov@kamniro.ru

Long-term abundance trends of yellowfin sole *Limanda aspera*, Alaska plaice *Pleuronectes quadrituberculatus*, Sakhalin sole *Limanda sakhalinensis*, longhead dab *Myzopsetta proboscidea* and flathead sole *Hippoglossoides elassodon* from the east part of the Sea of Okhotsk were studied. An assessment is made of the biotic and abiotic factors that affect their abundance. Among the abiotic factors we noted that cyclonic activity during the spawning period of flounders plays an important role, especially for yellowfin sole. Water temperature for spawning and post-spawning pelagic periods of life plays an important role in Alaska plaice, longhead dab and flathead sole abundance. Among the biotic factors, it is most likely that there are competitive interactions between highly abundant flounders like yellowfin sole and Sakhalin sole as well as with other species. Also the impact of predators and forage supply was observed to affect their abundance trends. From the early 1960s to late 1980s the empirical and model data did not demonstrate sufficient difference. Beginning in the mid-1990s the simulation results appeared different from the empirical data. However, the differences were small; 24 of 366 cases, about 6.6%. The equations used in the models to describe yellowfin sole and Alaska plaice population dynamics provided a more accurate description, compared to the equations describing the population dynamics of the other flounder species. This is practically important, because yellowfin sole is the main commercial species on West Kamchatka and Alaska plaice is also one of the most valuable commercial species.

29 October, 16:00 (FIS-P-5530)

Factors leading to stock collapse of Kodiak red king crabs and their failure to recover

William R. Bechtol and Gordon H. **Kruse**

School of Fisheries and Ocean Sciences, Juneau Center, University of Alaska Fairbanks, 17101 Point Lena Loop Rd., Juneau, AK, 99801, USA. E-mail: Gordon.Kruse@uaf.edu

The goal of this study was to understand the causes of the collapse and failure to recover by the red king crab *(Paralithodes camtschaticus)* stock off Kodiak Island, Alaska. This stock once supported the world's largest commercial fishery for red king crab with peak landings of 42,800 mt in 1965. However, the fishery has been closed since 1983 due to depressed crab abundance with no indications of forthcoming stock improvement. We conducted three analyses: (1) reconstruction of historical crab abundance over 1960-2004 with a length-based stock synthesis model incorporating data from pot and trawl assessment surveys, fishery landings, and dockside sampling; (2) estimation of stock-recruit relationships; and (3) development of predictive models incorporating environmental and ecological factors. It appears that, during a critical time of fishery development in the 1960s, an anomalous surge of strong recruitment promoted subsequent fishery overcapitalization. However, high harvest rates in the late 1960s were not sustainable and reproductive failures associated with female-biased sex ratios resulted in this male-only fishery. Recruitment varied among three different ecological regimes corresponding to shifts in approximately 1975 and 1985. Finally, closure of commercial fishing for more than 25 years has failed to produce stock recovery, likely owing to heightened predation mortality. In the late 1970s, groundfish predator biomass increased, and predator spatial distribution shifted into nearshore crab nursery areas in association with increased ocean temperatures. Thus, the population dynamics of Kodiak red king crabs can be explained largely by the combination of overfishing and climate-driven ecological regime shifts.

29 October, 16:20 (FIS-P-5548)

Peculiarities of climatic and oceanological influence on the long-term changes in species composition and abundance of pelagic and bottom fishes in Tatar Strait

Anatoliy Ya. **Velikanov** and Kim Sen Tok

Sakhalin Research Institute of Fisheries and Oceanography (SakhNIRO), 196, Komsomolskaya St., Yuzhno-Sakhalinsk, 693023, Russia
E-mail: velikanov@sakhniro.ru

In the past century, during the years when the intensity of the Tsushima Warm Current was high (1947-1949, 1973-1975 and 2002-2007), the frequency of major non-abundant south-latitude fish species increased near the western Sakhalin. Seasonal migrations of Japanese sardine to the Tatar Strait were observed mainly during periods of low water temperature (1932-1942 and 1976-1990); Japanese anchovy appeared in the years of high water temperature (1948-1967 and 1989-2008). The abundance of the main cold-water fish species that spawn in winter-spring and summer-autumn seasons has changed, for example, that of sardine and anchovy. In the 1970-1980s, when the Tsushima Current was not intensive, stock abundances of walleye pollock, capelin, Pacific cod and others that spawn in a winter-spring season were comparatively high. At the end of the 1980s and during the 1990s, the intensity of the Tsushima Current increased, but the stock abundance of the above mentioned species declined.. However, in these years there was an observed abundance increase for fish species with a summer-autumn type of spawn (yellow-fin flounder, arabesque greenling, Japanese anchovy). In the 1950-1960s, a high intensity of the Tsushima Current was also observed near the western Sakhalin. The same changes in abundance for the majority of the main warm-water and cold-water fish species in this region as were observed in the 1990s has also been noted during that time (1950-1960s). Yellow-fin flounder had the lowest stock abundance for the period of 1950-2000. This was caused by the bycatch activity in the 1950s and by high monsoon activity in the 1950-1960s, which resulted in non-abundance of this species.

29 October, 16:40 (FIS-P-5722)

Using the satellite altimetry data to reveal perspective areas of the Japanese flying squid fishery in the Japan Sea

Eugene V. **Samko** and Alexander V. Kapshiter

Pacific Research Fisheries Centre (TINRO-centre), 4, Shevchenko Alley, Vladivostok, 690600, Russia. E-mail: samko@tinro.ru

We analyzed the relationship between daily fishing effort for Japanese flying squid (*Todarodes pacificus* Steenstrup, 1880) and sea surface height (SSH) obtained from satellite altimetry in the Russian waters of the Japan Sea during summer and autumn 2003. Japanese flying squid is the most abundant species of nektonic pelagic communities in open and coastal waters of the Japan Sea. It occupies the Russian EEZ from June to November, and can be fished in July to October. Recent biomass in the Russian EEZ has been estimated at 200,000-500,000 tons, with >100,000 t allocated to the fishery. However, the total annual catch of squid within the EEZ by Japanese and Korean fishermen is <6,000 t, and Russian catches are negligible. To develop the squid fishery, new methods for identifying productive fishing grounds are necessary. We use sea level features as integrated indices of thermodynamic processes. The SSH is useful, because it describes thermodynamic conditions of the whole water layer, it indicates currents, eddies, and upwelling/downwelling, and it is directly connected to atmospheric dynamics. We used SSH anomalies for the area 40-44°N, 134-139°E available from the Colorado Center for Astrodynamics Research (http://argo.colorado.edu/~realtime/). The SSH anomaly (ξ) was calculated relative to the mean SSH based on data from all accessible satellites. Tendencies of SSH change ($\Delta\xi$) were calculated as: $\Delta\xi = \xi_0 - \xi_7$ where ξ_0 is the SSH anomaly on the day of a catch and ξ_7 is the SSH anomaly 7 days before the catch. Divergence of total flow was assumed in conditions of $\Delta\xi < 0$ and convergence when $\Delta\xi > 0$. Areas of active divergence correspond to upwelling and heightened biological productivity, where planktonivorous squid concentrate. On the other hand, plankton aggregate in the areas of convergence (*e.g.*, fronts) that are also favorable for concentration of planktonivores. Most fishing effort (62.3%) was located in conditions of strengthening convergence. However, effective catches (> 1.5 t per night) were obtained mainly in intermediate conditions – *i.e.*, stable, weakly dynamic areas.

29 October, 17:00 (FIS-P-5919)

Statistical and practical performance of Bayesian decision-support tools for terminal fisheries targeting Atnarko River, British Columbia, Chinook salmon (*Oncorhynchus tshawytscha*)

Gottfried **Pestal** and Tatiana Tunon

SOLV Consulting Ltd., Vancouver, BC, Canada. E-mail: gpestal@solv.ca

Terminal fisheries targeting Atnarko River, British Columbia, Chinook salmon (*Oncorhynchus tshawytscha*) are managed based on weekly projections of total escapement to the spawning grounds. A projection model using Bayesian updating was developed with the local manager in 2001, and has been used since the 2002 fishing season. We evaluate the performance of the projection model and associated decision-support tools over 8 fishing seasons. The statistical properties of models like this can be evaluated by comparing the weekly in-season projections to post-season estimates of escapement based on spawning ground surveys. However, the practical performance of the model during annual implementation of the fishery needs to be judged in a broader context (*e.g.*, sensitivity to alternative prior assumptions, manager's interpretation of model output, transparency in stakeholder discussions, projections *vs.* weekly management reference points, staff changes, model updating and maintenance).

29 October, 17:20 (FIS-P-5797)

Ecosystem-based risk assessment and forecasting for the Korean large purse seine fishery

You Jung **Kwon**[1], Jae Bong Lee[2], Do Hoon Kim[2], Hyeok Chan Kwon[1] and Chang Ik Zhang[1]

[1] Pukyong National University, 599-1 Daeyeon3-dong, Nam-gu, Busan, 608-737, R Korea. E-mail: kwonyj@pknu.ac.kr
[2] National Fisheries Research and Development Institute, 408-1 Shirang-ri. Gijang-up, Gijang-gun, Busan, 619-902, R Korea

The large purse seine fishery is one of Korea's major fisheries, accounting for more than 20% of total catch of the Korean coastal and offshore fisheries. Major species taken by the fishery include common mackerel (*Scomber japonicus*), jack mackerel (*Trachurus japonicus*), common squid (*Todarodes pacificus*), hairtail (*Trichiurus lepturus*), Spanish mackerel (*Scomberomorus niphonius*), and yellowtail (*Seriola quinqueradiata*). In this study, we carried out a risk assessment of the Korean large purse seine fishery using a new approach, Integrated Fisheries Risk Assessment Method for Ecosystem (IFRAME), considering sustainability, biodiversity, habitat quality and socio-economic status as management objectives. This approach has a two-tier analytical system. Common mackerel was assessed by a Tier 1 analysis, since more scientific data were available and quantitative stock assessment has been conducted for this species. A Tier 2 analysis was conducted for the remaining species, which are taken as bycatch, as quantitative data were not available for those species. We use this approach to forecast the changing structure of the ecosystem and risk indices by altering management options such as allocated TAC of common mackerel.

29 October, 17:40 (FIS-P-5890)

Structural breaks and price linkage between Hawaiian and Japanese tuna sashimi markets

Minling **Pan**[1] and Chin-Hwa (Jenny) Sun[2]

[1] NOAA-fisheries, Pacific Islands Fisheries Science Center, Honolulu, HI, USA. Email: Minling.Pan@noaa.gov
[2] National Taiwan Ocean University, visiting scholar, Inter-American Tropical Tuna Commission

It is important for fishery managers to understand fish price responses to changes in market structure, ecosystem conditions, and regulatory regimes. For example, income to fishers and in turn, the dynamics of the fleet, might be influenced by both the availability of resources and price levels. The objective of this research is threefold. First, this study uses a co-integration model to investigate possible potential long-run pricing relationships among the major landings of the Hawaiian tuna longline fishery (bigeye, yellowfin, skipjack, and albacore). This analysis will determine to what extent changes in price for one species might impact others in the Hawaiian tuna auction market. Second, a Multivariate Markov-switching autoregressive (MS-AR) model is used to identify regime shifts and price responses in Hawaiian bigeye and yellowfin tuna prices in relation to their own landings, explore

potential price linkages with tuna sashimi prices in Japan, and examine the possible effect of changing tuna quality, such as the fat content due to seasonal change of sea surface temperature (SST) on the major fishing ground. In addition, this study intends to evaluate the market effects of ENSO (El Niño/Southern Oscillation) cycles on biomass (represented by CPUE), landings, and prices. Anticipating fluctuations in abundance of the biomass caused by the ENSO cycles could help investors and fishery managers make sound decisions on expected tuna harvests in an uncertain environment. The findings of this research will promote advancements in understanding the ecosystem dynamics of global tuna fisheries by providing a vital bridge between human and natural elements in support of an ecosystem approach to management.

FIS-Paper Session Posters

FIS-P-5515

Biological characteristics of commercial stocks of sockeye salmon *Oncorhynchus nerka* in East Kamchatka, Koryak Plateau and some adjacent areas

Victor F. **Bugaev**, A.V. Bugaev and V.A. Dubynin

Kamchatka Research Institute of Fisheries and Oceanography (KamchatNIRO), 18 Naberezhnaya St., Petropavlovsk-Kamchatsky, 683000, Russia. E-mail: bugaevv@kamniro.ru

Juvenile sockeye salmon in most cases stay in the lakes for 1–2 years (sometimes for 3–4 years, and in exceptional cases – for 5–6 years). In river watersheds having no lakes with the depth more than 13–18 m, sockeye salmon can migrate to sea in their first year at age 0+. In the ocean, sockeye salmon usually spend 3 years, sometimes 2–4 years and in exceptional cases – 5 years. The age structure of local stocks of sockeye salmon within an area does not exhibit any correlation with geographical latitude of the location of spawning.

The length, the weight and the fecundity of mature sockeye salmon from East Kamchaka, Koryak Plateau, Anadyrsky Gulf and Bering Island is correlated to the geographical latitude of the outlet of the natal river. The correlations increase the characteristics northward. This is likely because juvenile sockeye salmon from these rivers migrate directly to the open waters of the Bering Sea and Pacific Ocean. In contrast, sockeye salmon from the Okhotsk Sea West Kamchatka migrate to the open waters around the southern corner of Kamchatka through the North-Kuril straits. There is also a positive correlation of sockeye salmon body size increase and latitude but some disturbing exceptions occur.

FIS-P-5517

Seasonal and interannual variations in the age structure of walleye pollock in commercial catches in the western Bering Sea

Elena V. **Gritsay**

Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia
E-mail: gritsay@tinro.ru

There is seasonal and interannual variations in the length-age structure of walleye pollock in commercial catches in the Russian waters of Bering Sea (Navarin area). The seasonal variability in length structure occurs as the abundance of immature fish increase from summer to winter. Since the end of 1970's younger walleye Pollock have been caught in the Navarin area. Four age groups from 2+ up to 5+ years-old dominate. Older fish represent less than 5.5 % of the total catch. There were strong year classes in 1992, 1999-2001; an average year class in 1996; and weak year classes in 1993-1995, 1997-1998 and 2002-2004. In 2005-2006 the age structure and proportion of year classes in the Russian and US waters was practically the same. There was low recruitment of the eastern Bering Sea population and an increase in the migration of middle-age fish into Russian EEZ.

FIS-P-5528

Effects of spawning stock biomass and environmental conditions on walleye pollock (*Theragra chalcogramma*) recruitment in the northern Japan Sea

Tetsuichiro **Funamoto**

Hokkaido National Fisheries Research Institute, 116 Katsurakoi, Kushiro, Hokkaido, 085-0802, Japan. E-mail: tetsuf@fra.affrc.go.jp

The northern Japan Sea stock (JSS) of walleye pollock (*Theragra chalcogramma*) is an important fisheries resource in Japan, with the annual catches of about 100–150 thousand tons from the 1970s to early 1990s. However, the recruitment decreased beginning about 1990, resulting in a decline in biomass. In this study, I analyzed the factors causing this recruitment decline by investigating the relationship between recruitment, spawning stock biomass (SSB) and environmental factors using a generalized additive model (GAM). Sea surface temperature

(SST), ocean current strength and wind intensity data were used as environmental variables. A GAM fit to the data showed the importance of these three environmental factors and SSB in determining the recruitment. Recruitment was negatively related to SST and ocean current strength and positively related to SSB. A dome-shaped relationship was observed between wind intensity and recruitment. The values of SST and ocean current strength (wind intensity) have been mostly high (low) since the 1990s, and SSB has been decreasing since the late 1990s. These findings suggest that the recruitment decline of JSS after 1990 was caused by warm water temperature, strong ocean current and weak wind. The decrease in SSB after the late 1990s amplified this decline in recruitment.

FIS-P-5545

Organochlorine pesticides in marine and freshwater organisms from the Russian Far East

Margarita D. **Boyarova**[1] and Olga N. Lukyanova[2]

[1] Pacific State Economic University, 19 Okeansky Ave., Vladivostok, 690950, Russia. E-mail: olgaluk@gmail.com
[2] Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia

Organochlorine pesticides (OCP) are of great importance because of their bioaccumulative nature and toxic biological effects on wildlife and humans. The content of DDT and its metabolites and isomers of hexachlorcyclohexane (HCH) was detected in organs of sea gulls, fishes, mollusks and marine plants from Peter the Great Bay in the western part of the Sea of Japan/East Sea in 1998-2008. The total concentration of pesticides in soft tissues of mussels collected near Vladivostok varied from 1 to 30 ng/g wet weight. In flounders from the same area HCH isomer levels ranged from 30 to 45 ng/g and the content of DDT and its metabolites varied from 10 to 170 ng/g in different years. The chemicals amounted to 3,000-4,000 ng/g in livers of gulls sampled on the south portion of the Bay. In 2006 the OCP content was detected in freshwater organisms of different trophic levels from phytoplankton to predatory fishes from the Khanka Lake in the south of the Russian Far East. The total OCP level reached 340-890 ng/g of dry weight and was highest in the predator's livers. These data confirm a long-term presence and new input of OCP in marine and freshwater ecosystems of the Russian Far East.

FIS-P-5570

Environmental effects on forage and longline fishery performance for albacore (*Thunnus alalunga*) in the American Samoa Exclusive Economic Zone

Réka **Domokos**

Pacific Islands Fisheries Science Center, NMFS, NOAA, 2570 Dole St., Honolulu, HI, 96822, USA. E-mail: reka.domokos@noaa.gov

The South Equatorial Counter Current (SECC) strongly influences the American Samoa Exclusive Economic Zone (EEZ) and changes strength on a seasonal and ENSO cycle. Strong SECC is associated with a predominantly anticyclonic eddy field as well as increased micronekton biomass and catch-per-unit-effort (CPUE) for albacore tuna, the economically important target species of the local longline fishery. Strong SECC carries chlorophyll *a*-rich waters from upwelling regions at the north coast of New Guinea towards the EEZ, most likely resulting in the observed increase in micronekton biomass, forage for albacore. Relatively stable anticyclonic eddies show a further increase in micronekton biomass, apparently advected in from neighboring SECC waters. The presence of forage presumably concentrates albacore, thus resulting in the observed increase in CPUE. High shear regions of neither anticyclonic nor cyclonic eddies correlate with increased micronekton biomass. Areas characterized by South Equatorial Current (SEC) waters correspond to areas with the lowest micronekton biomass and the highest number of aggregative structures, which are most likely small pelagic fish shoals. Micronekton composition in SEC waters differs from that in the SECC. During El Niños, the seasonal signals at the north shore of New Guinea and in the SECC are exceptionally strong and correspond to higher albacore CPUE in the EEZ. Results suggest that the strength of upwelling and the resulting increase in chlorophyll *a* at New Guinea, as well as the Southern Oscillation Index, could be used to predict the performance of the local longline fishery for albacore tuna in the American Samoa EEZ.

FIS-P-5572

Precautionary management may destabilize a fishery: Examples using loop analysis

Kevin **Thompson**[1], Grant Thompson[2], OSU Qualitative Analysis Group[1]

[1] Department of Fisheries and Wildlife, Oregon State University, 104 Nash Hall, Corvallis, OR, 97331, USA
E-mail: kevin.thompson@oregonstate.edu
[2] NOAA-Fisheries, Alaska Fisheries Science Center, 7600 Sand Point Way, N.E, Seattle, WA, 98115, USA

Loop analysis is a methodology that allows for qualitative analysis of complex systems. It has been used to study a number of ecological and natural resource questions including environmental changes, invasive species, and ecosystem effects of fisheries. Using this modeling framework, we investigated the possibility that management actions that are intended to be precautionary may actually destabilize a fishery. While it is well known that introduction of positive feedback tends to be destabilizing, the existence of large negative feedback loops can yield a similar result. We found that fishery systems were stable when managers regulated the fishery through imposition of a per-unit-effort tax rate that was independent of stock size. However, results differed in a more complex system where managers increased tax rates more rapidly when stock size was low. Sufficiently high rates of tax increase in response to low stock size were found to destabilize the fishery even though all feedback loops were negative. This indicates that, within certain management structures, being too precautionary may destabilize a fishery system.

FIS PAPER

FIS-P-5575

Seasonal- and age-dependent activities of antioxidant enzymes in holothurian *Eupentacta fraudatrix*

Liudmila S. **Dolmatova** and Olga A. Zaika

V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: dolmatova@poi.dvo.ru

The holothurian *Eupentacta fraudatrix* is a source of biologically active substances and a prospective mariculture species. The aim of this study was to investigate the seasonal- and age-dependence of the antioxidant enzyme activities in the coelomic fluid of *E. fraudatrix*. Specimens were collected twice a month during May-October 2008 in Alexeev Bay (Peter the Great Bay, Sea of Japan) at a depth of about 1.5 m. The animals were distributed into two groups by body length: 3-4 cm (I) and 4.5-5.5 cm (II). Activities of superoxide dismutase (SOD), catalase, and glutathione reductase (GR) in group II increased significantly in June compared to their values in May (at maximal temperatures of 15°C and 8°C, correspondingly). The next three months, catalase and GR activities significantly decreased, especially in August (period of temperature rise to 21-23°C), and reached lower levels compared to those in May. In October, enzyme activities insignificantly increased again. However, SOD activity increased during July and August compared to levels in May. The scale of variations in seasonal enzyme activities in group I, especially in May-June, was not so large as that in group II. Thus, the seasonal changes in activities of antioxidant enzymes were observed in both groups studied, and significant body-length/age dependence was also revealed. Apparently, the changes found are connected both to changes in physiological activities of animals during reproductive cycle, and to different level of oxygen consumption in tissues of animals of different age.

FIS-P-5590

Relationship in temporal variability between temperature and recruitment of Pacific cod (*Gadus macrocephalus*) off the northeast coast of Japan

Yugo **Shimizu**[1] and Yoji Narimatsu[2]

[1] Tohoku National Fisheries Research Institute, Shinhama 3-27-5 Shiogama, Miyagi, 985-0001, Japan. E-mail: yugo@affrc.go.jp
[2] Tohoku National Fisheries Research Institute, Hachinohe Station, 25-259 Shimomekurakubo, Same, Hachinohe, Aomori, 031-0841, Japan

In order to determine the key oceanographic processes that induce variability in recruitment of Pacific cod (*Gadus macrocephalus*) off the northeast coast of Japan (Sanriku and Joban coasts), we examined correlations between the time series of a population size, at age 0+, based on data from a bottom trawl survey, and the temperature

at the sea surface, 100m, and 200 m depths during 1996-2007. The population size at age 0+ had significant negative correlation with (a) annual average temperatures at each depth, and (b) sea surface temperature in June, respectively. The result (b) suggests that the recruitment is significantly decreased at warm temperatures that occur around the migration life stage, *i.e.*, from pelagic to demersal.

FIS-P-5597

New data on age and growth of spiny dogfish *Squalus acanthias* in the northwestern Pacific Ocean

Alexei M. **Orlov**[1], Eugeny F. Kulish[1], Alexander O. Shubin[2] and Ilyas N. Mukhametov[2]

[1] Russian Federal Research Institute of Fisheries and Oceanography (VNIRO), 17 V. Krasnoselskaya St., Moscow, 107140, Russia
E-mail: orlov@vniro.ru

[2] Sakhalin Research Institute of Fisheries and Oceanography (SakhNIRO), 196 Komsomolskaya St., Yuzhno-Sakhalinsk, 693016, Russia

The spiny dogfish *Squalus acanthias* occurs in the pacific waters off the Kuril Islands and Kamchatka relatively rarely, mostly during the summer and autumn feeding migrations, and are harvested as by-catch in the Pacific salmon fisheries. Until now, information on this species age and growth were limited to studies made in the 1930s. In the present study, 267 second dorsal spines were sampled in the Pacific waters of the Kuril Islands and Kamchatka from driftnet catches of salmon in 2005-2006. The dogfish found in catches were individuals of 67 to 123 cm, weighing 1140 to 5970 g, aged 10-24 years. Comparison of the growth rate of dogfish shows that in the area surveyed individuals grew somewhat faster than animals from the Sea of Japan and the Northeast Pacific. The growth rates in males and females were somewhat different. The female life span is longer since no males over 20 years were recorded in catches while the females reached 24 years. The coefficient K for growth rate in males and females was 0.06 and 0.04, respectively. The asymptotic length values $L\infty$ for males and females were 121.4 and 158.8 cm, respectively. The size of the spine (length, base width and base length) agrees with the age of dogfish, and might be used in future to facilitate the study of its age structure in the study area.

FIS-P-5675

The artificial radionuclides Sr-90 and Cs-137 in commercial fishes and sea water of Japan Sea

Galina S. **Borisenko**

Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia
E-mail: vera_borisenko@mail.ru

We investigated the dynamics of change of specific activity anthropogenic radionuclides Sr-90 and Cs-137 in commercial fishes and their habitat for the period 1997-2006 (Shelf of Primorye and Central Part of Japan Sea). Among the large number of radioactive isotopes polluting the sea, the products of nuclear division of Sr-90 and Cs-137 represent a special danger, having a long half-life (29.1 and 30.0 years respectively) and being analogues of biogenic elements of calcium and potassium, irreplaceable in metabolism. For the period 1997-2006, a decrease in volumetric activity Cs-137 from 5,8 up to 3,0 Bk/м^3 and Sr-90 from 5.4 up to 2.8 Bk/м^3 was observed, that can be explained by physical process - radioactive disintegration of radioisotopes. Uptake of radionuclides in fish occurs through gills, the integumentary system and food. According to our research, specific activity of Cs-137 in fish for the 10-year period has decreased also in water in 2 times from 3.1 up to 1.6 Bk/kg while specific activity Sr-90 only in 1.5 times from 2.4 up to 1.5 Bk/kg. This result can be explained by the different rate of metabolic processes in fish: the period of semiejection of Cs-137 lasts 140 days, and the period of semiejection of Sr-90 lasts 365 days, therefore reduction of Sr-90 activity occurs more slowly than Cs-137. Using a sanitary and hygienic approach, the content of Sr-90 and Cs-137 in investigated fishes in the Japan Sea was considerably below admissible levels (100-130 Bq/kg accordingly) and their use of food does not represent a radiation hazard.

FIS-P-5678

Population biology of Korean pomfret *Pampus echinogaster* (Basilewsky, 1855) (Perciformes: Stromateidae) on the Western Coast of Korea, Yellow Sea

Chul-Woong **Oh**[1] and Jong-Hun Na[2]

[1] Department of Marine Biology, Pukyong National University, Busan, 608-737, R Korea. E-mail: ohcw@pknu.ac.kr
[2] Division of Marine Production System Management, Pukyong National University, Busan, 608-737, R Korea

Investigations were made on the population biology of *Pampus echinogaster* (Basilewsky, 1855) in the coastal areas of Korea, Yellow Sea, between August 2005 and July 2006. The population structure was not significantly different between males and females. Monthly variation in the gonadosomatic index (GSI) of both sexes defined the spawning period as extending from March through July. A similar pattern was also observed in the change in maturity stages. For males and females, GSI was positively correlated with the hepatosomatic index (HSI). Fecundity, ranging from 41,250 to 103,610 eggs, was related to body size, indicating that body size is a useful determinant of fecundity. The sexual maturity (L_{50}) was estimated as 14.98 cm TL for males and 19.32 cm TL for females. Parameters of growth estimated by the modified von Bertalanffy growth function model showed that the values of L_{∞} and K for combined data were 39.12 cm TL and 0.65 yr^{-1}. The growth performance index of this study (2.75) was higher than that of the previous study (2.45). This difference could be attributed to the sampling method. The recruitment patterns indicated one normally distributed group. The percentage of the recruitment was 51.04% in the spawning season and the highest in August (19.78%).

FIS-P-5687

Distribution and size composition of spiny dogfish in the North Pacific

Alexei M. **Orlov**[1], Vadim F. Savinykh[2], Dmitry V. Pelenev[1] and Eugeny F. Kulish[1]

[1] Russian Federal Research Institute of Fisheries and Oceanography (VNIRO), 17 V. Krasnosel'skaya St., Moscow, 107140, Russia E-mail: orlov@vniro.ru
[2] Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia

Results of long-term research on the spatial and vertical distribution of spiny dogfish *Squalus acanthias* in the North Pacific and its size composition are provided. This report is based on the analysis of datasets of TINRO-Center from 1970 to 2007 and Alaska Fisheries Science Center from 1983 to 2007. In total, 6728 captures of spiny dogfish were analyzed (2407 with indication of capture depth). Description of size composition is based on measurements of 413 specimens caught by driftnets, 328 by pelagic trawls and 387 by bottom trawls.

The occurrence of spiny dogfish in the water column and near the bottom differed considerably. Seasonal and long-term changes in the spatial distribution were observed. This species is most widely distributed in the North Pacific in summer and autumn months during feeding migrations. The wide distribution of spiny dogfish in the Bering Sea that occurred after 2000 is likely associated with recent climate change.

In the water column, the maximum number of spiny dogfish captures was observed within the upper 25 m layer (about 90%). Near the bottom, this species occurred at depths less than 50 m (over 45%) and within the depth range of 101-200 m (over 50%). During the daytime, spiny dogfish catches are considerably larger as compared to nighttime, suggesting vertical diurnal migrations. This species was caught at water temperatures ranging from 0 to 12.7ºC; maximum catches were observed at temperatures over 8ºC.

Size compositions of spiny dogfish caught in bottom and pelagic trawls were rather similar (average length 69.1 and 68.6 cm respectively). Considerably larger specimens (average length 75.3 cm) were caught in driftnets.

FIS-P-5702

Ecologically driven spatial dynamics in pre-wintering juvenile walleye pollock (*Theragra charcogramma*) in the coastal sea off northeastern Hokkaido, Japan

Naoki **Tojo**[1], Akira Nishmura[2], Tetsuichiro Funamoto[2], Orio Yamamura[2], Hiroki Yasuma[3] and Kazushi Miyashita[3]

[1] Laboratory of Marine Ecosystem Change Analysis, Graduate School of Environmental Science, Hokkaido University, 3-1-1 Minato, Hakodate, Hokkaido, 041-8611, Japan. E-mail: ntojo@ees.hokudai.ac.jp
[2] Hokkaido National Fisheries Research Institute,Fisheries Research Agency, 116 Katsurakoi, Kushiro, Hokkaido, 085-0802, Japan
[3] Laboratory of Marine Ecosystem Change Analysis, Hokkaido University, 3-1-1 Minato, Hakodate, Hokkaido, 041-8611, Japan

Walleye pollock (*Theragra chalcogramma*) is an important fishing target species along the coast of the North Pacific Rim. The Pacific stock of walleye pollock is the largest in Japan, and many biological studies have been conducted, especially on its early life stages. These biological studies are important, but ecological approaches involving interacting species and relationships with environmental variables are also important in considering an ecosystem-based fisheries management context. In this study, we aimed to understand the ecological interactions of juvenile walleye pollock. In August and September, hydroacoustic surveys were conducted over the coastal shelf off northeastern Hokkaido, Doto area. Fish samples were collected at 26 to 28 stations, and temperature and salinity were measured with CTD at each trawling station. Fish densities at the specific locations were obtained using a hydroacoustics echosounder (EK60, 38kHz, 120kHz) in surveys from 2003 to 2006. Juvenile pollock and their prey (zooplankton) were identified using ΔMVBS method. Temperature, salinity, and derived bioenergetic variables were geostatistically interpolated with cross validation criteria from the STD stations. The CPUE of adult pollock and predatory cottidae were converted to indices of main predatory pressure, applying probability kriging. Visual and statistical comparisons between juveniles and the prey, predator, and marine environmental variables were made. Juvenile distributions had a significant non-linear relationship (GAM, $P<0.001$) with specific growth rate (SGR) and predatory pressures. Our results suggest that the fall distribution of juvenile pollock is determined by its habitat selection as the survival strategy, driven by seasonal coastal current and mesoscale warm core eddies.

FIS-P-5726

Biotransformation and oxidative stress biomarkers as useful tools in assessment of pollution effects in estuaries of Peter the Great Bay (Japan/East Sea)

Svetlana A. **Ireykina**

Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia
E-mail: ir_lana@live.ru

Peter the Great Bay receives freshwater from many rivers, which are of great fisheries and agricultural importance. Some fish species (haarder mullet, rudd, crucian) and crab *Eriocheir japonica*, inhabiting estuarine zones of the bay, were used to evaluate the metabolic alterations in organisms from polluted estuaries. Fish and crabs were collected in 2008-2009. To measure the effects of anthropogenic exposure on their cellular defense system, the activity of detoxification enzyme glutathione-S-transferase (GST), glutathione (GSH), lipid peroxidation, measured as malondialdehyde (MDA) levels, and antioxidative enzymes superoxide dismutase and catalase (CAT) were determined in fish liver and crab gills. Many pollutants in aquatic systems exert their toxic effects due to oxidative stress. There were significant differences in biomarker activity in fish species and crabs from various sites. Eurybiontic crucian exhibit higher CAT (15 U/mg prot.), GST (80 nmol/min/mg prot.) activities and GSH content (4 mkg/mg prot.) in comparison to harder mullet (10, 30 and 4, respectively). The suite of biochemical indicators indicates a good physiological condition of animals from estuaries of Shkotovka and Sukhodol rivers and depressed condition from the Tesnya River. Crabs from the latter had lower activity of CAT, but higher GST activity and MDA level. These results, coupled to our previous data, lead us to conclude that biotransformation and antioxidative enzyme activities in fish and crabs from rivers and estuaries of Peter the Great Bay are likely to be useful tools for assessing the impacts of pollution.

FIS-P-5807

Concentration of trace metals in the tissues of common dolphins (*Delphinus delphis*) on the east coast of Korea

Seock-Woo Jang[1], Seong-Gil **Kim**[1], Ok-In Choi[1], Seong-Soo Kim[1] and Zang-Geun Kim[2]

[1] National Fisheries Research and Development Institute, Busan, 619-902, R Korea. E-mail: cosmas@nfrdi.go.kr
[2] Cetacean Research Institute, National Fisheries Research and Development Institute, Ulsan, 139-29, R Korea

The common dolphin (*Delphinus delphis*) found along the coasts can be an important indicator of trace metal accumulation in tissues on marine mammals. However, very little is known about trace metal concentrations in tissues of common dolphins inhabiting the sea of Korea. Therefore, the main objective of this study is to collect baseline data that will help to provide some important information necessary for the health assessment of common dolphins around the East Sea of Korea. The concentrations of trace metals (As, Cd, Cr, Cu, Pb, Hg, Se, and Zn) were determined in the liver, kidney, muscle, intestine and heart of 12 common dolphins stranded on the east coast of Korea in 2006. Cu, Hg, Se, Zn concentrations were highest in the liver relative to concentrations in kidney, muscle, intestine and heart tissue. The trace metal concentrations order of liver accumulation was Zn> Hg> Cd> Se> Cu> As> Cr> Pb. By contrast, Cd concentrations of kidney accumulation were highest and the trace metal concentrations order of kidney accumulation was Cd> Zn> Cu> Hg> Se> As> Pb> Cr. Significant differences in As, Cr and Pb concentrations were not found for the accumulation of all the tissues. No significant differences were observed among common dolphin size and sex with metal concentration of each organ.

FIS PAPER

FIS-P-5847

Myxozoa parasites in fishes of the northwest Japan Sea

Nadezhda L. **Aseeva**

Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia
E-mail: aseeva_n@hotmail.com

Recently, 130 species of Myxozoa parasites, belonging to 17 families and 21 genera, have been documented from fishes of the Japan Sea. Most of them (112) are of marine origin, but 20 species are of freshwater origin. The highest species diversity has parasitofauna of Pleuronectiformes, which are infected by 46 species of Myxozoa. Four genera of Myxozoa (*Alataspora*, *Palliatus*, *Pseudoalataspora*, and *Parvicapsula*) are observed in flounders only, but the genus *Sphaeromyxa* has never been observed in fish of this order. The Myxozoa parasites of flounders have various shapes of their spores and vegetative forms. The fishes from the order Scorpaeniformes are infected by 32 Myxozoa species with predominance of the genera *Sphaeromyxa*, *Myxidium*, and *Ceratomyxa*. The Gadiformes fishes are infected by three species of these parasites belonging to the genera *Zschokkella*, *Myxidium* and *Sphaeromyxa* (the *Sphaeromyxa* were found in *Eleginus gracilis* only). The Clupeiformes fishes have another three species of Myxozoa belonging to the genera *Ceratomyxa* and *Ortholinea*. Anadromous and semi-anadromous fishes of the orders Mugiliformes, Salmonifomes, and Perciformes are infected by 12 species of Myxozoa belonging to the genera Myxidium, *Myxosoma*, *Myxobolus*, *Sphaerospora*, and *Chloromyxum*. All of them, with inclusion of *Myxidium*, have a freshwater origin, but are adapted to marine life. The fishes from the orders Squaliformes, Rajiformes, Beloniformes, Perciformes, and Tetraodontiformes are infected insignificantly and have no more than a single species of Myxozoa for each host.

FIS-P-5857

Seasonal occurrence and distribution of Japanese mantis shrimp *Oratosquilla oratoria* larvae off Yeonpyeong-do near the Korean coast in the Yellow Sea

Wongyu Park[1], Chaewoo Ma[1], Miyoung Song[2], Myoung-Ho Sohn[2], Hakjin Hwang[2], Jong-Bin Kim[2], Kwangho Choi[2] and In-Ja **Yeon**[2]

[1] Dept. of Marine BioTechnology Soonchunhyang University, Asan, Chungchungnam-Do, 336-745, R Korea
[2] West Sea Fisheries Research Institute, NFRDI, 707, Eulwhang-dong, Jung-gu, Incheon, R Korea. E-mail: ijyeon@nfrdi.go.kr

Seasonal changes and distribution of Japanese mantis shrimp larvae, *Oratosquilla oratoria* (De Haan 1844), were investigated off Yeonpyeong-Do near the Korean coast in the Yellow Sea. *O. ortoria* larvae were collected monthly at 15 stations from June to October in 2007. A bongo net with 303-μm mesh was deployed once at each station with a double oblique tow. No larvae were discovered in June. No Zoea I and II were captured during the entire sampling period. Zoea III occurred in July for the first time and were found until September. The proportion of later stages increased after July. The number of zoeal stages deceased during the summer months and no larvae were found in October. Of zoeal stages, zoea IV was most abundant in number. Zoeal abundance was highest in July and August, particularly at the stations near the coast. Occurrence of *O. oratoria* larvae appear to be timed to the phytoplankton bloom. *O. oratoria* larvae may be retained and grow within our study sites without advection to growing areas. The absence of zoea I and II is consistent with previous studies in other portions of the ranges of this species.

FIS-P-5858

Larval occurrence and distribution of swimming crab *Charybdis japonica* (Milne Edwards, 1860) off Yeonpyeong-do near Korean coast in the Yellow Sea

Myoung-Ho Sohn[1], Miyoung Song[1], Hakjin Hwang[1], Yang-Jae Im[1], In-Ja Yeon[1], Wongyu **Park**[2], Chaewoo Ma[2] and Jae-Won Kim[3]

[1] West Sea Fisheries Research Institute, NFRDI, 707, Eulwhang-dong, Jung-gu, Incheon, 400-420, R Korea
[2] Department of Marine BioTechnology, Soonchunhyang University, Asan, Chungchungnam-Do, 336-745, R Korea
E-mail: pwg09@hotmail.com
[3] Department of Marine Life-Science, Gangwon provincial college, Gangneung, Gangwon-do, 210-804, R Korea

Associations between larval occurrence and distribution of swimming crab, *Charybdis japonica* (Milne Edwards, 1860) and sea surface temperature (SST) were investigated off Yeonpyeong-Do near the Korean coast in the Yellow Sea. *C. japonica* larvae were collected monthly at 15 stations from early June to late October in 2006 and 2007. Bongo net with 303 μM mesh was deployed once at each station with a double oblique tow. No larvae were caught in June in both years. Zoea I (84%) predominated in late July in 2006 and early August in 2007. However, during the entire sampling period in both years, the megalopal stage was most abundant: 92.7% in 2006 and 78.4% in 2007. The abundance of megalopa was the highest at all stations in late August in both years. In 2006, SST increased from 16.5ºC in June to 24.7ºC in September and decreased to 20.5ºC in October. In 2007, SST increased from 16.7ºC in June to 24.9ºC in August and decreased to 21.6ºC in October. The timing of larval hatching of *C. japonica* may be related to the timing of phytoplankton bloom in the study area. We cannot definitely state where *C. japonica* larvae originate from the study results. However, *C. japonica* larvae appear to have hatched outside our study sites and have been advected into our study sites after larval growth. The pattern of distribution of larval stages in our study area is similar other published reports.

FIS-P-5872

Seasonal species composition of marine organisms collected by a shrimp beam trawl in the Nakdong River estuary, Korea

Jong Hee **Lee**[1,2], Jae Bong Lee[2], Jung Nyun Kim[2], Dong Woo Lee[2] and Dae Soo Chang[2]

[1] Pukyong National University, Busan, 608-737, R Korea. E-mail: francis@pknu.ac.kr
[2] National Fisheries Research and Development Institute, Busan, 619-705, R Korea

Species composition and abundance of marine organisms in the Nakdong River estuary were investigated seasonally from November 2007 to November 2008. During the study period, a total of 169 species, 93 families, and 6 phyla were collected in study area. Phyla were composed two species of Bivalvia, 11 species of Cephalopoda, 43 species of Crustecea, 8 species of Echinodermata, 6 species of Gastropoda, and 99 species of Pisces. The seasonal dominant species were *Acropoma japonicum* in autumn, *Apogon lineatus* in winter, *Siphonalia spadicea fuscolineata* in spring and *Crangon hakodatei* in summer in terms of number of individuals. In terms of abundance, the dominant species were *Chelidonichthys spinosus* in autumn, *Liphius litulon* in winter and spring, and *Raja kenojei* in summer. The number of species and abundance of organisms, species composition, and diversity indices fluctuated with the seasons. Organisms were divided into 18 groups by seasonal variation using self-organizing map.

FIS-P-5916

Differences of growth and density in *Ruditapes philippinarum* in the intertidal area in Tae-an on the west coast of South Korea

Hyoungsum **Han**, Chaewoo Ma and Wongyu Park

Department of Marine Biotechnology, Soonchunhyang University, 646 Eupnae-ri, Asan-si, Chungcheongnam-do, 336-745, R Korea
E-mail: stoyman@naver.com

The west coast of South Korea is characterized by great tidal ranges over 8 m. A large tidal range affects biological processes of benthic animals. We investigated the differences in growth and density of *Ruditapes philippinarum* in the intertidal area in Tae-an, South Korea. *R. philippinarum* were collected at two locations of four stations in the lowest intertidal zone (LIZ) and in the middle intertidal zone (MIZ), respectively. *R. philippinarum* was captured using a quadrat (50 cm X 50 cm) on the day of the highest tidal range once a month from April to June 2009 and will be sampled until September 2009. The height and width of *R. philippinarum*, organic matter, and Chl-*a* in the sediment were measured. Organic matter and shell height and width in LIZ were significantly higher than those in MIZ. Early juvenile density in LIZ was significantly higher than in MIZ. Adults were found in LIZ but none were found in MIZ. Chl-*a* was similar at all stations. *R. philippinarum* growth may be negatively related to exposure duration to air because shorter clams are exposed to air the more it feeds. Higher juvenile density in LIZ may be closely related to a higher survival rate of juveniles. Subsequently, lower juvenile density and a lack of adults in MIZ resulted from lower survival rate of juveniles. Although various environmental factors may have affected the growth and density of *R. philippinarum*, we suggest that exposure duration to air influenced the growth and density of *R. philippinarum*.

FIS-P-5918

Gonadal maturation and spawning in the Pacific herring, *Clupea pallasii*, in the East/ Japan Sea of Korea

Hae-Won **Lee**[1], Byung-Kyu Hong[1], Young-Min Choi[2] and Dong-Woo Lee[1]

[1] Dokdo Fisheries Research Center, National Fisheries Research and Development Institute, Pohang, 791-110, R Korea. E-mail: roundsea@nfrdi.go.kr
[2] Department of Fisheries Resource Research, National Fisheries Research and Development Institute, Busan, 619-905, R Korea

Gonad maturation in the Pacific herring, *Clupea Pallasii,* was investigated using a histological method. Specimens were collected monthly from November 2007 to June 2009 in the East/Japan Sea of Korea. The female gonadosomatic index (GSI) began to increase in October, reached a maximum in January, and declined sharply in March. By contrast, male GSI began to increase in August and reached a maximum in January. The annual female reproductive cycle of *C. pallasii* can be divided into four successive stages: early growing (April-June), late growing (July-November), ripe and spent (December-February), and recovery (March) stages. Males passed through early growing (May-June), late growing (July-October), ripe and spent (November-February), and recovery (March- April) stages. These results indicate that the spawning season was December to February. The relationship between fecundity (F_c) and body length (BL) was $F_c=1.2863BL^{3.1068}$. Fecundity ranged from 15,126-66,523 eggs for body lengths of 22.5-29.5 cm and increased with body length. The body length at 50% maturity was 24.12 cm.

FIS-P-5920

Using classification trees to capture a manager's interpretation of Bayesian projections

Tatiana **Tunon** and Gottfried Pestal

SOLV Consulting Ltd., Vancouver, BC, Canada. E-mail: ttunon@solv.ca

Terminal fisheries targeting Atnarko River, British Columbia, chinook salmon (*Oncorhynchus tshawytscha*) are managed based on weekly projections of total escapement to the spawning grounds. A projection model using Bayesian updating was developed with the local manager in 2001, and has been used since the 2002 fishing season.

A crucial step in the development was to explore and document the end-user's interpretation of Bayesian projections. We presented the manager with observed and simulated sets of in-season data, elicited his assessments of stock status based on the model output, and fit a simple classification tree of binary choices to the responses. The resulting classification trees capture both the characteristics of the quantitative projection model and the subjective judgments of the fisheries manager (*e.g.* choices of prior assumptions, approach to reconciling projections based on alternate model structures, decisions based on a range of projections relative to management reference points).

FIS-P-5957

Feeding habits of yellow goosefish, *Lophius litulon*, and John Dory, *Zeus faber* in the northern part of the East China Sea

Jung Hwa **Choi**, Bong Jun Sung, Jung Nyun Kim, Taeg-Yun Oh, Dae Soo Chang and Hyung Kee Cha

Fisheries Resources Research Team, National Fisheries Research and Development Institute, Busan, 619-902, R Korea
E-mail: choijh@nfrdi.re.kr

The John Dory, *Zeus faber* (Family Zeidae), is widely distributed from the North Atlantic to New Zealand. It is an active predator, but it is not commercially fished in Korea. The yellow goosefish, *Lophius litulon* (Family Lophiidae), is found in the southern and western seas around Korea, where it is an economically important species. *L. litulon* and *Z. faber* are carnivorous fishes. *L. litulon* is an ambush predator living on the sea floor and *Z. faber* is an active predator that feeds mainly on schooling bony fishes. Most fishes undergo an ontogenetic shift in diet with increased body size. The timing of the shift depends on attack success rate, handling times, relative profitability and the rate of encounter of each fish. In this study, the feeding habits of *L. litulon* and *Z. faber* was studied based on the analysis stomach contents of specimens collected in the northern part of the East China Sea. In total, 132 hauls were taken during six experimental trawl survey cruises conducted seasonally during March 2005-October 2007. All specimens were obtained with an otter trawl. Their main prey items are similar. Fish and crustaceans were the most important prey and neither species showed ontogenetic changes in preferred species. In particular, *Trichiurus lepturus* and *Engraulis japonicus* were preferred prey of *L. litulon*, whereas *Z. faber* prefers *Acropoma japonicum*. Larger (> 24 cm) *Z. faber* preferred bigger prey, such as *T. lepturus* and *Larimichthys polyactis*, while smaller fish preferred *E. japonicus* and *A. japonicum*. However, *L. lithulon* did not exhibit a relationship between prey and predator size.

FIS PAPER

FIS-P-5988

Comparisons of spatiotemporal variations in abundance and size composition of Pacific saury between the high-seas and coastal fishing grounds in the Northwestern Pacific

Wen-Bin **Huang**

Graduate Institute of Biological Resources and Technology, Meilum Campus, National Dong Hwa University, 123 Hua-Shi Rd., Hualien City, 970, Taiwan. E-mail: wbhuang1999@ntu.edu.tw; bruce@mail.ndhu.edu.tw

Abundances and size compositions of Pacific saury were compared between the high-seas and coastal fishing grounds in the Northwestern Pacific during 2000 – 2005 using Taiwanese fishery data. The large-sized saury was dominant (44.3 – 71.4% of catch) in the beginning of the fishing season, while the medium-sized saury followed and dominated from September to the end of the fishing season with the highest proportion of catch (70.1 – 92.4%). In the high seas, total CPUE (about 71.2 % of the mean coastal value) and CPUEs of both large- (about 55.0%) and medium-sized saury (about 81.8%) were significantly smaller than those in coastal waters. Mean proportions of large- and medium-sized saury in the high-seas catch were about 86.6 and 107.0% of the coastal values, respectively. A highly consistent relationship of the variations between the total and medium-sized CPUEs was found. The CPUEs for total and medium-sized saury were negatively correlated to seawater temperature. When taking away the effects of the temperature, total CPUE and CPUE of medium-sized saury were larger in the shoreward, southward, and shallower waters of the fishing grounds, while the CPUE of large-sized saury was only larger in the shoreward waters.

POC Paper Session

Co-Convenors: Michael G. Foreman (Canada) and Ichiro Yasuda (Japan)

Papers are invited on all aspects of physical oceanography and climate in the North Pacific and its marginal seas (except S8 and S9 topics).

Friday, October 30 (9:00-17:20)

9:00 ***Introduction by Convenors***

9:05 **Dake Chen and Tao Lian**
A theoretical framework for tropical Indo-Pacific climate variability (POC-P-5758)

9:25 **Jürgen Alheit**
Impact of climate variability on northern hemisphere marine ecosystems: Regime shifts and teleconnection patterns (POC-P-5760)

9:45 **Chan Joo Jang**
North Pacific mixed layer depth projections from IPCC AR4 models (POC-P-5991)

10:05 **Howard J. Freeland and Denis Gilbert**
A new estimate of the steric contribution to global sea-level rise (POC-P-5647)

10:25 **Enrique N. Curchitser, William Large, Kate Hedstrom and Jon Wolf**
Downscaling climate simulations in the North Pacific Ocean using a fully coupled multi-scale model (POC-P-5978)

10:45 ***Coffee / tea break***

11:05 **Young Jae Ro**
Impact of the Indonesian Through Flow on the water characteristics in western Pacific marginal seas (POC-P-5674)

11:25 **Fan Wang and Chuanyu Liu**
A warm tongue intrusion into the Yellow Sea in winter and its inter-annual variability (POC-P-5543)

11:45 **Olga O. Trusenkova, Timofei Gulenko, Dmitry D. Kaplunenko and Vyacheslav B. Lobanov**
Large-scale patterns of the Japan/East Sea sea level and its dynamic forcings (POC-P-5547)

12:05 **Dmitry D. Kaplunenko, Vyacheslav B. Lobanov and Olga O. Trusenkova**
Effects of variability 'separation' for the northern Japan/East Sea obtained from satellite data (POC-P-5795)

12:25 **Hanna Na, Kwang-Yul Kim, Kyung-Il Chang and Kuh Kim**
Relationship between the interannual variability of the Korea Strait Bottom Cold Water, upper water temperatures and surface heat fluxes in the East Sea (POC-P-5785)

12:45 ***Lunch***

14:00 **John Calder and Jackie Grebmeier**
Synthesis of recent ocean data from the Pacific sector of the Arctic by the Pacific Arctic Group (POC-P-5967)

14:20 **Victor Kuzin, Valentina Malakhova and Elena Golubeva**
Dissolved methane transport in the Arctic water: Observed data and simulation (POC-P-5816)

14:40 **Eduard A. Spivak, Nina I. Savelieva and Anatoly N. Salyuk**
Summer hydrography of the southeastern part of the Laptev Sea – Results from the Pacific Oceanological Institute expedition in September 2006 (POC-P-5668)

15:00 **Humio Mitsudera, Keisuke Uchimoto and Tomohiro Nakamura**
Mechanisms of the cold water belt formation off the Soya Warm Current (POC-P-5840)

15:20 **Jinhee Yoon, Sang-Wook Yeh, Young Ho Kim and Jong-Seoung Kug**
The characteristic response of the Kuroshio Extension region to a warm pool El Niño (POC-P-5896)

15:40 ***Coffee / tea break***

16:00 **Michael Foreman, Piotr Czajko and Dario Stucchi**
Simulating spring–neap salinity variations in Knight Inlet, Canada (POC-P-5713)

16:20 **Anastasiya A. Abrosimova and Igor A. Zhabin**
Interaction of sea and river waters in the estuary of the Amur River (POC-P-5749)

16:40 **Hitoshi Kaneko, Ichiro Yasuda and Sachihiko Itoh**
Direct measurement of turbulence mixing along a meridional transect in the western North Pacific (POC-P-5924)

17:00 **Elena A. Vilyanskaya, G.V. Shevchenko, O. Kusaylo and A. Kato**
Water temperature changes in the nearshore zone of Aniva Bay from mooring observations (POC-P-5544)

17:20 ***Session ends***

POC-P Posters

POC-P-5512 **Svetlana P. Shkorba**
Research on the influence of the thermal regime of water on ice cover in the Japan Sea

POC-P-5513 **Nadezda M. Vakulskaya**
Analysis of spatio-temporal distribution typizations of ice areas and ice volumes according to ice thicknesses in the Bering Sea

POC-P-5522 **Ekaterina Potalova**
Estimation of wind stress curl on Far-Eastern seas from tropical cyclone movements

POC-P-5526 **Valentina V. Moroz**
The thermohaline structure and temperature anomaly dynamics in the Kuril Islands area

POC-P-5529 **Talgat R. Kilmatov and Elena Dmitrieva**
The climatic trend of non-homogeneous SSTs in the northern Pacific Ocean and stability of the Kuroshio Extension jet

POC-P-5550 **Yury I. Zuenko**
One-dimensional model of water productivity changes because of convective regime reconstruction

POC-P-5562 **Elena Dmitrieva, Vladimir Ponomarev and Nina I. Savelieva**
Classification of the meteorological–hydrological time series of the Asian-Pacific region using cluster analysis

POC-P-5563 **Galina A. Vlasova, Svetlana U. Glebova and Gleb S. Vlasov**
Seasonal variability of the water circulation in the Sea of Okhotsk under the influence of synoptic processes in 2003-2004

POC-P-5564 **Galina A. Vlasova, Bui Hong Long, Antonina M. Polyakova, Nguyen Ba Xuan, Gennady I. Yurasov and Le Dinh Mau**
Preliminary results of the seasonal variability of water circulation in the South China Sea under the influence of the synoptic processes

POC-P-5567 **Antonina M. Polyakova**
Destructive tsunamis near the coast of Primorye

POC-P-5568 **Antonina M. Polyakova**
Atmospheric circulation over the South China Sea

POC-P-5574 **Gennady I. Yurasov**
Upwelling and its influence on ice conditions in Peter the Great Bay

POC-P-5621 **Vladimir B. Darnitskiy and Maxim A. Ishchenko**
On the differentiation of thermohaline processes in the Sea of Japan to the south of the Subarctic Front: Part I

POC-P-5622 **Vladimir B. Darnitskiy and Maxim A. Ishchenko**
On the differentiation of thermohaline processes in the Sea of Japan to the south of the Subarctic Front: Part II

POC-P-5634 **Cai Yi, Zhanggui Wang and Licheng Feng**
The Numerical Simulation of the effects of global warming on ocean ecosystems in Bohai Sea

POC-P-5662 **Boris S. Dyakov**
Large-scale fluctuations in the salinity of the Tsusima Current in the second half of the 20th century

POC-P-5671 **Fedor Khrapchenkov and Nadezda Dulova**
Influence of eddies and tides on the vertical structure of acoustic speed field on the east coast of Kamchatka and the Kuriles

POC-P-5672 **Fedor Khrapchenkov**
Dynamics of the runoff lenses of the Amur River in summer of 2005–2008

POC-P-5682 **Liying Wan, Hui Wang and Jiang Zhu**
A "Dressed" Ensemble Kalman Filter method using different seasonal ensembles in the Pacific

POC-P-5698 **Kwang Young Jung and Young Jae Ro**
Stratification induced by Nam-Gang Dam water releases based on a numerical model in the Kangjin Bay, South Sea, Korea

POC-P-5707 **Vladimir B. Darnitskiy and Maxim A. Ishchenko**
Synoptic and long-term dynamics of water in the vicinity of the junction of Hawaii and the Imperial submarine ridges

POC-P-5728 **Larissa A. Gayko**
Variability of water and air temperature in the coastal zone of the northwestern Sea of Japan

POC-P-5735 **Valentina V. Moroz**
Thermohaline structure peculiarities in the South Kuril Straits zone

POC-P-5752 **Vladimir Ponomarev, Vera Petrova and Elena Dmitrieva**
Changing climate and linkages of surface heat fluxes in the North Pacific

POC-P-5788 **Vladimir B. Darnitskiy and Maxim A. Ishchenko**
Long-term thermohaline dynamics in the region of the northwestern Hawaiian Ridge Seamounts

POC-P-5864 **Tatsuro Watanabe, Daisuke Simizu, Kou Nishiuchi, Toru Hasegawa and Osamu Katoh**
Surface current structure and its variability in the southwestern Japan Sea derived by satellite-tracked surface drifters

POC-P-5870 **Satoshi Osafune and Ichiro Yasuda**
Numerical study of bidecadal water mass variations in the subarctic North Pacific related to the 18.6-year tidal cycle

POC-P-5893 **Hironori Higashi, Hiroshi Koshikawa, Kunio Kohata, Shogo Murakami and Motoyuki Mizuochi**
Relationship between water quality trend and climate change in Ise Bay, Japan

POC-P-5910 **Takeshi Matsuno, Takahiro Endoh, Eisuke Tsutsumi, Ken-ichi Fukudome, Joji Ishizaka, Hisashi Yamaguchi, Sarat Tripathy, In-Seong Han, Jae-Hak Lee, Sang-Tae Jang and Sang-Hyun Kim**
Vertical transport of subsurface nutrients in the East China Sea shelf for primary production

POC-P-5923 **Oleg A. Bukin, Alexey V. Bulanov, Alexey A. Ilin, Sergey S. Golik and Ekaterina B. Sokolova**
Femtosecond laser-induced breakdown spectroscopy for the detection of marine water and elemental composition of phytoplankton cells

POC-P-5944 **Joon-Soo Lee, Hye-Hyun Lee, Won Duk Yoon, Joon-Yong Yang, and Sang Ok Chung**
Analysis of the long-term temporal variations in the Yellow Sea using the cluster method

POC-P-5945 **Vladimir V. Plotnikov**
Estimation of ice cover conditions in the Japan Sea

POC-P-5970 **Hui-wang Gao, Gu Ming, Ren-lei Wang and Yu-huan Xue**
Characteristics of atmospheric turbulence of the marine–atmospheric boundary layer over the north Yellow Sea

POC-Paper Session Oral Presentations

30 October, 9:05 (POC-P-5758)

A theoretical framework for tropical Indo-Pacific climate variability

Dake **Chen**[1,2] and Tao Lian[1]

[1] State Key Lab of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, Hangzhou, PR China
E-mail: dchen@sio.org.cn
[2] Lamont-Doherty Earth Observatory of Columbia University, New York, USA. E-mail: dchen@ldeo.columbia.edu

Although the interaction between the tropical Pacific and Indian Oceans has long been recognized, the climate variations in the two basins are often studied separately, with emphasis on the Pacific El Niño–Southern Oscillation (ENSO) phenomenon and an emerging interest on the so-called Indian Ocean Dipole (IOD). Because of the huge warm water pool that straddles across the tropical western Pacific and eastern Indian Oceans, the climate variations in these two oceans are closely related and need to be studied as a whole. Observations reveal a striking out-of-phase relationship between the zonal sea surface height (SSH) gradients in these two oceans and, to a lesser extent, between the corresponding sea surface temperature (SST) gradients. This can be explained in simple terms as follows. The Walker circulation ascends above the warm pool, with easterly surface winds on the Pacific side and westerly on the Indian side, which piles waters up in the warm pool and lowers SSH and SST in the eastern Pacific and western Indian Oceans. This produces a tripole structure with opposite zonal gradients of SSH/SST in the two oceans. When the double-cell Walker circulation weakens or strengthens, these gradients decrease or increase together, and positive feedbacks between the gradients and the Walker circulation take place. This mode of variability is very robust and has been referred to as Indo-Pacific Tripole (IPT). Here we present an analytical conceptual model of IPT. For a range of realistic parameters, the model shows that IPT behaves like a self-sustaining oscillation mainly driven by ENSO, and that occasionally it can be excited from the Indian side by an anomalous Asian Monsoon without provoking a full-blown ENSO event. The model IPT consists of both local ocean–atmosphere coupling and inter-basin interaction, thus providing a unified theoretical framework for tropical Indo-Pacific climate variability.

30 October, 9:25 (POC-P-5760)

Impact of climate variability on northern hemisphere marine ecosystems: Regime shifts and teleconnection patterns

Jürgen **Alheit**

Leibniz Institute for Baltic Sea Research, Seestr. 15, 18119, Warnemünde, Germany. E-mail: juergen.alheit@io-warnemuende.de

Understanding the role of natural variability, occurring over a variety of time scales, is essential if we are to effectively manage marine ecosystems and their living resources in the wake of predicted global change. Evidence has been accumulated that climate variability can cause ecosystem regime shifts. These shifts can re-organize marine communities and trophodynamic relationships and induce changes in the mix of dominating species. Examples of regime shifts in the Atlantic (Baltic Sea, North Sea, NW Mediterranean) and Pacific (Japan/East Sea, Oyashio/Kuroshio System) will be described, based on long-term time series of atmospheric, hydrographic and ecosystem variables. The focus will be on the pelagic realm, including phytoplankton, zooplankton and small pelagic fishes such as sardines, anchovies, sprat and saury. Often, aquatic ecosystems being separated by thousands of kilometres from each other react synchronously to the same climate signal, as did NE European shelf seas and lakes in association with the increase of the North Atlantic Oscillation index and NW Pacific ecosystems in association with the weakening of the East Asian winter monsoon, events all of which happened in the late 1980s. This Atlantic–Pacific teleconnection pattern seems to be mediated by the dynamics of the Arctic Oscillation and the Siberian High.

30 October, 9:45 (POC-P-5991)

North Pacific mixed layer depth projections from IPCC AR4 models

Chan Joo **Jang**

Korea Ocean Research and Development Institute, 1270 Sa-dong, Ansan, Gyeonggi-do, R Korea, 426-170. E-mail: cjjang@kordi.re.kr

Global climate model projections from the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR4) are used to estimate changes in the mixed layer depth over the North Pacific under global warming. The mixed layer depths are generally found to be shallowing in most of the North Pacific, while deepening in the Kuroshio extention region and parts of the Bering Sea and Sea of Okhotsk. These trends are compared with previous analyses at Station Papa and are shown to be related to changes in the surface wind stress.

30 October, 10:05 (POC-P-5647)

A new estimate of the steric contribution to global sea-level rise

Howard J. **Freeland**[1] and Denis Gilbert[2]

[1] Institute of Ocean Sciences, Fisheries and Oceans Canada, P.O. Box 6000, Sidney, BC, V8L 4B2, Canada
E-mail: howard.freeland@dfo-mpo.gc.ca
[2] Institute Maurice Lamontagne, Fisheries and Oceans Canada, Mont Joli, QC, G5H 3Z4, Canada

It is well known from observations by the altimetric satellites (predominantly TOPEX/Poseidon and Jason-1) that global sea level is rising. What is less well known is exactly how the observed sea-level rise is partitioned between a steric contribution (sea-level rising because of changes in ambient temperature and salinity) and a contribution arising from the addition of new water mass to the oceans. Strictly, such a separation is not possible because of the nonlinearity in the equation of state for seawater, but in practice the nonlinearities are sufficiently small to allow this separation as a very good first approximation.

A careful comparison of the WOCE one-time survey with recent observations by the Argo array indicates a steric component to sea-level rise of 2.2 mm/year between the early 1990s and 2006 to 2008. This is a significantly larger rise rate than found by previous estimates and with recent estimates of melt rate from ice sheets allows a much closer explanation of the total rise rate as reported by altimetric satellites, 3.2 ± 0.4 mm/year over this period.

30 October, 10:25 (POC-P-5978)

Downscaling climate simulations in the North Pacific Ocean using a fully coupled multi-scale model

Enrique N. **Curchitser**[1], William Large[2], Kate Hedstrom[3] and Jon Wolf[2]

[1] Institute of Marine and Coastal Sciences, Rutgers University, 71 Dudley Rd., New Brunswick, NJ, 08901, USA
E-mail: enrique@marine.rutgers.edu
[2] National Center for Atmospheric Research, 1850 Table Mesa Dr., Boulder, CO, 80305, USA
[3] Arctic Region Super Computing Center, University of Alaska, Fairbanks, 909 Koyukuk Dr., Suite 105, Fairbanks, AK, 99775, USA

As the models used for the Intergovernmental Panel on Climate Change assessments keep evolving, interest is rising in the impacts of climate change on regional scales. Because of the substantial cost of running existing climate models, critical processes, such as mesoscale eddy-induced variability and coastal upwelling are either parameterized, or simply not resolved. There are several studies using one-way downscaling of climate models to particular regions, though those studies do not permit important feedbacks in the climate system, limiting their use for future projections. In this paper we present a fully coupled multi-scale climate model based on the NCAR CCSM global model and the ROMS (Regional Ocean Modeling System). We will show that features, such as coastal upwelling, produced by the higher-resolution model have significant impacts on the global climate system.

30 October, 11:05 (POC-P-5674)

Impact of the Indonesian Through Flow on the water characteristics in western Pacific marginal seas

Young Jae **Ro**

Deptartment of Oceanography, Chungnam National University, Taejon, 305-764, R Korea. E-mail: royoungj@cnu.ac.kr

Owing to the geographical location of the Korean Peninsula with its surrounding water bodies, diverse influences have been considered. For example, there is 1) summertime buoyancy input through the Korea and Tsushima Channels, 2) wintertime deep convection with cold water mass formation in the northern East Sea, 3) cold water formation in the northern part of the Yellow Sea during the winter monsoon, and 4) an impact of the Changjiang Diluted Water on the southern part of the Yellow Sea during summer monsoon and its passage toward the East (Japan) Sea.

The importance of the Indonesian Through Flow (ITF) study stands out from the many aspects of climate change in the Indonesian maritime–continent, as well as in the Indian Ocean, including the role in the El Niño/Southern Oscillation (ENSO), exchange of heat and water budget between Pacific and Indian Oceans, *etc.* The recent study by Mayer *et al.* (2009) with model simulations of over 30 years shows highly variable ITF transports. The Pacific water is connected through the various pathways into Indian Ocean, namely Makassar Strait, Maluku and Halmahera straits that are connected to the Lombok and Ombai straits.

This study aims toward better understanding of 1) anomalies in the western sub-tropic Pacific water and their correlation with ENSO signatures, 2) interannual variability of the Kuroshio, 3) correlation between ITF and Kuroshio, and 4) overall influences of western equatorial water, variability of the sub-tropic Pacific water and the Kuroshio on the water characteristics around the Korean Peninsula.

30 October, 11:25 (POC-P-5543)

A warm tongue intrusion into the Yellow Sea in winter and its inter-annual variability

Fan **Wang** and Chuanyu Liu

Key Laboratory of Ocean Circulation and Waves (KLOCAW), Institute of Oceanology, Chinese Academy of Sciences, Qingdao, 266071, PR China. E-mail: fwang@qdio.ac.cn

A warm tongue intrusion along the west side of the Yellow Sea (YS) trough is the outstanding characteristic of sea surface temperature (SST) in the YS in winter and is regarded as the extension of the YS Warm Current (YSWC). Based on NOAA/NASA AVHRR Pathfinder SST and AVISO Merged Sea Level Anomaly data in February, as the representative of winter, the present study analyzed the distribution and inter-annual variability of the warm tongue, and its relationship with the surface thermal fronts and currents. Statistical analyses showed obvious inter-annual variability of the westward shifting path of the warm tongue significantly correlating with the position and strength of the front (YF-N) north of the warm tongue origin, while it was less related to the local wind, SST in the western part of the South YS, or to the YSWC strength. The correlation suggested that when the YF-N across the trough entrance moves southward or becomes stronger, the warm tongue path's westward shift becomes more significant. The YF-N's position and strength are closely related with SST in the eastern South YS and mass/heat transports of the YSWC origin, respectively. It is noteworthy that the warm tongue path's westward shift has a significant correlation with SST, not only along the path but also east of the Changjiang River estuary near the northern edge of the Taiwan Warm Current (TWC) where a zone of northward geostrophic velocity anomaly extends to the warm tongue path. That implies that the source of the warm tongue may be from the TWC, besides that of the YSWC, which has not been mentioned before.

30 October, 11:45 (POC-P-5547)

Large-scale patterns of the Japan/East Sea sea level and its dynamic forcings

Olga O. **Trusenkova**, Timofei Gulenko, Dmitry D. Kaplunenko and Vyacheslav B. Lobanov

V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: trolia@poi.dvo.ru

Sea level is an important indicator of climate state/change and dynamic processes in the ocean. Since the early 1990s satellite altimetry has provided regular data on the open sea level anomalies (SLA). Using altimetric SLA, seasonal, interannual, and decadal variability of the Japan/East Sea (JES) sea level was studied. Presently, the AVISO product of 1/3°-gridded weekly SLA with a 16-year duration is available. In this study large-scale SLA patterns are revisited for the JES, using Empirical Orthogonal Functions (EOFs). EOFs are based on correlations in the original data rather than on conventional covariances, allowing for better resolution of low-amplitude signals in the northern JES and pattern adjustment in subsequent decompositions. The leading EOF mode, accounting for the highest (lowest) level in the entire JES in October (March), can be related to the steric signal and throughflow transport imbalance. EOF 2 represents a seesaw between the southern and northern JES, with the same timing of extremes as the synchronous EOF 1. EOF 2 corresponds to the simultaneous circulation strengthening (weakening) in the entire JES in autumn (late winter) caused by the south–north steric level difference which, in turn, can be related to the differential cooling and throughflow transport imbalance. EOF 3 represents a seesaw between the western and eastern JES, oscillating on semi-annual, annual, quasi-biennial, and interannual timescales. It can be forced by an alternating cyclonic/anticyclonic wind stress curl. Comparison is made with EOF modes of the JES sea surface temperature. Suggested SLA forcings are supported by simulations with an oceanic model.

30 October, 12:05 (POC-P-5795)

Effects of variability 'separation' for the northern Japan/East Sea obtained from satellite data

Dmitry D. **Kaplunenko**, Vyacheslav B. Lobanov and Olga O. Trusenkova

V.I. Il'ichev Pacific Oceanological Institute (POI), FEBRAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: dimkap@poi.dvo.ru

Recent satellite data of Sea Surface Height (SSH) and Sea Surface Temperature (SST) provide important regular information to study the variability of the Japan/East Sea (JES) from seasonal to interannual scales. In our work we examined the spatial and time variability for 3 specific domains of the JES using daily SST and weekly SSH with a space separation for areas encompassing the entire basin (Entire JES, EJES, 1st domain), the area north from 40° (Northern Japan/East Sea, NJES, 2nd domain) and for the NJES, excluding the Tsushima Current region (Limited NJES, LNJES, 3rd domain). Complex Empirical Orthogonal Functions (CEOF) analysis was applied to these domains using initial and first order anomalies (Trusenkova *et al.*, 2008). The temporal components of CEOF were analyzed using wavelet decomposition. It was found that space separation for the corresponding domains can help with observations of spatial and time variability of the studied field which cannot otherwise be found due to effects of noisy signals and/or excluding/including processes affected by different spatial scales. Hence, in most cases for the SSH and SST, the spatial separation can give the same results as separation spatial variability, namely: [1st order anomalies for the EJES (CEOF1-CEOF2, separation of variability by a subpolar front and separation of the northern and western parts of EJES), initial (CEOF2-CEOF3, difference between northern and western NJES, separation on two parts of NJES by Tsushima Warm Current region) anomalies of NJES, initial (CEOF2-CEOF3, separation between central and eastern parts of LNJES) anomalies of LNJES]. The derived anomalies of the first order can help to define the time variability for CEOF temporal components. Hence using these methods for both SSH and SST, annual, semi-annual, biennial, quasi-biennial and 4-year variabilities have been found for initial and 1st order anomalies.

30 October, 12:25 (POC-P-5785)

Relationship between the interannual variability of the Korea Strait Bottom Cold Water, upper water temperatures and surface heat fluxes in the East Sea

Hanna **Na**[1], Kwang-Yul Kim[1], Kyung-Il Chang[1] and Kuh Kim[2]

[1] School of Earth and Environmental Sciences, Seoul National University, Seoul, 151-742, R Korea
E-mail: hanna.ocean@gmail.com
[2] Pohang University of Science and Technology, Pohang 790-784, R Korea

Long-term upper water temperatures in the East Sea were analyzed in order to investigate the temperature variability in the Korea Strait and its relationship with the upper water temperature in the East Sea [Minobe *et al.*, 2004]. The second Cyclostationary EOF (CSEOF) mode of the vertical temperature section in the Korea Strait represents the interannual variability of Korea Strait Bottom Cold Water (KSBCW) and large variance is found at the western channel with bottom intensification characteristics. The corresponding PC time series of this mode shows a major spectral peak at ~ 3 years. Patterns of the upper water temperature and atmospheric variables were obtained to be physically consistent with this mode via regression analysis. Regions of large variance are along the eastern coast of Korea and at the northwestern area of the East Sea. These patterns implicate pathways of the cold water from the northern region to the Korea Strait. Among the various atmospheric variables, surface heat flux indicates a notable relationship between the surface heat loss over the Vladivostok area in the winter season and the amount of KSBCW as inferred from the upper water temperature variability. Physical interpretations of this relationship will be discussed and stochastic forecasts of the interannual KSBCW variability using various climate indices will also be discussed.

30 October, 14:00 (POC-P-5967)

Synthesis of recent ocean data from the Pacific sector of the Arctic by the Pacific Arctic Group

John **Calder**[1] and Jackie Grebmeier[2]

[1] U.S. National Oceanic and Atmospheric Administration, Climate Program Office, 1100 Wayne Ave., Silver Spring, MD, 20910, USA
E-mail: John.Calder@noaa.gov
[2] Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science, Solomon's, MD, 20688, USA

The Pacific Arctic Group (PAG) is an informal mechanism for exchange of information on science issues related to the Pacific sector of the Arctic. Current activities include a synthesis of recent information on the Pacific Arctic and coordination of field observations during the 2010 and 2011 field seasons. Both topics will be discussed in this presentation.

The synthesis activity was conceived as an International Polar Year Legacy activity and has been endorsed by the IPY International Project Office. It will be performed by teams of experts who volunteer to undertake the task. Three teams have been formed as of the time of abstract submission and more are anticipated. The first three teams will focus on modeling of the physical and biological state of the region, on biological observations, and on the marine carbon cycle. The overall objectives of the synthesis effort are to:

- Present results from research, observation and modeling activities related to the PAG area, both retrospective and IPY efforts
- Share information on current modeling activities; work toward a shared modeling system
- Identify major new findings and understanding of state and processes in the PAG area
- Using best available model projections, prepare hypotheses regarding the future evolution of the physics and biology of the region
- Prepare scientific conclusions and recommendations to guide future PAG science activities
- Specifically for the PAG region, identify critical marine components of a future Arctic Observing Network

The synthesis teams have three defined focal points for their efforts. A session has been arranged at the Ocean Sciences Meeting in Portland Oregon in February 2010 for presenting results available at that time. More complete results will be presented at t he International Polar Year science conference in Oslo in June 2010. And an arrangement has been reached with Springer to publish the final synthesis papers in book form in 2011.

Members of the PAG will meet in China just prior to the PICES meeting to discuss field activities in 2010 and 2011. Proposed operations of research vessels in the Pacific Arctic sector will be presented and points of contact will be given so that additional collaborations may be considered.

Participation in the PAG is open to all interested scientists.

30 October, 14:20 (POC-P-5816)

Dissolved methane transport in the Arctic water: Observed data and simulation

Victor **Kuzin**, Valentina Malakhova and Elena Golubeva

Laboratory of Mathematical Modeling of Processes in Atmosphere and Hydrosphere, Institute of Computational Mathematics and Mathematical Geophysics, Siberian Division of Russian Academy of Sciences, 6 Lavrentieva Ave., Novosibirsk, 630090, Russia.
E mail: kuzin@sscc.ru

As part of the global carbon cycle, enormous quantities of methane occur in marine sediments. The extensive Arctic shelves may play an important role in methane cycling because of their large area. Based on observed data, an attempt was made to identify the main sources of dissolved methane in the Arctic Ocean. One of the mechanisms to release methane to the ocean is through submarine mud volcanism, hydrocarbon seeps and vents. Other sources of methane include methane gas hydrates. Siberian rivers are also a strong source of dissolved surface methane that comes from the wetlands.

A 3D mathematical model of the dissolved gas transport by the ocean currents is used to assess the amount of a possible methane flux from the submarine sources. The ocean model has been constructed at the Institute of Computational Mathematics and Mathematical Geophysics SB RAS, for the North Atlantic and Arctic basins. For modeling Arctic methane fluxes, the three above-mentioned methane sources were taken into account.

The results of the numerical simulation show that the propagation of dissolved methane into the Arctic basin is realized by two ways according to the atmospheric regimes and is associated with the North Atlantic/Arctic Oscillations. In the cyclonic circulation mode a high concentration of methane is formed in the region of Taimyr. In the anticyclonic mode, the dissolved methane is concentrated in the central Arctic.

30 October, 14:40 (POC-P-5668)

Summer hydrography of the southeastern part of the Laptev Sea – Results from the Pacific Oceanological Institute expedition in September 2006

Eduard A. **Spivak**, Nina I. Savelieva and Anatoly N. Salyuk

V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyaskya St., Vladivostok, 690041, Russia. E-mail: stilo@poi.dvo.ru

In September 2006 a series of oceanographic observations in Buor Khaya Bay in the southeastern part of the Laptev Sea and estuarine zone of the Lena River were carried out by an expedition from the Pacific Oceanological Institute, Far Eastern Branch of the Russian Academy of Science. Observations were conducted in two phases. The first phase of the research was done in the Lena River delta on board the research vessel *Neptun*. In the second phase, two meridian sections were surveyed from the ice breaker *Captain Danilkin*. CTD profiles (temperature, salinity, CDOM) and hydrochemistry samples at 65 oceanographic stations were collected over 30 days.

The area of investigation is characterized by a two-layer vertical structure. Warmer and fresher waters characterize the surface waters and up to 10–12 m depth, there is mixing of river water with upper layer arctic waters.

Colder and saltier waters were identified under the 10–12 m depth layer. The river influence is more evident in the Lena River delta where there was a mixed water column. Minimum values of salinity and maximum values of temperature were observed in the southern part of Buor Khaya Bay in the vicinity of the Lena River delta. The horizontal distribution of temperature and salinity is characterized by three areas: fresher and warm waters in the vicinity of the Lena River delta, a transitional area, and arctic waters in the northern part of the section. Values of salinity (S ~0) and temperature decreases from 12°C to 6°C seaward were observed in the delta. The spatial distribution of temperature, salinity, and hydrochemical parameters will be discussed.

30 October, 15:00 (POC-P-5840)

Mechanisms of the cold water belt formation off the Soya Warm Current

Humio **Mitsudera**, Keisuke Uchimoto and Tomohiro Nakamura

Institute of Low Temperature Science, Hokkaido University, Kita 19, Nishi 8, Sapporo, 060-0819, Japan
E-mail: humiom@lowtem.hokudai.ac.jp

The Soya Warm Current (SWC) flows along the northern coast of Hokkaido, and is intensified when it passes through a shallow strait between the Japan Sea and the Sea of Okhotsk. In summer, it has a jet-like structure downstream of the strait with a surface maximum speed exceeding 1 m/s at its axis. A cold water belt is formed offshore of SWC with a subsurface doming structure. It is well-known that there is abundant primary production along the cold belt even during summer. In this presentation, mechanisms of the cold water belt formation and subsurface doming are discussed from a point of view of nonlinear resonance by interaction between a barotropic stratified flow and a shallow sill. When the barotropic current rides over the sill, the thermocline is displaced greatly and consequently the subsurface layer may outcrop, owing to resonance of the internal Kelvin wave. This corresponds to upwelling phenomena along the southwestern coast of Sakhalin Island. The thermocline elevation then propagates downstream from the sill as baroclinic waves along the potential vorticity front associated with the ambient barotropic flow. This baroclinic adjustment causes the subsurface doming structure that closely resembles the cold water belt along SWC.

30 October, 15:20 (POC-P-5896)

The characteristic response of the Kuroshio Extension region to a warm pool El Niño

Jinhee **Yoon**, Sang-Wook Yeh, Young Ho Kim and Jong-Seoung Kug

Climate Change and Coastal Disaster Research Department, Korea Ocean Research and Development Institute, Ansan, P.O. Box 29, Seoul, 425-600, R Korea. E-mail: jiny.yoon@gmail.com

During the late 1990s and the 2000s, El Niño events showed somewhat different characteristics compared to the conventional El Niño. A new type of El Niño, the so-called "warm pool El Niño", is characterized by an anomalous warm sea surface temperature (SST) in the central equatorial Pacific and its tropical–midlatitude teleconnection is distinguished from that of a conventional El Niño. When a conventional El Niño event occurs in the equatorial Pacific, the anomalous SST has a mostly negative sign in the Kuroshio Extension region. The negative SST anomalies in the Kuroshio Extension region accompany an enhanced wind magnitude, which is associated with the alternation of mixed layer depth and air-sea heat flux interaction in the same region. In the case of a warm pool El Niño, however, the anomalous warm SST appears in the Kuroshio Extension region, which seems to be associated with not only atmospheric forcing but also with the modulation of the Kuroshio activity.

30 October, 16:00 (POC-P-5713)

Simulating spring–neap salinity variations in Knight Inlet, Canada

Michael **Foreman**[1], Piotr Czajko[2] and Dario Stucchi[1]

[1] Institute of Ocean Sciences, Fisheries and Oceans Canada, P.O. Box 6000, Sidney, BC, V8L 4B2, Canada
E-mail: mike.foreman@dfo-mpo.gc.ca
[2] Department of Mechanical Engineering, University of Victoria, Victoria, BC, V8W 3P6, Canada

Time series of near-surface salinities measured downstream of the sill in Knight Inlet show increasingly large, fortnightly oscillations as the upstream river discharge increases in May and June. Similar phenomena have been observed elsewhere along the British Columbia coast and are generally attributed to spring–neap variations in tidal mixing over shallow regions like this sill. In this presentation, we will describe attempts to simulate the phenomenon with FVCOM (the Finite Volume Coastal Ocean Model). The problem has important biological consequences as the natural mortality of sea lice, a common parasite to both farmed and wild salmon in the region, varies inversely with the salinity. Any credible sea lice model that is coupled to the FVCOM circulation model therefore needs to have these salinity oscillations represented accurately.

30 October, 16:20 (POC-P-5749)

Interaction of sea and river waters in the estuary of the Amur River

Anastasiya A. **Abrosimova** and Igor A. Zhabin

Laboratory of Hydrological Processes and Climate, Department of General Oceanology, V.I. Il'ichev Pacific Oceanological Institute, FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia. E-mail: amber@poi.dvo.ru

Estuaries are highly productive and biologically active zones where there is a mixing of fresh and sea waters. Hydrological processes which occur here play an important role in the functioning of coastal ecosystems. A study of the Amur River Estuary was carried out in June 2005–2007 and in April 2008. Spatial and temporal variability of the oceanographic parameters in this area were studied using *in situ* observations. Remote sensing information, in visible and IR-ranges, from the NOAA satellites, Terra and Aqua, were also used. Analysis of the data showed that the river discharge in the cold period of the year had a greater influence on hydrological conditions of the southern part of the Estuary than during the warm period. The water stratification in the southern part of Estuary was based on periodic advection of waters from the East/Japan Sea during a tidal cycle. An increase in water salinity from 2005 to 2007, which is possibly connected with variations in river discharge, was noted. In summer, low salinity waters flow out through the northern outlet of the Estuary. It was determined that there is front which separates warmer river waters in the northwestern part of the Estuary from colder modified East/Japan Sea waters in the southeastern area. These structural elements are visible on satellite images as warmer and turbid waters. The joint usage of instrument measurements and satellite data help us to obtain a greater amount of information about the interaction of fresh and sea waters.

30 October, 16:40 (POC-P-5924)

Direct measurement of turbulence mixing along a meridional transect in the western North Pacific

Hitoshi **Kaneko**, Ichiro Yasuda and Sachihiko Itoh

Ocean Research Institute, University of Tokyo, 1-15-1, Minamidai, Nakano, Tokyo, 164-8639, Japan. E-mail: kaneko@ori.u-tokyo.ac.jp

Hydrographic observations, including direct measurements of turbulence mixing, were conducted along the meridional transect of the western North Pacific during the summer of 2008. Mixing level was generally enhanced around main and seasonal pycnoclines, exhibiting turbulent dissipation rates (vertical diffusivity) of about 10^{-9}–10^{-8} W kg^{-1} (2×10^{-6} to 2×10^{-5} m^2 s^{-1}) and 10^{-9}–10^{-7} W kg^{-1} (3×10^{-6} to 3×10^{-5} m^2 s^{-1}), respectively. Markedly strong turbulent mixing was observed in the Kuroshio Extension region and in the zone of 10–25°N in the subtropical gyre, where turbulent dissipation rates (vertical diffusivity) in the main pycnocline were 10^{-9}–10^{-7} W kg^{-1} (2×10^{-6} to 3×10^{-5} m^2 s^{-1}). In contrast, turbulent mixing in water columns between these pycnoclines was weaker than those at both pycnolines typically in the zone south of the Kuroshio Extension where Subtropical Mode Water develops around the depth of 100–300 m between the two pycnoclines: the dissipation rate (vertical diffusivity) was about 0.1×10^{-9} to 0.3×10^{-9} W kg^{-1} (1×10^{-6} m^2 s^{-1}). On the other hand, beneath the main pycnocline where North Pacific Intermediate Water occurs, the dissipation rate (vertical diffusivity) increased to about the range 10^{-9}–10^{-8} W kg^{-1} (1×10^{-5} to 4×10^{-5} m^2 s^{-1}).

30 October, 17:00 (POC-P-5544)

Water temperature changes in the nearshore zone of Aniva Bay from mooring observations

Elena A. **Vilyanskaya**, G.V. Shevchenko, O. Kusaylo and A. Kato

V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, Laboratory of Hydrology Processes and Climate, 43 Baltiyskaya St., Vladivostok, 690041, Russia. E-mail: vily05@mail.ru

Aniva Bay is a half-closed water pool located in the southern part of Sakhalin Island. This area has become the center of attention of many scientists: on one hand, a condensing gas plant and shipping terminal are located in Prigorodnoe village; on the other hand, Aniva Bay is a fishing area, with particularly high catches of pink salmon. The Sakhalin Research Institute of Fisheries and Oceanography, along with the Sakhalin Hydrometeorological Agency, carried out a special field experiment to investigate the water temperature and the current velocity variations in Aniva Bay in July-October 2003. Five moorings with SonTek Argonaut 3D current meters were installed in the nearshore zone, in the northern part of the Bay. Sharp fluctuations of the water temperature near the coast was observed to have an impact on salmon approaches to the Bay. The occurence of a sharp temperature decrease is revealed for the coastal areas of the Bay. This was also traced from satellite data. The phenomenon of upwelling had not been observed earlier. Upwelling areas are biologically productive zones. However, the water temperature at the Monetka and Yunona stations fell below zero, from 6 ºC to –0,6 ºC, for the Monetka station. During the sharp drop in the water temperature, wind was from the northeastern direction, with a speed of 5–7 m/s. Low temperatures persisted for about 3 days, with mostly northeastern winds, after which the water temperature increased to above zero. Similar events occurred in July. Abnormal temperatures were not detected in August. Therefore, research of dynamic processes in the coastal zone is both scientific and practical interest.

POC-Paper Session Posters

POC-P-5512

Research on the influence of the thermal regime of water on ice cover in the Japan Sea

Svetlana P. **Shkorba**

Ice Research Laboratory, V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: sshkorba@yandex.ru.

Correlations of sea ice cover during the period of maximum ice development (February) and temperature of the surface water layer in the northern part of the Pacific Ocean, taken with shifts of 0, 1, 3, 6, 9 and 12 months, are calculated in order to estimate the influence of the thermal regime of water on ice cover. The optimum set of thermal regime indicators, which are most closely connected with the subsequent evolution of ice conditions, was selected. Archives, allowing us to estimate the influence of a thermal regime on the Far East seas, can be applied for forecasting. Results were confirmed by calculating critical values of correlation coefficients. At a 95% significance level the critical values of correlation coefficients range from 0.42 to 0.50. At 80% significance the critical values are from 0.26 to 0.34. The Pacific waters do not directly influence the Japan Sea in regard to hydrodynamic features. Positive correlations are observed in the northern and the northeastern parts of the sea and negative ones in the south. The area where negative correlation coefficients are the greatest is in the southwestern area which reflects the influence of the Kuroshio Current influence. Here, negative correlation coefficients dominate. Noticeable zones with positive correlations are detected only with synchronous analysis and a one-year shift.

POC-P-5513

Analysis of spatio-temporal distribution typizations of ice areas and ice volumes according to ice thicknesses in the Bering Sea

Nadezda M. **Vakulskaya**

Ice Research Laboratory, V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia.
E-mail: vakulskaya@poi.dvo.ru

Understanding the evolutionary process of ice cover formation and applying this knowledge to the Bering Sea is critical in carrying out statistical analyses. Detailed research of spatio-temporal distributions of ice areas and ice volumes, according to thicknesses calculated by the A.N. Chetyrbotskii large-scale model of sea ice evolution, is executed on the basis of their typization, or characterization, results. According to these results, ice covers of sea areas produce relatively homogeneous groups under the signs of the considered metric parameters of a condition. The given typizations allow us to better estimate the influence of constraining factors on ice formation. This is necessary when developing forecast methods. The absence of symmetry in the distributions of separate ice thicknesses during the processes of ice cover formation and its destruction is revealed. The gradation of ice thickness dominates in any temporal interval of ice cover evolution. Durations of ice cover formation last longer than durations of its breakup. Distribution characteristics of the ice areas and ice volumes in seaways are similar to those of the ice areas and ice volumes of fast ice. The differences between them are marked by their ice melting periods. In the melting period of fast ice, fragments are taken out to the open sea and sequentially pass into categories of seaway ice. During this period the seaway ice areas and volumes of minor thickness gradations are increased and fast ice areas and ice volumes are reduced.

POC-P-5522

Estimation of wind stress curl on Far-Eastern seas from tropical cyclone movements

Ekaterina **Potalova**

Laboratory of the Ocean-Atmosphere Interaction Studies, V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia. E-mail: gata@poi.dvo.ru

In their movement, tropical cyclones (TC), are able to reach middle and high latitudes and have an affect on the waters of the Sea of Japan and Okhotsk Sea, in particular, on the upper layers of these seas. Estimations of wind stress curl were made for the cases of two tropical cyclones, Wendy (7808) and Irving (7910). Results show that tropical cyclones lead to a sharp increase in wind stress curl values, which exceed the monthly average by several times. In both cases, the wind stress curl field was defined by the appearance of clearly-defined cyclonic circulation, with changes of wind stress curl sign as a whole. This demonstrates that although TCs, which move over Far-Eastern seas, are often weaked, they contribute significantly to the dynamical processes of this region, which are especially important in the warm months.

POC-P-5526

The thermohaline structure and temperature anomaly dynamics in the Kuril Islands area

Valentina V. **Moroz**

V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia. E-mail: moroz@poi.dvo.ru

The thermohaline structure and its variability were analyzed based on the resources from the Pacific Oceanological Institute, Far Eastern Branch, Russian Academy of Sciences (POI FEB RAS) data bank. These resources included archived materials from national research cruises and data from modern observations conducted by POI in the Kuril Islands area. It was found that in the Okhotsk Sea, along the Kuril Islands, there was an abrupt "end" of the cold intermediate layer core, with a minimum temperature lower than +1°C, at a distance of 40–60 miles (~65–95 km) from the islands' coast. The abrupt "end" of the cold intermediate layer indicates the existence of a clear frontal division between the intermediate waters of the Okhotsk Sea and the tidal vertically mixed waters in the straits. This cold intermediate layer in the Okhotsk Sea does not mix with the one in the Oyashio Current, and is affected by the cold winter conditions in the region. However, in the sub-strait zone of the Bussol Strait, the coldest and lowest-salinity waters of the Sea of Okhotsk, intrusions were found. The formation mechanisms and the dynamics of the temperature anomalies in the zones of the Kuril Island straits were analyzed.

POC-P-5529

The climatic trend of non-homogeneous SSTs in the northern Pacific Ocean and stability of the Kuroshio Extension jet

Talgat R. **Kilmatov**[1] and Elena Dmitrieva[2]

[1] Pacific State University of Economics (PSUE), 19 Okeansky St., Vladivostok, 690091, Russia. E-mail: talgat_k@mail.ru
[2] V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia

The spatial distribution of non-homogeneous sea surface temperatures (SSTs) characterizes the ocean deviation from the equilibrium of thermodynamic conditions, the available potential energy level, and the possibility of the kinetic energy production. A spatial distribution of non-uniform temperatures was calculated for the latitude and longitude sections in the North Pacific using the HadSST dataset. The time variability of temperature non-uniformities for the last 60 years (1947-2007) is considered. The climatic trend of the temperature non-uniformity time series was calculated from data averaged over l2 periods for 5 years (1948-1952, 1953-1957) for each section.

A nonlinear variational model of jet currents applied to the Kuroshio Extension is constructed. The mathematical model is based on the functional variations of minimum entropy production used to study the structures' stability in a stationary state. The model shows that the north–south difference in water density (temperature) is the determining parameter for the jet current to exist. Comparison of the SST (Hadley SST) results and the modeling data shows that the climatic trend will lead to the destruction of the Kuroshio Extension as a jet current. The

spatial smoothing of the SST gradient will cause the reduction of the available potential energy, leading to the reduction of the kinetic energy. It is probable that there will be structural changes in the climatic circulation and ecological systems.

POC-P-5550

One-dimensional model of water productivity changes because of convective regime reconstruction

Yury I. **Zuenko**

Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia
E-mail: zuenko_yury@hotmail.com

A simple 1-D model is developed to estimate the changes of annual production and nutrient concentrations in the Japan/East Sea in the process of convective regime reconstruction caused by the sea surface warming. The model simulates phosphorus circulation and includes the processes of deep and slope convection, turbulence mixing, primary production, organic matter sinking and destruction. The density, phosphorus, and oxygen profiles for the deep-water part of the Sea in the 1970s (before the beginning of convective mixing reconstruction) are used as the starting conditions. Three regimes of convection are modeled:

1. Hyperventilation: annual slope convection and sea surface cooling to $\sigma_t = 27.348$ that causes deep convective mixing in the 1400 m layer. This regime provides stable but unrealistic profiles of phosphorus (too low concentration in the deep layer) and oxygen (too high content in the deep layer); annual production is estimated in 250 gC/m^2.

2. Moderate ventilation: annual sea surface cooling to $\sigma_t = 27.32$ that causes convective mixing in the 400 m layer, with episodes of deep convection to 1400 m and slope convection in every 4th year. This regime provides nonsteady profiles of phosphorus and oxygen but their average concentrations are close to real ones observed in the 1970s; besides, the intermediate and deep layers are similar in their properties as they were in the 1970s; annual production fluctuates from 190 to 250 gC/m^2, which looks reasonable.

3. Weak ventilation: annual sea surface cooling to $\sigma_t = 27.32$ that causes convective mixing in the 400 m layer, without the episodes of deep and slope convection. This regime provides the tendencies to nutrient increase and oxygen depletion in the deep and bottom layers (the concentrations become stable in 2 decades) and causes separation of the intermediate and deep layers as was observed in the 1990s; annual production decreases gradually but also stabilizes in 2 decades at the level of 120 gC/m^2.

The third regime is supposedly typical for the recent period of climate warming, so a decrease of the Japan/East Sea productivity is concluded. However, stabilization on the level of approximately half the current productivity is predicted.

POC-P-5562

Classification of the meteorological–hydrological time series of the Asian-Pacific region using cluster analysis

Elena **Dmitrieva**, Vladimir Ponomarev and Nina I. Savelieva

V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: e_dmitrieva@poi.dvo.ru

A cluster analysis of time series of atmosphere and hydrosphere characteristics over the Northwest Pacific was carried out for two periods: before and after the mid-1970s. Classes of time series similar in structure were distinguished from a set of climatic indices, anomalies of surface pressure in the atmospheric centers of action, Amur River discharge, SST and ice extent of the Okhotsk and Japan seas. The composition of classes was modified after the climate regime shift in the 1970s over the North Pacific which was caused by the change in regional climate and teleconnections. A cluster analysis was also used for the classification of SST anomalies in the Japan/East Sea (1°×1° horizontal resolution), and their spectra. Domains with different scales of SST oscillations were determined.

POC-P-5563

Seasonal variability of the water circulation in the Sea of Okhotsk under the influence of synoptic processes in 2003-2004

Galina A. **Vlasova**[1], Svetlana U. Glebova[2] and Gleb S. Vlasov[3]

[1] V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: gavlasova@mail.ru
[2] Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia
[3] V.V. Kuibyshev Far Eastern State Technical University, 10 Pushiskaya St., Vladivostok, 690950, Russia

Surface water circulation in the Sea of Okhotsk during the period 2003-2004 is studied using numerical simulations forced by different types of synoptic situations using the classification scheme of Svetlana Glebova. A good correlation between atmospheric and hydrodynamic processes is detected. The common kvazi-stationary stability of hydrodynamic structures is shown for the currents independent of time: the prevailing cyclonic motion in the sea is explained by the cyclonic character of atmospheric circulation above the Far East basin. A powerful cyclonic rotation is detected in the central part of the studied region above the Central-Okhotsk Plateau, independent of the season. It is probably connected not only with atmospheric circulation, but also with other permanent factors, for example, large formations of the bottom relief. The seasonal variability of hydrodynamic processes for different types of atmospheric circulation is shown. So, the powerful cyclonic rotation dissipates as a result of a weakening of the winter monsoon for the "warm" type of atmospheric processes, one of which most often was shaped in the winter period of 2004. The alongshore warm jet streams were observed as result of the convergence of the currents with the coast. The zonal orientation of cyclonic structures was observed owing to zonal low pressure gradients during the prevailing "monsoon" season with a "small-gradient" barometric pressure synoptic type appearing in the summer season.

POC-P-5564

Preliminary results of the seasonal variability of water circulation in the South China Sea under the influence of the synoptic processes

Galina A. **Vlasova**[1], Bui Hong Long[2], Antonina M. Polyakova[1], Nguyen Ba Xuan[2], Gennady I. Yurasov[1] and Le Dinh Mau[2]

[1] V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: gavlasova@mail.ru
[2] Cau Da 01, Vinh Nguyen, Institute of Oceanography, Nha Trang, Vietnam

On the basis of hydrodynamic modelling, integrated functions of the currents have been designed and maps of water circulation of South China Sea for all 12 months from the period 1946–2006 are constructed. A preliminary analysis of the maps reveals the following long-term empirical seasonal laws of water circulation:

1. There is general cyclonic water circulation in the South China Sea for all seasons;
2. Cyclonic whirlwinds in the Gulf of Siam and anticyclonic whirlwinds about Hainan Island occur irrespective of the season;
3. Individual seasonal features of water circulation of the South China Sea reveal that:
    d. During the autumn period, the cyclonic circulation along the northwestern part of Kalimantan Island is most strongly pronounced;
    e. During the winter season (January) the current pattern is completely opposite to that of the rest of the year;
    f. In the spring (March) there is practically no anticyclonic water circulation in the Karimata Strait which is observed during the other seasons;
    g. In the summer the current pattern is opposite to the conventional pattern for the rest of the year.

POC-P-5567

Destructive tsunamis near the coast of Primorye

Antonina M. **Polyakova**

V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: polyak@poi.dvo.ru

Destructive tsunamis have been reliably confirmed by 4 cases taking place on the coast of Primorye: in 1907, 1940, 1983, 1993. In one case, a ship was sunk in De-Kastre Bay. In another case, hay stacks from the fields were washed away to sea near Grossevichi village. The most observed tsunami runup was recorded on May 26, 1983, with a horizontal inundation of more than 800 m and a runup height of 6.5–7.0 m. The first maximum runup was observed on the coast of the Preobrazhenie– Rudnaya Pristan' settlements. The second one was observed in Peter the Great Bay. The maximum observed inundation was more than 800 m, and the runup height was 6.5–7.0 m in Lidovka Bay.

POC-P-5568

Atmospheric circulation over the South China Sea

Antonina M. **Polyakova**

V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: polyak@poi.dvo.ru

One way to investigate atmospheric circulation is by classification. The present classification is carried out on the basis of a 10-year period of observations and compared with other classifications, it considers the character of cyclone trajectories and the location of anticyclones. Three types of atmospheric circulation are distinguished: 1) a small gradient barometric pressure system over the South China Sea; 2) a small gradient barometric pressure system over the South China Sea with a strong wind over the northern part of the sea; 3) a hurricane consisting of 3 subtypes: a) hurricane over the northern part of the sea; b) hurricane over the centre core of the sea; c) hurricane over southern part of the sea.

POC-P-5574

Upwelling and its influence on ice conditions in Peter the Great Bay

Gennady I. **Yurasov**

V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia. E-mail: yug@poi.dvo.ru

Upwelling is a well-known phenomenon connected with the transport of cold waters from intermediate depths to the surface in coastal areas of the sea. Peter the Great Bay (the Sea of Japan, southern coast of Prymorskii Krai) is not an exception in this sense. According to the oceanographic observations carried out in the Bay, upwelling starts to develop here in September–October. It is caused by a strong winter monsoon with northerly winds. As a rule the upwelling has the greatest development in November when cold waters from underlying depths appear at a coastal slope on the background of relatively warm surface water. In December at the same areas, the upwelling is not revealed in temperature distributions, because of winter cooling of the surface water, while it is distinctly expressed in salinity and nutrients. During the winter season the upwelling supplies the surface waters of Peter the Great Bay with a heat (instead of cold, as during the warm season) and interferes with continuous ice cover in the whole Bay. This confirms the fact that if winter is cold enough, continuous ice cover occupies the shallower secondary Amurskii Bay only, and the deeper secondary Ussuriiskii Bay and waters of the open part of Peter the Great Bay remain almost ice-free even in the severest winters.

POC-P-5621

On the differentiation of thermohaline processes in the Sea of Japan to the south of the Subarctic Front: Part I

Vladimir B. Darnitskiy[1] and Maxim A. **Ishchenko**[2]

[1] Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia
[2] V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: maksim@poi.dvo.ru

The Sea of Japan has become an arena of international cooperation among the countries of the Asian Pacific Regions (APR) in the last few years, resulting in a number in a number of international conferences, the last of which (PEACE-IV) has taken place at the Pacific Oceanological Institute, Far Eastern Branch, the Russian Academy of Sciences (POI FEB RAS) in 2008. Because Russia, Japan, North Korea and South Korea have economic zones of different sizes, and each country has its own databases, the analysis of the sea level varies, depending on how complete each country's database is. This situation improves when the S. Levitus international database (1994) is able to be shared by each state.

Here, we use one of the last versions of Levitus' database – 2006. The Sea of Japan sea area is limited by an area bounded by 35–40°N.L. and 130–140°E.L., *i.e.*, to the south of the Subarctic Front where domestic research has been rare.

The geological structure of the Sea of Japan is characterized by submarine elevations located in almost half the area (Bersenev, Lelikova, 1979). Most of them are located in the southern half of the sea to the south of the Subarctic Front. It is known that the flow near the seamounts is characterized by intense vortex activity (Darnitsky, 1980, 1992; Zyrianov, 1985). Consequently, the consistent and more complex interaction of water with the seamounts in the intermediate and upper layers of the sea can be indirectly determined by the dynamics of temperature–salinity parameters. Local dynamics of the water are correlated with the general circulation of the sea, complicating the fluctuational processes and blocking various water masses from the seamounts of different morphologies and heights. We find that the changes in water temperature ($AT°_w$) and salinity (AS ‰) characterising the intense interaction of the subarctic waters which are distributed to the north of the Subarctic Front and subtropical waters, arriving through Tsusima passage, are important.

A latitudinal strip of the Sea of Japan on a longitude has been broken into two 5°x5° squares. For convenience of calculations, and proceeding from 5°-grids of data processing used in the past, methods described by Darnitsky and Ischenko (2008) were used to study the Pacific waters of the Japanese archipelago. The information was processed for 2-month periods: November–December, February–March and April–May to 600 m depth.

POC PAPER

POC-P-5622

On the differentiation of thermohaline processes in the Sea of Japan to the south of the Subarctic Front: Part II

Vladimir B. Darnitskiy[1] and Maxim A. **Ishchenko**[2]

[1] Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia
[2] V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: maksim@poi.dvo.ru

It is observed that in the top 0-600 m layer, the quasicyclic periods of fluctuations of both water temperature ($AT°_w$), and salinity (AS‰), have the greatest variations in the top 400 m layer. Intradecadal cycles are known in many geophysical systems and are caused by the periodic cycles of the planet, and interactions in the ocean–atmosphere system. Circulation and heat exchange are the major factors defining the intradecadal interaction of waters between the surface of the sea and the atmosphere, and include advection of waters from Tsusima passage, and tidal interactions, particularly with the seamounts of the southern Sea of Japan. The differentiation of cyclic processes on water depths is defined by the stratification of waters in the vertical: on the top is a quasihomogeneous layer, followed by a seasonal thermocline layer of varying depth (from 10 m depth in northern areas to 80–130 m depth on the coasts of Korea and Japan with a spreading water mass that actually hollows in the Sea of Japan.

In the Sea of Japan three types of vertical distribution of salinity are observed. The first type is characterised by a well expressed subsurface (150 m) maximum of salinity which is observed in a zone of the East Korean and Tsusima warm currents. It is most prevalent in the southern part of the sea during the warm period of the year. During the winter it is absent from the area. South of the Subarctic Front an intermediate salinity minimum of 34.070-34.097 ‰ is observed, and in the 100-300 m layer waters of the decreasing salinity, with values of 34-34.065 ‰, is found. A secondary maximum of salinity is found in the 200-500 m layer. The features of these vertical structures cause a distinction in quasicyclic processes on $AT°_w$ and AS ‰ in the same squares and on the different horizons.

The difference in cycles between the next squares can be also caused by various vortical activities, meandering of the main currents, and the chaotic fluctuations in water volumes near the top of the Jamato-bank and other underwater seamounts in the southern part of the Sea of Japan. Another important feature in the dynamics of the inter-annual two-month season is a long-term wave (polymodal approximation) allocated to increased amplitudes of $AT°_w$ and AS ‰ of the interacting waters.

Long-term cycles have a duration of 8 to 18 years, and the continuity of their interactions is limited to the upper 100 m layer, but not always. Intermediate waters did not have harmonized cycles.

To establish the reasons for the difference in amplitudes of $AT°_w$ and AS ‰, additional sources of information are required. Some possible interpretations of observed phenomena will be presented in the report.

POC-P-5634

The Numerical Simulation of the effects of global warming on ocean ecosystems in Bohai Sea

Cai **Yi**, Zhanggui Wang and Licheng Feng

National Research Center for Marine Environmental Forecasting, 8 Da Huisi, Haidian District, Beijing, 100081, PR China. E-mail: caiyicaiyi.cai@gmail.com

We discuss the effects of global warming on ocean ecosystems in the Bohai Sea using the COHERENS (Coupled Hydrodynamical Ecological model for REgioNal Shelf seas) model which couples ocean dynamics and the biological cycle. Case 1 scenario supposes that the air temperature in the Bohai Sea is raised 1ºC and the sea surface temperature is raised by 0.6ºC. Case 2 supposes that the air temperature in Bohai Sea is raised by 2ºC and the sea temperature is raised by 1.2ºC. The numerical results for case 1 showed that the sea surface temperature in the Bohai Sea increases by about 0.7–0.8ºC. The increase in surface microplankton in Bohai Sea changes with season although the air temperature uniformly increases through the year. The increase in surface microplankton is more than 30% in January and February and is less than 2% from June to September, increasing 11% annually. Seasonally, microplankton variation is opposite to that of the sea surface temperature. The surface microplankton increase is greater in the coastal waters than in the interior of the ocean. Nitrate is decreased by about 10% in spring and 2-4% in summer. For case 2, the sea surface temperature in Bohai Sea increases by about 1.5–1.6ºC. The increase of surface microplankton is greater than 50-60% in January and February and 2-4% from June to September The annual increase is 17%. The surface microplankton increase of case 2 is 50% more than that of case 1 although the air temperature has doubled.

POC-P-5662

Large-scale fluctuations in the salinity of the Tsusima Current in the second half of the 20th century

Boris S. **Dyakov**

Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia
E-mail: djakov@tinro.ru

Using N.N. Zubova's formula (1926), the average salinity was calculated for layers 0-50, 0-100, 50-200, 0-200 and 0-500 m on standard sections of the Sea of Japan. In the southeastern part of the Sea of Japan an interannual variability in salinity on section "PM-9" showed a negative linear trend in layers 50-200 m depth, and 0-200 and 0-500 m depth. In the summer the salinity trend is statistically significant in these layers, especially in the layer of

50-200 m (R^2 = 0.16; 99.0 %). A statistically significant trend in salinity reduction was also observed in the area of the Korea Strait in the 0-100 m layer. This is evidence that there is a reduction in salinity of the waters of the Tsusima Current and, subsequently, the mass of Pacific water. The similar conclusion was made by Rudyh (2008) about the reduction in salinity in the majority of layers and areas of the Sea of Japan.

The reasons for the long-term tendency in the reduction of salinity of the Tsusima Current are stated in the following. In the last 20-30 years of the last century, measurements taken at hydrometeorological stations in the Sea of Japan detected an increasing trend in the accumulation of precipitation which, in some cases, was significant at a level of 90-95% (Dashko, Varlamov, 2003). Taranova (2006) has noted a tendency in the increasing speed of formation of intermediate waters with lowered salinity, with density 26.9-27.3 kg/m^3, in the Sea of Japan. In the opinion of the author, the catalyst for this phenomenon is the fluctuation in intensity of the Siberian anticyclone.

POC-P-5671

Influence of eddies and tides on the vertical structure of acoustic speed field on the east coast of Kamchatka and the Kuriles

Fedor **Khrapchenkov** and Nadezda Dulova

V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: fedi@poi.dvo.ru

It is known that in the coastal area of the Kamchatka Peninsula during the warm period, a cold intermediate layer (up to 200-250m) is formed. It leads to the formation of homogeneous closed and half-closed lenses, in which salinity, temperature, and acoustic speeds do not change, and to an increase of horizontal gradients on the ocean side of the Kamchatka Current up to the depth of 500 m (from 0.2 up to 0.58 m/s per km). The thickness of the lenses in the vertical changes from 100 to 200 m, and the width varies from 15 to 95 miles (~25 to 155 km). Vertical gradients of acoustic speed change from 2.86 s^{-1} above the lens down to 0.5 s^{-1} under the lens. Horizontal gradients change to the east up to 0.3 m/s per km on an axis of the acoustic sound channel and up to 1.6 m/s per km above the axis. At the coast the lenses are either closed with the same gradients as in the east, or pass to the continental slope. Formation and dispersion of eddies leads to a seasonal layer jump rising to the surface with a simultaneous reduction of its thickness down to 10 m and an increase in the vertical gradient of acoustic speed up to 4 s^{-1}.

This paper considers the influence of anticyclonic eddies and tides on the variability of the acoustic speed field on a shelf and a slope of the Kamchatka Peninsula and Kuriles, which affects both the change of the jump layer, and the characteristics of the acoustic sound channel.

POC PAPER

POC-P-5672

Dynamics of the runoff lenses of the Amur River in summer of 2005–2008

Fedor **Khrapchenkov**

V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: fedi@poi.dvo.ru

In summer, the runoff of the Amur River enters Sakhalin Bay in the Sea of Okhotsk through the northern waterway of the Amur estuary. During the flood interval, waters from the Bay to the northern extremity of Sakhalin Island are observed. Further, these waters are involved in forming the stream of the East-Sakhalin Current and extend along the east coast of the island. The position of the runoff lens of the Amur River and its area changes, depending on the features of atmospheric circulation and intensity of the tidal phenomena in this region. On the lens borders of freshered waters, significant gradients of temperature and salinity and a quick change of water color from brownish to deep-blue, are observed. Freshening of the surface layer in the lens is traced up to depth of 20 m; thus the freshest water borrows a surface layer about 5 m thick.

In this paper, the distribution features of the transformed waters along the northern coast Sakhalin Island are analyzed from remote sensing measurements from the NOAA series of satellites and from hydrological measurements in

2005–2008. The runoff lens is well traced on IR-images from July to September. On the edge of the lens along the coast, a runoff front with water temperature of 9.5ºC and salinity 28.5 psu is formed, and under the lens a sharp layer of discontinuity of salinity (up to 1 psu/m), temperatures (up to 2ºC/m) and density is formed.

POC-P-5682

A "Dressed" Ensemble Kalman Filter method using different seasonal ensembles in the Pacific

Liying **Wan**[1], Hui Wang[1] and Jiang Zhu[2]

[1] National Marine Environmental Forecasting Center, State of Ocean Administration, 8 Dahuisi Rd., Haidian District, Beijing, 100081, PR China. E-mail: wanly@nmefc.gov.cn
[2] Institute of Atmospheric Physics, Chinese Academy of Science, 9804 P.O. Box, Beijing, 100029, PR China

By using different seasonal ensembles, we designed a Dressed Ensemble Kalman Filter (DrEnKF) experiment in the Pacific to assimilate sea surface height data in 2006. At the same time, we also performed a control experiment, an Ensemble Operational Interpolation (EnOI) experiment and a climatology ensemble DrEnKF experiment. We compared the RMS errors and the correlation patterns between the three experimental results and the independently reanalysed Merged satellite and *in situ* Global Daily Sea Surface Temperature (MGDSST) data sets based on Japan and Argo floats data sets. The comparison results show that the DrEnKF experiment with a different seasonal ensemble performs better than EnOI and DrEnKF with the climatology ensemble, and it can avoid using experimental parameters.

POC-P-5698

Stratification induced by Nam-Gang Dam water releases based on a numerical model in the Kangjin Bay, South Sea, Korea

Kwang Young **Jung** and Young Jae Ro

Department of Oceanography, Chungnam National University, 220 Gung-dong, Yuseong-gu, Daejeon, 305-764, R Korea

E-mail: kyjung@cnu.ac.kr

Fresh water introduced by Nam-Gang (NG) Dam discharge flows into the Kangjin Bay, a semi-enclosed coastal embayment surrounded by Namhaedo and Changseondo. In the summer season, a 3-day continuous discharge over 1,000 m^3/sec occurred 2~4 times a year from 2002 to 2008. Peak discharge rates of 5,512.1 m^3/sec (Aug. 2002) and 3,523.4 m^3/sec (Aug. 2004) were recorded, and between 15~30 August 2004, the total amount of discharged water was 8.41×10^8 m^3 so that it occupied about half of whole volume of the Kangjin basin. To understand the behavior of the introduced freshwater input and its impact on the local ecosystem, intensive modeling efforts have been made (Ro *et al.*, 2007). Among those, the influence of buoyancy input on the formation of stratification and its inhibition of the vertical mixing is one of the key issues in association with hypoxia formation. Based on the model and field observations, with a large amount of discharge, the surface salinity dropped down to 10 psu, which is 10~15 psu lower than the bottom salinity in the Kangjin Bay. This induced strong surface stratification with a Richardson number of 10~100. Strong surface stratification in the Kangjin Bay was followed by the inhibition of surface-aerated water mixing with bottom water. At the bottom, the sediment oxygen demand (CSOD: 23.3~26.0 mg O_2/g-dry wt; Ro, 2006) was very high in the summer season. Without an oxygen supply from the surface layer through the mixing process, bottom water is quickly depleted of oxygen.

POC-P-5707

Synoptic and long-term dynamics of water in the vicinity of the junction of Hawaii and the Imperial submarine ridges

Vladimir B. Darnitskiy[1] and Maxim A. **Ishchenko**[2]

[1] Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia
[2] V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: maksim@poi.dvo.ru

During fishing expeditions by Russian fishing vessels (1968–1973), in Hawaiian waters, research was also carried out on the R/Vs *TINRO* and *TURNIF* in which the structure and dynamics of the ichthyofauna and oceanographic conditions at the junction of the Hawaii and the Imperial submarine ridges were studied. In the area south of the Imperial Seamounts, more than 80 species of fish have been discovered, while in the northwestern Hawaiian Ridge, more than 150 species have been found (Borets, 1979; Borets and Darnitsky, 1983, Belyaev and Darnitsky, 2003). Oceanographic observations have detected the existence of Taylor vortices (Darnitsky, 1978, 1979) and geostrophic vortices with a scale of 10 to 100–200 km (Darnitsky, 1979, 1980) and topographic Rossby waves on both sides of the Hawaiian and Emperor seamounts (Darnitsky, Mishanina, 1982, 1987). A simulation of vortex systems over the Milwaukee seamounts (Kozlov *et al.*, 1982) have also revealed mesoscale structures in the density fields and hydrochemical parameters.

On some seamounts (Milwaukee, Kolahan) oceanographic surveys were repeated many times, which allowed the examination of the synoptic variability at different scales and the structure of vortex fields under a variety of seasonal and weather conditions (Darnitsky and Zigelman, 1987). Some results of these studies will be presented. Some features of the ecology of fish on seamounts (Darnitsky *et al*., 1984) will also be considered These studies have been confirmed by tracking the trajectories of buoys of neutral buoyancy (Bograd *et al*., 1997), conducted in 1991–1993.

Flow dynamic interaction with the submarine ridges is characterized not only by generating a vortex of different magnitude and sign (trend changes in water masses) but by the deviation from the general directions of zonal flows, in their tendency to follow along the ridge. These processes have a direct impact on the development of plankton communities, producing a pronounced variability in biomass and species, and determining the intensity and path of migration of plankton, including passive transport, dispersion and concentration. Consequently, in certain areas of the underwater mountain range, compared with the surrounding waters, there is a high plankton biomass, a shift of faunas of different origin, as well as a separation in their frontal zones. As a rule, in these areas, the general regularities of zonal distribution of living organisms does not comply.

In the changing the dynamics of the local waters, distinct, large-scale phenomena in the hydrosphere, with deviations of the mean flow trajectories, determine the variability of plankton populations in the isolated seamounts, and submarine ridges, in composition as well as in biomass. These factors, in turn, have a significant influence on the behavior, development and movement of fish species here: their feeding migrations, feeding grounds, and concentrations, are determined by the availability of fish food and are likely to affect the dynamics of their numbers (Darnitsky *et al.*, 1984).

The long-term dynamics of the thermohaline conditions was studied using the 1960 to 2000 archive of Levitus (2006) with the variability amplitude characteristics (Darnitskiy, Ischenko, 2008). We establish that there is a long-term increase in the amplitudes, which indicates a frequency in the dynamic processes between different water bodies in the vicinity of seamounts.

POC-P-5728

Variability of water and air temperature in the coastal zone of the northwestern Sea of Japan

Larissa A. **Gayko**

V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: gayko@yandex.ru

The tendencies of climate change, namely global warming, are of great interest. The study of atmosphere and ocean interaction in a coastal zone is essential since these systems have a large influence on the economy and ecology of the coast. The southern part of Primorski Krai is bounded by the waters of Peter-the-Great Bay and to the east by the waters of the Sea of Japan and Tatar Strait. Hydrometeorological measurements were made in the surveyed coastal waters at hydrometeorological stations (HMS) of: Possyet, Gamov, Vladivostok, Tokarevsky, Nakhodka, Povorotny, Rudnaya Pristan, Belkin, Sosunovo, and Zolotoi. This paper deals with the analysis of long-term series observations of the surface temperature of sea water and air temperature, conducted at the hydrometeorological stations on the coast of Primorski Krai from 1881 to 2008. At the stations of Peter-the-Great Bay and along the eastern coast, instrumental observations of the air temperature have revealed a positive trend, *i.e.*, there is a rise of air temperature. A significant trend in water temperature has not been shown, except for Vladivostok and Possyet. The water temperature distribution has been significantly influenced by advective factors. For the last hundred years (1908-2008) in Vladivostok, the water temperature has increased by 0.64°C, and the air temperature by 1.74°C.

POC-P-5735

Thermohaline structure peculiarities in the South Kuril Straits zone

Valentina V. **Moroz**

V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: moroz@poi.dvo.ru

From a summary of multi-year observations (obtained by Japan and by the Russian Pacific Oceanological Institute research cruises in the Kuril Islands area), peculiarities found during the formation of the thermohaline structure in the South Kuril Straits zone were analyzed. It was found that changes in phase in tidal and ebb currents occur non-simultaneously and in relation with it, the current dynamics are very complex. In zones where the current speed and direction change abruptly a longitudinal front is usually formed. In these zones, peculiarities in the thermohaline structure appear. The considerable range of thermohaline characteristics is related to the peculiarities of water circulation in this region, especially with the seasonal and interannual change in intensity of the Soya Current. The sub-strait zone of the South Kuril Straits is replenished both by the warm and the salty Soya Current waters, and by the cold and less salty Okhotsk Sea waters. As a result of the variability in the flow of water through the straits to the ocean, the water circulation in the sub-strait area is variable, as are the thermohaline and dynamic characteristics of the particular zones of the Oyashio Current. Such variability has both seasonal and interannual characteristics.

POC-P-5752

Changing climate and linkages of surface heat fluxes in the North Pacific

Vladimir **Ponomarev**, Vera Petrova and Elena Dmitrieva

V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: pvi711@yandex.ru

The climatic tendencies and oscillations in the net heat flux and other components of the surface heat balance over the Pacific north of 30°S are studied by using statistical methods and NCEP NCAR reanalyzed data from 1948 to 2008. In the western area of the Pacific subtropical gyre both winter and annual mean heat flux from the ocean to the atmosphere is most significantly rising during this period. Moreover, in summer the net heat flux from the sea surface to the deep ocean, as well as the amplitude of the heat flux annual cycle, are also substantially increasing in this area. It accompanies the most prevailing SST trend in the Kuroshio area in winter. At the same

time, different features of interdecadal oscillations in the surface heat fluxes and surface sea/air temperature are shown in western/eastern regions of the subtropic and subarctic gyres, in various ocean and land key areas. The change in the spectra of net heat flux and SST anomalies after the climate regime shift in the 1970s over different Pacific areas, as well as changes in lagged/unlagged statistical relationships between those anomalies and climatic indices, are revealed. It is shown that during recent decadal warming, the extreme anomalies of the net heat flux in the western area of the subtropical gyre become most closely related to the extreme events in the Northwest Pacific marginal sea and land areas.

POC-P-5788

Long-term thermohaline dynamics in the region of the northwestern Hawaiian Ridge Seamounts

Vladimir B. Darnitskiy[1] and Maxim A. **Ishchenko**[2]

[1] Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia
[2] V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: maksim@poi.dvo.ru

Long-term dynamics in the thermohaline conditions of Hawaii–Imperial junction (GIS) data for oceanographic surveys made by the R/V *TINRO* could not be investigated because of the short time series of observations and the various grids of stations used for making the surveys. Therefore, the area was divided into 5° squares – to the west and east of the ridges between latitudes 30-35°N. (the district of northwestern Hawaii) and 35-40°N. (southern seamounts of the Imperial chain). Partitioning in this specified manner was motivated by different levels of eddy activity to the west and east of the ridges: for the longitude the area of 165-170°E.L. to the west of the Imperial Ridge, 170-175°E.L. for the central part of northwestern Hawaiian Ridge, and 175-180°E.L. to the east of the ridge (district of the Shatsky Rise).

Calculations were carried out according to the method of Darnitsky and Ishchenko (2008) to study the cyclic processes near the Japanese archipelago. However, in this area (GIS) data are limited to the upper 200-m layer, with fewer observations at depths lower than 300 or 400 m (Levitus, 2006). Analyses of this information (1960-2000) showed that to the west of the Hawaiian Ridge at the surface, there is an increase in short-period amplitudes ($AT°_w$) of 2 to 8°C from 1960–1980. with an average periodicity for the interannual variations of 3.3 years after which there was a decrease of 0 to 4°C by 1990-1995. However, during the 1990-1992 period $AT°_w$ values at 100 and 200 m depth of up to 15-16°C were observed. A long-term component that is approximated by a sixth degree polymodal function demonstrated a 35–year long period confounded by shorter 12.5- and 17.5-year long periods. The polymodal approximation of long-term trends at depths of 100 and 200 m had secondary extremal points during the period from 1962–1965 at 100 m depth, a maximum of $AT°_w$ = 9,5°C and a 2 to 3 year right (forward) phase shift of the main maximum. The average year-to-year cycle increased to 3.6 years. At 200 m depth, the core of maximum amplitudes $AT°_w$ shifted to the right by 8 years as observed in 1988, and short-period fluctuations in $AT°_w$ increased to 4 years. From these facts we can conclude that there is a different trend in the interaction of water in different depths.

To the east (170-175°E), in the region of dynamic processes, the northwestern part of the Hawaiian seamounts also showed zonal flows in the course of interannual amplitudes $AT°_w$. The first period of $AT°_w$ increase was observed between 1960–1968, when $AT°_w$ peaked to 10°C (1965) on the 100 m layer (an increase of about 8°C. The second period of increases in $AT°_w$ had a flatter structure and was observed for 20 years (from 1968–1988), with maximum $AT°_w$ amplitude at the surface and at 100 m of around 8°C. The 100 and 200 m depths had similar values. This indicates an increase in the intensity of the interaction of different waters at these depths. The third period lasted about 12 years - from 1988–2000. This period was characterized by a convergence of amplitudes of $AT°_w$ for all three depths, which began during the decrease in $AT°_w$ in the previous period.

A generally increasing cycle in $AT°_w$ in all three "squares" near the Hawaiian Ridge Seamounts was observed. If the short-period cycles of change have been within 3–4 years, then long-range cycles can last from 10–12 to 25–35 years.

POC PAPER

POC-P-5864

Surface current structure and its variability in the southwestern Japan Sea derived by satellite-tracked surface drifters

Tatsuro **Watanabe**[1], Daisuke Simizu[1], Kou Nishiuchi[2], Toru Hasegawa[2] and Osamu Katoh[1]

[1] Japan Sea National Fisheries Research Institute, Fisheries Research Agency, 1-5939-22 Suido-cho, Niigata, 951-8121, Japan
E-mail: tatsuro@fra.affrc.go.jp
[2] Seikai National Fisheries Research Institute, Fisheries Research Agency, 1551-8 Taira-machi, Nagasaki, 851-2213, Japan

Based on a dataset from satellite-tracked surface drifters (WOCE/SVP) and our new deployments during 2004–2008, the surface current structure in the Tsushima Warm Current (TWC) region of the southwestern Japan Sea was examined. The gridded mean current velocity and the mean kinetic energy (KE) fields calculated from all available drifter data revealed the typical structure and seasonality of three branches of the TWC. On the other hand, the mean eddy kinetic energy (EKE) field indicated that a large EKE area was distributed around the second branch of the TWC (SBTWC) because large meanders of the SBTWC and moving warm eddies occurred frequently. By comparing the EKE field to the KE field, we found the highest variability area where the ratio of EKE to KE was extremely large to the east of the Oki Islands. Our analysis suggested that the generation of alternate warm and cold eddies there induced this high ratio. The occurrence of a warm or cold eddy was related to the route – either nearshore or offshore – of the SBTWC. When the offshore route of the SBTWC became dominant, a warm eddy was frequently generated east of the Oki Islands. In contrast, when the nearshore route of the SBTWC became dominant, a cold eddy was more likely to be generated.

POC-P-5870

Numerical study of bidecadal water mass variations in the subarctic North Pacific related to the 18.6-year tidal cycle

Satoshi **Osafune** and Ichiro Yasuda

Ocean Research Institute, University of Tokyo, 1-15-1 Minamidai, Nakano-ku, Tokyo, 164-8639, Japan. E-mail: osafune@ori.u-tokyo.ac.jp

Bidecadal variations of water mass, such as salinity in the surface layer and isopycnal potential temperature in the intermediate layer, have been observed around or downstream of the strong tidal mixing region like the Kuril Islands and the Aleutian Islands. It is shown that those variations can be explained by modification of the water mass by vertical mixing, which should be modulated, related to the 18.6-year tidal cycle. We conducted a series of numerical experiments using an Ocean General Circulation Model, in which tidal mixing in the localized sites is represented by elevating vertical diffusivity up to 20, 50 and 200 cm^2/s. An 18.6-year oscillation of the elevated diffusivity induced bidecadal water mass variations similar to those observed. A budget analysis of salinity in the surface layer suggested that the water mass variation in this model is induced in a simple balance. The anomaly caused by the anomalous mixing in the strong mixing region spreads by the mean current. The amplitude of the anomaly is related not only to the amplitude of the diffusivity, but also to the mean profile, which is affected by the mean value of the diffusivity. As a result, large diffusivity does not necessarily lead to large water mass variation, and relatively small diffusivity can cause water mass variation effectively. This result indicates the importance of tidally induced vertical mixing, and emphasizes the necessity to clarify spatial and temporal variations of tidal mixing.

POC-P-5893

Relationship between water quality trend and climate change in Ise Bay, Japan

Hironori **Higashi**, Hiroshi Koshikawa, Kunio Kohata, Shogo Murakami and Motoyuki Mizuochi

Asian Environment Research Group, National Institutes for Environmental Studies, 16-2 Onogawa, Tsukuba, Ibaraki, 305-8506, Japan
E-mail: higashi@nies.go.jp

We studied climate change impacts on hydrodynamic and water quality in Ise Bay, Japan, for the period 1981–2004 using observed and numerical simulated results. Statistical trend analyses for marine water quality, meteorological and river runoff conditions were carried out. The air temperature and the northwesterly strong-wind events had increasing and decreasing trends, respectively, whereas neither the precipitation nor the river runoff showed a significant trend. The trend in the chemical oxygen demand (COD) of the bottom water was characterized by a spatial feature distribution, showing decreasing trend in the western and the increasing trend in the eastern bay. To clarify the relationship between the climate changes and the water quality trend, numerical quasi-3D simulations were carried out. The simulation results indicated the remarkable changes in the mean current were caused by the wind pattern changes, whereas the effect of the air temperature changes on the hydrodynamic flow in the bay was negligible. The hydrodynamic changes were the main reason for the water quality trend. The increasing trend of the COD in the eastern bay was produced by the decrease in inflow from the open sea, and the decreasing trend in the western bay was the result of shortages in the nutrient supply from the bay head due to the relatively strong trend in the northward flow which is part of the clockwise circulation. The wind pattern change could be considered the most important factor for the environment and ecosystem in Ise Bay.

POC-P-5910

Vertical transport of subsurface nutrients in the East China Sea shelf for primary production

Takeshi **Matsuno**[1], Takahiro Endoh[2], Eisuke Tsutsumi[2], Ken-ichi Fukudome[2], Joji Ishizaka[3], Hisashi Yamaguchi[3], Sarat Tripathy[3], In-Seong Han[4], Jae-Hak Lee[5], Sang-Tae Jang[5] and Sang-Hyun Kim[6]

1 Research Institute for applied Mechanics, Kyushu University, 6-1 Kasuga Kohen, Kasuga, Fukuoka, 816-8580, Japan
E-mail: matsuno@riam.kyushu-u.ac.jp
2 Research Institute for applied Mechanics, Kyushu University, 6-1 Kasuga Kohen, Kasuga, [2] Fukuoka, 816-8580, Japan
3 Hydrospheric Atmospheric Research Center, Nagoya University, Furo-cho, Chikusa-ku, Nagoya, Aichi, 464-8601, Japan
4 Ocean climate Lab., Ocean Research Team, National Fisheries Research and Development Institute, 408-1 Shirang-Ri, Gijang-Eup, Gijang-Gun, Busan, 619-902, R Korea
5 Climate Change and Coastal Disaster Research Department, Korea Ocean Research and Development Institute, P.O.Box 29, Ansan, Kyunggido, 425-600, R Korea
6 College of Ocean Science, Cheju National University, Jeju, Jeju-do, R Korea

The vertical exchange of nutrients can strongly affect primary production in the shelf region of the East China Sea, where the seasonal pycnocline is not deep, and can be significantly controlled by the wind field. Long-term climate change may cause serious variations in the nutrient budget in the shelf region, resulting in a change in primary production there. It is then very important to determine quantitatively the vertical processes related to the nutrient flux. In this study we discuss the upward transport of subsurface water into the upper layer, based on observations in the shelf region southwest of Jeju Island, in 2007 and 2008. One observation, detected by a satellite-tracked *surface* drifter, was an abrupt increase in salinity accompanied by a decrease in temperature, which occurred by Ekman divergence associated with the passage of a tropical depression. A significant part of the salinity increase is explained by the upward advection of deeper saline water. Using reanalyzed wind data provided by the Japan Meteorological Agency, the upward transport of nutrients, owing to the passage of typhoons and low pressure systems, was integrated and it is suggested that the total amount of nutrients transported is comparable with that from Changjiang. The other observation is the nutrient supply for the subsurface chlorophyll maximum during calm conditions. The vertical profile of nutrients and turbulent energy dissipation rate were measured following a drifter track in August 2008. The vertical eddy diffusivity was about 10^{-5} m^2s^{-1} below the mixed layer. It is suggested that the vertical diffusion can supply enough nutrients to maintain the chlorophyll maximum just below the surface mixed layer.

POC-P-5923

Femtosecond laser-induced breakdown spectroscopy for the detection of marine water and elemental composition of phytoplankton cells

Oleg A. Bukin[1], Alexey V. **Bulanov**[2], Alexey A. Ilin[2], Sergey S. Golik[3] and Ekaterina B. Sokolova[3]

[1] G.I. Nevelskoi Maritime State University, 50a Verkhneportovaya St., 690059, Vladivostok, Russia
[2] V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: lotar85@gmail.com
[3] Institute for Automation and Control Processes FEB RAS, 5 Radio St., 690041, Vladivostok, Russia

The development of a new fast method of monitoring the environment has great value for dealing with problems of climate change and changes in the biosphere. Special significance is attached to monitoring phytoplankton communities which play an important role in the balance of the atmosphere. Marine water and phytoplankton cell samples were analyzed by laser-induced breakdown spectroscopy (LIBS) using femtosecond pulses. This research is connected with the new method of LIBS to provide fast analysis of the elemental composition of biological organisms. Investigations were conducted in the East Sea. Comparison of several samples with an annual interval is presented. The following scheme of experiment was used. The breakdown of the object was excited by the in-focus radiation of a femtosecond Ti:Sa laser. The image of a laser spark was analyzed by a specially designed optical system which is based on a multichannel optical spectrum analyzer. Emission lines of potassium, magnesium, sodium, calcium, chlorine, carbon dioxide, CH, oxygen, hydrogen, and nitrogen were registered in the spectral range 400–850 nm. The registered spectra consisted of resolved lines with a high background-to-signal ratio (SBR). Advantages of the obtained spectra with those resulting from the classical nanosecond LIBS have been demonstrated. The active optical method, such as that provided by LIBS, is well suited to efficient and large-scale measurements.

POC-P-5944

Analysis of the long-term temporal variations in the Yellow Sea using the cluster method

Joon-Soo **Lee**, Hye-Hyun Lee, Won Duk Yoon, Joon-Yong Yang, and Sang Ok Chung

Ecology and Oceanography Division, National Fisheries Research and Development Institute 408-1, Sirang-ri, Gijang-eup, Gijang-gun Busan, 619-705, R Korea. E-mail: leejoonsoo@nfrdi.go.kr

The Yellow Sea is a semi-enclosed shallow sea and its water characteristics are highly variable with season, so that cluster analysis, classifying observation data statistically, has been used to overcome difficulties in defining water masses (Su *et al.*, 1983; Kim *et al.*, 1991; Liu *et al.*, 1992; Hur *et al.*, 1999). However, water mass studies using the cluster method have been mainly focused on seasonal or spatial distributions without consideration of long-term temporal variation. This study analyzes long-term temporal variation (1967~2007) of water masses in the Yellow Sea using serial oceanographic observations made in winter (February) and summer (August) by National Fisheries Research and Development Institute (NFRDI), Korea. Considering the vertically well-mixed condition in winter and stratified condition in summer, observation data at the surface and 50 m depth were analyzed.

In the cluster analysis, difficulties in estimating the number of clusters are caused by the diversity of input data and abnormal values contained within them. In this study, to decide the number of clusters, the Random Simulation Test (RST) technique (Guidi, 2009) was adopted. As a cluster method, we used the Spatially Constrained Clustering (SCC) technique, which considers spatial connectivity during the clustering procedure. Names are assigned to each group of water masses classified by the RST method, and their spatial distributions for 41 years are investigated. In addition, an Empirical Orthogonal Function (EOF) analysis is carried out to understand the temporal and spatial variation of the water masses. Detailed results will be shown in the poster session.

POC-P-5945

Estimation of ice cover conditions in the Japan Sea

Vladimir V. **Plotnikov**

Ice research Laboratory, V V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: vlad_plot@poi.dvo.ru

Results of the analysis of long-term archives of decadal ice observations in the Japan Sea are presented. Ice cover conditions using traditional parameters (concentration, stage of development and form of ice) are estimated. A close connection between independent parameters of ice cover (concentration and form of ice) shows a redundancy in characteristics. Two independent variables (concentration (S) and stage of development (B) of ice) are sufficient for the description of an ice cover. The third variable (form of ice (F)) can be estimated easily according to the regression equation: $F = C \cdot \exp(B \cdot S)$, where C is the coefficient of regression.

The calculated results are important from an applied position. Now, satellite information is the basic source of data for determining ice cover conditions. However, the quality (resolution) of this information is still far from perfect in regard to the estimation of the dominant sizes of the ice floes, which are important navigating features during ice conditions. Usually, satellite images do not provide data on the distributions of ice forms; therefore, the missing information can be restored effectively using this discussed method of calculations.

POC-P-5970

Characteristics of atmospheric turbulence of the marine–atmospheric boundary layer over the north Yellow Sea

Hui-wang Gao, Gu **Ming**, Ren-lei Wang and Yu-huan Xue

Laboratory of Marine Environment and Ecology, Ministry of Education, Ocean University of China, Qingda, 266100, PR China

In recent decades a great deal of attention has been paid to air–sea interaction. Large studies see the ocean and atmosphere as a coupled system. In recent years the State Oceanic Administration People's Republic of China has regarded the marine–atmospheric boundary layer of marginal seas as an important research subject. Fast response instruments were used onboard the R/V *Dongfanghong 2* and four seasonal observations were made in two years between 2006 and 2007. Each observation lasted about two weeks over the north Yellow Sea. It was found that a low pass filter can easily counter the effects of vessel swing. Velocity spectra fulfilled the –2/3 law. In addition, a spectral rise was found in the low frequency range. The slope was about –2. The turbulence intensity and standard deviation of wind was calculated. From the change of turbulence intensity in one autumn day, it was found that the main complication of atmospheric turbulence intensity over the sea is the thermal effect. Due to the special properties of the ocean, the magnitude of turbulence intensity over the sea surface is 10^{-2}, which is lower than that when land is the underlying surface. Whether standard deviations of horizontal wind meet the Monin–Obukhov similarity relation is discussed. Winter data in the unstable stratification show that standard deviations of horizontal wind basically meet the 1/3 law. Autumn and winter data verify that the standard deviation of vertical velocity meets Monin–Obukhov similarity theory very well. Air–sea interaction parameters like C_d, C_h, C_e, u^*, L, and t are calculated. The active process of climate and weather modelling will be discussed.

W1 BIO Workshop
Natural supplies of iron to the North Pacific and linkages between iron supply and ecosystem responses

Co-Sponsored by SOLAS

Co-Convenors: Fei Chai (U.S.A.), William R. Crawford (Canada) and Shigenobu Takeda (Japan)

In the subarctic North Pacific Ocean, iron plays a central role in regulating phytoplankton productivity and pelagic ecosystem structure. There are several processes that supply iron from land, shelf sediment and deep waters to the upper ocean. The goal of this workshop is to examine mechanisms of these iron supply processes, including atmospheric deposition of mineral aerosols and combustion substances, lateral transport of coastal iron-enriched waters by eddies and boundary currents, and deep vertical mixing during winter or by strong tidal currents at narrow straits. Such knowledge will be used to identify key biogeochemical pathways that should be introduced into the ecosystem models and to plan international scientific programs for better understanding of marine ecosystem responses to changing iron supplies in the North Pacific.

Sunday, October 25 (9:00-15:30)

9:00 ***Introduction by Convenors***

9:05 **Kenneth W. Bruland (Invited)**
Reactive iron in the subarctic North Pacific; natural iron enrichments (W1-5643)

9:35 **Jun Nishioka, Tsuneo Ono, Hiroaki Saito, Takeshi Nakatsuka, Shigenobu Takeda, Wm. K. Johnson and C.S. Wong**
Comparison of iron distribution between the western and the eastern subarctic Pacific (W1-5750)

9:55 **Eric Roy, Mark Wells and Fei Chai**
The role of Haida eddies in iron transport to the eastern subarctic Pacific Ocean (W1-5681)

10:15 **Hiroaki Saito, Kazutaka Takahashi, Yoshiko Kondo, Jun Nishioka, Tomonori Isada, Akira Kuwata, Miwa Nakamachi, Yuji Okazaki, Yugo Shimizu and Koji Suzuki**
Factors controlling the spatial variability of spring bloom dynamics in the Oyashio Region (W1-5691)

10:35 ***Coffee / tea break***

11:00 **Roberta C. Hamme, Sonia Batten, William Crawford, Kathleen Dohan, Steven Emerson, Karina Giesbrecht, Jim Gower, Maria Kavanaugh, Deirdre Lockwood, Christopher L. Sabine and Frank Whitney**
Natural volcanic iron fertilization of the Subarctic North Pacific (W1-5905)

11:20 **Ai Hattori-Saito, Tomonori Isada, Natsuko Komazaki, Hiroshi Hattori, Kenshi Kuma, R. Michael L. McKay, Tsutomu Ikeda and Koji Suzuki**
Fe nutrition in micro-sized diatoms in the Oyashio region of the NW subarctic Pacific during spring 2007 (W1-5748)

11:40 **Keisuke Uchimoto, Tomohiro Nakamura, Jun Nishioka, Humio Mitsudera, Michiyo Yamamoto-Kawai, Kazuhiro Misumi and Daisuke Tsumune**
A simulation of chlorofluorocarbons in the Sea of Okhotsk (W1-5751)

12:00 **Kazuhiro Misumi, Daisuke Tsumune, Yoshikatsu Yoshida, Takeshi Yoshimura, Keisuke Uchimoto, Tomohiro Nakamura, Jun Nishioka, Humio Mitsudera, Frank O. Bryan, Keith Lindsay, J. Keith Moore and Scott C. Doney**
Numerical simulation of iron export from the Sea of Okhotsk to the North Pacific (W1-5907)

12:20 ***Lunch***

14:00 **Yasuhiro Yamanaka, S. Lan Smith, Hiroshi Sumata, Naoki Yoshie, Taketo Hashioka, Takeshi Okunishi, Masahiko Shigemitsu, Maki N. Noguchi and Naosuke Okada (Invited)**
New NEMURO-based model incorporating the iron cycle (W1-5836)

14:30 **Stephanie Dutkiewicz, Fanny Monteiro and Mick Follows (Invited)**
Interplay between ecosystem structures and iron availability in a global marine ecosystem model (W1-5759)

15:00 **Discussions**

15:30 ***Workshop ends***
Coffee / tea break

16:00 **WG-22 Meeting**

18:00 ***Meeting ends***

W1 Poster

W1-5936 **Youngju Lee and Joong Ki Choi**
Effect of Asian dust on the picophytoplankton growth rate and cell cycle

W1 Oral Presentations

25 October, 9:05 (W1-5643), Invited

Reactive iron in the subarctic North Pacific; natural iron enrichments

Kenneth W. **Bruland**

Department of Ocean Sciences, University of California at Santa Cruz, Santa Cruz, CA, 95064, USA. E-mail: Bruland@ucsc.edu

Much of the subarctic North Pacific is an iron-limited, high-nutrient, lower-than-expected chlorophyll (HNLC) regime. My research group has been studying the naturally occurring high-chlorophyll regions that develop at the boundaries of these Fe-limited HNLC waters and nitrate-poor, Fe-rich coastal waters. For example, we have examined the "green belt" that occurs at the shelf break in the southeastern Bering Sea (Aguilar-Islas *et al.*, 2007) and the "iron curtain" hypothesis. In the summer of 2007 we carried out a major field study to test the hypothesis that regions of high biomass observed in satellite imagery in the northern Gulf of Alaska (GoA) in mid-summer are the result of the high river and glacial melt runoff during this time of year into the Alaska Coastal Current (ACC) enriching the ACC with both dissolved and leachable particulate iron, and the resultant mixing of this high iron coastal water with the HNLC waters of the adjacent GoA via mesoscale anti-cyclonic eddies. We examined the roles of Sitka and Kenai Eddies, 100 to 200 km in diameter, in transporting dissolved and leachable particulate Fe from the shelf regions offshore into the open Gulf of Alaska. Using a series of surfacewater transects and vertical profiles within and outside of eddies, we demonstrate the importance of eddies to the GoA region in both the current summer season and subsequent seasons. These studies provide insight into mechanisms of iron supply to this region and key biogeochemical pathways of reactive forms of iron that should be introduced in ecosystem models.

25 October, 9:35 (W1-5750)

Comparison of iron distribution between the western and the eastern subarctic Pacific

Jun **Nishioka**[1], Tsuneo Ono[2], Hiroaki Saito[3], Takeshi Nakatsuka[4], Shigenobu Takeda[5], Wm. K. Johnson[6] and C.S. Wong[6]

1 Pan-Okhotsk Research Center, Institute of Low Temperature Science, Hokkaido University, Sapporo, Hokkaido, Japan
2 Hokkaido National Fisheries Research Institute, Kushiro, Hokkaido, Japan
3 Touhoku National Fisheries Research Institute, Shiogama, Miyagi, Japan
4 Graduate School of Environmental Studies, Nagoya University, Nagoya, Japan
5 Department of Aquatic Bioscience, University of Tokyo, Bunkyo, Tokyo, Japan
6 Climate Chemistry Laboratory, Institute of Ocean Sciences, Fisheries and Oceans Canada, BC, Canada

Vertical measurements of iron in the western subarctic Pacific (WSP) indicated that increased gradients in dissolved iron concentrations with depth from subsurface to intermediate water (NPIW) were greater in the WSP relative to those of the station Papa in the eastern subarctic Pacific (ESP). Furthermore, particulate iron concentration is extremely high in the water column of the western region. We also found that extremely high total iron concentrations in the surface in the WSP were observed only in subarctic water masses north of the subarctic front (SF), and that this feature was clearly separated by the SF boundary. Additionally, time series of iron observations clearly show that there was temporal variability in dissolved iron and total iron concentrations in the WSP. The higher temporal variability was observed to be stronger in the upstream of the Oyashio flow than at the oceanic station in the downstream of the Oyashio flow and at the ESP. From the spatial and temporal iron distributions, we determined that the high iron input, mainly in the particulate phase, occurs north of the SF and upstream of the Oyashio region, and the iron is subsequently distributed to the cold subarctic water in the WSP area. The results are consistent with our previous report that the iron-rich water is transported from the Sea of Okhotsk to the WSP. Therefore, the presence of iron in the WSP cannot be solely explained by aeolian dust supplies over the study area.

25 October, 9:55 (W1-5681)

The role of Haida eddies in iron transport to the eastern subarctic Pacific Ocean

Eric Roy, Mark **Wells** and Fei Chai

School of Marine Sciences, University of Maine, Orono, ME, 04469, USA. E-mail: mlwells@maine.edu

The constraint of carbon export by iron supply to the high nitrate, low chlorophyll (HNLC) subarctic Pacific likely has contributed to past global climate change. Each year, mesoscale (~100 km diameter) eddies form off the Canadian and Alaskan coasts and transport coastal waters to the open ocean. We studied the distribution of dissolved (<0.45 μm) and total iron in Canadian coastal shelf waters, in a 3 month old eddy off the Queen Charlotte Islands (Haida Gwaii), and in surrounding oceanic waters. Our measurements show that iron levels were near oceanic levels in eddy surface waters while concentrations of iron below 80 m were ten-fold higher than outside the eddy. A simple one-dimensional advective/diffusion model's estimates indicate that iron infusion to surface waters in this single eddy roughly matches the total annual dissolvable aerosol iron inputs to the entire eastern subarctic Pacific. We are analyzing the potential impact of eddies on iron transport in more detail using the Pacific Regional Ocean Model System (ROMS) model, utilizing the modeled vertical and horizontal velocities with our limited iron measurements. These estimates of vertical and horizontal iron fluxes will help better ascertain whether eddy transport mechanisms can represent a major source of Fe to this HNLC region. However, in contrast to aerosol inputs that persist or increase during periods of glaciation, the mechanisms driving eddy formation would be greatly diminished or absent during glacial low sea level stands. The reduction of these mechanisms would in turn reduce iron transport to the eastern subarctic Pacific and provide a potential negative feedback mechanism affecting global climate.

25 October, 10:15 (W1-5691)

Factors controlling the spatial variability of spring bloom dynamics in the Oyashio Region

Hiroaki **Saito**[1], Kazutaka Takahashi[1], Yoshiko Kondo[2], Jun Nishioka[3], Tomonori Isada[4], Akira Kuwata[1], Miwa Nakamachi[1], Yuji Okazaki[1], Yugo Shimizu[1] and Koji Suzuki[4]

1 Tohoku National Fisheries Research Institute, Fisheries Research Agency, Shinhama-cho, Shiogama, Miyagi, 985-0001, Japan
E-mail: hsaito@affrc.go.jp
2 Department of Biological Sciences, University of Southern California, Los Angeles, CA, 90089, USA
3 Pan-Okhotsk Research center, Hokkaido University, Kita-Ku, Sapporo, 060-0819, Japan
4 Graduate School of Environmental Science, Hokkaido University, Kita-ku, Sapporo, 060-0810, Japan

Spring phytoplankton bloom is a routine event in the Oyashio region of the western subarctic Pacific. In addition to the ample supply of macro-nutrients to the euphotic zone by winter mixing, the high concentration of iron enables diatoms to utilize nitrate and that induces spring blooms. The supply of iron makes the Oyashio region different from the HNLC subarctic Pacific. The timing and magnitude of spring phytoplankton blooms are spatially heterogeneous. Satellite remote sensing clearly represents the variability in chlorophyll concentration, and the variations of environmental factors associated with the chlorophyll concentration are also detected by the monitoring study along the *A-line* across the Oyashio region. However, the time resolution (monthly to bimonthly) and the limited observational parameters in the *A-line* monitoring programme prevent further understanding of the factors controlling the phytoplankton dynamics in the Oyashio region. In order to overcome such limitations, we carried out repeated mapping observations in the Oyashio region in 2008 in the BLOSSOM (BLOoming plankton Succession Study in the Oyashio Marine ecosystem) project. Finer temporal resolution and more observational parameters than those obtained in the *A-line* monitoring revealed that light and/or iron availabilities, which were mainly determined by the physical properties, would affect the spatial heterogeneity of the spring bloom dynamics in the Oyashio region.

25 October, 11:00 (W1-5905)

Natural volcanic iron fertilization of the Subarctic North Pacific

Roberta C. Hamme[1], Sonia Batten[2], William **Crawford**[3], Kathleen Dohan[4], Steven Emerson[5], Karina Giesbrecht[1], Jim Gower[3], Maria Kavanaugh[6], Deirdre Lockwood[5], Christopher L. Sabine[7] and Frank Whitney[3]

1 School of Earth and Ocean Sciences, University of Victoria, Victoria, BC, V8W 3P6, Canada. E-mail: rhamme@uvic.ca
2 Sir Alister Hardy Foundation for Ocean Science, Nanaimo, BC, V0V 1N8, Canada
3 Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, V8L 4B2, Canada
4 Earth and Space Research, Seattle, WA, 98121, USA
5 School of Oceanography, University of Washington, Seattle, WA, 98195, USA
6 College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR, 97331, USA
7 Pacific Marine Environmental Laboratory, National Oceanic and Atmospheric Administration, Seattle, WA, 98115, USA

We present evidence of a widespread bloom in the Subarctic Pacific in August-September 2008, which may have been caused by volcanic ash input. Satellite-derived surface chlorophyll and brightness from MODIS showed the highest average values seen in this region since 1997 and showed that the phenomenon was widespread over the entire Eastern Subarctic Pacific. Two cruises to Station P (50ºN 145ºW) in late August confirmed unusually high net community production (from O_2/Ar measurements) and gross production (from short-term ^{14}C incubations). Nitrate and silicate concentrations were lower than normally observed in this HNLC region. Seawater pCO_2 and pH measured on a mooring at Station P demonstrate drawdowns in DIC and alkalinity beginning on August 13. Mesozooplankton biomass, from continuous plankton recorder surveys, was unusually high in August 2008. The timing of the beginning of this bloom event matches the unusually broad dispersal of volcanic ash from the eruption of Kasatochi in the Aleutian Islands August 7-8. Evidence from satellite altimetry and derived currents as well as the widespread nature of the bloom argues against mesoscale eddies as a cause. Although mixed layers were deeper in this region during winter of 2008, normal stratification was established by mid-June and the summer was not significantly cloudier than normal. QuikSCAT winds for the region show that August 2008 was only somewhat winder than average, suggesting that enhanced vertical mixing was not a primary driver. A large-scale iron fertilization of the region by volcanic ash remains the principal hypothesis for this event.

25 October, 11:20 (W1-5748)

Fe nutrition in micro-sized diatoms in the Oyashio region of the NW subarctic Pacific during spring 2007

Ai **Hattori-Saito**[1], Tomonori Isada[1], Natsuko Komazaki[3], Hiroshi Hattori[3], Kenshi Kuma[1,2], R. Michael L. McKay[4], Tsutomu Ikeda[2] and Koji Suzuki[1]

1 Graduate School of Environmental Science and Faculty, Hokkaido University, N10 W5 Kita-ku, Sapporo, 060-0810, Japan
E-mail: aihat@ees.hokudai.ac.jp
2 Faculty of Fisheries Sciences, Hokkaido University, 3-1-1 Minato, Hakodate, 041-8611, Japan
3 School of Marine Biology and Sciences, Tokai University, 5-1-1-1 Minamisawa, Minami-ku, Sapporo, 005-8601, Japan
4 Department of Biological Sciences, Bowling Green State University, Bowling Green, OH, 43403, USA

It is hypothesized that Fe availability significantly controls the growth of phytoplankton in the Oyashio region during spring. We examined Fe stress in micro-sized (20-200 µm) diatoms at a station in the Oyashio region during the spring bloom period from 6 April to 1 May in 2007, by immunological ferredoxin/flavodoxin assays. The abundance and species composition of the diatoms were also examined concurrently with the hydrographic conditions, including dissolved Fe (D-Fe) and macronutrient concentrations. Chlorophyll *a* concentrations at 5 m depth were consistently high (2-29 mg m^{-3}), indicating that phytoplankton had bloomed throughout the cruise. Macronutrients were replete but dissolved Fe concentrations were relatively low (0.17-0.53 nM). Only flavodoxin, an *in situ* diagnostic marker for Fe deficiency in the micro-sized diatoms was detected throughout the cruise. A similar result was also obtained from our previous survey conducted in the Oyashio region during the diatom bloom in May 2005. According to the microscopic analyses of the diatoms collected from 5 m depth, chain-forming centric diatoms dominated the phytoplankton community throughout the cruise. Interestingly, the dominant diatom species changed from *Thalassiosira* to *Chaetoceros* species on 25th April. This community shift coincided with decreases in flavodoxin accumulation. Over all, our results suggest that bloom-forming, micro-sized diatoms are often stressed by low Fe availability in the Oyashio region during spring.

25 October, 11:40 (W1-5751)

A simulation of chlorofluorocarbons in the Sea of Okhotsk

Keisuke **Uchimoto**[1], Tomohiro Nakamura[1], Jun Nishioka[1], Humio Mitsudera[1], Michiyo Yamamoto-Kawai[2], Kazuhiro Misumi[3] and Daisuke Tsumune[3]

[1] Pan-Okhotsk Research Center, Institute of Low Temperature Science, Hokkaido University, Sapporo, Hokkaido, 060-0819, Japan
E-mail: uchimoto@lowtem.hokudai.ac.jp
[2] Institute of Ocean Sciences, Department of Fisheries and Oceans Canada, 9860 West Saanich Rd., Sidney, BC, V8L4B2, Canada
[3] Environmental Science Research Laboratory, Central Research Institute of Electric Power Industry, Abiko, Chiba, Japan

Recent observations have suggested that the Sea of Okhotsk is one of the main sources of iron for the North Pacific. Iron is transported in the intermediate layer from the northwestern part of the Sea of Okhotsk, where iron is supplied from the Amur River. As a first step toward modeling the iron transport from the Sea of Okhotsk to the Pacific, we simulate chlorofluorocarbons (CFCs) in the Sea of Okhotsk with a coarse ocean general circulation model, because CFCs are also transported in the intermediate layer in the Sea of Okhotsk. The model represents the observed CFCs distribution reasonably well. CFCs enter the intermediate layer at two sites. One is near the northern coast, especially on the northwestern shelf, and the other is along the Kuril Islands. In the former area, CFCs sink with the dense water formed by brine rejection in winter, and in the latter area, CFCs are transported into intermediate and deep layers by tidal mixing that is parameterized with large vertical diffusivity in the model. To clarify effects of these two processes, experiments without the tidal mixing parameterization and with little brine rejection have been carried out. Results show that brine rejection has a great influence only in the area along Sakhalin. In contrast, the influence of tidal mixing extends entirely over the Sea of Okhotsk, including deep layers.

25 October, 12:00 (W1-5907)

Numerical simulation of iron export from the Sea of Okhotsk to the North Pacific

Kazuhiro Misumi[1], Daisuke **Tsumune**[1], Yoshikatsu Yoshida[1], Takeshi Yoshimura[1], Keisuke Uchimoto[2], Tomohiro Nakamura[2], Jun Nishioka[2], Humio Mitsudera[2], Frank O. Bryan[3], Keith Lindsay[3], J. Keith Moore[4] and Scott C. Doney[5]

[1] Environmental Science Research Laboratory, Central Research Institute of Electric Power Industry, Abiko, Chiba, Japan
E-mail: misumi@criepi.denken.or.jp
[2] Pan-Okhotsk Research Center, Institute of Low Temperature Science, Hokkaido University, Sapporo, Hokkaido, Japan
[3] Oceanography Section, National Center for Atmospheric Research, Boulder, CO, USA
[4] Department of Earth System Science, University of California at Irvine, Irvine, CA, USA
[5] Department of Marine Chemistry and Geochemistry, Woods Hole Oceanographic Institution, Woods Hole, MA, USA

Sedimentary iron is recognized as an important iron source in the North Pacific, but the transport processes have not been fully clarified. We examine an importance of sedimentary iron export from the Sea of Okhotsk on iron cycle in the North Pacific by numerical simulation. We use a global ocean general circulation model (POP, Parallel Ocean Program) combined with the BEC (Biogeochemical Elemental Cycling) model with a resolution of 1.125° in longitude and roughly 0.5° in latitude. The model acceptably reproduces the physical fields in the Sea of Okhotsk: the dense shelf water is formed in the northern continental shelf, a cyclonic gyre with southward western boundary current develops in the central basin and water is exchanged through the straits between the Kuril Islands. We carried out a sensitivity study with the different scavenging parameters. The case with lower iron scavenging simulates high iron concentrations in the Sea of Okhotsk and western subarctic Pacific, corresponding to observed data. Sedimentary iron mainly supplied in the northern continental shelf of the Sea of Okhotsk is transported through the depth below the euphotic layer and is exported to the western subarctic Pacific. We conclude that iron exported from the Sea of Okhotsk likely contributes to the high iron concentrations in the western North Pacific.

25 October, 14:00 (W1-5836), Invited

New NEMURO-based model incorporating the iron cycle

Yasuhiro **Yamanaka**[1,2,3], S. Lan Smith[3], Hiroshi Sumata[1], Naoki Yoshie[4], Taketo Hashioka[2,3], Takeshi Okunishi[5], Masahiko Shigemitsu[1], Maki N. Noguchi[3] and Naosuke Okada[1]

[1] Faculty of Environmental Earth Science, Hokkaido University, N10W5 Kita-ward, Sapporo, Hokkaido, 060-0810, Japan
E-mail: galapen@ees.hokudai.ac.jp
[2] Core Research for Evolutional Science and Technology (CREST), Japan Science and Technology Agency, 5 Sanbancho, Tokyo, 102-0075, Japan
[3] Japan Agency for Marine-Earth Science and Technology, Yokohama, 236-0001, Japan
[4] Center for Marine Environmental Studies, Ehime University, 2-5 Bunkyo-cho, Matsuyama, Ehime, 790-8577, Japan
[5] National Research Institute of Fisheries Science, Fisheries Research Agency, 2-12-4 Fukuura, Kanazawa, Yokohama, Kanagawa, 236-8648, Japan

Supplies of essential micro-nutrient iron to the upper ocean largely determines regional differences in biological production in the North Pacific Ocean. The original NEMURO developed by the PICES/GLOBEC CCCC model task team didn't include iron, so we have developed a new ecosystem model including iron cycling with the new Optimal Uptake (OU) kinetics for multiple nutrients. Smith and Yamanaka (L&O, 2007) and Smith *et al*. (MEPS, 2009) showed that, compared to the classic Michaelis-Menten (MM) kinetics, OU kinetics better explains the observed nutrient uptakes from both laboratory and shipboard experiments. By fitting the respective versions (MM and OU kinetics) of an identical ecosystem model to the same data, Smith *et al*. (*submitted to* DSRI) have rigorously compared MM and OU kinetics in a modeling study of the SERIES iron-enrichment experiment. MM kinetics couldn't reproduce the observed increase in Si uptake rate as a function of the decreasing trend in concentration of silicic acid. Also, the MM kinetics predicts Si limitation throughout nearly all of the experiment after iron-fertilization. By contrast, OU kinetics reproduces the observed increase in Si uptake rate and matches the observed estimate for the timing of the return to iron limitation. Previous studies have shown that including the iron cycle (with MM kinetics) has fixed problems in models without iron (*e.g.*, overestimates of chlorophyll *a* in the Southern Ocean and of nutrient concentration in the subarctic North Pacific). However, the inclusion of the iron cycle has degraded model performance for some regions such as the Equatorial Pacific. We are estimating the key parameters of our model with OU kinetics for 17 sites including JGOFS stations.

25 October, 14:30 (W1-5759), Invited

Interplay between ecosystem structures and iron availability in a global marine ecosystem model

Stephanie **Dutkiewicz**, Fanny Monteiro and Mick Follows

Program in Atmosphere, Ocean and Climate, Massachusetts Institute of Technology, 54-1412, 77 Massachusetts Ave., Cambridge, MA, 02139, USA. E-mail: stephd@mit.edu

We examine the interplay between marine ecosystem structures and iron supplies in the context of a global three-dimensional ocean model where self-assembling phytoplankton communities emerge from a wide set of potentially viable organism types. The parameterization of the iron cycling includes representations of advection/diffusion, biological uptake, remineralization, aeolian and sedimentary sources, and explicit complexation with an organic ligand and scavenging. The availability of iron significantly regulates ecosystem structures in the modeled Pacific Ocean. In particular, the treatment of the sources of iron in the model strongly affects the distribution and relative abundance of diazotrophs in the subtropical gyres. Though not yet well constrained, studies have suggested that the solubility of dust-borne iron is likely spatially variable. The solubility is dependent on the chemical and mechanical processes affecting the dust in its transit from land. The modeled distribution of diazotrophs is improved when we apply an atmospheric iron source which explicitly reflects the regional variations in solubility.

W1 Poster

W1-5936

Effect of Asian dust on the picophytoplankton growth rate and cell cycle

Youngju **Lee** and Joong Ki Choi

Plankton Laboratory, Department of Oceanography, Inha University, 253 Yonghyun-dong, Nam-gu, Incheon, 402-751, R Korea
E-mail: jkchoi@inha.ac.kr

To investigate the effect of Asian dust on picophytoplankton, we carried out laboratory experiments for the variations of growth rate and DNA cell cycle on *Prochlorococcus* and *Synechococcus* after addition of Asian dust. There are no differences in the growth rates of control samples and experimental samples with additions of 5%, 20%, 50% Asian dust, respectively. The specific growth rates of *Prochlorococcus* and *Synechococcus* in the experiment with additions of 50% Asian dust were lower than others and the additions of 20% and 50% Asian dust also induced a *Synechococcus* cell cycle response. But the fifty percent addition of Asian dust was high concentration relative to the concentration in the ocean during Asian dust periods. These results indicated that there is physiological effect of high concentration Asian dust on the picophytoplankton growth and cell cycle.

W2 BIO Workshop
Standardizing methods for estimating jellyfish concentration and development of an international monitoring network

Co-Convenors: Hideki Akiyama (Japan), Richard D. Brodeur (U.S.A.) and Young-Shil Kang (Korea)

Some jellyfish make massive blooms in the North Pacific coastal and oceanic waters, damaging fisheries and causing large social and economic problems. To date, there have been discussions about bloom mechanisms, distribution, and biological and ecological characteristics of the jellyfish species. However, there are limitations in understanding the dynamics of these massive blooms and providing scientific information to management. One major limitation is standards for sampling and a lack of monitoring. The goals of this workshop are: 1) to understand the problems and develop techniques for estimating concentrations of jellyfishes; 2) to evaluate the status of national/regional monitoring systems for jellyfishes; 3) to emphasize why standard methods and international monitoring are needed; and 4) to develop an implementation plan and schedule for improving abundance and distribution information on jellyfish blooms.

Saturday, October 24 (14:00-18:00)

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

14:05 **Jennifer E. Purcell (Invited)**
Broad-scale research on jellyfish (W2-5604)

14:30 **Kazuhiro Sadayasu, Yoshimi Takao and Ryuichi Matsukura**
Echo trace counting method for estimating the giant jellyfish *Nemopilema nomurai* density and distribution using a quantitative echosounder (W2-5877)

14:45 **Kyoung-Hoon Lee, Soo-Jeong Jang, Won Duk Yoon, Chang-Doo Park and Seong-Wook Park**
Density estimates of ***Nemopilema nomurai*** jellyfish in Yellow Sea during 2006-2009 (W2-5874)

15:00 **Hideki Ikeda, Hiroko Okawachi, Atsushi Yoshida, Miwa Hayashi and Shin-ichi Uye**
Spatio-temporal distribution of the giant jellyfish *Nemopilema nomurai* in East Asian waters by sighting survey from a ferry (W2-5535)

15:15 **Haruto Ishii, Yasuyuki Nogata and Noriaki Endo**
Horizontal and vertical distribution of jellyfish, *Aurelia aurita* medusae, and estimation of its abundance with underwater video system in Tokyo Bay (W2-5711)

15:30 ***Coffee / tea break***

15:50 **Richard D. Brodeur, Cynthia L. Suchman, Elizabeth A. Daly and Lanaya N. Fitzgerald**
Habitat and ecology of large medusa in the northern California Current: An overview of recent studies (W2-5821)

16:05 **Naoki Fujii, Shinya Magome, Atsushi Kaneda and Hidetaka Takeoka**
Monitoring method for moon jellyfish abundance in the western Seto Inland Sea, Japan (W2-5849)

16:20 **Hao-Hsien Chang, Chang-Yu Lai, and Wen-Tseng Lo**
A study on the ecological significance of the box jellyfish, *Carybdea rastonii* Haacke (Cnidaria: Cubozoa), from the east coast of Taiwan (W2-5868)

16:45 **Chang-Hoon Han and Shin-ichi Uye**
Quantification of the abundance and distribution of the common jellyfish *Aurelia aurita* s.l. with a Dual-frequency IDentification SONar (DIDSON) (W2-5680)

17:00 **Akira Okuno, Tatsuro Watanabe, Naoto Honda and Katsumi Takayama**
Jellyfish transport simulation taking the diurnal vertical migration into account (W2-5661)

17:15 **Discussion, summary, recommendations**

18:00 ***Workshop ends***

W2 Oral Presentations

24 October, 14:05 (W2-5604), Invited

Broad-scale research on jellyfish

Jennifer E. **Purcell**

Shannon Point Marine Center, Western Washington University, 1900 Shannon Point Rd., Anacortes, WA, 98221, USA
E-mail: purcelj3@wwu.edu

Recently there has been increased interest in jellyfish because problems with jellyfish, such as reduced fish catches, fish kills in aquaculture pens, and blocked power plant intakes, have increased around the world. The probable causes of increased jellyfish blooms, such as ocean warming, overfishing, eutrophication and hypoxia, and species introductions, are increasing problems at global scales. Research on jellyfish needs to be conducted on scales larger than typically has been done. Sampling for jellyfish distributions, abundances, and biomass over large temporal and spatial scales are necessary to understand their importance in estuarine and marine food webs and for their inclusion in ecosystem models. Many of the most valuable large-scale data on jellyfish populations have come from their bycatch in scientific fisheries, such as in the Bering Sea. Implementation of methods for systematic collection of jellyfish data during fisheries cruises around the world would provide such large-scale data. Here, I present examples of ongoing large-scale sampling of jellyfish populations in several countries and methods that include fishery, aerial, ferry, and beach surveys. Consumption rates may be estimated over large scales by use of metabolic rates. Such methods can provide large-scale data on jellyfish populations and their effects.

24 October, 14:30 (W2-5877)

Echo trace counting method for estimating the giant jellyfish *Nemopilema nomurai* density and distribution using a quantitative echosounder

Kazuhiro **Sadayasu**, Yoshimi Takao and Ryuichi Matsukura

Fisheries Information Science Group, Fisheries Technology Division, National Research Institute of Fisheries Engineering, Fisheries Research Agency, 7620-7 Hasaki, Kamisu, Ibaraki, 314-0408, Japan. E-mail: sadayasu@affrc.go.jp

Explosive occurrences of the giant jellyfish *Nemopilema nomurai* which interfere with coastal fisheries have taken place in the Sea of Japan in recent years. Quantitative information on the distribution of this jellyfish is needed not only to minimize damage to fisheries but also to study the effects of these blooms on the marine ecosystem. An acoustic echo trace counting method using a quantitative echosounder was developed to assess the abundance and distribution of the giant jellyfish. An acoustic survey was conducted in Wakasa Bay on November 2007. A hull-mounted quantitative echosounder (SIMRAD EK60) was operated at 0.256 ms pulse duration with a 0.2 s ping interval. Cruise speed was maintained at 8 kt during the acoustic survey to obtain high-resolution echograms which enable us to discriminate between jellyfishes and other organisms. An underwater video camera with a depth sensor was put in a pelagic trawl for counting jellyfish at each depth. The giant jellyfish was identifiably and individually detected as an echo trace in the high-resolution echograms. These echo traces were verified as the giant jellyfish from the pelagic trawl sampling. An acoustical sampled volume within which echo traces were counted was estimated by comparison between experimental and theoretical methods to determine densities of the jellyfish. This acoustical monitoring method combined with visual observation and other methods is able to provide reliable distribution information of jellyfish quickly, and will be helpful to monitor damage in the fishery and ecosystem.

24 October, 14:45 (W2-5874)

Density estimates of *Nemopilema nomurai* jellyfish in Yellow Sea during 2006-2009

Kyoung-Hoon **Lee**[1], Soo-Jeong Jang[2], Won Duk Yoon[2], Chang-Doo Park[1] and Seong-Wook Park[1]

[1] Fisheries Engineering Division, National Fisheries Research & Development Institute, 152-1 Haeanro, Gijang-Up, Gijang-Gun, Busan, 619-705, R Korea. E-mail: khlee71@nfrdi.go.kr

[2] Ecology and Oceanography Division, National Fisheries Research and Development Institute, 152-1 Haeanro, Gijang-Up, Gijang-Gun, Busan, 619-705, R Korea

Nemopilema nomurai, a jellyfish which is presumed to be developing in the East China Sea, has recently migrated into the Yellow Sea during recent years. National Fisheries Research and Development Institute (NFRDI) estimated its biomass by bottom trawl fishing surveys and sighting surveys during 5 years. These methods are effective in estimating density of jellyfish and its associated community in near bottom or surface, but they have difficulty in investigating the vertical distribution of jellyfishes. However, in this case, the hydroacoustic method can be utilized extensively and effectively to examine vertical distribution in short periods of time. This research was conducted by echo counting method with scientific echosounder system (Simrad EK-500 and EK-60 systems) with 2 frequencies in order to estimate *N. nomurai* densities as they migrated into Korea-China waters for the summer season during 4 years (2006-2009). Then, the jellyfish echo signals were extracted from other sound backscattering scatterers on the basis of a single echo shape for individuals for comparison with a synchronized acoustic camera system (DIDSON, Soundmetrics). In addition, the density estimates by echo counting method could be compared with those values from trawl sampling and sighting surveys. The distributed density in 2008 of *N. nomurai* jellyfish, which drifted into the survey area, was relatively around 4 times lower than in 2006 and 2007. The densities in the summer of 2009 will be analyzed to compare with the previous years.

24 October, 15:00 (W2-5535)

Spatio-temporal distribution of the giant jellyfish *Nemopilema nomurai* in East Asian waters by sighting survey from a ferry

Hideki **Ikeda**, Hiroko Okawachi, Atsushi Yoshida, Miwa Hayashi and Shin-ichi Uye

Graduate School of Biosphere Science, Hiroshima University, 4-4 Kagamiyama 1 chome, Higashi-Hiroshima 739-8528, Japan
E-mail: hydekid@hiroshima-u.ac.jp

The giant jellyfish *Nemopilea nomurai* has caused massive blooms in the East Asian Marginal Seas and serious damage to fisheries almost annually since 2002. The medusae originate in the East China Sea and Yellow Sea and drift into the Japan Sea by the Tsushima Current. To investigate the geographical distribution of this jellyfish, we have been conducting sighting surveys of *N. nomurai* from passenger ferries travelling between Japan and China. We surveyed between the ports of Shimonoseki and Qingdao (since 2006), Shimonoseki (Osaka) and Taicang (Shanghai) (since 2007), and Kobe and Tiangjin (since 2008), covering the nursery ground of this species. In July 2006 and 2007, young medusae occurred extensively over the entire Yellow Sea with the average abundance of 2.17 medusae 100 m^{-2} and 3.32 medusae 100 m^{-2}, respectively. Thereafter, the abundance decreased in the Yellow Sea due to transport through the Tsushima Strait to the Japan Sea. In October and November of both years, a mass occurrence of the giant jellyfish took place along the Japanese coast. However, in July 2008, the density of medusae in the Yellow Sea (average: 0.02 medusae 100 m^{-2}) was about 2 orders of magnitude lower than that in the preceding years. Consequently, medusae were very scarce in the Japan Sea, causing no significant damage to the fisheries. Therefore, monitoring from the ferries is valid to forecast year-to-year variation in the intensity of mass occurrence of *N. nomurai* medusae along the Japanese coast.

24 October, 15:15 (W2-5711)

Horizontal and vertical distribution of jellyfish, *Aurelia aurita* medusae, and estimation of its abundance with underwater video system in Tokyo Bay

Haruto **Ishii**[1], Yasuyuki Nogata[2] and Noriaki Endo[2]

[1] Tokyo University of Marine Science and Technology, 4-5-7 Kounan, Minato-ku, Tokyo, 108-8477, Japan
E-mail: ishii@kaiyodai.ac.jp
[2] Central Institute of Electric Power Industry, Japan

Natural aggregations of *Aurelia aurita* medusae were observed by eye and by underwater video system in the innermost part of Tokyo Bay, Japan, in 2006. Observations were conducted throughout day and night. Most of aggregations were equally distributed in the water column between the surface and bottom layer. Apparent diel vertical migrations were not observed in *A. aurita* medusae. Moreover, significant difference in the bell diameter of medusae among the depths was not observed. We calculated the abundance and the biomass of *A. aurita* medusae in the innermost part of Tokyo Bay, and these were used to estimate feeding impact of *A. aurita* medusae on the biomass and the production in the zooplankton community.

24 October, 15:50 (W2-5821)

Habitat and ecology of large medusa in the northern California Current: An overview of recent studies

Richard D. **Brodeur**[1], Cynthia L. Suchman[2], Elizabeth A. Daly[3] and Lanaya N. Fitzgerald[4]

[1] NOAA Northwest Fisheries Science Center, Hatfield Marine Science Center, Newport, OR, 97365, USA
Email: Rick.Brodeur@noaa.gov
[2] Virginia Institute of Marine Science, Gloucester Point, VA, 23062, USA
[3] Cooperative Institute for Marine Resources Studies, Oregon State University, Newport, OR, 97365, USA
[4] Hatfield Marine Science Center, Oregon State University, Newport, OR, 97365, USA

The northern California Current is a productive upwelling zone that is home to large populations of medusae particularly during late summer. Our research has focused on understanding their habitat requirements and whether their presence may affect coastal fish populations. We have conducted seasonal trawl surveys along the Oregon and Washington coasts since 2000 and have documented a substantial biomass of jellyfish consisting primarily of four species (*Chrysaora fuscescens, Aurelia labiata, Aequorea* spp., and *Phacellophora camtschatica*). We also examined the vertical distribution using ROV deployments throughout the water column. Different seasonal patterns were observed between the dominant taxa: *C. fuscesens* abundances generally peaked in July, August, or September, whereas *Aequorea* spp. most often attained maximum numbers in May or June. General Additive Modeling of the mesoscale data indicated that station catches for both species correlated with latitude, temperature, salinity, and distance from shore. Moreover, analysis of interannual variability revealed that highest catches of medusae correlated with cool Spring-Summer conditions (negative anomalies of the Pacific Decadal Oscillation) and low Winter-Summer runoff from the Columbia River. By summer (July-Sept.), their biomass exceeds that of small pelagic fishes by 6-10 fold due primarily to exponential individual growth of jellyfish. Spatial overlap of these jellyfish with pelagic fishes is minimal, but there are regions of intense overlap where trophic interactions may be occurring. Trophic overlap can be high with planktivorous species such as Pacific sardines and herring that consume copepods and euphausiid eggs. We found no indication of predation by jellyfish on the early life stages of marine fishes in the field, but laboratory studies show that *C. fuscescens* can consume gadid larvae within the first hour that they co-occur in a tank. Future studies will hopefully incorporate acoustic and other remote methods for monitoring population levels through time.

24 October, 16:05 (W2-5849)

Monitoring method for moon jellyfish abundance in the western Seto Inland Sea, Japan

Naoki **Fujii**[1], Shinya Magome[2], Atsushi Kaneda[3] and Hidetaka Takeoka[4]

[1] Center for Marine Environmental Studies, Ehime University, 2-5 Bunkyo-chou, Matsuyama, Ehime, 790-8577, Japan
E-mail: medusae@sci.ehime-u.ac.jp
[2] National Institute of Advanced Industrial Science and Technology, 2-2-2 Hiro-Suehiro, Kure, Hiroshima, 737-0197, Japan
[3] Development of Marine Bioscience, Fukui Prefectural University, 1-1 Gakuen-chou, Obama, Fukui, 917-0003, Japan
[4] Center for Marine Environmental Studies, Ehime University, 2-5 Bunkyo-chou, Matsuyama, Ehime, 790-8577, Japan

Moon jellyfish blooms damage fisheries and cause substantial social and economic problems in the Seto Inland Sea of Japan. To fully understand the mechanisms behind moon jellyfish blooms and their shifts in abundance, it is essential to examine the temporal shifts in jellyfish blooms with environmental fluctuations. However, what seems to be lacking is an effective monitoring method of jellyfish abundance. In our presentation, we propose such a monitoring method. Jellyfish are distributed somewhat heterogeneously in the sea. However, jellyfish distributions are dependent on characteristics of the region, such as water currents. In the Uwa Sea, located in western Seto Inland Sea, jellyfish aggregations are distributed in the surface waters near coastal lines during the summer months. Monitoring the appearance of moon jellyfish aggregations will potentially indicate jellyfish abundance. In this study, the following methods were used:

1) Jellyfish Aggregations Monitoring System in the Uwa Sea (JAMSUS; 2003-2009)

Using a video monitoring system set up on a hill with a full view of Hokezu Bay (part of the Uwa Sea) during summer and autumn from 2003 to 2009, we observed dense aggregations of moon jellyfish. The aggregation frequency of occurrence varied widely in Hokezu Bay. Moon jellyfish aggregations appeared most frequently during 2007 for the monitoring period (2003-2008).

2) Aerial Survey throughout Uwa Sea (2000-2009)

Aerial surveys were used to study the distribution and abundance of surface and near-surface aggregations of moon jellyfish. Our results indicated that the aerial surveys and JAMSUS method showed much of the same pattern in the appearance of moon jellyfish aggregations.

24 October, 16:20 (W2-5868)

A study on the ecological significance of the box jellyfish, *Carybdea rastonii* Haacke (Cnidaria: Cubozoa), from the east coast of Taiwan

Hao-Hsien **Chang**, Chang-Yu Lai, and Wen-Tseng Lo

Department of Marine Biotechnology and Resources, National Sun Yet-Sen University, 70 Lienhai Rd., 80424, Kaohsiung, Taiwan
E-mail: hhchang@staff.nsysu.edu.tw

Concerning the deadly venom of box jellyfish, most investigations on cubozoan have been done in the fields of toxicology, morphology, and medical-related research. However, despite of the increasing interest in the ecology of gelatinous zooplankton, little is known about the ecological significance of cubomedusae. The box jelly (sea wasp) *Carybdea rastonii* Haccke is widely distributed in the Pacific Ocean and is known as a nuisance to bathers and fishermen, especially when they are abundant. In Taiwan during summer and fall, regular appearances of *C. rastonii* (up to 27.6 ind. m^{-3}) were observed in some shallow embayments from the east coast, close to the Kuroshio Current. Weekly population structures indicated at least two peaks of strobilation occurring during the sampling period. Significantly higher respiration rates (up to 0.126 µmol O_2 h^{-1} $mgDW^{-1}$, at 27ºC) were also found in *C. rastonii*, compared to most scyphozoans, suggesting a much higher energy demand. Investigations on box jellyfish digestion rate, an essential element in studying prey selection, daily ration, and feeding impact, showed averaged digestion times of 1.50 and 3.11 h $prey^{-1}$, and the mass-specific digestion times of 0.20 and 0.12 h mg WW $prey^{-1}$ using fish larvae and shrimps as prey, respectively. Along with the results from population dynamics and gut contents analysis, we concluded that *C. rastonii* is an important predator in this region, especially during its blooming seasons.

24 October, 16:45 (W2-5680)

Quantification of the abundance and distribution of the common jellyfish *Aurelia aurita* s.l. with a Dual-frequency IDentification SONar (DIDSON)

Chang-Hoon **Han**[1] and Shin-ichi Uye[2]

[1] National Fisheries Research and Development Institution, 408-1 Sirang-Ri, Gijang-Eup, Busan, R Korea
E-mail: chhan@nfrdi.go.kr
[2] Hiroshima University, 1-1-4 Kagamiyama, Higashi-Hiroshima, Hiroshima, Japan

A Dual-frequency IDentification SONar (DIDSON) was examined as a tool to determine the numerical abundance and spatial distribution of medusae of the common jellyfish *Aurelia aurita* s.l. in shallow coastal waters. The sonar image obtained in high frequency (1.8 MHz) mode enabled us to identify and count individual medusae of 4.1–19.6 cm (mean: 13.1 cm) bell diameter. Deployment of the DIDSON along three ~4-km-long transects in a shallow brackish-water lake (average depth: 5.1 m) revealed that *A. aurita* aggregated (*e.g.* >8.0 medusae m^{-3}) near the lake center. The medusae occurred throughout the water column, but tended to avoid low salinity surface and deoxygenated bottom layers. The overall average density of medusae estimated by the DIDSON was 3.3 times higher than that estimated by net sampling at 8 stations. Use of a DIDSON can facilitate quantitative determination of jellyfish populations that cause problem blooms worldwide in order to better understand their ecological importance.

24 October, 17:00 (W2-5661)

Jellyfish transport simulation taking the diurnal vertical migration into account

Akira **Okuno**, Tatsuro Watanabe, Naoto Honda and Katsumi Takayama

Japan Sea Fisheries Oceanography Division, Japan Sea National Research Institute, Fisheries Agency, 1-5939-22 Suido-cho, Niigata, 951-8121, Japan. E-mail: okuaki@affrc.go.jp

From recent field observations of the behavior of the giant jellyfish (*Nemopilema nomurai*), it has been shown that this jellyfish shows vigorous vertical migration. Thus a system to simulate the transport of the jellyfishes in the Japan Sea taking the vertical migration into account was developed. The system utilizes the physical data produced by JADE (JApan sea Data assimilation Experiment; an operational ocean prediction system). Since JADE produces both the past data (with data assimilation) and the forecast data, the system developed here can be used for both the simulation of past transport trajectories as well as transport prediction. In the transport simulation, virtual tracers which mimic the jellyfishes are released into the model ocean, and are tracked by numerical integration of the equation of motion. Horizontal movement of the tracers is assumed to be passive to the ambient horizontal velocity, including the effect of a random-walk type diffusion. Conversely, vertical movement of the tracers is not passive to the vertical velocity of sea water; rather a manner of active movement in the vertical direction is prescribed to the tracers. At present, only the diurnal vertical migration is implemented in the simulation. Since the oceanic currents in the Japan Sea show significant vertical shear in the velocity, the jellyfish transport depends on the swimming depth of the jellyfishes. From some simulations of past transport, it was revealed that the diurnal vertical migration can contribute to the determination of the observed transport path of the jellyfishes.

W3 BIO Workshop
Integrating marine mammal populations and rates of prey consumption in models and forecasts of climate change-ecosystem change in the North Pacific and North Atlantic Oceans

Co-Sponsored by ICES

Co-Convenors: Hidehiro Kato (Japan), Begoña Santos (ICES, Spain) and William J. Sydeman (U.S.A.)

In many marine ecosystems from tropical to arctic waters, marine mammals are showing considerable changes in abundance. In general, cetaceans, recovering from historical exploitation, are increasing, whereas some pinniped species are declining regionally, while others are increasing. Models of marine mammal prey consumption indicate that ~20-60% of secondary production may be taken by these top consumers. Therefore, marine mammals may exert «top-down» control on food webs, as well as functioning as competitors to fish, seabirds, and humans for mid-trophic level food resources. One of the goals of PICES and ICES science is to enhance forecasts of ecosystem change attributable to climate and anthropogenic forcings. Given this goal, the workshop will review and assess rates of marine mammal population and prey consumption changes in the North Pacific and North Atlantic. Presentations are invited on changes in marine mammal abundance, distribution, diet, and prey consumption. Discussion will focus on how to best integrate this information into models of ecosystem dynamics, with and without climate change and fishing impacts.

Tuesday, October 27 (14:00-18:00)

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

14:05 **Andrew W. Trites (Invited)**
Marine mammals in multi-species models: Assumptions, limitations and theoretical considerations (W3-5652)

14:30 **Frank A. Parrish**
Top-down pressure of foraging monk seals on subphotic fish communities; a possible symptom of a marine mammal population at carrying capacity (W3-5511)

14:50 **Rolf Ream and Lowell Fritz**
Pinniped population changes in the North Pacific: Recent trends in northern fur seal and Steller sea lion abundance (W3-5964)

15:10 **M. Begoña Santos and Graham J. Pierce (Invited)**
Integrating marine mammal populations and rates of prey consumption in models and forecasts of climate change-ecosystem change in the North Atlantic Ocean (W3-5779)

15:35 ***Coffee / tea break***

16:00 **Hiroshi Okamura, Hiroshi Nagashima, and Shiroh Yonezaki (Invited)**
Quantitative assessment of impacts on the sandlance population by consumption of minke whales (W3-5771)

16:25 **Hiroto Murase, Tsutomu Tamura, Tatsuya Isoda, Ryosuke Okamoto, Hidehiro Kato, Shiroh Yonezaki, Hikaru Watanabe, Naoki Tojo, Ryuichi Matsukura, Kazushi Miyashita, Hiroshi Kiwada, Koji Matsuoka, Sigetoshi Nishiwaki, Denzo Inagake, Makoto Okazaki, Hiroshi Okamura, Yoshihiro Fujise and Shigeyuki Kawahara**
Prey preferences of common minke (*Balaenoptera acutorostrata*), Bryde's (*B. edeni*) and sei (*B. borealis*) whales in the western North Pacific (W3-5724)

16:45 **Jarrod A. Santora, William J. Sydeman and Christian S. Reiss**
Of whales and krill: Investigating the patch dynamics between foraging whales and krill (W3-5725)

17:05 **Valeriy I. Fadeev**
Benthos and food supply studies in feeding grounds of the Okhotsk-Korean gray whale population off the northeast coast of Sakhalin Island (Russia), 2004-2008 (W3-5718)

17:25 **Kyung-Jun Song, Zang Geun Kim, Seok-Gwan Choi, Yong-Rock An and Chang Ik Zhang**
Stomach contents of bycaught minke whales (*Balaenoptera acutorostrata*) in Korean waters (W3-5853)

17:45 William **Sydeman**
Synthesis

18:00 ***Workshop ends***

W3 Posters

W3-5719 **Sergey I. Kiyashko, Svetlana A. Rodkina, Vladimir I. Kharlamenko and Valeriy I. Fadeev**
Macrobenthos trophic relationships in western grey whale feeding areas (northeast coast of Sakhalin Island, Okhotsk Sea)

W3-5720 **Natalia L. Demchenko and Valeriy I. Fadeev**
Quantitative distribution and species composition of amphipods from the feeding ground of western gray whales on the seashore near the Chayvo Bay (northeastern coast of Sakhalin Island, Okhotsk Sea)

W3-5739 **Kenji Konishi, Hiroshi Kiwada, Koji Matsuoka, Toshihide Kitakado, Takashi Hakamada and Tsutomu Tamura**
Modeling prediction of temporal and spatial distribution of Bryde's whales in the western North Pacific

W3-5777 **Elena Ieno, M. Begoña Santos, Alex Edridge, Paul M. Thompson and Graham J. Pierce**
Long-term variation in seal diet and relationships with fish abundance

W3-5843 **Hyun Woo Kim, Zang Geun Kim, Seok-Gwan Choi and Yong-Rock An**
Estimating the population size of Indo-Pacific bottlenose dolphins, Tursiops aduncus, in coastal waters off Jeju Island

W3-5862 **Ah-Ra Ko, Zang Geun Kim, Seok-Gwan Choi, Kyung-Hoon Shin and Se-Jong Ju**
Understanding the feeding ecology of minke whales, *Balaenoptera acutorostrata*, in Korean Seas using trophic lipid markers

W3-5886 **Kristen Ampela**
The diet of gray seals (*Halichoerus grypus*) in United States waters, estimated from hard remains and blubber fatty acids

W3-5921 **Hyun Woo Kim, Zang Geun Kim, Seok-Gwan Choi and Yong-Rock An**
First record of the Indo-Pacific bottlenose dolphins, *Tursiops aduncus*, in Korean waters, by means of skull morphometry and external morphology

W3-5943 **Kyum Joon Park, Seok-Gwan Choi, Yong-Rock An, Zang Geun Kim, Ji Eun Park, Hyun Woo Kim, Tae-Geon Park, Young Ran Lee and Dae-Yeon Moon**
Abundance estimation of minke whales (*Balanoptera acutorostrata*) in the East Sea, using the sighting survey in 2009

W3-5987 **Valeriy A. Vladimirov, Sergey P. Starodymov, Alexey G. Afanasyev-Grigoryev and Vladimir V. Vertyankin**
Distribution and abundance of western gray whales off the northeast coast of Sakhalin Island, Russia, 2008

W3 Oral Presentations

27 October, 14:05 (W3-5652), Invited

Marine mammals in multi-species models: Assumptions, limitations and theoretical considerations

Andrew W. **Trites**

Marine Mammal Research Unit, Room 247, AERL, 2202 Main Mall, University of British Columbia, Vancouver, BC, V6T 1Z4, Canada
E-mail: a.trites@fisheries.ubc.ca

Ecosystem models are one of the best tools to understand predator– prey interactions and forecast how ecosystems will respond to climate change and anthropogenic forcing. Marine mammals are one of the better studied species group and tend to have better information than most species to feed the data needs of ecosystem models (*i.e.*, they tend to have data to determine biomass, diet composition, consumption, production, ecotrophic efficiency and export). Of these six model parameters, the least is known about how much marine mammals consume, how it relates to age and body size, and how it varies through the year. Field observations and empirical studies with captive animals suggest that many of the current assumptions about consumption are wrong and may lead to erroneous model conclusions. Experimental manipulations and observational studies are shedding new light on the choices made by marine mammals and the costs of obtaining different species of prey. They highlight the importance of deriving functional response curves, estimating vulnerabilities to being eaten, and establishing the seasonal energy densities of prey. Continued validation and correction of current assumptions about consumption is needed to elucidate whether marine mammals exert top-down control on food webs, whether they compete with fisheries and other species groups, and whether marine mammal numbers will respond favorably or negatively to warming of the oceans.

27 October, 14:30 (W3-5511)

Top-down pressure of foraging monk seals on subphotic fish communities; a possible symptom of a marine mammal population at carrying capacity

Frank A. **Parrish**

Pacific Islands Fisheries Science Center, NOAA Fisheries, 2570 Dole Street, Honolulu, HI, 96822, USA
E-mail: frank.parrish@noaa.gov

Subphotic fish assemblages on seamounts in the Northwestern Hawaiian Islands were surveyed for patterns consistent with bottom-up pressure from regional oceanic productivity or top-down predation pressure from foraging monk seals (*Monachus schauinslandi*). Seamount fish assemblages are the deep extreme (350–500 m) of the seal's prey base and were examined to avoid the confounding effects of diverse habitat and benthic productivity inherent in shallow ecosystems (*e.g.*, coral reefs). The mean fish biomass-density of each seamount was compared to the independent variables of summit depth, substrate type, relief, oceanic productivity, distance to seal colonies, and seal colony population. Only the variables of distance to seal colony and seal colony population were retained in a multiple regression model that explained 31% of the variance. Possible implications of this finding are discussed in relation to recent results from trophic modeling and observations from field telemetry studies focused on the endangered Hawaiian monk seal.

27 October, 14:50 (W3-5964)

Pinniped population changes in the North Pacific: Recent trends in northern fur seal and Steller sea lion abundance

Rolf **Ream** and Lowell Fritz

National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, Seattle, 98115, USA
E-mail: rolf.ream@noaa.gov

Abundance has declined for a number of pinniped species in the North Pacific over the past four decades. Notable are Steller sea lions (SSL) and northern fur seals (NFS), which have a similar geographical range but differ in their habitat use. The western SSL stock declined by 75% during the 1970s and 1980s, while the eastern stock increased slightly. NFS populations were relatively stable during the 1980s to late 1990s, when abundance at many islands began to change. Recent population estimates for both species indicate strong regional trends. After increasing ~3% during 2000-2004, counts of western SSL during 2008 indicated stable or slightly declining trends. There was substantial regional variation in trends within the western SSL, however, ranging from -30% in the western Aleutians to +35% in the eastern Gulf of Alaska. NFS pup production at the largest colony, the Pribilof Islands, declined 40% during 1998-2008. NFS abundance also declined at the Commander Islands in Russia during recent years, but increased at most others, including Robben Island (+7.8%/yr), and Bogoslof Island (+12.8%/yr). Results for both species suggest some degree of distributional change, at least seasonally, among regions. The NFS declines at the Pribilofs cannot be accounted for by increases at other islands, but the distinct regional trends have clearly changed the distribution of the species; representing nearly 75% of worldwide abundance in 1992, the Pribilof population now represents only 48%. Declines in abundance of marine mammals provide an opportunity for investigating relationships between climate change and upper trophic level predators.

27 October, 15:10 (W3-5779), Invited

Integrating marine mammal populations and rates of prey consumption in models and forecasts of climate change-ecosystem change in the North Atlantic Ocean

M. Begoña **Santos**[1] and Graham J. Pierce[1,2]

[1] Instituto Español de Oceanografía, Centro Oceanográfico de Vigo, Apdo. 1552, 36200 Vigo, Spain. E-mail: m.b.santos@vi.ieo.es
[2] University of Aberdeen, School of Biological Sciences, Tillydrone Ave., Aberdeen, AB24 2TZ, Scotland, UK

The ICES Science Plan identifies research on climate change processes and predictions of its impacts as a High Priority Research topic for 2009-2013. Marine mammals, as top predators of the marine food web, play an important role in controlling prey populations and changes in their distribution and abundance are expected as a result of climate/global change.

Results from large-scale international surveys in the Northeast Atlantic have shown that most cetacean populations have not experienced large changes in abundance during the last 10 years but harbour porpoise (*Phocoena phocoena*) distribution has shifted towards southern waters. Changes in cetacean distribution have also been inferred from strandings and sightings data. Grey and harbour seal numbers have shown contrasting trends over the years. Changes in diet have been recorded in several species for which long-term data are available.

There is a wealth of data available for use in ecosystem models (*e.g.* trophodynamic models, multispecies VPA, *etc.*). Existing models have highlighted the need to take into account the complexities inherent in predator-prey relationships (*e.g.* how predators respond to changing availability of different prey, *i.e.* multispecies functional responses), their implications for predator populations, and the temporal and geographical scales at which predator and prey interact). Ecosystem models have traditionally simplified nature to relatively few components linked by mathematical functions. Forecasting impacts of climate/global change requires us to take into account not just changes in the functional form of the links but also changes in the component species, as species distributions shift according to their environmental preferences.

27 October, 16:00 (W3-5771), Invited

Quantitative assessment of impacts on the sandlance population by consumption of minke whales

Hiroshi **Okamura**[1], Hiroshi Nagashima[2], and Shiroh Yonezaki[1]

1 National Research Institute of Far Seas Fisheries, Fisheries Research Agency, Kanagawa, 236-8648, Japan
E-mail: okamura@fra.affrc.go.jp
2 Miyagi Prefectural Government, Fisheries Industry Infrastructure Development Division, 3-8-1 Honcho, Aoba-ku, Sendai, 980-8570, Japan

The role of top predators in the ecosystem is one of central interest in ecology and fisheries science. Quantifying impacts of consumption by predators on prey species will contribute toward the sustainable management of fisheries. The sandlance off Sanriku region, which is the northwestern Pacific coastal region of Japan, is an important fishery resource and is preyed upon by many predators including marine mammals such as minke whales and northern fur seals. We developed a Bayesian assessment model to investigate the effects of consumption by minke whales on sandlances off the Sanriku region. The model allows for various uncertainties making use of time series data historically collected by fisheries and researches. The impact of predation was examined in terms of MSY using a simple formula preliminarily. When we used the linear functional response curve, the median value of MSY was greatly increased. Whereas using the constant functional response, the impact was much smaller, where we saw only a small increase of the median value of MSY. We discuss the methods to estimate the global functional response curve from the field data.

27 October, 16:25 (W3-5724)

Prey preferences of common minke (*Balaenoptera acutorostrata*), Bryde's (*B. edeni*) and sei (*B. borealis*) whales in the western North Pacific

Hiroto **Murase**[1], Tsutomu Tamura[1], Tatsuya Isoda[1], Ryosuke Okamoto[2], Hidehiro Kato[2], Shiroh Yonezaki[3], Hikaru Watanabe[3], Naoki Tojo[4], Ryuichi Matsukura[4], Kazushi Miyashita[5], Hiroshi Kiwada[1], Koji Matsuoka[1], Sigetoshi Nishiwaki[1], Denzo Inagake[6], Makoto Okazaki[6], Hiroshi Okamura[3], Yoshihiro Fujise[1] and Shigeyuki Kawahara[7]

1 The Institute of Cetacean Research, 4-5 Toyomi-cho, Chuo-ku, Tokyo, 104-0055, Japan
2 Tokyo University of Marine Science and Technology, 4-5-7 Konan, Minato-ku, Tokyo, 108-8477, Japan
3 National Research Institute of Far Seas Fisheries, 2-12-4 Fukuura, Kanazawa, Yokohama, Kanagawa 236-8648, Japan
4 Graduate School of Environmental Science, Hokkaido University, 3-1-1 Minato-cho, Hakodata, Hokkaido 041-8611, Japan
5 Field Science Center for the Northern Biosphere, Hokkaido University, 3-1-1 Minato, Hakodate, Hokkaido, 041-8611, Japan
6 National Research Institute of Fisheries Science, 2-12-4 Fukuura, Kanazawa, Yokohama, Kanagawa, 236-8648, Japan
7 National Research Institute of Far Seas Fisheries, 5-7-1, Orido, Shimizu, Shizuoka, Shizuoka, 424-8633, Japan

Prey preferences of common minke, Bryde's and sei whales were estimated using data from large scale multidisciplinary ecological surveys. The surveys were conducted in the western North Pacific as part of the offshore component of JARPNII from 2002 to 2007. The surveys consisted of (1) oceanographic observation, (2) prey survey (net and acoustic) and cetacean survey (sighting and sampling). A prey preference index, Manly's α, was used in the analysis. The sum of Manly's α for all prey species is 1 and large values of Manly's α indicate prey preference. For minke whales, Manly's α of krill, Japanese anchovy and Pacific saury were 0.05 (se=0.03), 0.36 (se=0.19) and 0.59 (se=0.17), respectively. Minke whales showed preference toward pelagic fishes as previously reported. For Bryde's whales, Manly's α of krill and anchovy were 0.05 (se=0.04) and 0.95 (se=0.04), respectively. For sei whales, Manly's α of copepods, krill, anchovy and saury were 0.41 (se=0.10), 0.13 (se=0.04), 0.25 (se=0.10) and 0.20 (se=0.08), respectively. Though preys of three baleen whale species overlapped, Manly's α suggested their trophic niches were different from each other. Minke and sei whales coexisted in the same area but their prey utilization patterns were different. For example, it was observed that minke whales showed preference toward saury while sei whales showed preference toward copepods. Accumulation of prey preference data over long periods provides the basis for an appropriate choice of the form of the functional response which is required for ecosystem models for fisheries management.

27 October, 16:45 (W3-5725)

Of whales and krill: Investigating the patch dynamics between foraging whales and krill

Jarrod A. **Santora**[1], William J. Sydeman[1] and Christian S. Reiss[2]

[1] Farallon Institute for Advanced Ecosystem Research, P.O. Box 750756, Petaluma, CA, 94975, USA
E-mail: jasantora@gmail.com
[2] NOAA, Southwest Fisheries Science Center, 3333 Torrey Pines Court, La Jolla, CA, 92037, USA

It has been hypothesized that populations of baleen whales should recover, increase and reacquire favored habitats at regional and local scales. In considering their relatively huge metabolic requirements, they may drastically alter ecosystem organization. In the Southern Ocean, their prey item is krill *Euphausia superba*, but it is unclear how species utilize this common prey item. Moreover, in recent times, the human demand for krill has increased and there are concerns about the sustainability of krill fisheries. A clear framework is needed to investigate the role of baleen whales in ecosystems where krill fishing is projected to increase. To accomplish this, we need to use survey data where whale and krill distributions are measured simultaneously over many years in a fixed location. We use data collected in January-March 2003-2009 during the annual Antarctic Marine Living Resources (AMLR) program near the South Shetland Islands, Antarctica. Visual surveys for whales were conducted while krill were sampled acoustically and by nets. We focus on quantifying the spatial distribution of humpback (*Megaptera novaeangliae*) and fin (*Balaenoptera physalus*) whales to investigate their habitat requirements, exploitation of krill patches, and their potential effects on ecosystem dynamics. Key questions to be addressed are: 1. Are their predictable locations (*i.e.* foraging grounds) where whales regularly occur? 2. Are there preferences for specific krill patches (*i.e.* does size matter?), and 3. Does the relative abundance of whales relate to the interannual fluctuations of krill biomass and spatial variance?

27 October, 17:05 (W3-5718)

Benthos and food supply studies in feeding grounds of the Okhotsk-Korean gray whale population off the northeast coast of Sakhalin Island (Russia), 2004-2008

Valeriy I. **Fadeev**

A.V. Zhirmunsky Institute of Marine Biology (IBM), FEB RAS, 17 Palchevskogo St., Vladivostok, 690002, Russia
E-mail: vfadeev@mail.primorye.ru

The distribution and abundance of benthic prey have been studied in the Piltun (PFA) and Offshore (OFA) western gray whale feeding grounds off the Northeast coast of Sakhalin Island during 2004-2008. Independent distribution and photo-ID studies have indicated changes in whale abundance in the Piltun and Offshore feeding areas during this period. We investigated potential correlations in the variability of benthic whale prey (amphipods *Monoporeia affinis* and sand lance *Ammodytes hexapterus*) and the observed spatial whale distribution patterns. Sand lance abundance in the north of the PFA has shown an apparent decline in recent years, but this potential prey source is only available sporadically when compared to the consistent, rich amphipod assemblages that provides the main food source of western gray whales. Conversely, benthic food biomass in the deep-water (>20m) OFA was stable during 2004-2008. Likewise, whales were observed on those feeding grounds during all years in a zone of high abundance of ampeliscid amphipods (in a depth range of 41-53 m). The greatest changes in benthic prey abundance and distribution were observed in shallow PFA; the most notable decrease in the abundance and spatial distribution of the dominant amphipod (*Monoporeia affinis)* occurred in 2006 when sea ice persisted later in the summer season and the lowest bottom water temperatures were recorded.

27 October, 17:25 (W3-5853)

Stomach contents of bycaught minke whales (*Balaenoptera acutorostrata*) in Korean waters

Kyung-Jun **Song**[1], Zang Geun Kim[2], Seok-Gwan Choi[2], Yong-Rock An[2] and Chang Ik Zhang[1]

[1] Pukyong National University, 599-1 Daeyeon3-dong, Nam-gu, Busan, 608-737, R Korea
E-mail: kjsong329@hanmail.net

[2] Cetacean Research Institute, National Fisheries Research and Development Institute, 139-29 Maeam-dong, Nam-gu, Ulsan, 680-050, R Korea

The stomach contents of 54 minke whales (*Balaenoptera acutorostrata*), bycaught in Korean waters between 2000 and 2008, were analyzed to study the diet and feeding habits of the species in the area. Whale body length ranged from 3.9 to 8.5 m with a mean of 5.45 m (SD=1.07). A total of 9 prey species (3 crustaceans, 4 fishes and 2 cephalopods) were identified in the stomachs of minke whales. Relative importance of prey species was estimated by a CRI (Combined Rank Index) value, and euphausiid (*Euphausia pacifica*) was the most important prey species in this area occurring in 70.4% of the stomachs. Pacific anchovy (*Engraulis japonicus*) was the second most important prey species occurring in 11.1% of the stomachs. Most minke whales fed on a single prey species (74.0%), and fewer individuals had taken more than one prey species. This result suggests that minke whales in this area tended to feed on single prey species aggregations. Most minke whales fed on euphausiid in all age stages, and euphausiid was the dominant prey species in all months of our samples although sampling did not fully cover all age stages and months. Minke whales probably fed on prey species in this area throughout the year. Our results can be used as baseline data to understand the ecological role of minke whales in the area.

W3 Posters

W3-5719

Macrobenthos trophic relationships in western grey whale feeding areas (northeast coast of Sakhalin Island, Okhotsk Sea)

Sergey I. Kiyashko, Svetlana A. Rodkina, Vladimir I. Kharlamenko and Valeriy I. **Fadeev**

A.V. Zhirmunsky Institute of Marine Biology (IBM), FEB RAS, 17 Palchevskogo St., Vladivostok, 690002, Russia
E-mail: vfadeev@mail.primorye.ru

The factors that regulate or influence the production (growth) of forage benthos on the northeast Sakhalin shelf are poorly understood. It is essential to improve our knowledge of the trophodynamics and the environmental factors driving these processes. Obtaining more insight in the temporal and spatial changes of gray whale food resources will provide a better understanding of whale distribution and behavior which in turn would make management and conservation effort aimed at protection of the Western gray whale population more efficient. Amphipods obtain their food by filtering particulate organic material (POM) from the water column. Until now, the origin of this POM was unclear. Analyses of stable isotopes and molecular biomarkers have been carried out since 2006 to examine the trophodynamics of key prey species, collected from whale feeding areas, and for comparison, from inside Piltun Bay. Ratios of stable carbon and nitrogen isotopes and molecular biomarkers (fatty acid composition) indicated that phytoplankton are the main sources of organic material for mass zoobenthos production in the Piltun and Offshore feeding areas. Filter- and seston-feeders collected from inside Piltun Bay reflected similar results.

W3-5720

Quantitative distribution and species composition of amphipods from the feeding ground of western gray whales on the seashore near the Chayvo Bay (northeastern coast of Sakhalin Island, Okhotsk Sea)

Natalia L. Demchenko and Valeriy I. **Fadeev**

A.V. Zhirmunsky Institute of Marine Biology (IBM), FEB RAS, 17 Palchevskogo St., Vladivostok, 690002, Russia
E-mail: demnal82@gmail.com

The feeding of Western gray whales has been studied on the shallow sea area near the Chayvo Lagoon (Okhotsk Sea) since 2006. The species composition of amphipods and their quantitative abundance were determined in this region in July 2007 and 2008. Stations were sampled in the range of 10-15 m depth on well sorted fine sand sediments. About 21 amphipod species belonging to 16 genera and 9 families were found on the seashore near the Chayvo Bay. The species *Monoculodes synophthalmus* Bulycheva, 1952 was recorded for the first time in the Sea of Okhotsk. The assemblage of amphipod species in 2007 was very similar to the one found in 2008. In 2007, the average amphipod biomass at whale feeding sites near the Chayvo Bay in the 10-15 m range was 51.3±8.6 g/m^2, which is not significantly different (t-test, p=0.05) from the biomass level in 2008 (47.6±9.6 g/m^2). *Monoporeia affinis* was the most dominant species reaching up to 60-80% of total amphipod biomass in both years. The contribution of other species of amphipods to the total biomass varied in both years. The most common species near the Chayvo Bay, *Anisogammarus pugettensis*, *Eogammarus schmidti*, and *Anonyx nugax* were also the most common in the Piltun region (traditional western gray whale feeding area).

W3-5739

Modeling prediction of temporal and spatial distribution of Bryde's whales in the western North Pacific

Kenji **Konishi**[1], Hiroshi Kiwada[1], Koji Matsuoka[1], Toshihide Kitakado[2], Takashi Hakamada[1] and Tsutomu Tamura[1]

[1] The Institute of Cetacean Research, 4-5 Toyomi-cho, Chuo-ku, Tokyo, 104-0055, Japan. E-mail: Konishi@cetacean.jp
[2] Department of Marine Biosciences, Tokyo University of Marine Science and Technology 5-7, Konan 4, Minato-ku, Tokyo, 108-8477, Japan

The distribution of baleen whales is highly dependent on environmental factors, and therefore forecasting their distribution patterns is important for the evaluation of future environmental change in the ecosystem. Bryde's whale (*Balaenoptera edeni*) is one of the large consumers in the western North Pacific in summer. This study presents a model to predict temporal and spatial distribution of Bryde's whale's by taking environmental factors into account. Whale sighting surveys under the Second Phase of Japanese Whale Research Program in the Western North Pacific (JARPN II) were conducted every year from 2000 to 2008 in the area of the Pacific coast of Japan to latitude 170°E covering nearly 3 million km^2. A non-parametric multiplicative regression model (NPMR) was implemented based on whale sighting data from 2000 to 2006, using the densities of whales as a response variable and SST, chlorophyll *a* concentration, sea surface height (SSH), year, month and positions as explanatory variables. To validate the prediction performance of the model the predicted monthly distribution of Bryde's whales was compared to the actual sighting survey data in 2007. Another prediction was conducted for 2008. NPMR explanatory variables "positions", "SST" and "chlorophyll *a*" were selected as predictors in the models. The fitting of the response curve of this model showed high whale density at SST of 23°-26°C and low "chlorophyll *a*". The overlay results of mapping on GIS software showed that the predicted density distributions matched observed density from the sighting survey, demonstrating that the NPMR model successfully predicted the distribution of Bryde's whales.

W3-5777

Long-term variation in seal diet and relationships with fish abundance

Elena Ieno[1,2], M. Begoña Santos[1,3], Alex Edridge[1], Paul M. Thompson[4] and Graham J. **Pierce**[1,3]

[1] Oceanlab, University of Aberdeen, Main St., Newburgh, Aberdeenshire, AB41 6AA, UK
[2] Highland Statistics Ltd, 6 Laverock Rd., Newburgh, Ellon, Aberdeenshire, AB41 6FN, UK
[3] Instituto Español de Oceanografía, Centro Oceanográfico de Vigo, P.O. Box 1552, 36200, Vigo, Spain
[4] Lighthouse Field Station, University of Aberdeen, George St., Cromarty, Ross-shire, IV11 8YJ, UK
E-mail: g.j.pierce@abdn.ac.uk

Long time series of dietary data can potentially provide information on functional responses, *i.e.* how predator diet responds to changing prey abundance, *e.g.* related to overfishing or climate change. The present study examines long-term variation in diet of harbour seals (*Phoca vitulina*) in Orkney (NE Scotland), based on faecal sampling at haulout sites on the island of Eynhallow during 1986-2006. Most sampling visits took place during the summer (June-August) but in some years samples were also collected in other seasons. Samples were available for the years 1986-88, 1993-96, 1998, 2000-03 and 2005-06. In summer, haulouts on the island are used mainly by harbour seals but in winter grey seals (*Halichoerus grypus*) also use the island. The main component of the diet in summer is sandeels (Ammodytidae, mainly *Ammodytes* spp.), the average size of which in the samples showed a significant increase over the study period. Other species contributing to the diet included cod *Gadus morhua*, and other Gadidae, mackerel *Scomber scombrus*, herring *Clupea harengus* and the octopus *Eledone cirrhosa*. We describe results of analysis of relationships between trends in diet (prey size, prey numbers and overall diet composition) and prey availability, as indicated by large-scale indices of fish abundance, using a generalized additive mixed model approach.

W3-5843

Estimating the population size of Indo-Pacific bottlenose dolphins, Tursiops aduncus, in coastal waters off Jeju Island

Hyun Woo **Kim**[1,2], Zang Geun Kim[1], Seok-Gwan Choi[1] and Yong-Rock An[1]

[1] Cetacean Research Institute, 139-29 Mae Am-dong, Nam-gu, Ulsan, R Korea. E-mail: hwkim@nfrdi.go.kr
[2] Pukyong National University, 599-1 Daeyeon 3-dong, Nam-gu, Busan, Korea

Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) are year-round residents in coastal waters off Jeju Island, Korea. Based on photo-identification data from 2007 to 2009, we examined residency pattern and estimated the population size of dolphins in the area. During the 10 surveys, a total of 8 schools comprising 85 individuals were photographically identified by examining the distinctive nicks and notches on their dorsal fin. Sixty four percent of them were re-sighted more than twice during the surveys. Their population size in the area, estimated by mark-recapture analysis for closed population model, was 105 individuals with a CV of 8.8% (95% CI = 94-130), which indicated that their population size is relatively low compared with the other dolphin populations reported around the world. To ensure the conservation of dolphin populations, long term survey data are required to monitor their population fluctuation and change in age structure.

W3-5862

Understanding the feeding ecology of minke whales, *Balaenoptera acutorostrata*, in Korean Seas using trophic lipid markers

Ah-Ra **Ko**[1,3], Zang Geun Kim[2], Seok-Gwan Choi[2], Kyung-Hoon Shin[1] and Se-Jong Ju[3]

[1] Department of Environmental Marine Science, College of Science and Technology, Hanyang University, Ansan 426-791, R Korea
[2] Cetacean Research Institute,139-29, Mae Am-dong, Nam-gu, Ulsan 680-050, R Korea
[3] Marine Living Resource Research Department, KORDI, Ansan, P.O. Box 29, Seoul, 425-600, R Korea. E-mail: sjju@kordi.re.kr

In order to understand the feeding ecology of minke whales *Balaenoptera acutorostrata* in East Sea/Japan Sea, lipid biomarkers (*e.g.* fatty acids, sterols, compound-specific stable isotope ratio) were analyzed in blubber tissues of by-caught minke whales and their potential preys (*i.e.* anchovy *Engraulis japonica*, krill *Euphausia pacifica*). Lipid contents of minke whale blubber ranged from 68 to 81% of wet weight with a dominance of triacylglycerols (TG) (accounting for 96 to 98% of total lipids). No difference in lipid contents and class compositions was found, but fatty acid (FA) composition was different between the inner (near muscle) and outer layer (from skin to inner) of the blubber. Higher saturated fatty acids (SAFA) were found in the inner layer (22.94 to 25.24% of total fatty acids) than in the outer layer (20.43 to 20.95% of total fatty acids). Polyunsaturated fatty acids (PUFA), especially 22:6(n-3) and 20:5(n-3) known as FA trophic markers, were also found in higher concentrations in the outer layer than in the inner layer, and also appeared in high concentrations in the potential preys analyzed (anchovy and krill). The result of this study confirms that lipid trophic markers combined with compound-specific stable isotope ratio could be a useful chemical tracer to track the feeding history of minke whales.

W3-5886

The diet of gray seals (*Halichoerus grypus*) in United States waters, estimated from hard remains and blubber fatty acids

Kristen **Ampela**

The Graduate Center, The City University of New York, 365 Fifth Ave., New York, NY, 10016-4309, USA. E-mail: krs10a@gmail.com

Considered extinct in the U.S. prior to 1958, today there are more than 7,000 gray seals (*Halichoerus grypus*) in New England. The growing number of seals raises concerns about potential competitive interactions between seals and fisheries. This is the first long-term diet study of gray seals that breed and forage in the U.S. Scat (N = 305), stomach (N = 49), and blubber (N = 45) samples were collected in New England between 1994 and 2008. Hard prey remains and blubber fatty acid profiles were used to estimate 1) diet composition, 2) prey size, 3) diet diversity and 4) regional, temporal and intraspecific variation in diet. Of 34 prey taxa recovered, sand lance (*Ammodytes spp*.) dominated the diet by weight (53.3%) and number (66.3%). Skates (Rajidae) were recovered

most frequently in samples (24.5%). Average length of all prey items was 22.4 cm. Atlantic cod (*Gadus morhua*) comprised only 6.4% of the diet by weight; average length was 31.9 cm. Winter flounder (*Pseudopleuronectes americanus*), also economically important, comprised 19.0% of the diet by weight; average length was 27.4 cm. Scat sampling revealed significant differences in diet diversity and prey consumption between colonies <30km apart, suggesting that gray seals spend a substantial amount of time foraging close inshore. Fatty acid profiles best discriminated seals by age (W-L = 0.27, $F_{25,19} = 2.07$, $p = .054$). Although prey taxa of low economic importance dominated the diet, the size classes and total biomass of winter flounder prey indicated potential conflicts with this fishery.

W3-5921

First record of the Indo-Pacific bottlenose dolphins, *Tursiops aduncus*, in Korean waters, by means of skull morphometry and external morphology

Hyun Woo **Kim**[1,2], Zang Geun Kim[1], Seok-Gwan Choi[1] and Yong-Rock An[1]

[1] Cetacean Research Institute, 139-29 Mae Am-dong, Nam-gu, Ulsan, R Korea. E-mail: hwkim@nfrdi.go.kr
[2] Pukyong National University, 599-1 Daeyeon 3-dong, Nam-gu, Busan, R Korea

The presence of bottlenose dolphins (*Tursiops* sp.) in the coastal area of the Jeju Island, Korea, has been recognized for a long time. However, its taxonomic position was unclear because of the validity of this genus. The genus *Tursiops* has recently been determined to comprise two species: the common bottlenose dolphin (*Tursiops truncatus*) and the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*). To confirm its taxonomic position, skull morphometry of 2 specimens, juvenile and adult, bottlenose dolphins from the Jeju Island were examined. Also external morphological characters of the dolphins distributed in the same area were investigated using the photographs taken. Results from several proportions of cranial characters and ventral spotting of adult dolphins strongly support its identification as Indo-Pacific bottlenose dolphins.

W3-5943

Abundance estimation of minke whales (*Balanoptera acutorostrata*) in the East Sea, using the sighting survey in 2009

Kyum Joon **Park**[1], Seok-Gwan Choi[1], Yong-Rock An[1], Zang Geun Kim[2], Ji Eun Park[1], Hyun Woo Kim[1], Tae-Geon Park[1], Young Ran Lee[1] and Dae-Yeon Moon[1]

[1] Cetacean Research Institute, 139-29 Maeam-dong Nam-gu Ulsan, 680-050, Korea. E-mail : mogas@nfrdi.re.kr
[2] National Fisheries Research and Development Institute, 408-1, Sirang-ri, Gijang-eup, Gijang-gun, Busan, 619-705, R Korea

We conducted a shipboard sighting survey along transect lines in the East Sea (34°18'-38°32'N, 128°09'-130°50'E) from April to May 2009. The top barrel, IO (independence observation) barrel and the top bridge of the research vessel were used as observation sites. There were 41 minke whales (*Balanoptera acutorostrata*) in 36 primary sightings during 1,156 nautical miles of survey effort. Distance and angle of sighted animals from the transect line were recorded to calculate perpendicular distance. Three models (Uniform, Half-normal and Hazard-rate) were used to fit the detection function for minke whales in this survey. The uniform model was selected as the best fit using the AIC criterion (Akaike Information Criterion), and estimated the density of minke whales in the East Sea to be 0.049/n.m. (CV = 24.54%, 95% CI = 0.030-0.081/n.m.). The abundance was estimated to be 1,022 individuals (CV = 24.54%, 95% CI = 620-1,687).

W3-5987

Distribution and abundance of western gray whales off the northeast coast of Sakhalin Island, Russia, 2008

Valeriy A. **Vladimirov**[1], Sergey P. Starodymov[1], Alexey G. Afanasyev-Grigoryev[2] and Vladimir V. Vertyankin[3]

[1] All-Russian Research Institute of Fisheries and Oceanography (VNIRO), 17 V. Krasnosel'skaya St., Moscow, 107140, Russia
E-mail: vladimirov.vniro@gmail.com
[2] A.V. Zhirmunsky Institute of Marine Biology (IBM), FEB RAS, 17 Palchevskogo St., Vladivostok, 690002, Russia
[3] North-East Department of Fisheries Management (SevVostRybVod), 58 Koroleva St., Petropavlovsk-Kamchatskiy, 683049, Russia

Data from systematic shore- and vessel-based distribution surveys conducted off northeast Sakhalin in the summer-to-fall seasons of 2004-2008 indicate the presence of two primary gray-whale feeding areas. The nearshore Piltun feeding area is located adjacent to Piltun Bay and extends over a coastline stretch of about 120-km length from Ekhabi Bay in the north to Chayvo Bay in the south; whales predominantly feed in this area at a distance <5 km from shore in water depths <20m. The deeper Offshore feeding area is located about 35-50 km from shore to the southeast of Chayvo Bay in water depths of 35-60 m.

Comparison of whale distribution data collected in 2004-2008 shows significant variations between years. These variations include a shift in whale distribution from the northern to the southern Piltun feeding area that occurred from about 2004-2007, and an increased use of the Offshore feeding area from 2005-2008. In 2008, the maximum number of whales per survey recorded in the Piltun area decreased by 36% compared to 2007. At the same time, the maximum number of whales per survey recorded in the Offshore area increased by more than a factor of two in 2008 compared to 2007. Whale densities decreased in the northern and southern parts of the Piltun feeding area in 2008 compared to 2004-2007, but stayed comparable to the 2004-2007 results in the central part of the Piltun feeding area (*i.e.*, within about 10-15 km distance from the mouth of the Bay).

W4 BIO Workshop
Marine ecosystem model inter-comparisons (II)

Co-Sponsored by ESSAS

Co-Convenors: Harold P. Batchelder (U.S.A.), Shin-ichi Ito (Japan) and Bernard A. Megrey (U.S.A.)

The objective of the Marine Ecosystem Model Inter-comparison Project (MEMIP) is to compare the performance of various lower trophic level marine ecosystem simulation models at predicting the abundance and distribution of zooplankton functional groups. Models with high performance and broad generality will be priority candidates for examining the state of marine ecosystem's response to future global climate change.

This workshop will be technical, "hands-on", and focus on beginning to parameterize, execute and calibrate various 1-D versions of biogeochemical lower trophic level (LTL) marine ecosystem models. Multiple ecosystem models will be configured to three Pacific Ocean "location testbeds". The 1-D physical forcing for each site will be fixed (*e.g.*, to enforce a common physical environment) so that differences observed among simulations at a single site are due only to differences in ecosystem models. The three testbeds will be selected based on the availability of data sets suitable for this exercise-data for multiple years, good seasonal coverage, and breadth of state variables spanning inorganic nutrients, chlorophyll (or preferably phytoplankton carbon or nitrogen), and zooplankton biomass measures are needed. We plan to apply LTL models to Oyashio locations such as stations along Japan's A line, the middle shelf of the eastern Bering Sea (*i.e.*, at mooring M2), and a shelf station on the Newport line to represent the California Current upwelling system. The models will be used to identify mechanisms that are important controls on the level and variability of secondary production and to bound the levels of uncertainty in model predictions by calculating ensemble statistics. Comparisons of identical ecosystem model formulations (*e.g.*, not tuned to each specific location) at multiple locations will provide information on the spatial-temporal robustness of particular model structures and parameterizations.

Day 1, Saturday, October 24 (9:00-18:00)

9:00 ***Introduction by Convenors***

9:20 **Yvette H. Spitz (Invited)**
Considerations and challenges inherent to the intercomparison of pelagic ecosystem models (W4-5715)

9:50 **Naoki Yoshie, Shin-ichi Ito, Kosei Komatsu, Takahiko Kameda, Tsuneo Ono, Kiyotaka Hidaka, Toru Hasegawa, Akira Kuwata, Miwa Nakamachi, Yuji Okazaki, Takeshi Okunishi, Kazuaki Tadokoro, Hiroaki Saito and Yasuhiro Yamanaka (Invited)**
Comparison of two marine ecosystem models NEMRUO and eNEMURO in the western North Pacific (W4-5908)

10:20 Short discussion

10:30 ***Coffee / tea break***

10:50 **Angelica Peña (Invited)**
Comparing the responses of simple plankton ecosystem models to alternate formulations and increasing complexity (W4-5968)

11:10 Discussion on model comparison methods (testbeds, physical model, evaluation methods)

12:30 ***Lunch***

14:00 Coding for model comparison

15:30 ***Coffee / tea break***

15:50 Coding for model comparison

17:20 Report on today's progress

18:00 ***Day 1 Workshop ends***

Day 2, Sunday, October 25 (9:00-15:30)

9:00 ***Introduction by Convenors***

9:05 Discussion on model results

10:30 ***Coffee / tea break***

10:50 Discussion on model results

12:30 ***Lunch***

14:00 Discussion on future plans and writing report

15:30 ***Workshop ends***

W4 Oral Presentations

24 October, 9:20 (W4-5715), Invited

Considerations and challenges inherent to the intercomparison of pelagic ecosystem models

Yvette H. **Spitz**

Oregon State University, College of Oceanic and Atmospheric Sciences, Corvallis, OR, 97331, USA. E-mail: yvette@coas.oregonstate.edu

Existing ecosystem models are widely divergent in terms of their complexity, formulation and performance. As observationalists are providing an increasing number and diversity of *in situ* data, it is more imperative than ever to evaluate quantitatively the inter-comparison of pelagic ecosystem models. Specific questions that the scientific community need to answer are: 1) which ecosystem structures are most robust? 2) how much complexity is warranted? 3) can models applicable to many diverse ecosystems be developed? An approach to address these questions and the difficulties associated with it will be presented. In general, the availability of observations (including type and frequency of sampling) can hinder a definite answer to these questions. In addition, concentrations estimated from the simple and more complex models might compare well but the main element-flow-pathways might differ among the various models. Simple models might be applicable to various regions at a given time but might not be able to represent inter-annual and decadal changes of the ecosystem structure. These challenges and others will be discussed in relationship to the necessity for a framework of accepted standards for the quantitative evaluation of model selection and performance.

24 October, 9:50 (W4-5908), Invited

Comparison of two marine ecosystem models NEMRUO and eNEMURO in the western North Pacific

Naoki **Yoshie**[1], Shin-ichi Ito[3], Kosei Komatsu[4], Takahiko Kameda[4], Tsuneo Ono[5], Kiyotaka Hidaka[4], Toru Hasegawa[6], Akira Kuwata[3], Miwa Nakamachi[3], Yuji Okazaki[3], Takeshi Okunishi[4], Kazuaki Tadokoro[3], Hiroaki Saito[3] and Yasuhiro Yamanaka[7,8,9]

1 Center for Marine Environmental Studies, Ehime University, 2-5 Bunkyo-cho, Matsuyama 790-8577, Japan
E-mail:nyoshie@sci.ehime-u.ac.jp
2 Ocean Research Institute The University of Tokyo, 1-15-1 Minamidai, Nakano-ku, Tokyo 164-8639, Japan
3 Tohoku National Fisheries Research Institute, Fisheries Research Agency, 3-27-5 Shinhama-cho, Shiogama, 985-0001, Japan
4 National Research Institute of Fisheries Science, Fisheries Research Agency, 2-12-4 Fukuura, Kanazawa-Ku, Yokohama, 236-8648, Japan
5 Hokkaido National Fisheries Research Institute, Fisheries Research Agency, 116 Katsurakoi, Kushiro, 085-0802, Japan
6 Seikai National Fisheries Research Institute, Fisheries Research Agency, 1551-8 Taira-machi, Nagasaki, 851-2213, Japan
7 Graduate School of Environmental Science, Hokkaido University, N10W5 Kita-Ku, Sapporo, 060-0810, Japan
8 Frontier Research Center for Global Change, 3173-25 Showa-machi, Kanazawa-Ku, Yokohama, 236-0001, Japan
9 Japan Science and Technology Agency, Kawaguchi Center Building, 4-1-8 Honcho, Kawaguchi, 332-0012, Japan

We compared two lower trophic level (LTL) marine ecosystem models, NEMURO (North Pacific Ecosystem Model Used for Regional Oceanography, 3N-2P-3Z-4D) and eNEMURO (extended version of NEMURO, 3N-4P-4Z-4D). Because NEMURO, which was developed by the PICES/GLOBEC CCCC Model Task Team, did not include the microbial food web and the realistic phytoplankton temperature dependencies, we extended NEMURO by introducing the microbial food web and dividing diatoms to two compartments according to temperature dependency. We applied a box version of both models with the almost same biological parameters to five different ecological regions in the western North Pacific (subarctic: Oyashio region; subarctic-subtropical transition: Oyashio-Kuroshio transition region; continental slope: the slope water south of Honsyu island; subtropical: an offshore station at 138E-30N; and continental shelf: East China Sea), and compared the models to biogeochemical and ecological data observed at the seasonally repeated monitoring stations in each region. Both models successfully reproduced the seasonal biomass variations of total phytoplankton and net zooplankton and the concentrations of nitrate in all regions, although the concentrations of silicic acid simulated by NEMURO were slightly underestimated in the subtropical and continental shelf regions. The comparison of plankton community structures between the models and data observation showed that NEMURO underestimated small phytoplankton and small zooplankton and overestimated diatoms. The discrepancies between NEMURO and

observation were clearly improved by eNEMURO. The plankton community structures simulated by eNEMURO were more closely matched observational data than those simulated by NEMURO, especially in the subtropical and continental shelf regions.

24 October, 10:50 (W4-5968), Invited

Comparing the responses of simple plankton ecosystem models to alternate formulations and increasing complexity

Angelica **Peña**

Institute of Ocean Sciences, Fisheries and Oceans Canada, P.O. Box 6000, Sidney, BC, V8L 4B2, Canada
E-mail: angelica.pena@pac.dfo-mpo.gc.ca

Demands for marine ecosystem models are shifting toward using biogeochemical and ecological models to predict response to climate change. In the last decades, numerous plankton ecosystem models have been developed to simulate the lower trophic level dynamics of a particular region. These models differ in their formulations and level of complexity (increasing number of functional groups). Adding complexity to an ecosystem model may increase realism but at the cost of increasing the number of parameters that must be specified, thus, decreasing the degree to which it can be constrained by observations. In comparison, simple plankton models have been able to simulate observations in several regions but their response might be limited when employed in predicting potential responses to changes in the environment. Results from simple plankton models, all coupled to a one-dimensional mixed-layer model representation of the NE subarctic Pacific, will be presented to illustrate the effect of model complexity and model formulation on model output. In particular, I will focus on evaluating the sensitivity of a simple plankton model to different formulations of phytoplankton growth and zooplankton grazing, and on comparing the performance of three plankton ecosystem models with varying levels of complexity. The analysis is intended to help understand results from ecosystem model inter-comparison.

W5 FIS Workshop
Understanding the links between fishing technology, bycatch, marine ecosystems and ecosystem-based management

Co-Convenors: Heui Chun An (Korea), Kaoru Fujita (Japan) and Craig Rose (U.S.A.)

The methods and gears used to capture fish affect how many unwanted fish are captured (bycatch) and can disrupt other ecosystem components. Bycatch and discards significantly impede the sustainable use of living marine resources that are captured by commercial fisheries. To minimize unintended impacts on the environment, commercial fisheries should strive to improve selectivity to reduce the bycatch and discards of non-target species, as well as undersized commercial species. Research is exploring other effects of fishing gears on ecosystems, such as habitat damage and ghost fishing of derelict fishing gear, and developing new technologies to minimize such unintended impacts. This workshop will focus on the linkages between fishing technologies, ecosystems and ecosystem-based management, as well as on recent methodologies to reduce unintended effects of fishing. Particular emphasis will be placed on studies that have changed commercial fishing practices.

Friday, October 23 (9:00-12:45)

9:00 ***Introduction by Convenors***

9:05 **Tatsuro Matsuoka (Invited)**
Negative impacts in capture fisheries: Bycatch, discards, derelict fishing gear, and ghost fishing (W5-5995)

9:45 **Craig S. Rose**
Fishing gear technology to reduce bycatch and other ecosystem effects of Alaska trawl fisheries: Cooperative research with the fishing industry (W5-5763)

10:05 **Jong-Hun Na, Chul-Woong Oh and Sung-Tae Kim**
Variations in species composition, biomass, and density in shrimp trawl bycatch across seasons and tidal phases in southern Korean waters: Developing a fisheries risk management approach (W5-5679)

10:25 **Maria Rebecca A. Campos**
Linking fishing technology, bycatch, and marine ecosystems in Philippine fisheries policies (W5-5508)

10:45 ***Coffee / tea break***

11:05 **Heui Chun An, Bong Jin Cha, Seong Hun Kim, Chang-Doo Park, Kyoung-Hoon Lee, Seong-Wook Park and Jong Keun Shin**
Modification of white-spotted conger eel *Conger myriaster* net trap for reducing bycatch of non-target species (W5-5610)

11:25 **Réka Domokos**
Environmental effects on forage and longline fishery performance for albacore (*Thunnus alalunga*) in the American Samoa Exclusive Economic Zone (W5-5570)

11:45 **Yonghae Kim and Daesung Whang**
The effect of netting twine contrast on escape of juvenile sea bream in model trawl cod-ends (W5-5930)

12:05 **Kaoru Fujita, Yoshiki Matsushita and Seizo Hasegawa**
Development of bycatch reduction trawl nets to have benefits for fishermen (W5-5875)

12:25 Discussion and Recommendations

12:45 ***Workshop ends***

W5 Poster

W5-5982 **Ji Hyun Lee, Wan Ki Kim, M. Sidharthan, Sang Mok Jung, Hyun Woung Shin and Chae Sung Lee**

Comparison of benthic assemblages and associated fish communities on two artificial reef types deployed along the Pohang coast, South Korea

W5 Oral Presentations

23 October, 9:05 (W5-5995), Invited

Negative impacts in capture fisheries: Bycatch, discards, derelict fishing gear, and ghost fishing

Tatsuro **Matsuoka**

Faculty of Fisheries, Kagoshima University, 4-50-20 Shimoarata, 890-0056, Japan. E-mail: matsuoka@fish.kagoshima-u.ac.jp

The Code of Conduct for Responsible Fisheries urges the immediate needs to change the current fishing practices which have caused negative impacts to fisheries resources and environment, *i.e.* bycatch, discards, derelict fishing gear, and ghost fishing. This presentation focuses on unwanted mortality of aquatic organisms through fishing activities and reviews the issues from viewpoints of the capture processes that induce the problems, evaluation of mortality and approaches toward technical solutions. Historical development of bycatch and discard researches, estimation of the global amount of discards, bycatch-reducing gear designs and recent interests on the consequences of bycatch, *e.g.* survival of excluded and discarded organisms are discussed. Difficulties dealing with the issue in tropical and Asian waters are also discussed. The mechanisms causing mortality for derelict fishing gear observed through field research and the process of decreasing the ghost fishing function in terms of mortality and duration are presented. A model for macro-assessment of the ghost-fishing mortality in a fishing sector is proposed. The estimation of ghost fishing (GF) mortality N_m as; $N_m = E_d \cdot m$, where E_d: the number of fishing gear lost/abandoned in a unit time period in a sector and m: the number of GF mortality per gear is equivalent to the usual methodology for estimation of fishing mortality as CPUE multiplied by fishing efforts. International research cooperation on derelict fishing gear is recommended on the basis of the consequences of derelict fishing gear from external origins of gear losses and multi-lateral conflicts.

23 October, 9:45 (W5-5763)

Fishing gear technology to reduce bycatch and other ecosystem effects of Alaska trawl fisheries: Cooperative research with the fishing industry

Craig S. **Rose**

Alaska Fisheries Science Center, NMFS/NOAA, 7600 Sand Point Way NE, Seattle, WA, 98115, USA. E-mail: Craig.Rose@noaa.gov

The Conservation Engineering Project at the Alaska Fisheries Science Center has worked with the Alaska fishing industry to develop technical modifications to fishing gear and methods to reduce bycatch and other ecosystem effects. Results of several projects will be presented, demonstrating a range of development phases and collaborative arrangements. These include: 1) Salmon excluders for pollock trawls: Initial designs, based on direct behavior observations, allowed escape rates above 40% with little pollock loss, but resulted in net damage with high catch rates of pollock or jellyfish. Recent modifications have eliminated damage, but reduced escape rates. 2) Halibut excluders for cod and flatfish trawls: Both kinds of halibut excluders were based on size and shape differences between halibut and the targeted cod or flatfish. Both achieve substantial bycatch reductions and are in current use. 3) Trawl sweep lifters to protect sessile seafloor animals: Adding devices that lift trawl sweeps 5 to 10 cm above the seafloor reduced damage and mortality to structure-forming sessile animals and crabs, with little or no reduction in catch rates of flatfish, pollock or cod. Collaboration with the fishing industry has benefitted each of these projects. Implementation of bycatch reduction devices has been driven by direct bycatch limits, while the sweep modification is being considered as a requirement for Bering Sea flatfish trawlers.

23 October, 10:05 (W5-5679)

Variations in species composition, biomass, and density in shrimp trawl bycatch across seasons and tidal phases in southern Korean waters: Developing a fisheries risk management approach

Jong-Hun **Na**[1], Chul-Woong Oh[2] and Sung-Tae Kim[3]

[1] Division of Marine Production System Management, Pukyong National University, Busan, 608-737, R Korea
E-mail: jhna@pknu.ac.kr
[2] Department of Marine Biology, Pukyong National University, Busan, 608-737, R Korea
[3] National Fisheries Research and Development Institute, Busan, 619-902, R Korea

We quantitatively investigated compositions of fish and invertebrate bycatch in Korean shrimp fisheries. We sampled shrimp trawl bycatch from 48 commercial trawls over 1 year. These samples contained 108 taxa from 50 families, with 60 fish taxa contributing 51.2% of the total biomass and 48 invertebrate taxa 48.8%. However, 86.3% of the total individual organism density comprised invertebrates, while individual fishes made up the remainder. Within the bycatch, two fish species varied in population size structure by season, suggesting recruitment is seasonal in these taxa. Overall general catch characteristics (total bycatch biomass and organism density) varied significantly by season and tide, and a significant interaction effect was observed (season × tide) on total density, but not on total biomass. The data collected will be used in designing a program of long-term bycatch monitoring.

23 October, 10:25 (W5-5508)

Linking fishing technology, bycatch, and marine ecosystems in Philippine fisheries policies

Maria Rebecca A. **Campos**

Southeast Asia Regional Center for Graduate Study and Research in Agriculture and University of the Philippines-Open University, College, Laguna, 4031, Philippines. E-mail: cmaribec@yahoo.com

Although the Philippines is surrounded with many fishing grounds, most fishermen live in poverty, and their plight is getting worse, not better. Current fisheries policies for the area have failed to improve the situation but no research has been done to find out why. This report uses a model to simulate the effects of changes in the enforcement levels of current policies on fishing technology, bycatch and marine ecosystems. Investments of the government on different levels of enforcement were assessed using benefit cost analysis. The report assesses the effects of enforcing current fisheries policies more stringently. The situation would be transformed into one in which large and perhaps increasing numbers of people would continue to fish, expending larger amounts of effort to comply with various gear restrictions but, in all likelihood, harvesting no fewer fish. Because of overfishing, catch per unit effort and marginal productivity would decrease. Any additional fishing effort in the bay will result in a decrease in the average catch of all fishermen. Enforcement of current policies will not address the underlying problems of open access and the overfishing it leads to.

23 October, 11:05 (W5-5610)

Modification of white-spotted conger eel *Conger myriaster* net trap for reducing bycatch of non-target species

Heui Chun An, Bong Jin Cha, Seong Hun **Kim**, Chang-Doo Park, Kyoung-Hoon Lee, Seong-Wook Park and Jong Keun Shin

National Fisheries Research and Development Institute, 152-1 Haeanro, Gijang-Up, Gijang-Gun Busan, 619-902, R Korea
E-mail: anhc1@nfrdi.go.kr

Using net traps with mesh sizes under 35 mm has been prohibited to prevent and reduce bycatch of undersized fish in Korean regulations. However, for conger eel has a unique shape with a long length and short body height, compared to other marine species. This could cause the loss of bait and the lowering of catch rates with large mesh sizes. For this reason, fishermen targeting conger eel with traps have been requesting permission to use smaller mesh sizes. Under this background, we carried out experiments to estimate catch efficiency and bycatch rates by mesh size and length of entrance funnel. Based on the results of these experiments, we proposed that the mesh size of net traps for conger eel could be changed from 35 mm to 22 mm with a condition of using an

entrance funnel bigger than 140 mm circumference. However, fishermen encountered some problems with the modified traps. They found the entrance funnels of modified traps to be too narrow to put bait into the trap or to take captured eels out of the trap. We carried out a second field experiment to estimate an optimum circumference for the entrance funnels of net traps for conger eel.

23 October, 11:25 (W5-5570)

Environmental effects on forage and longline fishery performance for albacore (*Thunnus alalunga*) in the American Samoa Exclusive Economic Zone

Réka **Domokos**

Pacific Islands Fisheries Science Center, NMFS, NOAA, 2570 Dole St. Honolulu, HI, 96822, USA. E-mail: reka.domokos@noaa.gov

The South Equatorial Counter Current (SECC) strongly influences the American Samoa Exclusive Economic Zone (EEZ) and changes strength on a seasonal and ENSO cycle. Strong SECC is associated with a predominantly anticyclonic eddy field as well as increased micronekton biomass and catch-per-unit-effort (CPUE) for albacore tuna, the economically important target species of the local longline fishery. Strong SECC carries chlorophyll *a*-rich waters from upwelling regions at the north coast of New Guinea towards the EEZ, most likely resulting in the observed increase in micronekton biomass, forage for albacore. Relatively stable anticyclonic eddies show a further increase in micronekton biomass, apparently advected in from neighboring SECC waters. The presence of forage presumably concentrates albacore, thus resulting in the observed increase in CPUE. High shear regions of neither anticyclonic nor cyclonic eddies correlate with increased micronekton biomass. Areas characterized by South Equatorial Current (SEC) waters correspond to areas with the lowest micronekton biomass and the highest number of aggregative structures, which are most likely small pelagic fish shoals. Micronekton composition in SEC waters differs from that in the SECC. During El Niños, the seasonal signals at the north shore of New Guinea and in the SECC are exceptionally strong and correspond to higher albacore CPUE in the EEZ. Results suggest that the strength of upwelling and the resulting increase in chlorophyll *a* at New Guinea, as well as the Southern Oscillation Index, could be used to predict the performance of the local longline fishery for albacore tuna in the American Samoa EEZ.

23 October, 11:45 (W5-5930)

The effect of netting twine contrast on escape of juvenile sea bream in model trawl cod-ends

Yonghae **Kim** and Daesung Whang

College of Marine Science, Gyeongsang University, 445 Inpyeongdong, Tongyoung, 650-160, R Korea. E-mail: yonghae@gnu.kr

The by-catch of undersized juvenile fish has long occurred and caused serious problems in commercial fisheries although many methods, such as square-mesh window, flexible grid systems *etc.*, have been developed to mitigate the escape of small fish. The main reason for this by-catch of juvenile fish from a behavioral point of view is considered specific optomotor response rather than erratic escape response. The optomotor responses have generally been observed in response to clearly visible objects in water flow. Visual stimulus of the nets, affecting fishing selectivity, could be varied by twine diameter, color, materials *etc.* under different light conditions and visual geometries. In this study two cylindrical model cod-ends (reef knots mesh size 43mm, diameter 40cm and length 130cm by 80% hanging ratio) were made of high-contrast,dark brown PE netting twine (diameter 0.4mm) and low contrast, light blue PA monofilament twine (diameter 0.4mm). The each model cod-end filled with 200 juvenile sea bream (mean body length 6cm) was set in the water channel (width 80cm, depth 80cm) of light blue circular tank under flow speed 0.90m/s for 30 min. The light conditions were relatively bright 100lx, dim 1lx and dark. The resulting retention of juvenile sea bream was 15-35% lower in the low contrast cod-end with PA monofilament than with the high contrast netting of dark brown PE twine under bright and dim light conditions while no difference was observed under dark conditions. Therefore low contrast of nets in the cod-end could help to reduce juvenile by-catch by disturbing the orderly optomotor response.

23 October, 12:05 (W5-5875)

Development of bycatch reduction trawl nets to have benefits for fishermen

Kaoru **Fujita**[1], Yoshiki Matsushita[2] and Seizo Hasegawa[1]

[1] National Research Institute of Fisheries Engineering, Fishery Research Agency, 7620-7 Hasaki, Kamisu, Ibaraki, 314-0408, Japan E-mail: duke@fra.affrc.go.jp
[2] Faculty of Fisheries, Nagasaki University, 1-14 Bunkyo, Nagasaki, Nagasaki, 852-8521, Japan

We developed two types of trawl net which reduce bycatch and have new benefits for coastal fishermen. One is a selective trawl net for a multi-species fishery which has a two-level codend with the Bycatch Exclusion Window (BEW) at the top panel of the upper-bag. Organisms that entered trawl net were separated depending on species-specific behaviour in the trawl net. Small fish could escape through the BEW while large fish, small shrimp and squid were caught in the upper-bag. Unnecessary portions of the catch, such as starfish and shells, passed into the lower-bag. Since this selective trawl net separated the catches into the upper-bag or the lower-bag, the time for sorting was reduced and the quality of the catches was improved. These benefits promoted the introduction of this selective trawl net. The success of the development of this selective fishing gear motivated fishermen to practice bycatch reduction activities. The other trawl net is designed to target off-bottom species and to reduce catch of demersal species for the conservation of demersal species and their habitats. The net has a higher mouth opening and narrower sweeping width during towing than the conventional net. This net caught more off-bottom species than the conventional net with very little catch of demersal fish. Introduction of trawl nets on a voluntary basis requires a good balance between bycatch reduction and commercial performances.

W5 Poster

W5-5982

Comparison of benthic assemblages and associated fish communities on two artificial reef types deployed along the Pohang coast, South Korea

Ji Hyun **Lee**[1,2], Wan Ki Kim[1], M. Sidharthan[2], Sang Mok Jung[2], Hyun Woung Shin[2] and Chae Sung Lee[1]

[1] Aquaculture Research Team, East Sea Fisheries Research Institute, National Fisheries Research and Development Institute, 30-6 Dongdeok-Ri, Gangneung, Gangwon-Do, 210 861, R Korea. E-mail: pander27@nfrdi.go.kr
[2] Department of Marine Biotechnology, Soonchunhyang University, 646 Shinchang-Myun, Eupnae-Ri, Asan City, 336 745, R Korea

Several types of artificial reef modules are deployed along the Korean coast to support the sustainable growth and development of benthic communities and associated fish aggregations. Many of these artificial reef modules are not functioning properly due to climatic changes and anthropogenic activities. In view of this, performance of two artificial reef types (dice and ship), deployed in 2002 along the Guriang-po, Pohang coast, were investigated from 2007-2009. Quadrat samples were collected at top, middle and bottom surfaces on each artificial reef module using SCUBA. The total biomass of benthic assemblages consisted of dominant species belonging to the classes stelleroidea, echinoidea and holothuroidea (echinoderms: 33.4%); ascidiacea (chordates: 31.8%) and bivalvia, gastropoda and polyplacophora (molluscs: 23.9 %), respectively. The dominant benthic species, by mean biomass, encountered on artificial reefs were: *Stichopus japonicus* (487.330 g m^{-2}) and *Halocynthia roretzi* (220.670 g m^{-2}) from the ship type and *Herdmania mirabilis* (236.170 g m^{-2}) and *Hemicentrotus pulcherrimus* (145.170 g m^{-2}) from the dice type. CPUE estimates showed a predominant aggregation of *Alcichthys alcicornis*, *Sebastes schlegeli*, *Hexagrammos otakii* and *Lophius litulon* along the artificial reefs. The species diversity and biomass of benthic assemblages on ship-type artificial reefs were found to be two- to three-fold higher than dice-type. After seven years, fish aggregations in both dice and ship type artificial reef modules significantly increased ($P<0.05$) when compared to adjacent natural reef areas. Results demonstrated the structural advantages and effective performance of ship and dice-type artificial reefs for fish aggregation in Pohang coast.

W6 MEQ Workshop and a Laboratory Demonstration Review of selected harmful algae in the PICES Region: V. Cyst forming HAB species and HAB-S Meeting

Co-Convenors: Changkyu Lee (Korea) and Charles Trick (Canada)

Analogous to the seeds of terrestrial plants, phytoplankton cysts are the hardy resting forms that allow phytoplankton (usually flagellates) to survive during extreme environmental conditions. These cysts fall out of the water column into sediments often after large blooms, thereby forming seed beds. Characterization of the distribution of seed beds in coastal waters can assist with forecasting the intensity of HAB events. However, proper identification is often difficult as many cysts can look alike. This workshop will focus on new methods for identification of cysts as well as findings on their ecology and physiology. Presentations are encouraged on known distributions of cysts in coastal waters (cyst mapping), and studies on their ecophysiology.

Saturday, October 24 (9:00-12:30) , Workshop 6 Presentations

9:00 ***Introduction by Convenors***

9:10 **Kazumi Matsuoka (Invited)**
Modern dinoflagellate cyst study (W6-5776)

9:40 **Ruixiang Li, Jun Pan, Yan Li and Ping Sun**
Distribution of dinoflagellate cysts in surface sediments in the Yellow Sea in autumn (W6-5694)

10:00 **Tatiana V. Morozova and Tatiana Yu. Orlova**
Resting stages of HAB species in recent marine sediments from Peter the Great Bay, Sea of Japan (East Sea) (W6-5531)

10:20 **Hyeon Ho Shin, Yang Ho Yoon and Kazumi Matsuoka**
Dinoflagellate cyst assemblages as an indicator of changed nutrient levels in Korean and Japanese coastal areas (W6-5737)

10:40 ***Coffee / tea break***

11:00 **Donald M. Anderson, B.A. Keafer, K. Norton, D.J. McGillicuddy, R. He, C.H. Pilskaln, D. Couture and J. Martin**
Toxic blooms of *Alexandrium fundyense* in the Gulf of Maine: The role of cysts in population dynamics and long-term patterns of shellfish toxicity (W6-5892)

11:20 **Ichiro Imai, Shigeru Itakura and Mineo Yamaguchi**
Cyst dynamics and occurrences of red tides of *Heterosigma akashiwo* and *Chattonella* spp. in temperate coastal waters (W6-5781)

11:40 **Ken-ichiro Ishii, Mitsunori Iwataki, Kazumi Matsuoka and Ichiro Imai**
Species identification of resting spores of *Chaetoceros* (Bacillariophyceae) (W6-5786)

12:00 Summary and outcome

12:30 ***Workshop ends***

Sunday, October 25 (9:00-18:00), HAB-S Meeting Presentations

9:00 **Vera Trainer and Hak-Gyoon Kim**
Welcome, goals of HAB Section meeting

Country Reports (2008-09) and HAE-DAT (year 2004) reports

9:10 **Korea (Yangsoon Kang)**

9:20 **Japan (Shigeru Itakura)**

9:30 **China (Jinhui Wang)**

9:45 **Canada (Charles Trick)**

10:00 **U.S.A. (Vera L. Trainer)**

10:15 **Tatiana Yu. Orlova**
Current situation and perspective for HABs monitoring on the Russian Pacific coast (HAB-5532)

10:30 ***Coffee / tea break***

11:00 **Mingyuan Zhu and Zongling Wang**
The study on the occurrence of green tide in Yellow Sea in 2009 (HAB-5708)

11:15 **Donald Anderson**
Report on ICES HAB working group and potential areas of collaboration

11:45 Discussion of future workshops, special sessions, special PICES report on HAB species

12:30 ***Lunch***

14:00 **Takafumi Yoshida**
Integrated harmful algal bloom website demonstration

14:20 **Monica Lion**
The joint Harmful Algal Bloom Programme and International Oceanographic Data and Information Exchange Harmful Algae Information System: An update

14:40 **Vera L. Trainer**
PICES Seafood Safety Project

15:00 **William P. Cochlan**
Report on GEOHAB Open Science Meeting on HABs and Eutrophication

15:20 Discussion of afternoon presentations

15:30 ***Coffee / tea break***

16:00 **John K. Keesing, Dongyan Liu, Qianguo Xing, Ping Shi and Peter Fearns**
Recurrent large scale macroalgal blooms in the Yellow Sea (HAB-6015)

16:20 Final discussion and assistance in entering year 2004 data into HAE-DAT

18:00 ***Meeting ends***

W6 Oral Presentations

24 October, 9:10 (W6-5776), Invited

Modern dinoflagellate cyst study

Kazumi **Matsuoka**

Institute for East China Sea Research, Nagasaki University, 1-14 Bunkyo-machi, Nagasaki, 852-8521, Japan
E-mail: kazu-mtk@nagasaki-u.ac.jp

Some phytoplankton, particularly coastal inhabitants such as diatoms, dinoflagellates, prasinophytes, raphidophytes , usually produce resting cells in their life-cycle. These resting cells are referred to differently (*i.e.* resting cyst or planozygote for dinoflagellates, resting cyst for raphydophytes, phycoma for prasinophytes, resting cell and/or resting spore for diatoms) according to cyst formation processes. Resting cells can survive in harsh environments and stay in surface of sediments for certain periods of quiescence and dormancy, which induce simultaneous germination in response to specific environmental conditions. The eco-physiological significances of these resting cells can be summarized as follows: 1. Biogeographical distribution of harmful species; 2. Identification of seed beds of harmful species; 3. Population dynamics of harmful species recorded in sediments; 4. Artificial introduction of harmful species; 5. Expansion of timing of harmful species; and 6. Living cysts as "seed bank" of harmful species. Since methodology, identification, classification, ecology and physiology of these resting cysts can provide basic knowledge for the above-mentioned subjects related with HAB events, several case studies using modern dinoflagellate cysts such as the biogeographical distribution of *Pyrodinium bahamense*, the possibility of artificial introduction of *Gymnodinium catenatum* into Japan, the process length of *Lingulodinium polyedrum* as salinity proxy, the eutrophication signal suggested by dinoflagellate cysts records in sediments, and the seasonality of encystment reveled through sediment trap experiments, and other topics, are introduced.

24 October, 9:40 (W6-5694)

Distribution of dinoflagellate cysts in surface sediments in the Yellow Sea in autumn

Ruixiang **Li**[1,2], Jun Pan[1,2], Yan Li[1,2] and Ping Sun[1,2]

[1] First Institute of Oceanography, SOA, Qingdao, 266061, PR China. E-mail: liruixiang@fio.org.cn
[2] Key Lab of Science and Engineering for Marine Ecological Environment, SOA, Qingdao, 266061, PR China

The dinoflagellate cysts in surface sediment was investigated at 22 stations in Yellow Sea in October 2007. Forty cyst species were identified, covering 14 genera. The abundance of cysts varied from 10 cysts/cm^3 to 519 cysts/cm^3, with an average of 107.68 cysts /cm^3. Cyst abundances increased from north to south in investigated area. The highest abundance was recorded at the north of Changjiang river estuary (32.3333ºE,122.6181ºN). *Scrippsiella trochoidea, Alexandrium* sp. and *Gonyaulax* sp. were the dominant cyst species in surface sediments. In addition, *Gonyaulax* sp. was the dominant cyst species in the cold water mass of central Yellow Sea (101 cysts /cm^3). Cysts of toxic dinoflagellates are distributed widely in the surface of sediment.

24 October, 10:00 (W6-5531)

Resting stages of HAB species in recent marine sediments from Peter the Great Bay, Sea of Japan (East Sea)

Tatiana V. **Morozova** and Tatiana Yu. Orlova

A.V. Zhirmunsky Institute of Marine Biology (IBM), FEB RAS, 17 Palchevskogo St., Vladivostok, 690002, Russia
E-mail: tmorozova@imb.dvo.ru

Qualitative and quantitative composition of resting stages of planktonic microalgae in recent marine sediments of Peter the Great Bay (Sea of Japan) were researched. Surface sediments were collected from 31 stations in 2000-2007. A total of sixty one types of resting stages represented by dinoflagellate (47 species) and raphidophyte (1) cysts and diatom spores and resting cells (13) were recorded. Cysts and resting cells of eight potentially toxic species and bloom-forming species were found in surface sediments: *Alexandrium tamarense, Alexandrium*

cf. *minutum, Alexandrium* sp., *Cochlodinium* cf. *polykrikoides, Gymnodinium* cf. *catenatum, P. reticulatum, Heterosigma* cf. *akashiwo*, and *Pseudo-nitzschia* sp. Their total density reached 4690 cells/cm^3. Cysts of species of the genus *Alexandrium* (PSP-toxin producers) were widespread in the surface sediments of the investigated area; their total density varied from 0 to 994 cells/cm^3. In some place *Gymnodinium* cf. *catenatum* cysts were found with densities 14-30 cells/cm^3. Cyst density of the species *P. reticulatum* (yessotoxin producer) reached 126 cells/cm^3. Furthermore, resting cells of the diatom *Pseudo-nitzschia* sp. (potential producer of domoic acid) were found. Their density varied from 0 to 44 cells/cm^3. In general cyst density of the raphidophyte *Heterosigma* cf. *akashiwo* (bloom-forming species) did not exceed 70 cells/cm^3; however this species was dominant at the one station (4676 cells/cm^3). Cysts of *Cochlodinium* cf. *polykrikoides* were found at some stations with densities below 45 cells/cm^3. Due to the great species diversity of microalgae resting stages and presence of HAB species ones, regular monitoring of marine sediments is a necessity.

24 October, 10:20 (W6-5737)

Dinoflagellate cyst assemblages as an indicator of changed nutrient levels in Korean and Japanese coastal areas

Hyeon Ho **Shin**[1], Yang Ho Yoon[1] and Kazumi Matsuoka[2]

[1] Faculty of Marine Technology, Chonnam National University, San 96-1, Dundeok-dong, Yeosu 550-749, R Korea
E-mail: shh961121@hotmail.com
[2] Institute for East China Sea Research, Nagasaki University, 1551-7 Taira-machi, Nagasaki, 851-2213, Japan

The relationship between dinoflagellate cysts and environmental conditions has been well documented around the world. In addition, paleo-environmental studies using dinoflagellate cysts have become increasingly popular during the last 30 years, especially studies on eutrophic and industrially polluted areas. However, the relationship between dinoflagellate cyst assemblages and environmental conditions has yet to be fully understood. This study aims to reconstruct the enhanced nutrient levels in Gamak Bay of Korea and Ariake Bay of Japan for the past several decades based on integration of literatures relating to dinoflagellate cysts as indicator of increased levels of nutrients. To examine the dinoflagellate cysts records in relation to changes of nutrient levels, collected three sediment cores were analyzed. In Gamak Bay, the dinoflagellate cyst assemblages were characterized by high proportions of heterotrophic cysts such as *Brigantedinium* spp., *Protoperidinium americanum* and *Polykrikos* cysts, which suggested that nutrients levels in Gamak Bay may have already been increased before 1970s, and then enhanced to hypertrophic condition in the 1990s. In contrast, the dinoflagellate cyst assemblages in Ariake Bay were characterized by high relative abundances of autotrophic *L. machaerophorum* and *Spiniferites* spp., which suggested that the nutrient level in Ariake Bay has increased since the mid-1960s and then might be enhanced to hypertrophic condition in the mid-1980s. Dinoflagellate cyst assemblages reflecting environmental changes were different between the two bays due to different mechanisms of nutrient enrichment. This suggests that the indicators of nutrient levels encoded in dinoflagellate cyst assemblages may vary with environmental characteristics in a given study area.

24 October, 11:00 (W6-5892)

Toxic blooms of *Alexandrium fundyense* in the Gulf of Maine: The role of cysts in population dynamics and long-term patterns of shellfish toxicity

Donald M. **Anderson**, B.A. Keafer, K. Norton, D.J. McGillicuddy, R. He, C.H. Pilskaln, D. Couture and J. Martin

Department of Biology, Woods Hole Oceanographic Institution, MS 32, 266 Woods Hole Rd., Woods Hole, 02543-1049, USA

Resting cysts play important roles in bloom initiation, termination, and species dispersal for many harmful algal bloom (HAB species). Here we present the results of six mapping surveys for living *Alexandrium fundyense* cysts in the Gulf of Maine, each covering hundreds of km in the alongshore direction, and 50 – 100 km in the offshore. The overall pattern is one of large interannual variability, with an apparent increase in recent years. Hindcasting studies using a physical-biological numerical model demonstrate that major cyst deposition or accumulation events were the dominant factors leading to massive *A. fundyense* bloom in the western GOM and southern New England in 2005 and again in 2008, and that cyst abundance in Gulf of Maine bottom sediments can be a first-order predictor of the magnitude of the resulting regional bloom. Monitoring of the regional abundance of cysts may thus hold the key to interannual forecasts of *A. fundyense* bloom severity in this region.

This presentation will discuss these interannual changes in the context of the blooms that occurred before and after the mapping efforts and the temporal trends in PSP toxicity in the region over the last several decades as well. Evidence will be presented in support of the hypothesis that we have entered a "new era" that is likely to have sustained and significant toxic blooms in the coming years to decades. A cyst seedbed-based conceptual model will be presented that is consistent with observed patterns of interannual to decadal variability in the severity of blooms and shellfish toxicity in the Gulf of Maine.

24 October, 11:20 (W6-5781)

Cyst dynamics and occurrences of red tides of *Heterosigma akashiwo* and *Chattonella* spp. in temperate coastal waters

Ichiro **Imai**[1], Shigeru Itakura[2] and Mineo Yamaguchi[3]

[1] Division of Marine Bioresource and Environmental Science, Graduate School of Fisheries Sciences, Hokkaido University, 3-1-1 Minatocho, Hakodate, Hokkaido, 041-8611, Japan. E-mail: imai1ro@fish.hokudai.ac.jp
[2] Fisheries Agency, Kasumigaseki, Chiyoda-ku, Tokyo 100-8907, Japan
[3] National Research Institute of Fisheries and Environment of Inland Sea, FRA, Hatsukaichi, Hiroshima, 739-0452, Japan

Marine raphidophyte species such as *Heterosigma akashiwo* and *Chattonella* spp. (*C. antiqua*, *C. marina* and *C. ovata*) have a cyst stage in their life cycles and these cysts play an important role in initiating blooms in coastal waters. The cysts settle to the sea bottom to overwinter and thereby ensure the persistent existence in the same area, and the germination of cysts provides the inoculum for blooms to overlying waters. Cyst dynamics and bloom occurrences in the Seto Inland Sea of Japan were investigated for these raphidophyte species. In the case of *Chattonella*, a small portion of cyst populations in bottom sediments actually germinate and the growth of the resulting vegetative populations holds the key to subsequent development to the red tides. *Chattonella* spp. adopt the inoculation strategy of "long period germination", which allows *Chattonella* more chances for the population developments during summer. Abundant cyst deposition actually occurred during the red tide period. In case of *Heterosigma akashiwo*, blooms occur in early summer with a great regularity, suggesting an important role of cysts in sediments as seed populations. Relatively small portion of cyst populations appear to germinate in the field, and develop to red tides by the growth of vegetative cell populations. Cysts are also abundantly deposited to sediments after the peak of bloom, and have mandatory dormant period of around one week. The life cycle strategies of raphidophytes thus well adapt to shallow coastal waters in temperate areas such as the Seto Inland Sea.

24 October, 11:40 (W6-5786)

Species identification of resting spores of *Chaetoceros* (Bacillariophyceae)

Ken-ichiro **Ishii**[1], Mitsunori Iwataki[2], Kazumi Matsuoka[2] and Ichiro Imai[1,3]

[1] Laboratory of Marine Environmental Microbiology, Division of Applied Biosciences, Graduate School of Agriculture, Kyoto University, Kitashirakawa - Oiwakecho, Sakyoku, Kyoto, 606-8502, Japan. E-mail: ken1ro@kais.kyoto-u.ac.jp
[2] Institute for East China Sea Research, Nagasaki University, Nagasaki, 852-8521, Japan
[3] Present address: Plankton Laboratory, Division of Marine Bioresource and Environmental Science, Graduate School of Fisheries Sciences, Hokkaido University, Hakodate, Hokkaido, 041-8611, Japan

Diatoms are excellent competitors for dinoflagellates and raphidophytes, and occasionally prevent occurrences of harmful flagellate bloom in costal ecosystems. On the other hand, diatoms give fishery damage to farmed *Porphyra* thalli by bleaching in Japanese costal waters. Many diatom species are known to form resting stage cells as survival strategies for unfavorable growth conditions, and they play an important role in initiating diatom blooms. The diatom genus *Chaetoceros* is composed of more than 200 extant species, and many species of *Chaetoceros* are known to form resting spores, which are also important for bloom dynamics. Currently morphological information on *Chaetoceros* vegetative cell, and the identification standard has well been established. However, the level of morphological information has been limited and unfilled about resting spore of modern *Chaetoceros* species. In this study, we examined the morphology of *Chaetoceros* resting spores in details based on combination of primary valve, mantle and secondary valve. Morphological characteristics required to establish an identification standard for resting spores of the species of genus *Chaetoceros* were discussed on the basis of fossil resting spore identification. We could identify 18 species of genus *Chaetoceros* by examining resting spores using a normal light microscope, and here propose a flow diagram for modern species identification of this genus.

HAB Section Meeting Oral Presentations

25 October, 10:15 (HAB-5532)

Current situation and perspective for HABs monitoring on the Russian Pacific coast

Tatiana Yu. **Orlova**

A.V. Zhirmunsky Institute of Marine Biology, FEB RAS, 17 Palchevskogo St., Vladivostok, 690041, Russia. E-mail: torlova@whoi.edu

Current situation and perspective for HABs monitoring on the Russian Pacific coast are presented. HABs monitoring program was conducted since 1993. The objectives of monitoring program were: to estimate the pre-existing normal (baseline) conditions and their variability, monitor HAB species, tracking the blooms, early warning of potentially harmful and toxic species, to document ecological harm or dysfunction. Observations show that there has been an apparent increase in the frequency and intensity of harmful algae blooms during the last two decades in the Russian coastal waters. The appearance of new, uncommon for these area potentially toxic algae, were found (*Prorocentrum*, *Cochlodinium*, *Ostreopsis*). The following trends in phytoplankton community were revealed: changes in the dominant species, total density and biomass increased, the density of the non-diatom component of the phytoplankton increased during the summer bloom. For solving the problem of biological safety of the Russian marine waters, the Center of Monitoring of HABs and Biotoxins was established in September 2007 in the Institute of Marine Biology FEB RAS. The DSP, ASP and PSP toxins were analyzed in the tissues of mollusk, sea water samples and cultures of potentially toxic algae by the immunoassay method ELISA. The perspectives for HABs monitoring in Russian waters are to assess actual or potential anthropogenic effects on HAB events, such as aquaculture or industrial activities or the introduction of novel species through discharge of ballast water. The national priority to cope with HABs is prevention of HABs through obligatory monitoring and proper arrangement of aquaculture strategy.

25 October, 11:00 (HAB-5708)

The study on the occurrence of green tide in Yellow Sea in 2009

Mingyuan **Zhu** and Zongling Wang

First Institute of Oceanography, SOA, Qingdao, 266061, PR China. E-mail: zhumingyuan@fio.org.cn

A large scale green tide was occurred during June to August 2008. It was the first large scale green tide in coastal water of China with serious impacts on the coastal environment of Qingdao City and resulting in heavy economic loss. However, the origin of the green tide remained unclear. To study the origin and process of the green tide, an investigation was conducted from January to June, 2009. There are four types of habitat for macro green algae, including aquaculture and salt ponds, estuarine wet lands, jetty and banks and aquaculture rafts. The first floating green algae were found out along offshore waters of southern Yellow Sea with an area of about 0.7 km^2. In early May, the area of floating algae increased to 200 km^2. It moved towards the north and reached the coastal waters of South Shandong Peninsula in June. The area was about 20,000 km^2. The role of physical, chemical and meteorological factors in this process was addressed.

25 October, 16:00 (HAB-6015)

Recurrent large scale macroalgal blooms in the Yellow Sea

John K. **Keesing**[1], Dongyan Liu[2], Qianguo Xing[2], Ping Shi[2] and Peter Fearns[3]

[1] CSIRO Marine and Atmospheric Research, Private Bag 5, Wembley, 6913, Australia. E-mail: john.keesing@csiro.au
[2] Yantai Institute of Coastal Zone Research for Sustainable Development, Chinese Academy of Sciences, Yantai, Shandong, 264003, PR China
[3] Curtin University of Technology, GPO Box U1987, Perth, 6845, Australia

A large green-tide or floating patches of marine macroalgae visible from space formed in the Yellow Sea off China in June 2009 with patches totalling 1227 km^2 affecting an area spread over 24000 km^2 on 22 June 2009. The re-occurrence of this green-tide phenomenon was predicted after a similar, but novel event in June 2008 which was found to have an anthropogenic origin in coastal Porphyra seaweed aquaculture 180 km away from the point of impact in Qingdao. At its peak offshore the bloom covered 1,200 km^2 and affected 40,000 km^2 . This is the largest green-tide ever reported, the most extensive translocation of a green tide and the first case of expansive seaweed aquaculture leading to a green-tide. Here we describe the pattern and time course of evolution of both blooms from satellite photographs and relate these to the prevailing oceanographic conditions and biological attributes of the algae which resulted in rapid growth of the bloom and lead to transport of the bloom north into the Yellow Sea and then onshore northwest to Qingdao. We predict that these macroalgal blooms are likely to recur annually unless mitigation measures are taken.

W7 MEQ/FIS Workshop
Interactions between aquaculture and marine eco-systems

Co-Convenors: Katsuyuki Abo (Japan), Kevin Amos (U.S.A.), Galina Gavrilova (Russia) and Hyun Jeong Lim (Korea)

Open-water marine aquaculture has ongoing interactions with its surrounding environment. Some of these interactions have the potential to cause negative and positive effects on the other. For example, pathogens may be transmitted from wild reservoirs to cultured animals and vice versa with the consequence of disease and mortality. Another example is the dispersal of nutrients from a farm site which in some instances negatively impacts the benthos while in other areas may enhance a nutrient-deficient marine zone or contribute to the culture of another aquatic species. Also, changing marine environments, including those impacted by global warming and ocean acidification, have the potential to affect these ecosystem interactions so as to investigate the culture of new farmed species - species that may perform better in altered environments. The PICES Working Group on Environmental Interactions of Marine Aquaculture (WGEIMA) has been charged to evaluate existing and potentially new interactions and to develop models that assess the risk of these interactions to include escapes of farmed marine animals (considerations for genetics, competition, and pathogen transfer), discharge of effluent from culture facilities, use of non-native species in culture, and the exchange of pathogens between farmed and wild aquatic animals. Major goals of this workshop include: 1) discussion of tools and models currently used by member countries to assess types of interactions and risks posed by them; 2) developing consensus on aquaculture technologies and indicators of interactions that will be used in completing the terms of reference and preparing report of WGEIMA to include species and methods of culture; and 3) identifying the process by which the work will be carried out under the terms of reference.

Saturday, October 24 (09:00 to 18:00)

9:00 ***Introduction by Convenors***

9:05 **Dario Stucchi, Michael Foreman, Ming Guo and Piotr Czajko (Invited)**
A coupled biophysical sea lice model for the Broughton Archipelago (W7-5582)

9:35 **Tamiji Yamamoto, Hajime Maeda, Osamu Matsuda and Toshiya Hashimoto (Invited)**
Effects of culture density on the growth and fecal production of oyster *Crassostrea gigas* (W7-5595)

10:05 **Xuelei Zhang**
Challenges and opportunities of environmental issues faced by coastal aquaculture in China (W7-5891)

10:30 ***Coffee / tea break***

10:50 **Galina S. Gavrilova**
Some ecological aspects of invertebrate mariculture in semi-closed bights (W7-5654)

11:15 **Jill B. Rolland and Lori L. Gustafson**
A model to exclude endemic pathogens from semi-open or open aquaculture facilities: Utilizing compartmentalization to promote epidemiologic separation in shellfish hatcheries (W7-5881)

11:40 **Lori L. Gustafson and Jill B. Rolland**
Marine reservoirs for infectious salmon anemia virus in pen-reared Atlantic salmon: Do they play a role in the U.S.? (W7-5879)

12:05 **Kevin H. Amos**
A review of infective doses of viral and bacterial pathogens for modeling interactions between marine pen-reared salmon and wild cohorts (W7-5801)

12:30 ***Lunch***

14:00 **J.E. Jack Rensel, Dale A. Kiefer and Frank O'Brien (Invited)**
Aquaculture modeling using a GIS-integrated simulation model (W7-5716)

14:30 **Katsuyuki Abo and Toshinori Takashi**
Assessing nutrient environments of Nori (*Porphyra*) aquaculture area by using numerical model (W7-5628)

14:55 **Brett R. Dumbauld and Jennifer L. Ruesink**
Evaluating the effects of bivalve shellfish aquaculture and its ecological role in the estuarine environment in the United States (W7-5823)

15:20 **Edward A. Black**
Aquaculture risk assessments and ecosystem-based management (W7-5989)

15:45 ***Coffee / tea break***

16:00 **Motoyuki Hara and Toyomitsu Horii**
Evaluation of the impacts of seedlings on abalone reproduction by genetic approach (W7-5940)

16:25 **Qtae Jo, Su-Kyoung Kim, Chae Sung Lee, Jin Yeong Kim and Victor D. Dzizyurov**
Production of healthier *Patinopecten yessoensis* seeds for aquaculture on the Korean and Russian coasts of the East Sea (W7-5827)

16:50 ***Workshop ends***

W7 Posters

W7-5730 **Larissa A. Gayko**
The long-term physical-statistical method for the forecast of mollusks' yield at marine farms in Primorye (Sea of Japan)

W7-5731 **Larissa A. Gayko**
Interrelation between hydrometeorological and biological parameters of marine farms in Primorye (Sea of Japan)

W7-5736 **Arthur A. Kos'yanenko**
The distribution of commercially important species of sea squirts (Ascidians) in Alekseeva Bay of Peter the Great Bay

W7-5744 **Liping Jiao, Gene J. Zheng, Tu Binh Minh, Liqi Chen and Paul K.S. Lam**
Persistent toxic substances in remote lake and coastal sediments from Svalbard, Norwegian Arctic: Levels, sources and fluxes

W7-5899 **Valeria E. Terekhova**
Effect of the prophylactic antibacterial treatment on the intestinal microflora of cultivated sea cucumber, *Apostichopus japonicus*

W7-6013 **Gary H. Wikfors**
Flow-cytometric applications for bivalve hemocytes: Tools for assessing mollusc/ecosystem interactions

W7-6014 **April N. Croxton, Gary H. Wikfors and Richard D. Gragg, III**
An evaluation of hemocyte profiles from oyster populations located in two Florida bays

W7 Oral Presentations

24 October, 9:05 (W7-5582), Invited

A coupled biophysical sea lice model for the Broughton Archipelago

Dario **Stucchi**, Michael Foreman, Ming Guo and Piotr Czajko

Institute of Ocean Sciences, Fisheries and Oceans Canada, P.O. Box 6000, Sidney, BC, V8L 4B2, Canada
E-mail: dario.stucchi@pac.dfo-mpo.gc.ca

Recent research on the interactions between sea lice and wild and farmed salmon in the Broughton Archipelago of British Columbia has underlined the need to better understand the role that physical oceanography plays in the development, behaviour and movement of these lice. In this talk we will describe biological models that estimate the production of sea lice eggs at salmon farms and simulate the development, mortality and behaviour of the planktonic larval (nauplius and copepodid) life stages. These biological models are coupled to a finite volume coastal ocean model that in turn provides the three-dimensional salinity, temperature and velocity fields that control the transport and development/mortality of the sea lice larvae. A three week simulation for March 2008 will be evaluated against available observations. The utility of these coupled models in an aquaculture management strategy will be briefly discussed.

24 October, 9:35 (W7-5595), Invited

Effects of culture density on the growth and fecal production of oyster *Crassostrea gigas*

Tamiji **Yamamoto**, Hajime Maeda, Osamu Matsuda and Toshiya Hashimoto

Laboratory of Aquatic Environmental Management, Graduate School of Biosphere Sciences, Hiroshima University, 1-4-4 Higashi-Hiroshima, Hiroshima, 739-8528, Japan. E-mail: tamyama@hiroshima-u.ac.jp

Effects of culture density on the growth and fecal production of oyster *Crassostrea gigas* in Hiroshima Bay were estimated using a numerical model expressing physiological processes of oyster by changing water exchange rate in and out of the cultivation raft. While the individual-based growth of oyster was higher with decreasing the culture density of oyster, total production was highest with 850 wires per raft. The individual-based fecal production was getting higher with decreasing the culture density, but total amount of fecal production was highest with 950 wires per raft. From these results, it was concluded that 850 wires per raft was the appropriate cultivation density under the environmental conditions of Hiroshima Bay with no consideration of sediment deterioration.

24 October, 10:05 (W7-5891)

Challenges and opportunities of environmental issues faced by coastal aquaculture in China

Xuelei **Zhang**

Center for Marine Ecology Research, First Institute of Oceanography, State Oceanic Administration, 6 Xianxialing Rd., Qingdao, 266061, PR China. E-mail: zhangxl@fio.org.cn

Coastal aquaculture is the most important fishery industry and continues to be more important until the natural fishery resources fully recover from past harvesting practices. Economic and social development has been increasing the demand for sea food and aquaculture production is expected to increase in response to the increasing demand. The available coastal area, however, is limited for traditional aquaculture and is largely exploited. This requires increased production efficiency - production within unit area and time. Traditional aquaculture which techniques are already well developed, will be under pressure to increase the intensity of use of the area and time. This presents a challenge – how to minimize the environmental impacts under more intensive manipulation of traditional aquaculture? A second challenge is how to minimize the environmental impacts by shifting the traditional mode (extracting) of aquaculture to the new mode (feeding)? Experience has shown that the population/species is more vulnerable to disease infections after generations of cultivation. Currently we have some solutions but most will create new environmental issues. So, another challenge will be how to maintain healthy aquaculture

during its development? On the other hand, increasing concerns about climate change and CO_2 control issues present an opportunity for an "old" mode of aquaculture – polyculture or integrated multitrophy aquaculture, which tries to combine extracting with feeding aquaculture. This type of culture has received a lot of studies but is only applied limitedly. The other opportunity comes from the "emerging" conception – marine ranching, which tries to "farm" fishes with other species in a more naturally mode but have only applied and succeeded in a few cases.

24 October, 10:50 (W7-5654)

Some ecological aspects of invertebrate mariculture in semi-closed bights

Galina S. **Gavrilova**

Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia
E-mail: gavrilova@tinro.ru

In Primorye the most of the bivalve farms are located in closed and semi-closed bights. Investigations were conducted in one of them - Sukhodol Bight, a typical marine aquaculture area in Peter the Great Bay (Sea of Japan). In generally, the hydrological conditions in Sukhodol Bight are typical of many bights within Peter the Great Bay. With a voluminous continental runoff the interaction of the coastal waters in the open part of the bay and estuarine waters determine the hydrological situation. The influence of mussel aquaculture was examined using a rate of sedimentation and rate of biodeposit accumulation. The rate of the biodeposit accumulation is related to the body weight of the mussels and according to calculation can be reached 150 g m^{-2} day^{-1}. The rates of sedimentation were obtained by observations and averaged 34 g m^{-2} day^{-1} during summer and fall. The volume of biodeposit accumulated immediately under the aquaculture facilities depends, mostly on the direction and velocity of currents. According to our data, this part of biodeposit can reach up to 23%. The volume of biodeposit accumualtion under mollusk cultivation sites is very considerable. One 1 ha of cultivation area will deliver to up to 0.46 t of the natural biodeposit in the system each day. It is evident that such processes should affect benthic conditions.

For Sukhodol Bight, propose a model of the farm that would include along with cultivation of filter-feeding mollusks, the growing of the juveniles of far-eastern trepang *Apostichopus japonicus*.

24 October, 11:15 (W7-5881)

A model to exclude endemic pathogens from semi-open or open aquaculture facilities: Utilizing compartmentalization to promote epidemiologic separation in shellfish hatcheries

Jill B. **Rolland**[1] and Lori L. Gustafson[2]

[1] U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Veterinary Services, National Center for Animal Health Programs, 4700 River Rd., Unit 46, Riverdale, MD, USA. E-mail: Jill.B.Rolland@aphis.usda.gov
[2] U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Veterinary Services, Centers for Epidemiology and Animal Health, 2150 Centre Ave., Bldg. B, Mailstop 2E6, Fort Collins, CO, USA

Mikrocytos mackini, commonly referred to as Denman Island Disease (DID), is an intracellular parasite affecting oysters (*Crassostrea gigas* and *Ostrea conchaphila*). The geographic distribution of DID is along the Canadian west coast as well as the west coast of Washington State and Puget Sound. Parasitism results in relatively low mortality (approximately 30%), and preferentially affects oysters greater than two years of age. The parasite has not caused disease in shellfish aquaculture in Washington State; however, the impacts on shellfish trade have be significant. To address these trade impacts aquatic animal systems with barriers to pathogen exchange, whether partial or complete, may attempt to substantiate a disease status distinct from their surrounding zone. Following the World Organization for Animal Health (OIE) guidelines for compartmentalization, it should be possible to substantiate a distinct disease status (or probability of disease) from contiguous or surrounding zones through a combination of surveillance and risk evaluations. Compartment biosecurity and early detection systems to prevent or alert an occurrence of pathogen transfer are some of the factors discussed in how shellfish hatcheries can promote epidemiologic separation to declare a higher health status from their surrounding zone.

24 October, 11:40 (W7-5879)

Marine reservoirs for infectious salmon anemia virus in pen-reared Atlantic salmon: Do they play a role in the U.S.?

Lori L. **Gustafson**[1] and Jill B. Rolland[2]

[1] U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Veterinary Services, Centers for Epidemiology and Animal Health, 2150 Centre Ave., Bldg. B, Mailstop 2E6, Fort Collins, CO, USA. E-mail: Lori.L.Gustafson@aphis.usda.gov

[2] U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Veterinary Services, National Center for Animal Health Programs, 4700 River Rd., Unit 46, Riverdale, MD, USA

Marine reservoirs for infectious salmon anemia virus (ISAV) have been documented: wild salmonids in the rivers of Norway, for example, are known to carry a parent type of the ISA virus. Further, sea lice are theorized potential vectors for disease transmission among or between farms and wild populations of salmonids. However, along the east coast of the United States, efforts to identify a marine reservoir for the North American pathogenic form of ISAV have failed. Genomic findings suggest a relatively distant evolution of the existing pathogenic forms from the circulating non-pathogenic parent type; and epidemiologic studies indicate that hydrographic patterns and cultured fish business practices, instead, seem to drive the local spread of disease. The recent cessation in ISA disease occurrence after re-configuration of bay management areas to better reflect hydrographic patterns, and completion of upgrades in local processing plant biosecurity, provide further evidence that a substantive marine reservoir for the pathogenic form of ISAV in North America is currently lacking. However, the seasonal occurrence and relative geographic ubiquity of PCR evidence of exposure to a non-pathogenic form of ISAV in U.S. caged salmon encourage continued exploration of the marine reservoir topic. We review previous efforts and available evidence in the study of marine reservoirs for ISAV in the U.S., and recommend approaches for continued study.

24 October, 12:05 (W7-5801)

A review of infective doses of viral and bacterial pathogens for modeling interactions between marine pen-reared salmon and wild cohorts

Kevin H. **Amos**

U.S. Department of Commerce, National Oceanic and Atmospheric Administration Aquaculture Program, 510 Desmond Dr. SE, Suite 103, Lacey, WA, 98503, USA

Salmon aquaculture is an important economic, cultural, and environmental activity that provides food, employment, stock enhancement, stock rehabilitation, and recreation. The potential exists for pathogen interactions between cultured and wild salmon. It is well documented that disease epizootics in farmed salmon have occurred as a consequence of being infected from wild reservoirs and consequently amplifying these pathogens within the aquaculture facility. While much has been published recently on interactions of sea lice between farmed and wild salmon, a limited amount of information is available on shedding rates of viral and bacterial pathogens from salmon farms undergoing epizootics. In order to construct risk models on the potential interactions of these shed pathogens, it is necessary to understand the quantity of viable pathogens to effect an infection in a susceptible host outside the salmon culture facility, including consideration of dilution factors on the exposure dose. This presentation will review dose/response data of selected viral and bacterial pathogens and consider potential shedding rates and dilution factors at a hypothetical site.

24 October, 14:00 (W7-5716), Invited

Aquaculture modeling using a GIS-integrated simulation model

J.E. Jack **Rensel**[1], Dale A. Kiefer[2] and Frank O'Brien[3]

[1] Rensel Associates Aquatic Sciences, 4209 234th St. NE, Arlington, WA, USA. Email: jackrensel@att.net
[2] University of Southern California, Departement of Biology Los Angeles, CA, USA
[3] System Science Applications, Los Angeles, CA, USA

Fish, shellfish and seaweed aquaculture are the fastest growing forms of food production in the world. Approximately one half the fish consumed by humans is produced by fish farms with the largest recent increases in marine waters worldwide (except in the U.S.). *AquaModel* is a water column and benthic effects simulation software modeling program designed to properly site fish farms and minimize adverse effects while optimizing fish production. The model operates within a unique 4D (Length, Width, Depth and Time) Geographic Information System and is highly graphic, allowing the user to visualize effects as they virtually occur. It has been applied in several locations throughout the world including Washington State, Southern California, and Puerto Rico. *AquaModel* includes unique bioenergetic modules for a variety of fish species that we have developed from our own laboratory studies and other sources. Validation includes the use of extensive NPDES monitoring data from the Pacific Northwest collected over the past 22 years. More information is at www.AquaModel.org

The presentation includes a brief overview of model components and illustration of near-field results from a proposed offshore demonstration farm in 100 m depth and 5 miles offshore of San Diego to be operated by Hubbs-SeaWorld Research Institute. An ongoing project in Hawaii is also discussed that included extensive use of GIS information and ocean observing systems used to drive the model. AquaModel now also operates in 2D or 3D mode or couples directly to separate 3D circulation models.

24 October, 14:30 (W7-5628)

Assessing nutrient environments of Nori (*Porphyra*) aquaculture area by using numerical model

Katsuyuki **Abo** and Toshinori Takashi

National Research Institute of Aquaculture, Fisheries Research Agency, 422-1 Nakatsu, Minami-ise, Mie, 516-0193, Japan
E-mail: abo@fra.affrc.go.jp

Nori (*Porphyra*) is one of the important mariculture productions in Japan. However, in recent years, the production is getting lower because of the bleaching of Nori which is caused by the deficiency of nutrient in the sea water. The nutrient level is governed by balance between terrestrial discharge, advection from adjacent area, absorption by diatoms and the other algae, nutrient release from bottom sediments, *etc.* We conducted modeling study to assess nutrient environments of Nori aquaculture area in Seto Inland Sea, one of the most important Nori aquaculture areas of Japan. Firstly, we developed a diagnosis model which can calculate the current velocity field from observed water density and meteorological data. The modeling study elucidated the effect of the current flow on the nutrient deficiency; the eastward current flow induced by seasonal wind governs the initial timing and level of the nutrient deficiency. Secondly, we developed an ecosystem model to calculate the nutrient level in the sea water. The model reproduced the fluctuation of nutrient level during the Nori aquaculture season in the eastern Seto Inland Sea. The model can be a good tool to predict the nutrient condition of Nori aquaculture area and to assess the interactions between Nori aquaculture and the surrounding eco-systems.

24 October, 14:55 (W7-5823)

Evaluating the effects of bivalve shellfish aquaculture and its ecological role in the estuarine environment in the United States

Brett R. **Dumbauld**[1] and Jennifer L. Ruesink[2]

[1] USDA-ARS, Hatfield Marine Science Center, 2030 SE Marine Science Dr., Newport, OR, 97365, USA
E-mail: brett.dumbauld@ars.usda.gov
[2] University of Washington, Department of Biology, Box 351800, Seattle, WA, 98195, USA

Bivalve shellfish aquaculture is important and occurs on all three coasts in the US, but is most significant on the US West Coast where it largely replaced open access fisheries for bivalves, particularly that for oysters, almost a century ago. Bivalve shellfish aquaculture modifies the estuary where it is placed in three primary ways: 1) changes in material processes – bivalves process food and produce wastes, 2) addition of structure and habitat-cultured organisms especially oysters, mussels and the structures on which they are grown add physical structure; and 3) pulse disturbances like harvest and bed maintenance cause physical disturbance and change habitat availability in time and space. These effects have not been extensively evaluated, but are currently receiving more scrutiny, in part due to changing human demographics and desires. Material processes like feeding and nutrient generation are most often evaluated with coupled biological-physical models that examine carrying capacity for aquaculture at the estuarine landscape scale, but are validated using field and laboratory measurements at smaller scales. Structural effects on estuarine habitat have generally been examined at intermediate scales through direct measurement of effects on benthic organisms and fish and invertebrate abundance. Shellfish aquaculture as habitat is usually compared with vegetated (seagrass and/or macroalgae) and open sand or mudflat habitats. Related studies of pulse disturbances due to harvest and planting operations are also usually conducted over short time intervals and at small spatial scales and the functional role of the habitat only rarely evaluated, especially at a relevant estuarine landscape scale.

24 October, 15:20 (W7-5989)

Aquaculture risk assessments and ecosystem-based management

Edward A. **Black**

Fisheries and Oceans Canada, 200 Kent St., Ottawa, ON, K1A 0E6, Canada. E-mail: edward.black@dfo-mpo.gc.ca

With much of the world capture fisheries approaching their productive limit aquaculture is the now the fastest seafood production system. In the face of incomplete data and knowledge of potential effects of aquaculture on the environment, risk analysis is viewed as one of the most promising tools for ensuring the sustainability of aquaculture and the ecosystems in which it is practiced. Ecosystem risk assessment is part of that ecosystem-based risk analysis. That risk assessment is an important component of the analysis and it can not be done well unless it is supported by the other components of risk analysis (policy, objectives, hazard identification, risk communication and risk management). In this presentation both the framework supporting an assessment of aquaculture effects and the models used in an assessment to predict those effects will be examined. Examples will be drawn from recent work in Canada and the United Nations' Joint Group of Experts on Marine Environmental Protection.

24 October, 16:00 (W7-5940)

Evaluation of the impacts of seedlings on abalone reproduction by genetic approach

Motoyuki Hara[1] and Toyomitsu **Horii**[2]

[1] FRA, National Research Institute of Aquaculture, 422-1 Nakatsuhamaura, Minami-ise, 516-0193, Japan
[2] FRA, National Research Institute of Fisheries Science, Yokosuka Branch, 6-31-1 Nagai, Yokosuka, 238-0316, Japan
E-mail: thorii@fra.affrc.go.jp

Abalone, *Haliotis* spp., is one of the most important shellfish fishery resources in Pacific coasts, but the catches in Japan have decreased rapidly since 1970s. The causes of the decline are not fully understood, but are assumed to be mainly over-exploitation and changes in marine environmental conditions. To recover the depleted abalone populations, the stock enhancement projects using hatchery seedlings have been implemented in the last 30 years in Japan. However, the stock abundance has not started increasing yet in many areas.

The genetic diversity of hatchery seedlings is known to be much lower than that of wild populations, and a growing concern underlies impact on wild populations in the area of aquaculture practices. We analyzed wild populations with naturally produced juveniles and stocked adult abalone populations in experimental area based on highly variable genetic markers. We assessed the impact of stocking released abalone to natural resources. In this paper, we discuss the valuation of the impacts of hatchery seedlings on wild population using the methods of population genetics and individual assignment tests. The results of those tests suggest that the stocked abalone were not as effective as wild populations in contributing to increasing the abundance of the wild populations.

24 October, 16:25 (W7-5827)

Production of healthier *Patinopecten yessoensis* seeds for aquaculture on the Korean and Russian coasts of the East Sea

Qtae **Jo**[1], Su-Kyoung Kim[1], Chae Sung Lee[1], Jin Yeong Kim[1] and Victor D. Dzizyurov[2]

[1] Aquaculture Department, Sea Fisheries Research Institute, Gangwon, 210-861, R Korea. E-mail: qtjo@nfrdi.go.kr
[2] Aquaculture Department, Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia

Hatchery operations for yesso scallop (*Patinopectin yessoensis*) have been of recent concern both in the Korean and Russian coastal waters of the East Sea (Sea of Japan). One of the key issues in the hatchery seed production is how to produce healthier seeds. The healthier hatchery seeds eliminate or minimize negative aspects of aquaculture activities or damage to ecosystem integrity which, in turn, can be a culprit of reduced productivity or mortality of the cultured species in the long run. Attention was given to some parameters influencing health-related physiology of the seed, including batch-specific quality of the reproductive outputs, quality and quantity of larval foods, administration of upper temperature, and water exchange. The first batch of the spawning scallops showed better results in terms of survival, growth, and resistance against parasitic ciliate infection over the second batch that was obtained 5 days after the first batch, mostly with statistical significance ($P<0.05$ or 0.01). We also detailed the effects of the parameters else on the seed viability both in and after the hatchery operations.

W7 Posters

W7-5730

The long-term physical-statistical method for the forecast of mollusks' yield at marine farms in Primorye (Sea of Japan)

Larissa A. **Gayko**

V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia E-mail: gayko@yandex.ru

Planned harvest is very important for normal activity of sea farms. In this paper a method of the long-term forecast of mollusk efficiency (exemplified by the Japanese scallop) was developed. Data on the marine shell yield for the Experimental Sea Station "Possyet" were used in this paper. To develop the method of the forecast the data on the marine shell yield were used as the predictor. The term "harvest" is the number and density of scallop spat collected per unit area (specimens/m^2), and used to restock the sea bed area. Various abiotic factors were used as predictors. The scheme of the long-range prognosis of production is most sustainable, when it is multileveled, that is, accounts for simultaneous states of the underlying surface, tropospheric circulation, stratospheric circulation or helio-physical factors. The technique of separate forecasting of the trend and random constituents was used for the first time for the prognosis of spat harvest in Primorye. As a principal method of mathematical statistics in forecasting random constituent of the Japanese scallop harvest for the first time the linear discriminate analysis was used. Formulated for the first time are rules for making phase and quantitative forecast of the random constituent of mollusk spat yield on the basis of combination of signs of linear discriminant functions. Formalization of physical statistical technique of the Japanese scallop spat harvest is performed, and rules of statistical and dynamic complexing of the forecast with different length of time before forecast phenomenon occurrence are elaborated. Quantitative criteria of mollusk harvest assessment are elaborated. Four schemes (of statistical and dynamic complexing) have been chosen, which we recommend to use for forecasting the Japanese scallop harvest.

W7-5731

Interrelation between hydrometeorological and biological parameters of marine farms in Primorye (Sea of Japan)

Larissa A. **Gayko**

V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia E-mail: gayko@yandex.ru

The aim of this research is to find the statistic dependences between hydrometeorological characteristics and productivities of cultivated organisms in order to select statistically valuable predictors for making up forecasting schemes. The period observations (from 1970 to 2008) were analyzed to find out the dependence: the mean values of the water and air temperature, salinity, spat density on the collectors were calculated; the duration of the ice period, the water and air temperature points rising above 0°C, and the sums of temperatures were calculated. Ecologically -based periods were determined in the annual cycle of the development of the pubertal growth of *Mizuhopecten yessoensis* (Jay): wintering, the periods from rising the temperature above 0°C until the beginning of spawning, the spawning itself, and the plankton development. A rather close relationship is obtained between the density of spat on the collectors and the sum of temperatures for these periods, the duration of the periods themselves, variability of the water temperature during the spawning period, and duration of the ice period. The results allow us to provide an early forecast on the likelihood of success of planted material.

W7-5736

The distribution of commercially important species of sea squirts (Ascidians) in Alekseeva Bay of Peter the Great Bay

Arthur A. **Kos'yanenko**

Laboratory of Marine Ecotoxicology, V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia. E-mail: kosyanPOI@inbox.ru

Ascidians are of interest because of their use as food, manufacturing materials, prophylactic substances, and pharmacological preparations. They are numerous and are a well-studied group of tunicates. All of the ascidians are exclusively marine forms which are sessile. In the Sea of Japan lives more than 60 species of ascidians but only two have commercial value - the knobby ascidian, *Halocynthia roretzi*, and the purple ascidian, *Halocynthia aurantium*. This research was carried out at the marine experimental station POI FEB RAS in Alekseeva Bay (Peter the Great Bay) in 2008. Ascidians were harvested at depths from 7 to 13 m. Estimates of ascidian density settlement were used in a hydrobiological frame area that was 1 m^2. The majority of animals were counted in the sea part of Alekseeva Bay at the stations 1 and 3 at 17 and 12 m depth and densities were equivalent at both stations. At stations 4 through 7 at depths from 7 to 10 m specimens of purple and knobby ascidians were rare and their quantity was 0.3-0.6 specimens/m^2. At stations 2 and 8 ascidians were not found. Based on the results of this research it is possible to conclude that purple and knobby ascidians prefer to settle mainly on stones and the rocks which are in an open part of a bay at a depth from 10 to 17 m.

W7-5744

Persistent toxic substances in remote lake and coastal sediments from Svalbard, Norwegian Arctic: Levels, sources and fluxes

Liping **Jiao**[1,2], Gene J. Zheng[2], Tu Binh Minh[2], Liqi Chen[1] and Paul K.S. Lam[2]

[1] Third Institute of Oceanography, State Oceanic Administration, 178 Daxue Rd., Xiamen, Fujian, PR China
[2] Department of Biology and Chemistry, City University of Hong Kong, 83 Tat Chee Ave., Kowloon, Hong Kong, SAR, PR China

Surface sediments from remote lakes and coastal areas from Ny-Alesund, Svalbard, Norwegian Arctic were analyzed for polycyclic aromatic hydrocarbons (PAHs), polybrominated diphenyl ethers (PBDEs), polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCPs). Relatively high levels of PAHs were encountered from several lakes from Ny-Alesund, which were within the range of levels reported for European high mountain lakes and some urban/industrialized areas in the world, pointing to the role of remote Arctic lakes as potential reservoir of semi-volatile organic compounds. Specific patterns of PBDEs were observed, showing higher concentrations of lower brominated compounds such as BDE-7, 17 and 28. Estimated surface sediment fluxes of PAHs in Ny-Alesund remote lakes were similar to those observed for some European high mountain lakes. The current PAH levels in sediments from three lakes exceeded Canadian sediment quality guidelines, suggesting the presence of possible risks for aquatic organisms and the need for further studies.

W7-5899

Effect of the prophylactic antibacterial treatment on the intestinal microflora of cultivated sea cucumber, *Apostichopus japonicus*

Valeria E. **Terekhova**

Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia. E-mail: allexxus@yandex.ru

A prophylactic application of fluoroquinolones (Antiback-500) for bacterial peptic ulcer of cultivated sea cucumber juveniles was established in the previous studies (Terekhova, Bel'kova, 2008). The effect of the "Antiback" preparation on the digestive tract microflora of sea cucumber was investigated.

It was established that the natural intestinal microflora of *Apostichopus japonicus* was represented (in the order of the number decreasing) by bacteria of the following genera: *Bacillus*, *Acinetobacter*, *Aeromonas*, *Pseudomonas*, *Staphylococcus*, *Alcaligenes* and *Vibrio*. Total number of the heterotrophic microflora is 1.3 x 10^7 CFU/ml.

The three-hour prophylactic bath with Antibak-500 (1 g per 50 l of sea water) does not influence the total number of the heterotrophic microflora of the intestines. However, the qualitative composition and quantitative proportion of microbe kinds change. After treatment, bacteria of *Pseudomonas* and *Alcaligenes* genera are eliminated from the intestines. The number of microorganisms of *Aeromonas* sp. and *Staphylococcus* sp. are reduced 1-2 orders of magnitude while that of *Vibrio alginolyticus* increases about 5 orders of magnitude.

As known, *V. alginolyticus* is a causative agent of vibriosis or bacillary necrosis among many species of hydrobionts (Austin B., Austin D., 2007). Therefore, its reproduction in the sea cucumber digestive tract after the antibacterial treatment is a manifestation of disbacteriosis and requires a correction.

The efficient and safe method of the dysbacteriosis treatment of any localization is an application of probiotics, especially antagonists of pathogenic microflora. According to the literary data, a group of natural antagonists of vibriosis is formed by bacteria of *Lactobacillus*; *Pseudomonas* and *Aeromonas* genera; some kinds of yeasts (*Saccharomyces cerevisiae*, *Saccharomyces exiguous, Phaffia rhodozyma*) and culture of unicellular algae *Tetraselmis suecica* (Irianto, Austin, 2002).

Because the use of the homoprobiotics is most effective, the antivibriosis activity of all strains of bacteria of Pseudomonas and Aeromonas genera separated from the sea cucumber intestines was studied. Using the disc technique, the only bacteria in the population under consideration as a natural antagonist for *V. alginolyticus* was a culture of *Aeromonas hydrophila.* Therefore, this culture can be considered as the possible corrector of intestinal dysbacteriosis of the Far-Eastern sea cucumber in the course of its artificial cultivation.

W7-6013

Flow-cytometric applications for bivalve hemocytes: Tools for assessing mollusc/ecosystem interactions

Gary H. **Wikfors**

NOAA/NMFS, 212 Rogers Ave., Milford, CT, 06460, USA. E-mail: Gary.Wikfors@noaa.gov

Flow-cytometry, a technology developed for clinical and biomedical analysis of human blood, has been applied more recently to analysis of hemocytes in a variety of vertebrate and invertebrate species, including bivalve molluscs. A flow-cytometer rapidly measures multiple optical characteristics of particles suspended in a fluid, yielding a relational database file for each sample that can be analyzed using visual programming, employing one or more of the optical measurements sequentially or simultaneously.

Early applications with bivalves focused on fundamental hematological measurements, such as numbers, sizes, internal complexity, and viability of circulating cells. Next, assays often adapted from existing biomedical procedures for immune-functional characteristics of human leucocytes, such as phagocytosis of non-self particles, respiratory burst, and aggregation, were developed. Although protocols for these assays have been validated for bivalves, in terms of demonstrating that biochemical probes respond to target physiological characteristics, interpretation of hemocyte variables, and changes in hemocyte variables associated with various experimental treatments and environmental stresses, remain challenging. It is often helpful to combine several assays and interpret them in context of the function of hemocytes within the organism. As the many environmental and developmental changes that can affect hemocytes are incompletely understood, it is imperative at this point to contrast experimental and control populations.

Environmental stresses, ranging from temperature fluctuations to nutritional deficiencies and exposure to natural and anthropogenic toxins, have been shown to cause immuno-modulation in various bivalve species. In cases wherein hemocyte defense functions, such as adhesion and phagocytosis, are suppressed, the shellfish are thought to be more susceptible to parasitic and pathogenic diseases; therefore, flow-cytometric hemocyte analyses can have wide application in assessing the interactions between aquacultured shellfish and the ecosystems in which they are grown.

W7-6014

An evaluation of hemocyte profiles from oyster populations located in two Florida bays

April N. **Croxton**[1,2], Gary H. Wikfors[2] and Richard D. Gragg, III[1]

[1] Environmental Sciences Institute, Florida Agricultural and Mechanical University, 1500 MLK Blvd., FSH-SRC 305D, Tallahassee, FL, 32307, USA. Email: april.croxton@noaa.gov

[2] National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center, Milford Laboratory, 212 Rogers Ave., Milford, CT, 06460, USA

The eastern oyster, *Crassostrea virginica*, has supported important US commercial fisheries for over 200 years. The presence of persistent organic pollutants, such as Polycyclic Aromatic Hydrocarbons (PAHs), in shellfish-harvesting areas has stimulated the need to understand the effects of these compounds on the physiology of oyster species. The survival of oyster populations in a contaminated environment depends greatly upon the protection provided by the oyster's internal immune defense system. The current study measures hemocyte characteristics (*e.g.* hemocyte types and viability) and functions (*e.g.* adhesion, phagocytosis, and generation of reactive oxygen species) in oysters from two Florida bays with varying PAH contaminant levels. In an initial profile study, a hemocyte profile of oysters was developed, suggesting that oysters collected from a contaminated site had a different hemocyte immune status compared to oysters from a relatively uncontaminated site. A follow-up transplant study examined alterations in hemocyte immune functions in oysters from a relatively uncontaminated site in Apalachicola Bay transplanted to a contaminated site in Tampa Bay. Results indicated that phagocytic activity of hemocytes was significantly reduced, and PAH body burden was increased in oysters transplanted from the relatively pristine site to the contaminated site. An oyster immune profile was generated which suggested hemocyte defense functions in oysters native to the contaminated site were less active than defense functions in oysters native to the relatively uncontaminated site. These results support laboratory studies which demonstrate the ability of PAHs to alter hemocyte defense functions in oysters.

W8 POC Workshop
Exploring the predictability and mechanisms of Pacific low frequency variability beyond inter-annual time scales

Co-Sponsored by CLIVAR

Co-Convenors: Emanuele Di Lorenzo (U.S.A.) and Shoshiro Minobe (Japan)

Understanding the dynamics that control climate variability in the Pacific basin is essential for exploring the degree of predictability of the ocean-atmosphere and sea-ice climate systems of the North Pacific. The goal of this workshop is to improve the conceptual and quantitative frameworks used by the PICES community to interpret low-frequency climate variability in the Pacific basin, ranging from interannual to multi-decadal timescales. Contributions are invited on a broad range of topics including: 1) studies that link regional to basin scale dynamics; 2) investigations of "regime shift", specifically the extent to which sharp transitions in the climate system are predictable and connected with low-frequency variations in the ocean-atmosphere and sea-ice systems; (3) studies that separate the stochastic and deterministic components of low-frequency climate fluctuations; (4) analysis of long-term observations collected in regional environments across the Pacific, specifically their relationship to large-scale climate processes as opposed to local-scale dynamics; (5) climate change and how it may impact the statistics of Pacific climate (*e.g.*, frequency of "regime shifts"); and (6) more generally studies that propose new mechanisms underlying low-frequency Pacific climate variability.

Day 1, Saturday, October 24 (9:00-18:00)

Topic 1: Pacific Large-scale dynamics and variability

9:00 **Sumant Nigam and Bin Guan (Invited)**
Ocean-atmosphere structure of Pacific decadal variability (W8-5931)

9:25 **Curtis Deutsch and Taka Ito (Invited)**
Oxygen variability in the North Pacific (W8-5799)

9:50 **Sang-Wook Yeh, Yune-Jung Kang, Yign Noh and Arthur J. Miller**
Characteristics in the North Pacific mean SST and its variability in climate transition periods (W8-5901)

10:10 **Skip McKinnell and Nate Mantua**
Regimelettes – PDO variability in the 21st Century (W8-5882)

10:30 ***Coffee / tea break***

10:50 **Muyin Wang, James E. Overland and Nicholas A. Bond**
A means for reducing projection uncertainty of climate models on regional scale (W8-5846)

Topic 2: Tropical / Extratropical connections

11:10 **Lixin Wu (Invited)**
A unified teleconnection mechanism between extratropical and tropical oceans (W8-5605)

11:35 **Michael Alexander, Daniel J. Vimont, Ping Chang and James Scott (Invited)**
The impact of extratropical atmospheric variability on the tropical Pacific: Testing the seasonal footprinting mechanism (W8-5648)

12:00 **Daniel J. Vimont (Invited)**
The role of thermodynamic coupling in connecting subtropical and tropical Pacific climate variations (W8-5762)

12:25 ***Lunch***

14:00 **Xiaohui Tang, Ping Chang and Fan Wang**
Influence of reducing weather noise on ENSO prediction (W8-5741)

Topic 3: Western North Pacific dynamics and variability

14:20 **Bo Qiu, Shuiming Chen and Niklas Schneider (Invited)**
Forced versus intrinsic variability of the Kuroshio Extension system on the decadal timescales (W8-5657)

14:45 **Shoshiro Minobe, Jiaxu Zhang and Miho Urasawa**
Kuroshio Extension variability during the last 50-years and its predictability (W8-5829)

15:05 **Rong-shuo Cai, Qi-long Zhang and Hong-jian Tan**
The long-term transport variation of Kuroshio and its adjacent currents in the western North Pacific Ocean (W8-5554)

15:25 ***Coffee / tea break***

15:50 **Poster viewing time**

16:20 **Masami Nonaka, Hisashi Nakamura, Bunmei Taguchi, Youichi Tanimoto and Hideharu Sasaki (Invited)**
Decadal variability in the oceanic frontal zones in the western North Pacific Ocean (W8-5796)

16:45 **Elena I. Ustinova and Yury D. Sorokin**
Low-frequency fluctuations of thermal conditions in the Far-Eastern Seas and large-scale climate processes (W8-5767)

17:05 **In-Seong Han, Young-Sang Suh, Jae-Dong Hwang and Joon-Soo Lee**
Long-term change of thermal structure in the surface layer due to wind-induced conditions around the Korean Peninsula (W8-5837)

17:25 **Konstantin A. Rogachev and Natalia V. Shlyk**
Surface freshening and mid-depth warming in the Pacific Western Subarctic since 1950s (W8-5518)

17:45 **Discussion**

18:00 ***Workshop ends***

Day 2, Sunday, October 25 (9:00-12:30)

Topic 4: Air Sea interaction and coupled structures

9:00 **Bunmei Taguchi, Hisashi Nakamura, Masami Nonaka, Nobumasa Komori, Akira Kuwano-Yoshida, Hideharu Sasaki, Koutarou Takaya and Shang-Ping Xie (Invited)**
Decadal variability of the Kuroshio/Oyashio Extension fronts and their atmospheric influences (W8-5755)

9:25 **Niklas Schneider, Yoshinori Sasaki, Axel Lauer, Bo Qiu, Arthur J. Miller and Detlef Stammer**
Extratropical ocean to atmosphere coupling via atmospheric Ekman pumping (W8-5938)

Topic 5: Discussion/Synthesis

9:45 **Emanuele Di Lorenzo, Niklas Schneider, Kim M. Cobb, Jason Furtado and Michael Alexander**
ENSO and the North Pacific Gyre Oscillation: An integrated view of Pacific decadal dynamics (W8-5586)

10:05 **Arthur J. Miller, Emanuele Di Lorenzo, Shoshiro Minobe and Niklas Schneider**
North Pacific decadal variability: Current understanding and unresolved issues (W8-5820)

10:30 ***Coffee / tea break***

10:50 **Summary and discussion**

11:35 **Publications/Reports**

12:05 ***Workshop ends***

W8 Posters

W8-5555 **Rong-shuo Cai, Qi-long Zhang and Qing-hua Qi**
Spatial and temporal oscillation and long-term variation in sea surface temperature field of the South China Sea

W8-5559 **Yuri Nikonov**
Description of seasonal water circulation variability in Tatar Strait in the Japan Sea by numerical method

W8-5690 **Ling Ling Liu, Rui Xin Huang and Fan Wang**
The role of diurnal cycle and mixed layer depth perturbations in ventilation: Subduction and obduction

W8-5803 **Gennady V. Khen**
Variability of the Kamchatka Current transport in the Kamchatka Strait

W8-5839 **In-Seong Han, Takeshi Matsuno, Tomoharu Senjyu, Young-Sang Suh and Joon-Soo Lee**
Behavior of low salinity water mass from Northern East China Sea to Korea Strait

W8 Oral Presentations

24 October, 9:00 (W8-5931), Invited

Ocean-atmosphere structure of Pacific decadal variability

Sumant **Nigam**[1] and Bin Guan[1,2]

[1] Department of Atmospheric and Oceanic Science, University of Maryland, 3419 Computer and Space Sciences Bldg., College Park, MD, 20742, USA. Email: nigam@atmos.umd.edu

[2] Water and Carbon Cycle Group, Jet Propulsion Laboratory, MS 300-233 California Institute of Technology, Pasadena, CA, 91109, USA

By focusing on spatial *and* temporal recurrence but without imposition of any periodicity constraints, a recent analysis of natural variability and secular trend in Pacific and Atlantic SSTs in the 20th century discriminates between biennial, ENSO, and decadal variabilities (Guan and Nigam, 2008, 2009). The analysis yields refined evolutionary descriptions and, equally importantly, separation of natural variability and secular trend – all without any advance filtering (and potential aliasing) of the SST record. The implicit accommodation of natural variability leads to a nonstationary SST secular trend, one that includes mid-century cooling.

Pacific decadal SST variability is resolved into two modes, Pan Pacific and North Pacific: The first, with horse-shoe structure in the Pacific, exhibits connections to the tropical-subtropical Atlantic resembling the AMO. The second, capturing the 1976/77 climate-shift, is closer to PDO in structure, and has interesting links to the North Atlantic as well as the western tropical Pacific and Indian Ocean. The physicality of the decadal modes was evaluated using analog counts and fish recruitment records.

Ocean-atmosphere structure of the decadal modes is being constructed from lead/lag regressions of their principal components on ocean heat-content, and on a nearly century-long upper-air data set. Upper-air meteorological fields for the 1908-1958 were recently made available by the surface/sea-level pressure based 20th Century Reanalysis Project at NOAA ESRL, Boulder. The atmospheric structure is being assessed at seasonal resolution, given the profound influence of the seasonal march in the atmosphere. It is hoped that the 4D structure will provide insights into the involved mechanisms.

24 October, 9:25 (W8-5799), Invited

Oxygen variability in the North Pacific

Curtis **Deutsch** and Taka Ito

Atmospheric and Oceanic Sciences, University of California, Los Angeles, 405 Hilgard Ave., 7125 Math Science Bldg., Los Angeles, 90024, USA. E-mail: cdeutsch@atmos.ucla.edu

Oxygen plays a fundamental role in the biogeochemistry of the ocean, integrating photosynthesis and respiration along circulation pathways, and influencing the physiology of marine organisms and important chemical reactions. I will review mounting evidence for pervasive changes in ocean oxygen concentrations in the North Pacific. The causes of these changes and their connection to climate changes will be illustrated using a hierarchy of models, from simple stochastic box models to state-of-the-art numerical simulations.

24 October, 9:50 (W8-5901)

Characteristics in the North Pacific mean SST and its variability in climate transition periods

Sang-Wook **Yeh**[1], Yune-Jung Kang[2], Yign Noh[2] and Arthur J. Miller[3]

[1] Ocean Climate and Environment, Korea Ocean Research and Development Institute (KORDI), P.O. Box 29, Ansan, 425-600, R Korea
E-mail: swyeh@kordi.re.kr
[2] Department of Atmospheric Science, Yonsei University, Seoul, R Korea
[3] Scripps Institution of Oceanography, La Jolla, CA, 92093-0224, USA

We examine characteristic changes in North Pacific sea surface temperature (SST) variability during the boreal winter for two periods during which the 1976-77 and the 1988-89 climate transitions occurred. The two leading SST modes are associated with Pacific Decadal Oscillation (PDO)-like SST variability and North Pacific Gyre Oscillation (NPGO)-like SST variability. It is found that the leading mode of SST variability in the North Pacific changes in the two climate transition periods. For example, while the PDO-like SST variability plays the dominant role in the 1976-77 climate transition, but it is not in the 1988-89 climate transition. In addition, we also discuss the different role of the surface heat fluxes versus wind stress field in relation to the 1976/77 climate transition in the North Pacific using forced runs in ocean model.

24 October, 10:10 (W8-5882)

Regimelettes – PDO variability in the 21st Century

Skip **McKinnell**[1] and Nate Mantua[2]

[1] PICES Secretariat, P.O. Box 6000, Sidney, V8L 4B2, Canada. E-mail: mckinnell@pices.int
[2] School of Aquatic and Fishery Sciences, University of Washington, P.O. Box 355020, Seattle, WA, 98195-5020, USA

Using SST data that were collected by remote sensing on a global scale and merged with *in situ* SST data, there are now nearly 30 years of SST timeseries on a 1x1 degree grid. An EOF analysis of these Higher Resolution SST data (HR-PDO) reveals features that are not strongly evident in estimates of the PDO index that were estimated from data series that began in 1900. Since 1981, there is no evidence of multi-decadal variability; the dominant and only spectral peak is decadal; perhaps offering some degree of predictability. The same spectral peak appears in EOF1 computed from SSH anomaly data despite the timeseries being 10 years shorter. The correlation between the two EOFs is -0.72 over a period of 200 months but its magnitude varies seasonally from a low of -0.51 in December to a high of -0.88 in March. Auto-correlation in the HR-PDO is higher than what appears in the PDO with shifts between phases occurring abruptly and persisting for about 5 years (regimelettes) with transient zero-crossings mid-period. The last shift occurred in October 2007 and it has persisted to the present.

24 October, 10:50 (W8-5846)

A means for reducing projection uncertainty of climate models on regional scale

Muyin **Wang**, James E. Overland and Nicholas A. Bond

Joint Institute for the Study of Atmosphere and Ocean (JISAO), University of Washington, 7600 Sand Point Way NE, Seattle, 98115, USA
E-mail: muyin.wang@noaa.gov

Muyun Wang

We explore climate model projection uncertainties across three major components, atmosphere, ocean and sea ice in the IPCC AR4 models. To have predictions for the responses of marine ecosystem to future climate change, one must first have reliable climate projections at regional scale. With much improvement over the past decades there is considerable confidence that the latest generation of coupled climate models provide credible, quantitative estimates of the future climate at continental scales and above. Yet the quality of climate projections from these models on the regional scale is, unfortunately, location and variable dependent. For regional studies, we propose a two-step strategy, in which outlier models are first removed based on their ability of simulating large-scale variability, *e.g.* the PDO over the North Pacific in the 20th century compared to the observations. The models' performance for individual regions and variables is then further evaluated before composite projections are

made. Examples for the Bering Sea and the Sea of Okhotsk will be presented. With this two-step approach the uncertainty spread is greatly reduced, and credibility in model projections for coupled climate/ecosystem studies is further increased.

James E. Overland

We explore AOGCM projection uncertainties across three major components, atmosphere, ocean and sea ice in coupled climate models based on IPCC AR4. To have predictions for the responses of marine ecosystem to future climate change, one must first have reliable climate projections at regional scale. There is much improvement of AR4 models over the previous set of AR3 models, yet in PICES there still is heard the opinion that because of the range of AR4 model results for the same variables, that the entire process is flawed. A meta-analysis of AR4 studies, however, does show considerable confidence that coupled climate models provide credible quantitative estimates of future climate change at continental scales and above. But the quality of climate projections from different models on regional scales is, unfortunately, location and variable dependent. For regional studies, we propose a two-step strategy, in which outlier models are first removed based on their ability of simulating large scale climate variability, *e.g.* the PDO over the North Pacific. The models' performance for individual regions and variables is then further evaluated before composite projections are made. With this two-step approach the uncertainty spread is greatly reduced, and credibility in model projections for coupled climate/ecosystem studies is further increased.

Nicholas A. Bond

Regional scale projections and their uncertainties from coupled climate models

We explore climate model projections for the atmosphere, ocean and sea ice in the IPCC AR4 models. Predictions of the responses of marine ecosystem to future climate change require reliable climate projections at regional scale. There is considerable confidence that the latest generation of coupled climate models provide credible, quantitative estimates of the future climate at continental scales. Nevertheless, the quality of climate projections from these models on the regional scale is, unfortunately, model, location and variable dependent. For regional studies, we propose a two-step strategy, in which outlier models are first removed based on their ability of simulating large-scale variability, *e.g.* the PDO over the North Pacific in the 20th century compared to the observations. The models' performance for individual regions and variables is then further evaluated before composite projections are made. Examples for the Bering Sea and the Sea of Okhotsk will be presented. Our approach is designed to provide credible projections for the 21st century for climate-ecosystem studies, and a means for assessing the uncertainty in these projections.

24 October, 11:10 (W8-5605), Invited

A unified teleconnection mechanism between extratropical and tropical oceans

Lixin **Wu**

Physical Oceanography Laboratory, Ocean University of China, 5 Yushan Rd., Qingdao, 266003, PR China. Email: lxwu@ouc.edu.cn

Extratropical ocean can affect tropical ocean through slow upper ocean overturning circulation, *i.e.* subtropical-tropical cell (STC). Recent studies also identify a fast surface coupled pathway controlled by wind-evaporation-SST (WES) feedback. Based on the observations and climate model simulations, we propose a unified "relay" teleconnection mechanism between extratropical and tropical decadal climate changes. This relayteleconnection is jointly maintained by both WES and STC dynamics as follow: warming (cooling) over the extratropical ocean can extend to the tropics at seasonal timescale through the WES mechanism, meanwhile the resulting wind anomalies decelerate (accelerate) trade winds that spin down (up) the STC to substantiate warming (cooling) response in the tropics. We will show that the WES-STC relay teleconnection operates in both hemispheres at decadal timescales.

24 October, 11:35 (W8-5648), Invited

The impact of extratropical atmospheric variability on the tropical Pacific: Testing the seasonal footprinting mechanism

Michael **Alexander**[1], Daniel J. Vimont[2], Ping Chang[3] and James Scott[1,4]

[1] NOAA-Earth System Research Laboratory, Boulder, CO, USA. E-mail: Michael.Alexander@noaa.gov
[2] Department of Atmospheric and Oceanic Sciences and Center for Climatic Research, University of Wisconsin – Madison, Madison, WI, USA
[3] Department of Oceanography, Texas A&M University, College Station, TX, USA
[4] Cooperative Institute for Research in Environmental Sciences, Climate Diagnostics Center, Boulder, CO, USA

Previous studies suggest that the "seasonal footprinting mechanism" (SFM) in which fluctuations in the North Pacific Oscillation (NPO) influence the ocean via surface heat fluxes during winter and the resulting springtime subtropical SST anomalies alter the atmosphere-ocean system over the tropics in the following summer, fall and winter. Here, we test the SFM hypothesis by imposing NPO-related surface heat flux forcing in an atmospheric GCM coupled to a reduced gravity ocean model in the tropics and a slab ocean in the extratropics. The forcing is only imposed through the first winter and then the model is free to evolve through the following winter. The evolution of the coupled model response to the forcing is consistent with the SFM hypothesis: the NPO-driven surface fluxes cause positive SST anomalies to form in the central and eastern subtropics during winter; these anomalies propagate towards the equator along with westerly wind anomalies during spring and reach the equator in summer and then amplify, leading to an ENSO event in the following winter. The anomalies reach the equator through a combination of thermodynamically coupled air-sea interactions and equatorial ocean dynamics. The NPO forcing caused warming in the ENSO region in ~70% of the simulations. The impact of the forcing on individual events depends on the state of the tropical atmosphere-ocean system and the evolution of the feedback to the forcing. These results have implications for both interannual and decadal variability throughout the Pacific.

24 October, 12:00 (W8-5762), Invited

The role of thermodynamic coupling in connecting subtropical and tropical Pacific climate variations

Daniel J. **Vimont**

Department of Atmospheric and Oceanic Sciences, University of Wisconsin – Madison, 1225 W. Dayton St., Madison, WI, 53705, USA
E-mail: dvimont@wisc.edu

It is well established that Pacific climate variability includes coherent variations in the tropics and mid- to high-latitudes. This coherence likely results from mechanisms by which tropics influence the higher latitudes, and by which the higher latitudes influence the tropics. The role of thermodynamic coupling in linking subtropical climate variability to tropical climate variability will be explored in this presentation. First, a theoretical framework for understanding the equatorward propagation of subtropical SST anomalies will be presented, with applications toward understanding the spatial structure of tropical decadal variability. This equatorward propagation exists due to the "wind, evaporation, sea surface temperature", or WES feedback. Next, the relative roles of the WES feedback and feedbacks associated with equatorial variations (*e.g.* the Bjerknes feedback, which plays a critical role in generating ENSO variability) will be demonstrated using a combination of coupled general circulation model experiments, and a simple intermediate coupled model. The latter set of experiments highlight the relative roles of the atmospheric North Pacific Oscillation, as well as the Pacific North America (PNA) pattern in generating ENSO variations in the equatorial Pacific.

24 October, 14:00 (W8-5741)

Influence of reducing weather noise on ENSO prediction

Xiaohui **Tang**[1], Ping Chang[2] and Fan Wang[1]

[1] Key Laboratory of Ocean Circulation and Waves, Institute of Oceanology, Chinese Academy of Sciences, Qingdao, 266071, PR China. E-mail: tangxiaohui@ms.qdio.ac.cn

[2] Department of Oceanography, Texas A&M University, College Station, TX, 77843, USA

El Niño-Southern Oscillation (ENSO) is the strongest interannual fluctuation in the tropical atmosphere-ocean system. Many studies showed that atmospheric noise forcing can affect ENSO predictability, but there is yet no discussion on how the weather noise impact ENSO forecast skills.

In this study, retrospective predictions of tropical sea surface temperature anomalies (SSTA) were conducted using an atmospheric general circulation model coupled to a 1-$^1/_2$ layer reduced gravity ocean model. A novel atmospheric noise filter is introduced into the coupled model to suppress weather noise in wind stresses and surface heat fluxes before they pass to the ocean, in order to test the impact of weather noise on ENSO-related SST prediction.

Results show that suppressing weather noise leads to a general improvement in model forecast skills. With appropriate initial conditions, reducing weather noise can alleviate drop of ENSO forecast skill caused by the so called "spring predictability barrier", and help maintaining considerably high skill in 3-4 leading seasons. Further analyses show that the improved ENSO forecast skill is mainly attributed to reducing weather noise in wind stresses. It is hypothesized that reducing weather noise boosts the signal-to-noise ratio in the tropical Pacific and improves the model's response to Bjerknes feedbacks between wind stress, thermocline and SST, resulting in an enhanced ENSO forecast skill.

24 October, 14:20 (W8-5657), Invited

Forced versus intrinsic variability of the Kuroshio Extension system on the decadal timescales

Bo **Qiu**, Shuiming Chen and Niklas Schneider

Department of Oceanography, University of Hawaii at Manoa, 1000 Pope Rd., Honolulu, HI, 96822, USA. E-mail: bo@soest.hawaii.edu

A ubiquitous feature of the northern hemisphere subtropical ocean circulation is the existence of an anticyclonic recirculation gyre (RG) on the southern flank of the wind-driven western boundary current outflow. The RGs significantly enhance the eastward volume and heat transport of the western boundary currents and their variability, and has been recognized in recent years to be crucial in understanding of the decadal midlatitude oceanic changes. The dynamic cause for the decadal western boundary current (WBC) variability, especially whether the observed variability is externally forced or reflects the intrinsic, nonlinear RG behavior, is still under debate. This cause in the Kuroshio Extension (KE) system is examined in this study by analyzing satellite altimeter sea surface height (SSH) data, adopting simplified dynamic models, and evaluating nonlinear eddy-mean flow interaction. Long-term SSH measurements reveal clearly that the KE system oscillates between a stable and an unstable dynamic state. Transitions between the two states are caused by PDO-related, basin-scale wind stress curl forcing in the eastern North Pacific. During the positive PDO phase, wind-induced negative SSH anomalies from the east work to weaken the KE jet, shifting its path southward. The latter migration causes the KE jet to override the shallow Shtsky Rise, leading to an enhanced eddy kinetic energy, *i.e.*, unstable state of the KE. With a time lag of 1~2 yrs, the enhanced eddy variability is found to strengthen the KE's southern RG. Helped by the incoming, positive SSH anomalies from the east due to the negatively-phased PDO forcing, this eddy-driven circulation works to switch the KE system to a dynamically stable state. While the eddy-driven nonlinear RG dynamics facilitates modulations of the KE system, the decadal transitions of the KE system are found to be largely paced by the external PDO wind forcing. Specifically, we argue that the decadal timescale in the PDO wind forcing originates in the coupling of the KE SST variability and the basin-wide, midlatitude atmospheric responses.

24 October, 14:45 (W8-5829)

Kuroshio Extension variability during the last 50-years and its predictability

Shoshiro **Minobe**, Jiaxu Zhang and Miho Urasawa

Graduate School of Science, Hokkaido University, N10, W8 Sapporo, Hokkaido, 060-0810, Japan. E-mail: minobe@mail.sci.hokudai.ac.jp

Latitudinal migrations and strength changes of the Kuroshio Extension (KE) are documented based on observational data for the first time during the last 50-years, and relations between these KE variations and atmospheric circulation anomalies are investigated. In order to know the KE changes before the satellite era, temperature observations archived in the World Ocean Database 2005 are newly gridded with a Gaussian filter whose e-folding scale of 100 km. The EOF analysis of zonally averaged (140°-150°E) heat content anomalies (0-1000 m averaged temperature) captures the KE meridional migration as the EOF-1 and the KE strength change as the EOF-2, consistent with a numerical study by Taguchi *et al.* (2007), who analyzed a 1/10° OGCM for the Earth Simulator (OFES). Lag correlation analysis indicate that the 1st mode of the Kuroshio Extension is associated with a mono-pole pattern of low-pass filtered (5-year running mean) sea-level pressure anomalies, associated with wind-stress curl anomalies around 35-43°N in the central North Pacific with a three-year lag. Also, the 2nd mode is linked to the meridional dipole pattern of the atmospheric circulation anomalies known as North Pacific Oscillation/West Pacific Pattern, accompanied by wind stress curl anomalies over 30-38°N in the eastern North Pacific with a five-year lag, consistent with an analysis of KE migration in OFES by Ceballos *et al.* (2009). These lag-relations indicate that the KE migration can be predicted (|r|=0.73) using atmospheric data with 1-year lead time, and KE strength (|r|=0.77) using atmospheric data with 3-year lead time.

24 October, 15:05 (W8-5554)

The long-term transport variation of Kuroshio and its adjacent currents in the western North Pacific Ocean

Rong-shuo **Cai** [1], Qi-long Zhang [2] and Hong-jian Tan[1]

[1] Key Lab of Global Change and Marine-Atmospheric Chemistry, Third Institute of Oceanography, State Oceanic Administration, Xiamen, 361005, PR China. E-mail: rscai@163.com

[2] Institute of Oceanology, Chinese Academy of Sciences, Qingdao, 266071, PR China

Based on the long time monthly mean sea temperature and salinity reanalysis data from the Japan Meteorological Agency (JMA), the volume transport of the Kuroshio and its adjacent currents in the western North Pacific Ocean were analyzed by using the dynamical method. The results show that the volume transports of the Kuroshio and its adjacent currents in the western North Pacific have distinct inter-annual and inter-decadal variations, and obvious long-term trends. In contrast to the Mindanao transport, the transport fluxes of Kuroshio (KC) and North Equator Current (NEC) exhibit prominent increasing trends in the past 50 years. These trends can be related to the wind anomaly over the tropical western Pacific and the warming in the tropical central and eastern Pacific Ocean under the background of global warming, though further studies are needed to clarify such linkages. The long-term variation of Kuroshio and its adjacent currents in the western North Pacific Ocean and their effects on the air-sea interaction and the East Asian climate, even on marine ecosystem in the East China Sea also should be investigated in the future.

24 October, 16:20 (W8-5796), Invited

Decadal variability in the oceanic frontal zones in the western North Pacific Ocean

Masami **Nonaka**[1], Hisashi Nakamura[1,2], Bunmei Taguchi[3], Youichi Tanimoto[1,3] and Hideharu Sasaki[4]

[1] Research Institute for Global Change, JAMSTEC, 3173-25 Showa-machi, Kanazawa-ku, Yokohama, 236-0001, Japan
E-mail: nona@jamstec.go.jp
[2] Graduate School of Science, the University of Tokyo, Hongo, Bunkyo-ku, Tokyo, 113-0033, Japan
[3] Graduate School of Environmental Earth Science, Hokkaido University, Sapporo, 060-0810, Japan
[4] Earth Simulator Center, JAMSTEC, 3173-25 Showa-machi, Kanazawa-ku, Yokohama, 236-0001, Japan

The western North Pacific (NP) region is known as one of the centers of action of Pacific decadal variability, and it is suggested that air-sea interactions in the region may have a key role to induce or intensify the decadal variations. As recent studies have revealed possible importance of oceanic frontal zones to feedbacks from the ocean to the atmosphere, we have investigated variations in the oceanic frontal zones based on a hindcast integration of an eddy-resolving OGCM. It is found that the corresponding decadal sea surface temperature anomalies (SSTAs) in the western NP region have their maxima along the two frontal zones, the Kuroshio Extension (KE-) and the Oyashio Extension (subarctic; SA-) frontal zones (FZs), suggesting the importance of meridional migration of the fontal region. Although the two frontal zones are usually considered as a unified one in studies using coarser horizontal resolution models and data products, SSTAs in the two FZs do not have high correlation. This indicates that, to some extent, they have different variability. Indeed, the OGCM result shows that variations in the Oyashio Current intensity can contribute to variations in SAFZ. In contrast, it is known that westward propagation of wind-induced Rossby waves can explain large meridional-scale variations in KEFZ, which are accompanied by small meridional-scale, *i.e.*, frontal-scale, variations. For the frontal-scale variations associated with the decadal variations in intensity of the KE Current, possible importance of advection of high (low) potential vorticity water to the north (south) of the KE Current is suggested.

24 October, 16:45 (W8-5767)

Low-frequency fluctuations of thermal conditions in the Far-Eastern Seas and large-scale climate processes

Elena I. **Ustinova** and Yury D. Sorokin

Pacific Fisheries Research Centre (TINRO-Centre), 4 Shevchenko Alley, Vladivostok, 690950, Russia. E-mail: eustinova@mail.ru

This study is devoted to low-frequency variability of thermal characteristics in the Far-Eastern Seas and the links between regional conditions and large-scale climatic oscillations. We estimated the contribution of the long-term components to total variance using updatable regional data sets. Previous work has found some ambiguity of the relationships between regional conditions and various climatic indices. In this paper, the unsteady features of the relationships were analyzed paying special attention to the sharp transitions in the North Pacific climatic system ("regime shifts"). In the transition periods some relationships becomes from positive to negative and visa versa. In a number of cases spatial boundary between distinct types of the relationships is the Polar front in the Japan/East Sea and the Subarctic front in the Northwestern Pacific. Among the climatic indices winter West Pacific Index has the steadiest connections with the regional thermal characteristics, since it reflect a state of the Far-Eastern upper-level trough in atmosphere. The "geometry" and intensity of the trough determines regional thermal conditions in many respects. However, in the beginning of 1980s and since 2006 correlation between winter WP and ice cover in the Okhotsk Sea sharply decreases. In the Sea "sub-regional" regime shift occurred at the beginning of the 1980s. Besides, here the frequency of the extreme situations and abrupt changes in thermal conditions has increased last 15 years. Potential statistical predictability of low-frequency thermal fluctuations in the Far-Eastern Seas is "better" in winter then in summer, and in spring in comparison with autumn.

24 October, 17:05 (W8-5837)

Long-term change of thermal structure in the surface layer due to wind-induced conditions around the Korean Peninsula

In-Seong **Han**, Young-Sang Suh, Jae-Dong Hwang and Joon-Soo Lee

Ecology and Oceanography Division, National Fisheries Research and Development Institute, 152-1 Haean-ro, Gijang-eup, Gijang-gun, Busan, 619-705, R Korea. E-mail: hanis@nfrdi.go.kr

Wind-speed related with East Asian Monsoon dramatically decreased during recent a few tens years in the Northwestern Pacific. Around the Korean Peninsula, wind-speed also clearly decreased about 30% during last 40 years. This significant change should be influenced to oceanic thermal structure in the upper layer. In the Korean Waters, temperature at surface and 30m-depth layer increased about 0.93°C and 0.20°C, though it at 50m-depth layer and 100m-depth layer decreased about 0.11°C and 0.43°C during last 39 years. It seems that temperature at the surface layers has an increase trend and around the subsurface layers has a decrease trend. We can also find out that significant increasing trend of sea surface temperature usually appeared in winter season. These phenomena usually appeared in the East Sea and Yellow Sea, though it could not be detected in the Northern East China Sea of Korea. Actually, we compute turbulent heat flux (latent heat flux and sensible heat flux) using long-term oceanographic and meteorological data around the Korean Peninsula. Sensible and latent heat was slightly decreased in the East Sea and Yellow Sea, though they were slightly increased in the Northern East China Sea of Korea. Wind-induced conditions could be influenced to thermal structure in the upper layer; one is change of vertical mixing between surface and sub-surface layers and the other is change of surface heat change like sensible and latent heat.

24 October, 17:25 (W8-5518)

Surface freshening and mid-depth warming in the Pacific Western Subarctic since 1950s

Konstantin A. Rogachev and Natalia V. **Shlyk**

V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: rogachev@poi.dvo.ru

Kamchatka and Upper Oyashio intermediate water exhibits a warming trend since 1950s. Temperature in this region increased by 1.4°C during 1953 to 2009 at potential density of 26.75 sigma theta (at depths of approximately 170 m). This rate of warming is much faster than that of the Global Ocean and the Okhotsk Sea. Western Bering Sea increased by 1.7°C at the same potential density. Upper Oyashio warming is likely linked to the anomalous westward penetration of warm water of the Alaskan Stream. Alaskan Stream breaks-up into Aleutian eddies at ~172°E south of Near Strait. These eddies play an important role in westward transport of Alaskan Stream water. The transport of warm water into the Kamchatka and Upper Oyashio is accomplished by the Aleutian eddies, rather than by a continuous flow of the Alaskan Stream. *In situ* sampling of these eddies was undertaken in 1990-2009. Argo and altimetry data show the two main pathways of the Aleutian eddy movement across the western subarctic gyre. The size of these eddies indicates their significant contribution to the warm water transport. Our observations indicate that the Alaskan Stream breaks up into *large* eddies in recent years, whereas the size of eddies were significantly *reduced* during 1990s. The volume transport in the mid-water column of the Aleutian eddies shows at least a *twofold* increase during recent years. It is plausible to interpret that the mid-depth warming and the increase of volume of the Aleutian eddies were due to the strengthening of the subarctic gyre.

25 October, 9:00 (W8-5755), Invited

Decadal variability of the Kuroshio/Oyashio Extension fronts and their atmospheric influences

Bunmei **Taguchi**[1], Hisashi Nakamura[2,3], Masami Nonaka[3], Nobumasa Komori[1], Akira Kuwano-Yoshida[1], Hideharu Sasaki[1], Koutarou Takaya[3] and Shang-Ping Xie[4]

1 Earth Simulator Center, Japan Agency for Marine-Earth Science and Technology, 3173-25 Showa-machi, Kanazawa-ku, Yokohama, 236-0001, Japan. E-mail: bunmei@jamstec.go.jp
2 Department of Earth and Planetary Science, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo, 113-0033, Japan
3 Research Institute for Global Change, Japan Agency for Marine-Earth Science and Technology, 3173-25 Showa-machi, Kanazawa-ku, Yokohama, 236-0001, Japan
4 International Pacific Research Center, SOEST, University of Hawaii at Manoa, Honolulu, HI, 96822, USA

This talk will address two ocean-atmosphere processes involving the Kuroshio/Oyashio Extension (KOE) fronts, which are relevant to the North Pacific climate variability. The first process concerns basin-scale wind forcing on the KOE frontal variability. Studies have shown that the wind forcing emanates westward-propagating oceanic Rossby waves that correspond well with large-scale patterns and their phase changes in sea surface height anomalies in the North Pacific basin. Multi-decadal eddy-resolving ocean simulations suggest that, upon the arrival of the Rossby waves in the KOE region, adjustment of Kuroshio Extension's recirculation gyres organizes the incoming signals into narrow oceanic frontal zones, causing low-frequency variability in sea surface temperature (SST) and surface heat fluxes (SHF) with large amplitudes along the fronts. Such frontal variability in the KOE region, a region of intense air-sea heat exchanges, points to the second process, differential SHF across the oceanic fronts as the forcing on the overlying atmosphere on large-scale. Using an atmospheric regional model, we confirm the importance of the near-surface baroclinicity, which is maintained by the cross-frontal SHF contrast counteracting poleward heat transports due to atmospheric eddies that relax the baroclinicity, in shaping seasonal (winter-spring) mean atmospheric storm-track along the oceanic frontal zones as observed. We will further discuss whether such ocean frontal influence on the mean atmospheric storm-track extends to the atmospheric low-frequency variability using a nearly century-long integration of a coupled GCM, whose ocean component has a horizontal resolution of 0.5º that can (barely) represent oceanic frontal features in the KOE region and their decadal variability.

25 October, 9:25 (W8-5938)

Extratropical ocean to atmosphere coupling via atmospheric Ekman pumping

Niklas **Schneider**[1,2], Yoshinori Sasaki[1], Axel Lauer[1], Bo Qiu[2], Arthur J. Miller[3] and Detlef Stammer[4]

1 International Pacific Research Center, University of Hawaii at Manoa, Honolulu, HI, USA. Email: nschneid@hawaii.edu
2 Department of Oceanography, University of Hawaii at Manoa, Honolulu, HI, USA
3 Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA, USA
4 Institut für Meereskunde, KlimaCampus Universitat Hamburg, Hamburg, Germany

A corner stone of geophyscial fluid dynamics is the transmission of a surface stress into the invicid flow away from the boundaries by Ekman pumping. Recent satellite bourne observations reveal a strong imprint of sea surface temperature (SST) on the surface stress in areas of strong SST fronts. This suggests that oceanic fronts impact the atmospheric circulation by modulating Ekman pumping. We estimate the impact of SST on atmospheric Ekman pumping using a high resolution atmospheric analysis. We find that the Ekman pumping due to SST is of the same order as atmospheric vertical velocities on time scales of months and longer. SST fronts modify the rate of damping of the tropospheric geostrophic circulation, and generate curl of the wind stress due to the spatial variations of the mixing in the atmospheric boundary layer, and due to the imprint of the sea surface temperature on the atmospheric boundary layer temperature and pressure, as suggested previously. Atmospheric Ekman pumping may be a key process to couple the ocean mesoscale and atmospheric circulation in the extratropics.

25 October, 9:45 (W8-5586)

ENSO and the North Pacific Gyre Oscillation: An integrated view of Pacific decadal dynamics

Emanuele **Di Lorenzo**[1], Niklas Schneider[2], Kim M. Cobb[1], Jason Furtado[1] and Michael Alexander[3]

[1] School of Earth and Atmospheric Sciences, Georgia Institute of Technology, GA, 30306, USA. E-mail: edl@gatech.edu
[2] International Pacific Research Center, University of Hawaii at Manoa, HI, USA
[3] NOAA/Earth System Research Laboratory, Boulder, CO, USA

We show that the Pacific Decadal Oscillation (PDO) and the North Pacific Gyre Oscillation (NPGO) are dynamically linked to each other through their relationships to ENSO. The PDO and NPGO are the oceanic expression of the two dominant modes of North Pacific atmospheric variability — the Aleutian Low (AL) and the North Pacific Oscillation (NPO). We compute the two dominant modes of ocean/atmosphere co-variability in the Pacific sector [40S-62N] and find that the first co-variability mode captures the mature phase of ENSO and its atmospheric teleconnections to the AL, while the second co-variability mode captures the NPGO/NPO tropical expression, which leads the ENSO mode by ~8-12 months. The atmospheric projections of these first two modes are used to extract the AL and NPO forcings related to ENSO. These forcings are then integrated with an AR-1 model and lead to skillful reconstructions of the PDO (R=0.65), NPGO (R=0.60), and Pacific surface temperature decadal variance (R=0.4-0.8). We synthesize these results with previous studies and propose a framework for quasi-deterministic decadal oscillations of Pacific climate.

25 October, 10:05 (W8-5820)

North Pacific decadal variability: Current understanding and unresolved issues

Arthur J. **Miller**[1], Emanuele Di Lorenzo[2], Shoshiro Minobe[3] and Niklas Schneider[4]

[1] Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA, USA. E-mail: ajmiller@ucsd.edu
[2] School of Earth and Atmospheric Sciences, Georgia Institute of Technology, GA, 30306, USA
[3] Natural History Sciences, Graduate School of Sciences, Hokkaido University, N10W8 Rigaku-8-goukan 3F, Sapporo, 060-0810, Japan
[4] International Pacific Research Center, University of Hawaii at Manoa, HI, USA

Current understanding of the mechanisms controlling North Pacific decadal variability will be summarized. Outstanding unresolved issues, including applications to ecosystems, will also be discussed.

W8 Posters

W8-5555

Spatial and temporal oscillation and long-term variation in sea surface temperature field of the South China Sea

Rong-shuo **Cai**[1,2], Qi-long Zhang [3] and Qing-hua Qi[1]

[1] Key Lab of Global Change and Marine-Atmospheric, Third Institute of Oceanography, State Oceanic Administration, Xiamen, 361005, PR China; Center for Monsoon System Research, Institute of Atmospheric Physics, Chinese Academy of Science, Beijing 100190, PR China. E-mail: rscai@163.com

[2] Institute of Oceanology, Chinese Academy of Sciences; Key Laboratory of Ocean Circulation and Waves (KLOCAW), Qingdao, 266071, PR China

Based on monthly mean Sea Surface Temperature (SST), 850 hPa wind and subtropical high index over the western Pacific during 1950-2006, the spatial and temporal oscillation and long-term variation in SST field of the South China Sea (SCS) are analyzed by using empirical orthogonal function (EOF), polynomial function and spectrum analysis, and then the causes of SST interannual and long-term variation are discussed by using correlation and composite analysis. The results show that SST anomaly fields have two major patterns. SSTs over the SCS have spatially in-phase interauunal variation and seasonal oscillation with out-of-phase between the west and east SCS. The SST in the central SCS exhibit significant interannual and interdecadal variations, and experienced a climate jump in 1981. The annual mean SST in the central SCS increased by 0.92°C from 1950 to 2006. It is also suggested that the interannual and long-term variations in SST of the SCS may be resulted from the meridional wind anomaly and zonal migration of the Subtropical High over the western Pacific.

W8-5559

Description of seasonal water circulation variability in Tatar Strait in the Japan Sea by numerical method

Yuri **Nikonov**

Sakhalin Meteoagency, 78 Zapadnaya St., Yuzhno-Sakhalinsk, Russia. E-mail: y_nikonov@sakhmeteo.ru

A numerical study is conducted for an area southeast of Sakhalin Island littoral, which has complicated hydrodynamic conditions, in order to obtain oceanic parameters with high temporal and spatial resolutions. The purpose of this paper is to examine the validity of a numerical ocean model outputs for hydrodynamic parameters in Tatar Strait.

Princeton Ocean Model is used in this study, because this model is known by its high performance in areas with steep bottom tropographies. For initial conditions, average parameters taken from the atlan of V.M. Pischalnik were chosen.

We will show the distributions of temperature and salinity and the flow maps, and compare them with observations around the Tatar Strait.

W8-5690

The role of diurnal cycle and mixed layer depth perturbations in ventilation: Subduction and obduction

Ling Ling **Liu**[1], Rui Xin Huang[2] and Fan Wang[1]

[1] Key Laboratory of Ocean Circulation and Waves (KLOCAW), Institute of Oceanology, Chinese Academy of Sciences, Qingdao, 266071, PR China. E-mail: liull@ms.qdio.ac.cn
[2] Department of Physical Oceanography, Woods Hole Oceanographic Institution, Woods Hole, MA, 02543, USA

Subduction/obduction is a key process for the study of watermass balance and climate. We refine the definition of the subduction/obduction rate especially suitable for the cases with diurnal cycle or mixed layer depth perturbation. First, in Eulerian coordinates the annual mean subduction/obduction rate can be calculated from the same definition used in previous studies by refining the time interval of trajectory tracing. Second, in the Lagrangian coordinates the annual mean subduction/obduction rate can be calculated through searching the primary trajectory, which is defined as the trajectory along which annual subduction/obduction rate is maximal among all possible one-year trajectories released from the base of the mixed layer at the given station; the corresponding rate of water mass exchange between the mixed layer and the permanent pycnocline is defined as the annual mean subduction/obduction rate in this station. Our analysis indicates that including the diurnal cycle, the subduction/obduction rate can increase on the order of 30% in both the Eulerian and the Lagrangian coordinates. In addition, perturbations of mixed layer depth can substantially modify the time of the effective entrainment/detrainment and the annual mean subduction/obduction rate.

W8-5803

Variability of the Kamchatka Current transport in the Kamchatka Strait

Gennady V. **Khen**

Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690950, Russia
E-mail: gennady1@tinro.ru

The Kamchatka Current has been noticeably weakened in period from 1950 up to the middle 1960s, further there has come the long period (from 1965 until 1989) of high activity of water exchange between Pacific and the Bering Sea. Water exchange again began to decrease at the beginning of 1990s and its minimum has come by the end of 1990s. The intensification of the Kamchatka Current was occurred at the beginning of 21 centuries, but present time transport is remained at low level which less long-term average. Comparison of variability of the Kamchatka Current and position of the Aleutian Low Pressure (ALP) in March-May was investigated. There are 3 typical positions of center ALP: eastern, western and intermediate. Dominance of the eastern type assumes prevalence of weak water exchange with Pacific. Extremely low transport quite obviously related with eastern ALP position, and extremely high transport just with western and intermediate types of ALP. Total transport of the Kamchatka Current (from surface to bottom) consisted 20-25 Sv during it intensification (1960 – 1980s), and occurred noticeably less (6-12 Sv) during 1950s, 1990s and 2000s. The week Kamchatka Current transport will have remained during next decade.

W8-5839

Behavior of low salinity water mass from Northern East China Sea to Korea Strait

In-Seong **Han**[1], Takeshi Matsuno[2], Tomoharu Senjyu[2], Young-Sang Suh[1] and Joon-Soo Lee[1]

[1] Ecology and Oceanography Division, National Fisheries Research and Development Institute, 152-1 Haean-ro, Gijang-eup, Gijang-gun, Busan, 619-705, R Korea. E-mail: hanis@nfrdi.go.kr

[2] Research Institute for Applied Mechanics, Kyushu University, Kasuga, Fukuoka, 816-8580, Japan

Low salinity water mass originated by Changjian Diluted Water (CDW) frequently approached around Jeju Island in summer and was damaged to breeding ground and fishing ground around the Jeju Island. Therefore, it is very important to clarify the behavior and distribution of low salinity water (LSW) in summer around the Northern East China Sea and Jeju Island. In this study, we examine the behavior of LSW mass by several observations around the Northern ECS, Jeju Strait and Korea Strait in summer since 2004. We examined several observation data such as ferryboat monitoring in Jeju and Korea Strait, *in situ* observations around the Northern ECS and South Sea of Korea, mooring observation in fisheries set-net in recent several years. In summer, LSW originated from CDW frequently approached to Jeju Island and Korea Strait. LSW usually moved from west off Jeju Island to Korea Strait via west coast of Jeju Island and Jeju Strait. It required about 3 weeks from west off Jeju Island to Korea Strait. LSW mass also clearly corresponded with high temperature and high concentration of chlorophyll *a* in Jeju and Korea Strait. In this study, we briefly examined the route, time required and change of salinity concentration in LSW by the results of various investigations in several years. However, we could not found out that the mechanism of high concentration of chlorophyll *a* appeared in LSW mass. It is needed to find out what is the source of high chlorophyll *a* in LSW by satellite information, ferryboat monitoring and *in situ* observations.

W9 POC/BIO Workshop
Mesoscale eddies and their roles in North Pacific ecosystems

Co-Convenors: Kyung-Il Chang (Korea), William R. Crawford (Canada), Shin-ichi Ito (Japan) and Vyacheslav Lobanov (Russia)

Mesoscale eddies move through the ocean carrying physical, biological, and chemical anomalies. They translate over space scales of hundreds to thousands of kilometers and exist for periods lasting from months to years. Eddies are found throughout the North Pacific Ocean in association with strong boundary currents like the Kuroshio and Oyashio and the Alaskan Stream, and also with North Pacific eastern boundary currents like the California and Alaska Currents. They are also prevalent in marginal seas. Generation and evolution of eddies are thought to be related to the shear instability of boundary currents like the Kuroshio, and topographic features in the California and Alaska Currents. Mesoscale eddies affect the structure of marine plankton in various ways. Horizontal advection and vertical mixing by eddies contribute to the generation of high chlorophyll concentration off the coast. They draw shelf water containing nutrients and planktons into the deep offshore waters. Mesoscale eddies are also important for survival of larvae. Eddy pumping also plays a role in episodic nutrient injections into the photic zone resulting in enhanced primary production inside the eddy for cyclonic eddies. For anticyclonic eddies, ageostrophic upwelling and divergent Ekman pumping due to winds over the eddies yield upwelling within the eddy. This workshop will address: 1) dynamical characteristics of mesoscale eddies in different parts of PICES domain, focusing on their similarity and difference; 2) influences of eddies in constituting the dominant physical forcing on the ecosystems; and 3) expected future eddy activities and their possible impacts on North Pacific ecosystems.

Friday, October 23 (9:00-18:00)

9:00 ***Introduction by Convenors***

9:05 **Carol Ladd, Elizabeth Atwood, William Crawford, Phyllis Stabeno and Frank Whitney (Invited)**
Eddies in the Gulf of Alaska (W9-5588)

9:35 **William Crawford and Nick Bolingbroke**
Cross-shelf exchange by mesoscale eddies in the northeast Pacific Ocean (W9-5656)

9:55 **Vincent Combes, Emanuele Di Lorenzo and Enrique N. Curchitser**
Interannual and decadal variations in eddy-induced cross-shelf transport in the Gulf of Alaska (W9-5598)

10:15 **Hiromichi Ueno, William Crawford and Hiroji Onishi**
Impact of Alaskan Stream eddies on chlorophyll distribution in the central subarctic North Pacific (W9-5792)

10:35 ***Coffee / tea break***

10:55 **Sonia Batten, William J. Sydeman, Mike Henry, David Hyrenbach and Ken Morgan**
Ship of opportunity observations of mesoscale eddies in the Gulf of Alaska (W9-5819)

11:15 **Vyacheslav B. Lobanov**
A census of anticyclonic eddies in the northern Japan/East Sea (W9-5802)

11:35 **Svetlana Y. Ladychenko and Vyacheslav B. Lobanov**
Mesoscale eddies near the Primorye coast in the northwestern Japan/East Sea (W9-5756)

11:55 **Sang-Shin Byun, Jong Jin Park, Jae-Hun Park and Kyung-Il Chang**
Observation of near-inertial waves in an anticyclonic mesoscale eddy in the southwestern East/Japan Sea (W9-5585)

12:15 **Sergey P. Zakharkov, Tatyana N. Gordeychuk and Elena A. Shtraikhert**
Variations of the production phytoplankton parameters of mesoscale anticyclonic eddy in the northwestern part of Sea of Japan (W9-5655)

12:35 ***Lunch***

14:00 **Shoshiro Minobe, Kunihiko Aoki, Youichi Tanimoto, Yoshinori Sasaki and Yoshikazu Sasai (Invited)**
Meridional eddy heat transport estimations using satellite data and eddy resolving OGCM (W9-5828)

14:30 **Sachihiko Itoh and Ichiro Yasuda**
Characteristics of mesoscale eddies in the Kuroshio–Oyashio Extension Region detected in the distribution of the sea surface height anomaly (W9-5866)

14:50 **Hiroshi Sumata, Taketo Hashioka, Maki N. Aita, Naoki Yoshie, Tatsuo Suzuki, Takashi T. Sakamoto, Naosuke Okada and Yasuhiro Yamanaka**
Effects of eddy transport on the nutrient supply into the euphotic zone simulated in an ocean ecosystem model (W9-5727)

15:10 **Xiao-Hua Zhu, Jea-Hun Park and Daji Huang**
Observation and dynamics of baroclinic eddies southeast of Okinawa Island (W9-5805)

15:30 ***Coffee / tea break***

15:50 **Jianping Gan and Anson Cheung**
Vertically varying cyclonic eddy in the southwestern South China Sea (W9-5963)

16:10 **Prescilla Kurien, Motoyoshi Ikeda and Vinu K. Valsala**
Mesoscale variability along the east coast of India in spring and fall revealed in satellite data and OGCM (W9-5617)

16:30 **Natalya B. Luk'yanova and Igor A. Zhabin**
The interaction of Soya Warm Current waters with the anticyclonic eddies in the southern Sea of Okhotsk (W9-5541)

16:50 **Discussion and summary**

18:00 ***Workshop ends***

W9 Oral Presentations

23 October, 9:05 (W9-5588), Invited

Eddies in the Gulf of Alaska

Carol **Ladd**[1], Elizabeth Atwood[2], William Crawford[3], Phyllis Stabeno[1] and Frank Whitney[3]

[1] NOAA-Research, Pacific Marine Environmental Laboratory, 7600 Sand Point Way, Seattle, WA, 98115, USA
E-mail: carol.ladd@noaa.gov
[2] University of Washington, 1122 NE Boat St., Seattle, WA, 98195, USA
[3] Institute of Ocean Sciences, Fisheries and Oceans Canada, P.O. Box 6000, Sidney, BC, V8L 4B2, Canada

The eastern boundary of the Gulf of Alaska (GOA) spawns numerous, ~200 km diameter, anticyclonic eddies that move into the basin and can persist for years. These eddies are important sources of coastal water and associated nutrients, iron, and biota to the high-nutrient, low-chlorophyll Gulf of Alaska basin. *In situ* measurements show that these eddies carry excess heat, salt, nitrate and silicic acid seaward from eddy formation regions. In addition, subsurface eddy core water contains high iron concentrations and low dissolved oxygen compared with surrounding basin water. A subsurface temperature maximum (mesothermal water) coincident in depth with the iron maximum suggests that eddies may play a role in the formation of temperature inversions observed throughout the Gulf of Alaska. In addition to the physical and chemical signatures, recent results suggest that these eddies also influence larval fish assemblages.

23 October, 9:35 (W9-5656)

Cross-shelf exchange by mesoscale eddies in the northeast Pacific Ocean

William **Crawford** and Nick Bolingbroke

Institute of Ocean Sciences, Fisheries and Oceans Canada, P.O. Box 6000, Sidney, BC, V8L 4B2, Canada
E-mail: bill.crawford@pac.dfo-mpo.gc.ca

Altimetry measurements by radar sensors from space since 1992 have provided nearly continuous measurements and are especially useful in cloud-covered regions because the radar signals penetrate clouds. By referencing these sea level measurements to recently determined dynamic ocean topography [Foreman *et al.* Geophys. Res. Lett., 49, L22606, 2008] we can determine absolute sea level heights, which provide accurate views of jets and eddies exchanging coastal and deep-sea waters along the entire coast of the northeast Pacific, from California to Alaska. Additional insight is provided by examination of variability of sub-surface water properties in historical data, and by adding satellite measurements of ocean surface chlorophyll to the altimetry maps. The combined images of chlorophyll and altimetry reveal significant differences in offshore transport among three distinct regions. Eddies of Alaska and northern British Columbia are largest and most buoyant, penetrating farthest offshore. Eddies and jets off California and Oregon are smaller and intense, and they tend to sink below the denser offshore waters. Eddies of northern Washington and southern British Columbia are weakest by far, so that nutrients and chlorophyll are retained on the continental shelf and are a factor in the large fisheries yield in these waters compared to surrounding regions.

23 October, 9:55 (W9-5598)

Interannual and decadal variations in eddy-induced cross-shelf transport in the Gulf of Alaska

Vincent **Combes**[1], Emanuele Di Lorenzo[1] and Enrique N. Curchitser[2]

[1] School of Earth and Atmospheric Sciences, Georgia Institute of Technology, GA, 30332, USA
E-mail: vincent.combes@eas.gatech.edu
[2] Institute of Marine and Coastal Sciences, Rutgers University, New Brunswick, NJ, USA

The marine ecosystem of the Gulf of Alaska (GOA) is one of the richest on the planet. Recent observational studies suggest that advection of iron-rich coastal water is the primary mechanism controlling open ocean productivity. Specifically, there is evidence that mesoscale eddies along the coastal GOA entrain iron-rich coastal waters into

the ocean interior. This study investigates the cross-shelf transport statistics in the GOA using a free-surface, hydrostatic, eddy-resolving primitive equation model over the period 1965–2004. The statistics of coastal water transport are computed using a model passive tracer, continuously released at the coast. The passive tracer can thus be considered a proxy for coastal biogeochemical quantities such as silicate, nitrate, iron, or oxygen. On average along the Alaska Current, it has been shown that at the surface while the advection of tracers by the average flow is directed toward the coast consistent with the dominant downwelling regime, it is the mean eddy-fluxes that contribute to offshore advection into the gyre interior. South of the Alaskan Peninsula, both the advection of tracers by the average flow and the mean eddy-fluxes contribute to the mean offshore advection. On interannual and longer time scales, the offshore transport of the passive tracer in the Alaskan Stream does not correlate with large-scale atmospheric forcing, nor with local winds. In contrast in the Alaska Current region, stronger offshore transport of the passive tracer coincides with periods of stronger downwelling (in particular during positive phases of the PDO), which trigger the development of stronger eddies.

23 October, 10:15 (W9-5792)

Impact of Alaskan Stream eddies on chlorophyll distribution in the central subarctic North Pacific

Hiromichi **Ueno**[1], William Crawford[2] and Hiroji Onishi[1]

[1] Division of Marine Bioresource and Environmental Science, Graduate School of Fisheries Science, Hokkaido University, 3-1-1 Minato-cho, Hakodate, 041-8611, Japan. Email: ueno@fish.hokudai.ac.jp
[2] Institute of Ocean Sciences, Fisheries and Oceans, P.O. Box 6000, Sidney, B.C., V8L 4B2, Canada

The impact of the Alaskan Stream (AS) eddies on the chlorophyll *a* (Chl-*a*) distribution in the central subarctic North Pacific was investigated through analysis of chlorophyll *a* and altimetry data from satellite observations. The climatological Chl-*a* distributions, averaged in the area and time where and when AS eddies were present, suggested that AS eddies contributed significantly to the Chl-*a* distribution in the deep-sea region of the subarctic North Pacific. The Chl-*a* distribution was closely related to the AS eddies regardless of whether the eddy was located in or detached from the AS. A combination of two or three AS eddies sometimes formed high Chl-*a* concentration belts that injected chlorophyll and coastal nutrient-rich waters southward from the Aleutian Islands far into the deep-sea region of the subarctic North Pacific. Observations of Chl-*a* by satellite provide information on the concentrations of phytoplankton at the sea surface and are therefore relevant to studies of biological productivity of this region.

23 October, 10:55 (W9-5819)

Ship of opportunity observations of mesoscale eddies in the Gulf of Alaska

Sonia **Batten**[1], William J. Sydeman[2], Mike Henry[2], David Hyrenbach[3] and Ken Morgan[4]

[1] Sir Alister Hardy Foundation for Ocean Science, c/o 4737 Vista View Cr., Nanaimo, BC, V9V 1N8, Canada E-mail: soba@sahfos.ac.uk
[2] Farallon Institute for Advanced Ecosystem Research, P.O. Box 750756, Petaluma, CA, 94975, USA
[3] Hawaii Pacific University, 1164 Bishop Street,Honolulu, HI, 96813, USA
[4] Environment Canada, Institute of Ocean Sciences, Sidney, BC, Canada

Ships-of-opportunity have crossed the Gulf of Alaska since 2000 collecting plankton samples with a Continuous Plankton Recorder towed behind the vessel. Although the location and timing of the transects is outside of our control, the ship lines often pass through and sample mesoscale eddies in the open ocean, readily visible from sea surface height anomaly data. Some physical and chlorophyll data were also collected via a CTD on some of the transects and some had a bird and mammal observer onboard. Over 35 eddies have been opportunistically sampled in the Gulf of Alaska by the survey. This dataset has allowed us to examine the influence of the origin, age and intensity of eddies on lower and upper trophic level properties; for example, both taxonomic richness and planktonic abundance appear to be enhanced within eddies in the western Gulf of Alaska, though some eddies in other regions show no apparent anomalies in biological properties. Although this type of ship-of-opportunity sampling is not an ideal method for sampling eddies, it is cost-effective and ongoing. This presentation will summarise the data so far acquired and its contribution to our understanding of the influence of mesoscale eddies on biological properties of oceanic waters.

23 October, 11:15 (W9-5802)

A census of anticyclonic eddies in the northern Japan/East Sea

Vyacheslav B. **Lobanov**

V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: lobanov@poi.dvo.ru

Observations of physical, chemical and biological parameters of anticyclonic eddies over the deep Japan Basin were done in a few cruises during 1999-2009. In total 15 eddies were sampled, some of them with detailed, multi parameter observations, and some of them were sampled repeatedly. The eddy size varied from 50 to 150 km and vertical penetration was traced down to the bottom of deep Japan Basin. The observations confirmed extreme values of physical and chemical parameters of the eddy core water masses. Most of the sampled eddies originated from the northwestern and western area of the sea and contained low salinity, relatively warm water in their core, located typically between 50 and 300 m. Even being translated far eastward down to 137ºE longitude, the eddies kept lower salinity signal. However, the eddies observed in the eastern part of the basin demonstrated a core of warm and high salinity water. This suggests their origin from modified Tsushima Current waters. A few eddies demonstrated a multilayer structure of their inner parts which suggests multiple interactions among the eddies during their life history. Extremely deep penetration of high salinity and high oxygen content just after convection of low potential vorticity waters down to 1000 m along the eddy periphery was observed in winter season. This indicates importance of the eddies for water subduction processes. Lens-like structure of the eddy core causes a splitting of main pycnocline with upward shift of its upper portion and deepening of its lower boundary. This causes variability of chemical and biological parameters with high values of Chl-*a*, primary production, zooplankton biomass and increased number of seals and whales in the eddy area observed in some cases. Thus the mesoscale eddies in the northern Japan/East Sea should be considered as an essential component of circulation and water mass formation and fluxes processes. They are the sites of intermediate water mass formation and spreading and are also the hot spots for marine biota.

23 October, 11:35 (W9-5756)

Mesoscale eddies near the Primorye coast in the northwestern Japan/East Sea

Svetlana Y. **Ladychenko** and Vyacheslav B. Lobanov

Laboratory of Physical Oceanology, V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia. E-mail: svemos@poi.dvo.ru

An important impact of eddy dynamics in the northwestern Japan/East Sea is intensification of cross-shelf water exchange, which provides coastal-zone effective ventilation with open sea water and transport of shelf water with organic elements, plankton and pollutants to the open sea. In the present study we investigated formation, evolution and characteristics of anticyclonic mesoscale eddies near the Primorye coast in the northwestern Japan/East Sea. We used NOAA AVHRR infrared images during summer-autumn period 2006-2008, hydrographic CTD observations and meteorological data. In order to research eddy formation and evolution and to determine their characteristics, we used a visual method of eddy identification from infrared images. The analysis demonstrated that several mesoscale eddies are always detected near the Primorye coast in autumn period. Typical eddy diameters vary from 20-100 km. Eddy life-time changes from several days to some months. Eddies formed in the northeast of research area and then drifted south-westward along the Primorye coast. Results of ship hydrographic observations show that anticyclonic eddies have a core of warm and less saline coastal water. Fresh coastal water is transported across the shelf-break at the eddy eastern side and deep sea water is advected onto the shelf along its western side. Eddies generate strong upwelling events at coastal area in autumn period. Eddies dynamics related with intensification and instability of the Primorye Current.

23 October, 11:55 (W9-5585)

Observation of near-inertial waves in an anticyclonic mesoscale eddy in the southwestern East/Japan Sea

Sang-Shin **Byun**[1], Jong Jin Park[2], Jae-Hun Park[3] and Kyung-Il Chang[1]

[1] School of Earth and Environmental Sciences/Research Institute of Oceanography, Seoul National University, 599 Gwanangno, Gwanak-gu, Seoul, 151-742, R Korea. E-mail: sangsin@snu.ac.kr
[2] Department of Physical Oceanography, Woods Hole Oceanographic Institution, Woods Hole, MA, 02543, USA
[3] University of Rhode Island, Narragansett, RI, 02882-1197, USA

Shear instabilities caused by near-inertial waves (NIWs) or their trapping and breaking can elevate the mixing levels in the water column, which may account for some observed biological patterns in the ocean. NIWs interacting with an anticyclonic mesoscale eddy were investigated using current meter data from a tall mooring deployed in the southwestern East Sea during November 2002 - March 2004. The mooring was equipped with six RCM current meters between 200 m and 2240 m depth levels, and an upward-looking acoustic Doppler current profiler at 160 m depth. The mooring was located near the center of an anticyclonic mesoscale eddy from October 23 to November 20, 2003. During the period we observed four energetic events of NIWs at 360 m. The NIW energy at 360 m is much stronger than those of 153 m and 200 m. The NIWs between 153 m and 200 m have lower intrinsic frequencies than the local Coriolis frequency, however those of 360 m have slightly higher or almost same intrinsic frequencies because the effective Coriolis frequency (the Coriolis frequency plus half the relative vorticity) in the eddy increases with depth. NIWs horizontally trapped in an anticyclonic eddy are well known to be rapidly amplified as they approach the critical depth where the effective Coriolis frequency is same as the NIW intrinsic frequency, and their energy at the depth is ultimately lost to turbulence and mixing. The observed strong NIW energy at 360 m is interpreted as amplifications near the critical depth.

23 October, 12:15 (W9-5655)

Variations of the production phytoplankton parameters of mesoscale anticyclonic eddy in the northwestern part of Sea of Japan

Sergey P. **Zakharkov**, Tatyana N. Gordeychuk and Elena A. Shtraikhert

V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia
E-mail: Zakharkov @poi.dvo.ru

We investigated variability of the production phytoplankton parameters in a zone of anticyclonic eddy formed in a northwest part of Sea of Japan since August 2002 till April, 2003 with use of satellite and natural data. Data on concentration of a chlorophyll *a* (Chl-*a*) and superficial temperature of the sea (SST) have been received by means of SeaWiFS colour scanner for 1998-2007 from a site <http://ocean.colour.gsfc.nasa.gov> and were analysed by SeaDAS software. Data *in situ* have been received during 30th cruise of the R/V "Academician Lavrentev" which was passing from February 26th till March 9th, 2003. During cruise tests for definition of Chl-*a* concentration, primary production and specific structure of a phytoplankton have been selected. Some of these data have been used to validate the satellite information. Anticyclonic eddy formation, proceeding from values of SST, began since August, 2002 with coordinates in the anticyclonic eddy centre – 40.5 N, 131 E and Chl-*a* concentration nearby 0,4 - 0,5 mg/m^3 and, apparently, has been connected with increase in inflow of subtropical waters at the north and interaction with cold Primorye and warm East Korean currents. Increase of Chl-*a* concentration in the anticyclonic eddy occurred earlier than that in surrounding subarctic waters. The maximum of development of phytoplankton in the anticyclonic eddy was observed in December 2002 and April 2003. For all period of supervision the maximum values of primary production were defined on anticyclonic eddy periphery.

23 October, 14:00 (W9-5828), Invited

Meridional eddy heat transport estimations using satellite data and eddy resolving OGCM

Shoshiro **Minobe**[1], Kunihiko Aoki[1], Youichi Tanimoto[2], Yoshinori Sasaki[3] and Yoshikazu Sasai[4]

[1] Graduate School of Science, Hokkaido University, N10, W8, Sapporo, Hokkaido, 060-0810, Japan
E-mail: minobe@mail.sci.hokudai.ac.jp
[2] Graduate School of Environmental Science, Kita Ku, Sapporo, Hokkaido, 060-0810, Japan
[3] International Pacific Research Center, University of Hawaii, Honolulu, HI, 96822, USA
[4] Japan Agency Marine Earth Science and Technology, Yokohama, Kanagawa, Japan

Mesoscale ocean eddies are important in transporting momentum, heat, freshwater, and nutrient horizontally and vertically, but our understanding of the nature and roles of the mesoscale eddies is inadequate. Recent eddy-resolving OGCM and satellite observations, however, have opened a new era for studies of the mesoscale eddies. In the present paper, we first explain two approaches for mesoscale eddies: one is an Eulerian approach, and the other is a Lagrangian approach. In the Eulerian approach, we estimate meridional eddy heat transports in the North Pacific by two independent methods: one uses an eddy resolving (1/10° resolution) OGCM, and the other uses satellite-derived SST and surface geostrophic velocities. The former is the first attempt of the eddy transport estimation using an eddy resolving OGCM. The latter method was employed by Qiu and Chen (2005), who used TRMM SST data limited south of 38°N, but we have expanded our estimation for the whole North Pacific by using AMSR-E SSTs. The resultant meridional eddy heat transport commonly indicates maximal values between the Kuroshio Extension and the subpolar front, where the eddy heat transport explains more than half of the total oceanic heat transport. In essence, the mesoscale eddies play a dominant role in bringing the heat further to the north of the Kuroshio Extension, which is inefficient in transporting heat northward due to its roughly zonal flow. As an example of Lagrangian approach, an eddy tracking analysis will also be presented.

23 October, 14:30 (W9-5866)

Characteristics of mesoscale eddies in the Kuroshio–Oyashio Extension Region detected in the distribution of the sea surface height anomaly

Sachihiko **Itoh** and Ichiro Yasuda

Ocean Research Institute, The University of Tokyo, 1-15-1 Minamidai, Nakano-ku, Tokyo, 164-8639, Japan
E-mail: itohsach@ori.u-tokyo.ac.jp

This study investigates the distribution of the sea surface height anomaly (SSHA) with the aim of determining the quantitative characteristics of mesoscale eddies in the Kuroshio–Oyashio Extension Region (KOER), where intense mesoscale eddies are commonly observed during hydrographic surveys. Dense distributions of both anticyclonic eddies (AEs) and cyclonic eddies (CEs) are detected for the first time in KOER with sufficient temporal and spatial coverage, using the Okubo–Weiss parameter without smoothing. Their contribution to the total SSHA variance is estimated to be about 50%. The zones of highest amplitudes are located north and south of the axis of the Kuroshio Extension (KE) for AEs and CEs, which represent warm-core and cold-core rings, respectively; the areas extend poleward along the Japan and Kuril–Kamchatka trenches, especially for AEs. Eddies of both polarities and with moderate amplitudes are also recognized along the Subarctic Front (SAF). Eddies in areas north and south of KE generally propagate westward, at a mean rate of 1–5 cm s^{-1}; those along the trenches south of 46°N and along SAF propagate poleward at mean rates of 1–2 and 0.5–1 cm s^{-1}, respectively. Because of the asymmetric distribution and amplitude of AEs and CEs in the areas north and south of KE and along the Japan and Kuril–Kamchatka trenches, there exist significant eddy fluxes of vorticity, heat, and salinity in these areas.

23 October, 14:50 (W9-5727)

Effects of eddy transport on the nutrient supply into the euphotic zone simulated in an ocean ecosystem model

Hiroshi **Sumata**[1], Taketo Hashioka[2], Maki N. Aita[2], Naoki Yoshie[3], Tatsuo Suzuki[2], Takashi T. Sakamoto[2], Naosuke Okada[1] and Yasuhiro Yamanaka[1]

[1] Graduate School of Environmental Earth Science, Hokkaido University, N10W5 Kita-ward, Sapporo, Hokkaido, 060-0810, Japan
E-mail: su@ees.hokudai.ac.jp
[2] Frontier Research Center for Global Change, Japan Agency for Marine-Earth Science and Technology, 2-15 Natsushima-cho, Yokosuka, Kanagawa, 237-0061, Japan
[3] Center for Marine Environmental Studies, Ehime University, 2-5 Bunkyo-cho, Matsuyama, Ehime, 790-8577, Japan

Hindcast experiment with an eddy-permitting, ocean ecosystem model is performed in order to investigate the process of nutrient supply into the euphotic zone by vertical and horizontal fluxes with multiple timescales. According to the model result, the temporal mean vertical advection supplies substantial part of nutrient from the aphotic zone from low- to high-latitudes, and contributions from seasonal and eddy vertical fluxes are limited within the tropical region except for regions where strong meandering currents exist. The vertical convection associated with deep mixed layer also largely contributes to the nutrient supply in the mid- to high-latitude oceans. Since the horizontal distribution of nutrient source is regulated by horizontal scales of vertical advection, and the vertical advection has much smaller spatial scale than the potential sink of nutrient, which is mainly regulated by temperature and light supply, redistribution of nutrient by horizontal advection is of vital importance to organize the spatio-temporal pattern of primary production. In particular, the horizontal advection due to seasonal and eddy fluctuations plays an important role in the redistribution process as well as the temporal mean horizontal advection. The relative importance of these fluctuations strongly depends on the horizontal scales and inhomogeneous spatial pattern of vertical nutrient supply.

23 October, 15:10 (W9-5805)

Observation and dynamics of baroclinic eddies southeast of Okinawa Island

Xiao-Hua **Zhu**[1], Jae-Hun Park[2] and Daji Huang[1]

[1] State Key Laboratory of Satellite Ocean Environment Dynamics, Second Institute of Oceanography, SOA, Hangzhou, 310012, PR China. E-mail: xhzhu@sio.org.cn
[2] Graduate School of Oceanography, University of Rhode Island, Narragnsett, RI, 02882, USA

In the region southeast of Okinawa, during May to July 2001, a cyclonic and an anticyclonic eddy were observed from combined measurements of hydrocasts, a moored acoustic Doppler current profiler (MADCP), pressure-recording inverted echo sounders (PIESs), satellite altimetry, and a coastal tide gauge. The hydrographic data showed that the lowest/highest temperature (T) and salinity (S) anomalies from a 13-year mean for the same season were respectively 3.0/+2.5°C and 0.20/+0.15 psu at 380/500 dbar for the cyclonic/anticyclonic eddies. From the PIES data, we estimated time-varying surface dynamic height (D) anomaly referred to 2000 dbar changing from 20 to 30 cm, and time-varying T and S anomalies at 500 dbar ranging through about ±2°C and ±0.2 psu, respectively. The passage of the eddies caused both satellite-measured sea surface height anomaly (SSHA) and tide-gauge-measured sea level anomaly to change from about –20 to 30 cm, consistent with the D anomaly from the PIESs. Bottom pressure sensors measured no variation related to these eddy activities, which indicated that the two eddies were dominated by baroclinicity.

23 October, 15:50 (W9-5963)

Vertically varying cyclonic eddy in the southwestern South China Sea

Jianping **Gan** and Anson Cheung

Department of Mathematics and the Atmospheric Marine and Coastal Environment Program, Hong Kong University of Science and Technology, Kowloon, Hong Kong SAR, PR China. E-mail: magan@ust.hk

As part of the 'basin gyre-estuarine circulation' investigation in the South China Sea, observational and three-dimensional modeling studies were conducted to investigate the vertical development and characteristics of a winter cyclonic eddy in the southwestern South China Sea (SSCS). The eddy is formed as a result of southward coastal jet separation off Vietnam. It develops at the onset of northeasterly monsoon in early October, matures in December and dissipates after January. The eddy, with its horizontal scale defined by the filtered Okubo-Weiss parameter, has relatively strong azimuthal currents in its southwestern part and exhibits a strong depth-dependent feature. The vorticity, radius and kinetic energy of the eddy decrease linearly from surface to 300 m in the vertically sheared flow, in which vertical eddy momentum and heat fluxes contribute to the vertical development and variation of the eddy. Depth-dependent vertical motion in the water column of the eddy is largely generated by the variation of ageostrophic divergence, in which the divergence and upward motion take place in the main pycnocline.

23 October, 16:10 (W9-5617)

Mesoscale variability along the east coast of India in spring and fall revealed in satellite data and OGCM

Prescilla **Kurien**[1], Motoyoshi Ikeda[1] and Vinu K. Valsala[2]

[1] Graduate School of Environmental Earth Sciences, Hokkaido University, Kita10 Nishi5, Sapporo, Hokkaido, 060 0810, Japan
E-mail: prescy@ees.hokudai.ac.jp

[2] Center for Global environmental Research, National Institute for Environmental Studies, Tsukuba, 305 8506, Japan

Since mesoscale meanders have great importance in nourishing coastal fisheries, satellite data analyses and a numerical modeling study were carried out for the east coast of India during spring inter-monsoon time (March-May), when biological productivity is high. The East India Coastal Current (EICC) system appears as a northward flowing western boundary current of a seasonal subtropical gyre in Bay of Bengal. A relatively clear sky permits satellite remote sensing of sea surface temperature and chlorophyll *a*, whose patterns were verified against geostrophic velocity in altimeter data: *i.e.*, phytoplankton grows in colder and nutrient richer water bounded by the seaward meanders. Progression of meanders in the EICC was revealed and compared with an eddy-resolving OGCM, which is capable of modeling wind-driven general circulation and the meander growth. The numerical solutions provided the following results, in a reasonable agreement with the linear stability theory and numerical solutions using a three layer quasi-geostrophic model. Baroclinic instability plays a key role, while meanders in the EICC are initiated by isolated mesoscale eddies propagating westward. The baroclinically unstable meanders have a wavelength of 500~700 km, grow in one month and propagate downstream of the EICC at several kilometers per day. From fall to winter (September-January), in which a cyclonic wind stress curl could provide a coastal current and consequent meanders, no persistent meander is observed in altimeter data and OGCM. Both hydrographic data and OGCM proved that the southward current has a narrow (100 km) core in the upper 100-m layer and prevents instability.

23 October, 16:30 (W9-5541)

The interaction of Soya Warm Current waters with the anticyclonic eddies in the southern Sea of Okhotsk

Natalya B. **Luk'yanova** and Igor A. Zhabin

Laboratory of Hydrological Processes and Climate, Department of General Oceanology, V.I. Il'ichev Pacific Oceanological Institute (POI), FEB RAS, 43 Baltiyskaya St., Vladivostok, 690041, Russia. E-mail: natalook@poi.dvo.ru

The Soya Warm Current (SWC) enters the Sea of Okhotsk through La Pérouse Strait (Soya Strait) and flows along the Hokkaido coast and Kuril Islands as a narrow boundary current, interacting with mesoscale eddies in the Kuril Basin. Yearly 2–4 large-scale eddies with diameters of 100 to 150 km are observed in the Kuril Basin. They are clearly observed in infrared satellite images of sea surface. Satellite (MODIS, AVHRR, AVISO altimetry) and hydrographic data were used to describe the interaction of anticyclonic eddies and SWC water in the southern Sea of Okhotsk. This study is focused mainly on the warm and salt SWC streams observed in satellite images around the southern Kuril Islands. Several streams were distinguishable at distances of more than 150-300 km from the coast. The warm and salt streamers are swirling around the cold and fresh core anticyclonic eddies. It is shown that the streamers formation depends on the transport of SWC. The SWC waters can actively take part in transformation of water mass in the Kuril Basin at the expense of advection of high salinity waters in abyssal sea, while the structure of the eddy field is practically not disturbed. The satellite chlorophyll information show that the SWC waters have low productivity. Eddies advect these low productive waters offshore to the central part of Kuril Basin. High levels of chlorophyll observed in eddy centers indicate that they supported phytoplankton blooms in autumn.

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W10 POC/BIO Workshop
Carbon data synthesis workshop

Co-Convenors: Masao Ishii (Japan) and Robert M. Key (U.S.A.)

This workshop will be a major step forward in the implementation of the North Pacific carbon data synthesis. Investigators who submit data to the synthesis will collectively review the progress of the QA/QC process, and discuss the degree of success of the techniques applied and whether different or additional approaches are necessary. This is a highly «hands-on» activity that will involve data originators who submit data to the synthesis and investigators participating in the synthesis processes, and will lead directly to value-added data products and collective publications.

Day 1, Friday October 23 (9:00-18:00)

9:00 **Masao Ishii**
Introduction: Background and goal of the workshop

Related activities

9:20 **R.M. Key, S. Jutterström, M. Hoppema, A. Olsen, T. Tanhua and D.W.R. Wallace (Invited)**
The CARINA data product (W10-5844)

10:00 **M. Aoyama**
Global nutrient data synthesis for WOCE and CLIVAR data based on Reference Material for Nutrients in Seawater

10:40 ***Coffee / tea break***

Overview of the datasets

11:00 **Toru Suzuki**
Overview of the Pacific carbon data collected

Some details of dataset and regional decadal trend: Report from each PI or WG

11:15 **Christopher Sabine**
US CLIVAR Repeat Hydrography/CO_2

11:30 **Akihiko Murata**
JAMSTEC's Repeat Hydrography/CO_2

11:45 **Wakita**
Western North Pacific repeat-lines and time-series stations by Hokkaido University, and JAMSTEC-MIO

12:00 **Masao Ishii**
Western North Pacific repeat-lines by MRI/JMA

12:15 **Masao Ishii**
Equatorial Pacific

12:30 ***Lunch***

14:00 **Sasaki** (or Bullister)
CFCs in the Pacific

Implementation of the 2nd-level QC

15:00 **Toru Suzuki**
Method of the 2nd-level QC using Matlab and the role of each WG. The working group web portals (created by T. Suzuki).

15:30 ***Coffee / tea break***

16:00 Discussion: How to implement the 2nd-level QC and publication of database

18:00 ***Day 1 Workshop ends***

Day 2 Saturday, October 24 (9:00-12:30)

9:00 Discussion: The time plan toward the completion of the Pacific data synthesis.
General discussion

10:30 ***Coffee / tea break***

12:30 ***Workshop ends***

14:00 CC-S Meeting

W10 Poster

W10-5733 **Chihiro Miyazaki, Shin-ichiro Nakaoka and Yukihiro Nojiri**
NIES ocean pCO_2 measurement of VOS over the Western Pacific

23 October, 9:20 (W10-5844), Invited

The CARINA data product

R.M. **Key**[1], S. Jutterström, M. Hoppema, A. Olsen, T. Tanhua and D.W.R. Wallace

[1] AOS Program, Princeton University, 300 Forrestal Rd., Sayre Hall, Princeton, 08544, USA. E-mail: key@princeton.edu

The CARBOOCEAN program sponsored a project called CARINA that was designed to assemble and calibrate historical open ocean data sets that would be useful to general biogeochemical investigations, particularly those aimed at understanding the inorganic carbon system. Most cruises were European, however, recent U.S. and Japanese CLIVAR cruises are included in the collection. These new cruises extend the data coverage and also serve as master data sets for quality control checks. The total collection includes 188 cruises, but some of these are actually time series or multiple cruises from a single focused project. The data have been divided into 3 regional data bases: Arctic and marginal seas, Atlantic Ocean and Southern Ocean.

Quality control for the individual cruises consisted of two parts. Primary (or 1st) QC consisted of assigning quality flags to each individual datum. Both the flags and the procedures were developed during the WOCE program. 1stQC is designed to improve data precision by noting anomalous measurements. Secondary QC (or 2nd) involves comparison of values between different cruises. 2ndQC techniques are designed to objectively quantify and then remove measurement bias. Measurement bias is quite common largely because readily available standards do not exist for many of the common oceanographic measurements, or have only recently become available. Once bias was identified and quantified, the various CARINA teams subjectively decided whether or not evidence was sufficient to warrant adjusting reported values. Since some of the considered measurements are known to change with time due to natural and/or anthropogenic causes, careful consideration was given to each parameter from each cruise.

Once QC was completed the original cruise data sets were made public through CDIAC and CCHDO. The 1stQC flags were reported with these individual cruise files, but no 2nd level adjustments were made to the data. All parameters in these files were converted to currently accepted CLIVAR units and formats. All available metadata and reports were submitted with the cruise files and each cruise file header included references to any known publications that used data from the cruise. Subsequently, the individual cruise files for each region were concatenated into a single large data file. In these merged products, the 2nd QC adjustments were applied. The parameters included in the merged products were limited to a common subset of the total different parameters. With respect to carbon, whenever at least 2 of the carbon system parameters (total alkalinity, total inorganic carbon, pH, pCO_2) were measured then a third was calculated (pCO_2 was not calculated). The three CARINA data products are offered to the community through CDIAC. These products significantly supplement the data of previous work (GLODAP) and extend the coverage into the Greenland-Norwegian Seas, Mediterranean Sea, and Arctic Ocean. Unlike GLODAP, all of the 2ndQC for commonly measured parameters was done as part of this project. QC has been documented on a website where all data, figures and interpretations that played a part in the decisions can be found. Several papers for a special issue of the new data journal Earth System Science Data have been drawn up for the final documentation of the project.

W10-5733

NIES ocean pCO_2 measurement of VOS over the Western Pacific

Chihiro **Miyazaki**, Shin-ichiro Nakaoka and Yukihiro Nojiri

Center for Global Environment Research, National Institute for Environmental Studies, 16-2, Onogawa, Tsukuba, Ibaraki, 305-8506, Japan
E-mail: miyazaki.chihiro@nies.go.jp

NIES ocean pCO_2 measurement of VOS over the Western Pacific has been performed by M/S Trans Future 5 since June 2006. The ship is a car carrier of Toyofuji Shipping Co. and sails from Japan to New Zealand via Australia, and returns to Japan. This cycle is fixed at every 6 weeks. We installed atmospheric and oceanic CO_2 measurement systems when this ship was built. At the present, we have succeeded to obtain CO_2 data for a couple of years.

Seasonality of delta pCO_2, which denotes the value of ocean pCO_2 minus atmospheric pCO_2, shows the characteristic variability over three areas. In the Northern Pacific (north of 10ºN), the seasonal amplitude of delta pCO_2 is large. The value of pCO_2 is positive in the summer, meaning the release of CO_2 from the ocean; whereas negative in the winter, meaning the uptake into the ocean. Over the Tasman sea, especially at the western area, delta pCO_2 is negative throughout the year, meaning persistent uptake area of CO_2. The seasonal amplitude is very small. On the other hand, over the Equatorial Pacific (from 10ºN to 10ºS), the interannual variability may be prominent, rather than the seasonal cycle.

These results prove that this recent accurate observation of CO_2 over the Western Pacific provides the correct information as a part of global climatology of surface ocean pCO_2.

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W

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Y

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Registrants
(as of September 23)

Australia

John Keesing
Marine and Atmospheric Research
CSIRO
Private Bag 5
Wembley, Western Australia 6913
Australia
john.keesing@csiro.au

Anthony D.M. Smith
Marine and Atmospheric Research
CSIRO
P.O. Box 1538
Hobart, TAS 7001
Australia
tony.d.smith@csiro.au

Canada

Edward Black
Fisheries and Oceans Canada
Biotechnology and Aquatic Animal
Health Sciences Branch
12th floor, 200 Kent St.
Ottawa, ON K1A 0E6
Canada
Edward.Black@dfo-mpo.gc.ca

James Christian
Fisheries and Oceans Canada
Canadian Centre for Climate
Modelling and Analysis
c/o University of Victoria,
P.O. Box 3065, STN CSC
Victoria, BC V8W 3V6
Canada
jim.christian@ec.gc.ca

William R. Crawford
Fisheries and Oceans Canada
Institute of Ocean Sciences
P.O. Box 6000
Sidney, BC V8L 4B2
Canada
bill.crawford@dfo-mpo.gc.ca

Michael G. Foreman
Fisheries and Oceans Canada
Institute of Ocean Sciences
P.O. Box 6000
Sidney, BC V8L 4B2
Canada
mike.foreman@dfo-mpo.gc.ca

Howard J. Freeland*
Fisheries and Oceans Canada
Institute of Ocean Sciences
P.O. Box 6000
Sidney, BC V8L 4B2
Canada
Howard.Freeland@dfo-mpo.gc.ca
*representative of Argo

Graham E. Gillespie
Fisheries and Oceans Canada
Pacific Biological Station
3190 Hammond Bay Rd.
Nanaimo, BC V9T 6N7
Canada
Graham.Gillespie@dfo-mpo.gc.ca

Lu Guan
Department of Biology
University of Victoria
39403-2375 Lam Circle
Victoria, BC V8N 6K8
Canada
lguan@uvic.ca

Tabitha Cheng Yee Hui
Marine Mammal Research Unit
University of British Columbia
Fisheries Centre, 2202 Main Mall
Vancouver, BC V6T 1Z4
Canada
t.hui@fisheries.ubc.ca

Glen Jamieson
Fisheries and Oceans Canada
Pacific Biological Station
804 San Malo Cr.
Parksville, BC V9P 1S4
Canada
Glen.Jamieson@dfo-mpo.gc.ca

Stewart Johnson
Fisheries and Oceans Canada
Pacific Biological Station
3190 Hammond Bay Rd.
Nanaimo, BC V9T 6N7
Canada
Stewart.Johnson@dfo-mpo.gc.ca

David L. Mackas
Fisheries and Oceans Canada
Institute of Ocean Sciences
P.O. Box 6000
Sidney, BC V8L 4B2
Canada
Dave.Mackas@dfo-mpo.gc.ca

Sylvain Paradis
Fisheries and Oceans Canada
Ecosystem Science Directorate
200 Kent St., 12th floor, Stn. 12S029
Ottawa, ON K1A 0E6
Canada
Sylvain.Paradis@dfo-mpo.gc.ca

Angelica Peña
Fisheries and Oceans Canada
Institute of Ocean Sciences
P.O. Box 6000
Sidney, BC V8L 4B2
Canada
angelica.pena@dfo-mpo.gc.ca

Gottfried Pestal
SOLV Consulting Ltd.
Unit 60607, RPO Granville Park
Vancouver, BC V6H 4B9
Canada
gpestal@solv.ca

Laura Richards
Fisheries and Oceans Canada
Pacific Biological Station
3190 Hammond Bay Rd.
Nanaimo, BC V9T 6N7
Canada
Laura.Richards@dfo-mpo.gc.ca

Peter S. Ross
Fisheries and Oceans Canada
Institute of Ocean Sciences
P.O. Box 6000
Sidney, BC V8L 4B2
Canada
peter.s.ross@dfo-mpo.gc.ca

Jon T. Schnute
Fisheries and Oceans Canada
Pacific Biological Station
3190 Hammond Bay Rd.
Nanaimo, BC V9T 6N7
Canada
Jon.Schnute@dfo-mpo.gc.ca

Darlene Smith
Fisheries and Oceans Canada
Federal Government of Canada
200 Kent St., STN 8W133
Ottawa, ON K1A 0E6
Canada
darlene.smith@dfo-mpo.gc.ca

Dario Stucchi
Fisheries and Oceans Canada
Institute of Ocean Sciences
P.O. Box 6000
Sidney, BC V8L 4B2
Canada
Dario.Stucchi@dfo-mpo.gc.ca

Thomas W. Therriault
Fisheries and Oceans Canada
Pacific Biological Station
3190 Hammond Bay Rd.
Nanaimo, BC V9T 6N7
Canada
Thomas.Therriault@dfo-mpo.gc.ca

Charles Trick
Schulich School of Medicine
University of Western Ontario
N. Campus Bldg., 1151 Richmond St. N.
London, ON N6A 5B7
Canada
trick@uwo.ca

Andrew W. Trites
Marine Mammal Research Unit
University of British Columbia
Fisheries Centre, Room 247, AERL,
2202 Main Mall
Vancouver, BC V6T 1Z4
Canada
trites@zoology.ubc.ca

Tatiana Tunon
SOLV Consulting Ltd.
Unit 60607, RPO Granville Park
Vancouver, BC V6H 4B9
Canada
ttunon@solv.ca

Chile

Vincent Combes
1275 Victor Lamas,
Departamento 1704
Concepcion
Chile
vincent.combes@gmail.com

China-Taipei

Hao-Hsien Chang
Department of Marine Biotechnology and Resources
National Sun Yet-Sen University
No. 70, Lienhai Rd.
Kaohsiung 80424
Taiwan
hhchang@staff.nsysu.edu.tw

Kuo Ping Chiang
Environmental Biology and Fishery Science
National Taiwan Ocean University
2, Pei-Ning Rd., Keelung 202
Taiwan
kpchiang@mail.ntou.edu.tw

Chih-hao Hsieh
Institute of Oceanography
National Taiwan University
No. 1, Sec. 4, Roosevelt Rd.
Taipei 10617
Taiwan
chsieh@ntu.edu.tw

Wen-Bin Huang
Graduate Institute of Biological Resources and Technology
National Dong Hwa University
123, Hua-Shi Rd.
Hualien City 970
Taiwan
wbhuang1999@ntu.edu.tw

Youree Jun
Institute of Oceanography
National Taiwan University
No. 1, Sec. 4, Roosevelt Rd.
Taipei 10617
Taiwan
ksyr83@hotmail.com

Wei-hsuan Teng
Institute of Oceanography
National Taiwan University
No. 1, Sec. 4, Roosevelt Rd.
Taipei 10617
Taiwan
r97241201@ntu.edu.tw

Chen-Yi Tu
Institute of Oceanography
National Taiwan University
No. 1, Sec. 4, Roosevelt Rd.
Taipei 106
Taiwan
tu.chenyi@gmail.com

Germany

Juergen Alheit
Biological Oceanography
Leibniz Institute for Baltic Sea Research, Seestr. 15
Rostock 18119
Germany
juergen.alheit@io-warnemuende.de

Lambini Cosmas Kombat Dayak
Humboldt University
Environmental economics
Lehrter Strase 65, 10557
Berlin 0049
Germany
cosmasworld@gmail.com

Hong Kong SAR PR China

Jianping Gan
Department of Mathematics
Hong Kong University of Science and Technology
Clear Water Bay, Kowloon,
Hong Kong SAR,
PR China
magan@ust.hk

India

Sirajuddin M. Horaginamani
Dept. Environmental Management
Bhararathidasan University
Palkaliperur
Tiruchirappalli, Tamil Nadu 620 024
India
ecosirajuddin@yahoo.com

Japan

Katsuyuki Abo
National Research Institute of Aquaculture, FRA
422-1 Nakatsu, Minami-Ise
Watari, Mie 516-0193
Japan
abo@fra.affrc.go.jp

Hideki Akiyama
East China Sea Fisheries Oceanography Division
Seikai National Fisheries Research Institute, FRA
1551-8 Taira-machi
Nagasaki, Nagasaki 851-2213
Japan
hakiyama@fra.affrc.go.jp

Michio Aoyama
Geochemical Research Department
Meteorological Research Institute
1-1 Nagamine
Tsukuba, Ibaraki 305-0052
Japan
maoyama@mri-jma.go.jp

Aymen Charef
Aquatic Biosciences
The University of Tokyo
1-1-1 Bunkyo ku
Tokyo 113-8657
Japan
aymen_charef@yahoo.com

Sanae Chiba
Environmental Biogeochemistry Research Program
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
3173-25 Showa-machi, Kanazawa-ku
Yokohama, Kanagawa 236-0001
Japan

Masahiko Fujii
Graduate School of Environmental Science
Hokkaido University
N10W5 Kita-ku
Sapporo, Hokkaido 060-0810
Japan
mfujii@ees.hokudai.ac.jp

Naoki Fujii
Center for Marine Environmental Studies
Ehime University
2-5 Bunkyo-cho
Matsuyama, Ehime 790-8577
Japan
medusae@sci.ehime-u.ac.jp

Tetsuichi Fujiki
Mutsu Institute for Oceanography
Japan Agency for Marine-Earth Science and Technology
690 Kitasekine, Sekine
Mutsu 035-0022
Japan
tfujiki@jamstec.go.jp

Tadanori Fujino
Japan Sea Fisheries Resources Division
Japan Sea National Fisheries Research Institute, FRA
1-5939-22 Suido-cho
Niigata, Niigata 951-8121
Japan
fnori@affrc.go.jp

Kaoru Fujita
Fisheries Technology Div.
National Research Institute of Fisheries Engineering, FRA
7620-7 Hasaki
Kamisu, Ibaraki 314-0408
Japan
duke@fra.affrc.go.jp

Tetsuichiro Funamoto
Hokkaido National Fisheries Research Institute, FRA
116 Katsurakoi
Kushiro, Hokkaido 085-0802
Japan
tetsuf@fra.affrc.go.jp

Takeo Hama
Life and Environmental Sciences
University of Tsukuba
1-1-1 Tennoudai
Tsukuba, Ibaraki 305-8572
Japan
thama@biol.tsukuba.ac.jp

Ai Hattori-Saito
Graduate School of Environmental Science
Hokkaido University
N10W5 Kita-ku
Sapporo, Hokkaido 060-0810
Japan
aihat@ees.hokudai.ac.jp

Hironori Higashi
Asian Environment Research Group
National Institute for Environmental Studies (NIES)
16-2 Onogawa
Tsukuba, Ibaraki 305-8506
Japan
higashi@nies.go.jp

Toyomitsu Horii
Fisheries Research Agency
National Research Institute of Fisheries Science, FRA
6-31-1 Nagai
Yokosuka, Kanagawa 238-0316
Japan
thorii@fra.affrc.go.jp

Felipe Hurtado Ferro
Ocean Research Institute
The University of Tokyo
1-15-1 Minamidai, Nakano-ku
Tokyo 164-8639
Japan
felipehurtado@nenv.k.u-tokyo.ac.jp

Hideki Ikeda
Graduate School of Biosphere Science
Hiroshima University
4-4, Kagamiyama 1 chome
Higashi-Hiroshima
Hiroshima 739-8528
Japan
hydekid@hiroshima-u.ac.jp

Ichiro Imai
Graduate School of Fisheries Sciences
Hokkaido University
3-1-1 Minato-cho
Hakodate, Hokkaido 041-8611
Japan
imai1ro@fish.hokudai.ac.jp

Yoichiro Ishibashi
Environmental Risk Assessment Unit
Japan NUS Co., Ltd.
8F Loop-X Bldg.
9-15 Kaigan 3-chome, Minato-ku
Tokyo 108-0022
Japan
ishibashi@janus.co.jp

Yukimasa Ishida*
Tohoku National Fisheries Research Institute, FRA
3-27-5 Shinhama-cho
Shiogama, Miyagi 985-0001
Japan
ishiday@fra.affrc.go.jp
* representative of NPAFC

Haruto Ishii
Faculty of Marine Science
Tokyo University of Marine Science and Technology
4-5-7 Konan, Minato-ku
Tokyo 108-8477
Japan
un8s-isi@asahi-net.or.jp

Ken-ichiro Ishii
Applied Biosciences Division
Graduate School of Agriculture, Kyoto University
Kitashirakawa – Oiwakecho, Sakyoku
Kyoto, Kyoto 606-8502
Japan
ken1ro@kais.kyoto-u.ac.jp

Masao Ishii
Geochemical Research Department
Meteorological Research Institute
1-1 Nagamine
Tsukuba, Ibaraki 305-0052
Japan
mishii@mri-jma.go.jp

Akira Ishikawa
Graduate School of Bioresources
Mie University
1577 Kurimamachiya
Tsu-city 514-8507
Japan
ishikawa@bio.mie-u.ac.jp

Joji Ishizaka
Nagoya University
Hydrospheric Atmospheric Research Center (HyARC)
Furo-cho, Chikusa-ku
Nagoya, Aichi 464-8601
Japan
jishizak@hyarc.nagoya-u.ac.jp

Shigeru Itakura
Resources Enhancement Promotion Department
Fisheries Agency
1-2-1 Kasumigaseki
Chiyoda-ku, Tokyo 100-8907
Japan
itakura@affrc.go.jp

Shin-ichi Ito
Tohoku National Fisheries Research Institute, FRA
3-27-5 Shinhama-cho
Shiogama, Miyagi 985-0001
Japan
goito@affrc.go.jp

Sachihiko Itoh
Fisheries Environmental Oceanography Division
Ocean Research Institute
University of Tokyo
1-15-1 Minamidai, Nakano-ku
Tokyo 164-8639
Japan
itohsach@ori.u-tokyo.ac.jp

Masahide Kaeriyama
Graduate School of Fishereis Sciences
Hokkaido University
3-1-1 Minato-cho
Hakodate, Hokkaido 041-8611
Japan
salmon@fish.hokudai.ac.jp

Koji Kakinoki
Japan Sea National Fisheries Research Institute
Fisheries Research Agency
1-5939-22 Suido-cho
Niigata 951-8121
Japan
kakinoki@affrc.go.jp

Yasuhiro Kamimura
Takehara Fisheries Research Lab.
Hiroshima University
5-8-1 Minato-machi
Takehara, Hiroshima 725-0024
Japan
m080161@hiroshima-u.ac.jp

Hitoshi Kaneko
Ocean Research Institute
University of Tokyo
1-15-1 Minamidai, Nakano-ku
Tokyo 164-8639
Japan
kaneko@ori.u-tokyo.ac.jp

Hidehiro Kato*
Laboratory of Cetaceans and Marine Mammals
Faculty of Marine Science
Tokyo University of Marine Science and Technology
4-5-7 Konan, Minato-ku
Tokyo 108-8477
Japan
katohide@kaiyodai.ac.jp
* representative of IWC

Masaya Katoh
Seikai National Fisheries Research Institute
Ishigaki Tropical Station
Fisheries Research Agency
1551-8 Taira-machi
Nagasaki, Nagasaki 907-0451
Japan
mkatoh@fra.affrc.go.jp

Hiroshi Kawai
Research Center for Inland Seas
Kobe University
1-1 Rokkodai, Nadaku
Kobe, Hyogo 657-8501
Japan
kawai@kobe-u.ac.jp

Tomohiko Kawamura
Ocean Research Institute
University of Tokyo
1-15-1 Minamidai, Nakano-ku
Tokyo 164-8639
Japan
kawamura@ori.u-tokyo.ac.jp

Ryo Kimura
Coastal Fisheries and Aquaculture Div.
National Research Institute of Fisheries Science (Yokosuka Stn.), FRA
6-31-1 Nagai
Yokosuka, Kanagawa 238-0316
Japan

Michio J. Kishi
Graduate School of Environmental Science
Hokkaido University
N10W5 Kita-ku
Sapporo, Hokkaido 060-0810
Japan
mjkishi@nifty.com

Tsuyoshi Kitamoto
Global Environmental Issues Div.,
Global Environmental Bureau
Ministry of the Environment, Japan
1-2-2 Kasumigaseki, Chiyoda-ku
Tokyo 100-8975
Japan

Keiji Kiyomatsu
Dept. Ocean Technology, Policy and Environment
The University of Tokyo
5-1-5 Kashiwanoha
Kashiwa, Chiba 277-8561
Japan
kiyomatsu@orca.k.u-tokyo.ac.jp

Toru Kobari
Faculty of Fisheries
Kagoshima University
4-50-20 Shimoarata
Kagoshima, Kagoshima 890-0056
Japan
kobari@fish.kagoshima-u.ac.jp

Kunio Kohata
Water and Soil Environment Div.
National Institute for Environmental Studies (NIES)
16-2 Onogawa
Tsukuba, Ibaraki 305-8506
Japan
kohata@nies.go.jp

Hiroshi Koshikawa
Asian Environment Research Group
National Institute for Environmental Studies (NIES)
16-2 Onogawa
Tsukuba, Ibaraki 305-8506
Japan
koshikaw@nies.go.jp

Prescilla Kurien
Graduate School of Environmental Science
Hokkaido University
N10W5 Kita-ku
Sapporo, Hokkaido 060-0810
Japan
prescy@ees.hokudai.ac.jp

Li-Feng Lu
Yokohama Institute for Earth Sciences
Research Institute for Global Change, JAMSTEC
3173-25 Showa-machi, Kanazawa-ku
Yokohama, Kanagawa 236-0001
Japan
Lifeng_lu@jamstec.go.jp

Mitsutaku Makino
Fisheries Research Agency
2-12-4 Fukuura, Kanazawa-ku
Yokohama, Kanagawa 236-8648
Japan
mmakino@affrc.go.jp

Takeshi Matsuno
Research Institute for Applied Mechanics
Kyushu University
6-1 Kasuga-kohen
Kasuga, 816-8580
Japan
matsuno@riam.kyushu-u.ac.jp

Kazumi Matsuoka
Institute for East China Sea Research
Nagasaki University
1-14 Bunkyo-machi
Nagasaki 852-8521
Japan
kazu-mtk@nagasaki-u.ac.jp

Tatsuro Matsuoka
Faculty of Fisheries
Kagoshima University
4-50-20 Shimoarata
Kagoshima, Kagoshima 890-0056
Japan
matsuoka@fish.kagoshima-u.ac.jp

Shoshiro Minobe
Natural History Sciences, Graduate School of Sciences
Hokkaido University
N10W8 Rigaku-8-goukan 3F
Sapporo, Hokkaido 060-0810
Japan
minobe@mail.sci.hokudai.ac.jp

Masato Minowa
11-1-506 Masago
Kagoshima 890-0066
Japan
k8092136@kadai.jp

Humio Mitsudera
Institute of Low Temperature Science
Hokkaido University
N19W8 Kita-ku
Sapporo, Hokkaido 060-0819
Japan
humiom@lowtem.hokudai.ac.jp

Chihiro Miyazaki
Center for Global Environmental Research
National Institute for Environmental Studies (NIES)
16-2 Onogawa
Tsukuba, Ibaraki 305-8506
Japan
miyazaki.chihiro@nies.go.jp

Yasumasa Miyazawa
Research Institute for Global Change
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
3173-25 Showa-machi, Kanazawa-ku
Yokohama, Kanagawa 236-0001
Japan

Natheer M. Mohammad
Ocean Research Institute
The University of Tokyo
1-15-1 Minamidai, Nakano-ku
Tokyo 164-8639
Japan
alabsinatheer@yahoo.com

Hirotada Moki
School of Science and Technology
University of Tokai
3-20-1 Shimizu-Orido
Shizuoka, Shizuoka 424-8610
Japan
8atgd004@mail.tokai-u.jp

Robinson M. Mugo
Lab. of Marine Environment and Resource Sensing, Graduate School of Fisheri
Hokkaido University
3-1-1 Minato-cho
Hakodate, Hokkaido 041-8611
Japan
robin_mugo@salmon.fish.hokudai.ac.jp

Hiroto Murase
The Institute of Cetacean Research
4-5 Toyomi-cho
Chuo-ku, Tokyo 104-0055
Japan
murase@cetacean.jp

Akihiko Murata
IORGC
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
2-15 Natsushima-cho
Yokosuka, Kanagawa 237-0061
Japan

Toshiya Nakano
Global Environment and Marine Dept.
Japan Meteorological Agency
1-3-4 Otemachi Chiyoda-ku
Tokyo, 100-8122
Japan
nakano_t@met.kishou.go.jp

Yuichiro Nishibe
Ocean Research Institute
University of Tokyo
1-15-1 Minamidai
Nakano, Tokyo, 1648639
Japan
nishibe@ori.u-tokyo.ac.jp

Masashi Nishimura
International Section
Japan Fisheries Association
Sankaido Bldg., 9-13 Akasaka 1, Minato-ku
Tokyo, 107-0052
Japan
mnishimu@suisankai.or.jp

Jun Nishioka
Institute of Low Temperature Science
Hokkaido University
N19W8 Kita-ku
Sapporo, Hokkaido 060-0819
Japan
nishioka@lowtem.hokudai.ac.jp

Yukihiro Nojiri
Center for Global Environmental Research
National Institute for Environmental Studies (NIES)
16-2 Onogawa
Tsukuba, Ibaraki 305-8506
Japan
nojiri@nies.go.jp

Masami Nonaka
Climate Variation Predictability and Applicability Research Program
Research Institute for Global Change, JAMSTEC
3173-25 Showa-machi, Kanazawa-ku
Yokohama, Kanagawa 236-0001
Japan

Suguru Okamoto
Graduate School of Fisheries Sciences
Hokkaido University
3-1-1 Minato-cho
Hakodate, Hokkaido 041-8611
Japan
oka@salmon.fish.hokudai.ac.jp

Hiroshi Okamura
Cetacean Management Section
National Research Institute of Far Seas Fisheries
2-12-4 Fukuura, Kanazawa-ku
Yokohama, Kanagawa 246-8648
Japan
okamura@fra.affrc.go.jp

Yuji Okazaki
Mixed Water Region Fisheries Oceanography Div.
Tohoku National Fisheries Research Institute, FRA
3-27-5 Shinhama-cho
Shiogama, Miyagi 985-0001
Japan
okazakiy@affrc.go.jp

Takeshi Okunishi
National Research Institute of Fisheries Science, FRA
2-12-4 Fukuura, Kanazawa-ku
Yokohama, Kanagawa 236-8648
Japan
okunishi@affrc.go.jp

Akira Okuno
Japan Sea Fisheries Oceanography Div.
Japan Sea National Fisheries Research Institute, FRA
1-5939-22 Suido-cho
Niigata 951-8121
Japan
okuaki@affrc.go.jp

Goh Onitsuka
Dept. Fishery Science and Technology
National Fisheries University
2-7-1 Nagata-Hon-machi
Shimonoseki, Yamaguchi 759-6595
Japan
onizuka@fish-u.ac.jp

Tsuneo Ono
Subarctic Fisheries Oceanography Div.
Hokkaido National Fisheries Research Institute, FRA
116 Katsurakoi
Kushiro, Hokkaido 085-0802
Japan
tono@fra.affrc.go.jp

Satoshi Osafune
Ocean Research Institute
University of Tokyo
1-15-1 Minamidai, Nakano-ku
Tokyo 164-8639
Japan
osafune@ori.u-tokyo.ac.jp

I Nyoman Radiarta
Faculty of Fisheries Sciences
Hokkaido University
3-1-1 Minato-cho
Hakodate, Hokkaido 041-8611
Japan
radiarta@salmon.fish.hokudai.ac.jp

Kazuhiro Sadayasu
Fisheries Information Science Group
National Research Institute of Fisheries Engineering, FRA
7620-7 Hasaki
Kamisu, Ibaraki 314-0408
Japan
sadayasu@affrc.go.jp

Toshiro Saino
RIGC, JAMSTEC
Environmental Biogeochemical Cycle Research Program
2-15 Natsushima-cho
Yokosuka, Kanagawa 237-0061
Japan
tsaino@jamstec.go.jp

Hiroaki Saito
Biological Oceanography Section
Tohoku National Fisheries Research Institute, FRA
3-27-5 Shinhama-cho
Shiogama, Miyagi 985-0001
Japan
hsaito@affrc.go.jp

Shu Saito
Ocean Climate Change Research Program
Research Institute for Global Change
JAMSTEC
2-15 Natsushima-cho
Yokosuka, Kanagawa 237-0061
Japan
ssaito@jamstec.go.jp

Sei-Ichi Saitoh
Graduate School of Fisheries Sciences
Hokkaido University
3-1-1 Minato-cho
Hakodate, Hokkaido 041-8611
Japan
ssaitoh@salmon.fish.hokudai.ac.jp

Yasunori Sakurai
Graduate School of Fisheries Sciences
Hokkaido University
3-1-1 Minato-cho
Hakodate, Hokkaido 041-8611
Japan
sakurai@fish.hokudai.ac.jp

Chiyuki Sassa
Seikai National Fisheries Research Institute, FRA
1551-8 Taira-machi
Nagasaki 851-2213
Japan
csassa@fra.affrc.go.jp

Tomoharu Senjyu
Research Institute for Applied Mechanics
Kyushu University
6-1 Kasuga-kohen
Kasuga, Fukuoka 816-8580
Japan
senjyu@riam.kyushu-u.ac.jp

Hyunju Seo
Marine Bioresource and Environmental Science Div.
Hokkaido University
3-1-1 Minato-cho
Hakodate, Hokkaido 041-8611
Japan
uagiri@hanmail.net

Yugo Shimizu
Physical Oceanography Section
Tohoku National Fisheries Research Institute, FRA
3-27-5 Shinhama-cho
Shiogama, Miyagi 985-0001
Japan
yugo@affrc.go.jp

Shinji Shimode
Plankton Div.
Ocean Research Institute
University of Tokyo
1-15-1 Minamidai, Nakano
Tokyo 164-8639
Japan
shimode@ori.u-tokyo.ac.jp

Yoshihiro Shiraiwa
Life and Environmental Sciences
University of Tsukuba
1-1-1 Tennoudai
Tsukuba, Ibaraki 305-8572
Japan
emilhux@biol.tsukuba.ac.jp

Jun Shoji
Takehara Fisheries Research Lab.
Hiroshima University
5-8-1 Minato-machi
Takehara, Hiroshima 725-0024
Japan
jshoji@hiroshima-u.ac.jp

Young Baek Son
Nagoya University
Hydrospheric Atmospheric Research Center (HyARC)
Furo-cho, Chigusa-ku
Nagoya, 464-8601
Japan
sonyb150@hotmail.com

Hiroya Sugisaki
National Research Institute of Fisheries Science, FRA
2-12-4 Fukuura, Kanazawa-ku
Yokohama, Kanagawa 236-8648
Japan
sugisaki@affrc.go.jp

Hiroshi Sumata
Graduate School of Environmental Science
Hokkaido University
N10W5 Kita-ku
Sapporo, Hokkaido 060-0810
Japan
su@ees.hokudai.ac.jp

Toru Suzuki
Marine Information Research Center (MIRC)
Japan Hydrographic Association
6F Daiichi Sogo Bldg., 1-6-6
Hanedakuko, Ota-ku
Tokyo 144-0041
Japan
suzuki@mirc.jha.jp

Toshikazu Suzuki
Faculty of Fisheries
Nagasaki University
1-14 Bunkyo-machi
Nagasaki 852-8521
Japan
tsuzuki@nagasaki-u.ac.jp

Bunmei Taguchi
Earth Simulator Center
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
3173-25 Showa-machi, Kanazawa-ku
Yokohama, Kanagawa 236-0001
Japan

Motomitsu Takahashi
East China Sea Fisheries Research Div.
Seikai National Fisheries Research Institute, FRA
1551-8 Taira-machi
Nagasaki, Nagasaki 851-2213
Japan
takahamt@fra.affrc.go.jp

Shigenobu Takeda*
Dept. Aquatic Bioscience
University of Tokyo
1-1-1 Yayoi, Bunkyo-ku
Tokyo 113-8657
Japan
atakeda@mail.ecc.u-tokyo.ac.jp
* representative of SOLAS

Hiroshige Tanaka
Seikai National Fisheries Research Institute, FRA
1551-8 Taira-machi
Nagasaki 851-2213
Japan
tanakahs@affrc.go.jp

Takeshi Terui
Graduate School of Environmental Science
Hokkaido University
N10W5 Kita-ku
Sapporo, Hokkaido 060-0810
Japan
tk4terui@ees.hokudai.ac.jp

Yongjun Tian
Japan Sea Fisheries Resources Div.
Japan Sea National Fisheries Research Institute, FRA
1-5939-22 Suido-cho
Niigata 951-8121
Japan
yjtian@fra.affrc.go.jp

Naoki Tojo
Lab. of Marine Ecosystem Change Analysis
Hokkaido University
3-1-1 Minato-cho
Hakodate, Hokkaido 041-8611
Japan
ntojo@ees.hokudai.ac.jp

Mayuko Tomida
Faculty of Fisheries Sciences
Hokkaido University
3-1-1 Minato-cho
Hakodate, Hokkaido 041-8611
Japan
delphi19_@hotmail.com

Masaya Toyokawa
Marine Productivity Div.
National Research Institute of Fisheries Science, FRA
2-12-4 Fukuura, Kanazawa-ku
Yokohama, Kanagawa 236-8648
Japan
mtoyokaw@affrc.go.jp

Atsushi Tsuda
Ocean Research Institute
University of Tokyo
1-15-1 Minamidai, Nakano-ku
Tokyo 164-8639
Japan
tsuda@ori.u-tokyo.ac.jp

Daisuke Tsumune
Environmental Science
Central Research Institute of Electric Power Industry
1646 Abiko
Abiko, Chiba 270-1194
Japan
tsumune@criepi.denken.or.jp

Keisuke Uchimoto
Institute of Low Temperature Science
Hokkaido University
N19W8 Kita-ku
Sapporo 060-0819
Japan
uchimoto@lowtem.hokudai.ac.jp

Hiromichi Ueno
Graduate School of Fisheries Science
Hokkaido University
3-1-1 Minato-cho
Hakodate, Hokkaido 041-8611
Japan
ueno@fish.hokudai.ac.jp

Tomowo Watanabe
National Research Institute of Fisheries Science, FRA
2-12-4 Fukuura, Kanazawa-ku
Yokohama, Kanagawa 236-8648
Japan
wattom@affrc.go.jp

Yasunori Watanabe
National Research Institute of Fisheries and Environment of Inland Sea, FRA
2-17-5 Maruishi
Hatsukaichi, Hiroshima 739-0452
Japan
ywat@affrc.go.jp

Yoshiro Watanabe
Living Marine Resources
Ocean Research Institute
University of Tokyo
1-15-1 Minamidai, Nakano-ku
Tokyo 164-8639
Japan
ywatanab@ori.u-tokyo.ac.jp

Yutaka Watanuki
Graduate School of Fisheries Sciences
Hokkaido University
3-1-1 Minato-cho
Hakodate, Hokkaido 040-8611
Japan
ywata@fish.hokudai.ac.jp

Nam-Il Won
1-15-1 Minamidai, Nakano
Tokyo 164-8639
Japan
niwon@ori.u-tokyo.ac.jp

Harumi Yamada
Resources Enhancement Promotion Dept.
Fisheries Agency
1-2-1 Kasumigaseki, Chiyoda-ku
Tokyo 100-8907
Japan
hyamada@affrc.go.jp

Atsushi Yamaguchi
Marine Biology Lab. (Plankton)
Hokkaido University
3-1-1 Minato-cho
Hakodate, Hokkaido 041-8611
Japan
a-yama@fish.hokudai.ac.jp

Hisashi Yamaguchi
Nagoya University
Hydrospheric Atmospheric Research Center (HyARC)
Furo-cho, Chikusa-ku
Nagoya, Aichi 464-8601
Japan
yamaguchi.hisashi@d.mbox.nagoya-u.ac.jp

Hidemasa Yamamoto
CEARAC (Special Monitoring and Coastal EnvironmentalAssessment Regional Activity Centre)
NOWPAP (Northwest Pacific Action Plan)
5-5 Ushijima Shin-machi
Toyama 930-0856
Japan
h-yamamoto@npec.or.jp

Tamiji Yamamoto
Graduate School of Biosphere Science
Hiroshima University
1-4-4 Kagamiyama
Higashi-Hiroshima
Hiroshima 739-8528
Japan
tamyama@hiroshima-u.ac.jp

Yasuhiro Yamanaka
Faculty of Environmental Earth Science
Hokkaido University
N10W5 Kita-ku
Sapporo, Hokkaido 060-0810
Japan
galapen@ees.hokudai.ac.jp

Ichiro Yasuda
Ocean Research Institute
University of Tokyo
1-15-1 Minamidai, Nakano-ku
Tokyo 164-8639
Japan
ichiro@ori.u-tokyo.ac.jp

Akihiko Yatsu
Seikai National Fisheries Research Institute, FRA
1551-8 Taira-machi
Nagasaki 851-2213
Japan
yatsua@fra.affrc.go.jp

Hisashi Yokoyama
National Research Institute of Aquaculture, FRA
422-1 Nakatsuhama-ura Minami-Ise
Watarai-gun Mie 516-0193
Japan
hyoko@fra.affrc.go.jp

Seokjin Yoon
Graduate School of Environmental Science
Hokkaido University
N10W5 Kita-ku
Sapporo 060-0810
Japan
seokjin.yoon@gmail.com

Takafumi Yoshida
CEARAC (Special Monitoring and Coastal EnvironmentalAssessment Regional Activity Centre)
NOWPAP (Northwest Pacific Action Plan)
5-5 Ushijima Shin-machi
Toyama 930-0856
Japan
yoshida@npec.or.jp

Naoki Yoshie
Center for Marine Environmental Studies
Ehime University
2-5 Bunkyo-cho
Matsuyama 790-8577
Japan
nyoshie@sci.ehime-u.ac.jp

Mongolia

Dulamsuren Dembee
Research and Training Dept.
National Cancer Center
Nam Jan Zhu St., Bayanzurkh District
Ulaanbaatar 976
Mongolia
duuya2002@yahoo.com

Nigeria

Aguegbo Chukwudi Alexander
Purchase
Chrome I-Tec Services Ltd
299 Ikorodu Rd.
Maryland, Lagos 299
Nigeria
admin@chromeitech.com

Okorie Charles Chibueze
Engineering
Fenotex Company Ltd
3 Adebayo St., Oshodi
Oshodi, Lagos 3
Nigeria
engineeringdepartment@chromeitech.com

Norway

Erlend Moksness
Flødevigen Marine Research Station
Institute of Marine Research
Nye Flødevigveien 20
His, 4817
Norway
moksness@imr.no

Erik Olsen
Institute of Marine Research
P.O. Box 1870, Nordnes
Bergen 5817
Norway
eriko@imr.no

PR China

Hongyan Bao
3663 North Zhongshan Rd.
Shanghai 200062
PR China
shinybao1986@163.com

Rongshuo Cai
Key Lab of Global Change and
Marine-Atmopheric Chemistry
Third Institute of Oceanography, SOA
178 Daxue Rd.
Xiamen, Fujian 361005
PR China
rscai@163.com

Yi Cai
Climate Change
National Research Center for Marine
Environmental Forecasting
8 Dahuisi Rd., Haidian District
Beijing 100081
PR China

Dake Chen
Second Institute of Oceanography, SOA
36 Baochu Bei Rd.
Hangzhou, Zhejiang 310012
PR China
dchen@sio.org.cn

Zhisong Cui
Marine Ecology Research Center
First Institute of Oceanography, SOA
6 Xian-Xia Ling Rd., Hi-Tech Park,
LaoShan District
Qingdao, Shandong 266061
PR China
czs@fio.org.cn

Jingfeng Fan
Dept. Marine Environmental Ecology
National Marine Environmental
Monitoring Center, SOA
42 Linghe St., Shahekou District
Dalian, Liaoning 116023
PR China
fanjingfeng@163.com

Licheng Feng
National Marine Environmental
Forecasting Center, SOA
8 Dahuisi Rd., Haidian District
Beijing 100081
PR China
fenglich@gmail.com

Shan Gao
National Marine Environmental
Forecasting Center
State Oceanic Administration (SOA)
8 Dahuisi Rd., Haidian District
Beijing 100081
PR China
gaoshan_shining@163.com

Zhongyong Gao
Key Lab of Global Change and
Marine-Atmospheric Chemistry
(GCMAC)
Third Institute of Oceanography, SOA
178 Daxue Rd.
Xiamen, Fujian 361005
PR China
zgao@263.net

Ming Gu
Marine Meteorology
Ocean University of China
238 Songling Rd.
Qingdao, Shandong 266100
PR China
guming_517@163.com

Chunjiang Guan
National Marine Environmental
Monitoring Center, SOA
42 Linghe St., Shahekou District
Dalian, Liaoning 116023
PR China
fb4680@people.com.cn

Hao Guo
National Marine Environmental
Monitoring Center, SOA
42 Linghe St., Shahekou District
Dalian, Liaoning 116023
PR China
hguo@nmemc.gov.cn

Jianhua He
Key Lab of Global Change and
Marine-Atmospheric Chemistry,
SOA
Third Institute of Oceanography
No. 178, Daxue Rd.
Xiamen, Fujian 361005
PR China

Juehui Ji
Air Sea Transport Co., Ltd
18 Xianggangzhong Rd., Room 1604,
Flat B, Futai Bldg.
Qingdao, Shandong 266071
PR China
jjh@airsea.com.cn

Liping Jiao
Key Lab of Global Change and
Marine-Atmospheric Chemistry
(GCMAC)
Third Institute of Oceanography, SOA
178 Daxue Rd.
Xiamen, Fujian 361005
PR China
anran790411@hotmail.com

Sui Jun
National Center for Oceanographic
Standards and Metrology
219 JieYuan West Rd., Nankai District
Tianjin 300112
PR China
yw@ncosm.gov.cn

Hongbo Li
National Marine Environmental
Monitoring Center, SOA
42 Linghe St., Shahekou District
Dalian, Liaoning 116023
PR China
marinepico@126.com

Ruixiang Li
Key Lab for Marine Ecology
First Institute of Oceanography, SOA
6 Xian-Xia Ling Rd., Hi-Tech Park,
LaoShan District
Qingdao, Shandong 266061
PR China
liruixiang@fio.org.cn

Zheng Li
First Institute of Oceanography, SOA
6 Xian-Xia Ling Rd., Hi-Tech Park,
LaoShan District
Qingdao, Shandong 266061
PR China
zhengli@fio.org.cn

Fengao Lin
National Marine Environmental
Monitoring Center, SOA
42 Linghe St., Shahekou District
Dalian, Liaoning 116023
PR China
falin316@126.com

Ning Lin
Dept. Marine Administrative
Management
National Marine Data and Information
Service, SOA
93 Liuwei Rd., Hedong District
Tianjin 300171
PR China
peterlin@mail.nmdis.gov.cn

Dongyan Liu
Chinese Academic Sciences
Yantai coastal zone institute
17th Chuihui Road,
Laishan District
Yantai, Shandong 264003
PR China
dyliu@yic.ac.cn

Guimei Liu
National Marine Environmental Forecasting Center
State Oceanic Administration (SOA)
8 Dahuisi Rd., Haidian District
Beijing 100081
PR China
liugm.us@gmail.com

Lingling Liu
Key Lab. of Ocean Circulation and Waves
Institute of Oceanology, Chinese Academy of Sciences
7 Nanhai Rd.
Qingdao, Shandong 266071
PR China
liull@ms.qdio.ac.cn

Jie Shi
College of Environmental Science and Engineering
Ocean University of China
238 Songling Rd.
Qingdao, Shandong 266100
PR China
shijie@ouc.edu.cn

Gongke Tan
International Cooperation Office
First Institute of Oceanography, SOA
6 Xian-Xia Ling Rd., Hi-Tech Park, LaoShan District
Qingdao, Shandong 266061
PR China
gongke_tan@fio.org.cn

Xiaohui Tang
Key Lab. of Ocean Circulation and Waves
Institute of Oceanology, Chinese Academy of Sciences
7 Nanhai Rd.
Qingdao, Shandong 266071
PR China
txhtang@gmail.com

Mingtao Tao
Rongcheng Ocean and Fishery Bureau
140 Guanhaidong Rd.
Rongcheng City
Weihai, Shandong 264300
PR China
rclab@126.com

Liying Wan
National Marine Environmental Forecasting Center, SOA
8 Dahuisi Rd., Haidian District
Beijing 100081
PR China
wanly@nmefc.gov.cn

Fan Wang
Key Lab. of Ocean Circulation and Waves
Institute of Oceanology
Chinese Academy of Sciences
7 Nanhai Rd.
Qingdao, Shandong 266071
PR China
fwang@ms.qdio.ac.cn

Hui Wang
National Marine Environmental Forecasting Center
State Oceanic Administration (SOA)
8 Dahuisi Rd., Haidian District
Beijing 100081
PR China
gaoshan.shining@gmail.com

Junwei Wang
Rongcheng Chudao Fishery Company Ltd
Dong Chudao, Ningjin, Rongcheng City
Weihai, Shandong 264312
PR China
smallwang11@gmail.com

Lijun Wang
National Marine Environmental Monitoring Center, SOA
42 Linghe St., Shahekou District
Dalian, Liaoning 116023
PR China
ljwang@nmemc.gov.cn

Zhang gui Wang
Climate Change
National Research Center for Marine Environmental Forecasting
8 Dahuisi Rd., Haidian District
Beijing 100081
PR China

Yamin Wang
College of Ocean
Shandong University at Weihai
180 Wenhuaxi Rd.
Weihai, Shandong 264209
PR China
wangyamin@sdu.edu.cn

Zhen Wang
National Marine Environmental Monitoring Center, SOA
42 Linghe St., Shahekou District
Dalian, Liaoning 116023
PR China
z_wang@163.com

Hao Wei
College of Marine Science and Engineering
Tianjin University of Science and Technology
1038 Dagu South Rd., Hexi District
Tianjin 300222
PR China
weihao@ouc.edu.cn

Zheng Wei
6 Xian-Xia Ling Rd.
Qingdao 266061
PR China
zhengwei@fio.org.cn

Lixin Wu
College of Physical and Environmental Oceanography
Ocean University of China
5 Yushan Rd.
Qingdao, Shandong 266003
PR China
lxwu@ouc.edu.cn

Xining Xu
Rongcheng Ocean and Fishery Bureau
140 Guanhaidong Rd., Rongcheng City
Weihai, Shandong 264300
PR China
rcyjtg@163.com

Jing Yang
Environmental Dept.
National Marine Environmental Forecasting Center, SOA
8 Dahuisi Rd., Haidian District
Beijing 100081
PR China
laky911@sina.com

Huaming Yu
College of Physical and Environmental Oceanography
Ocean University of China
238 Songling Rd.
Qingdao, Shandong 266100
PR China
huamingyu@gmail.com

Wen Yu
Engineering Physics
Tsinghua University
1 Tsinghua Garden
Beijing 100084
PR China
yuwen01@tsinghua.org.cn

Xiutang Yuan
Dept. Marine Environment and Ecology
National Marine Environmental Monitoring Center, SOA
42 Linghe St., Shahekou District
Dalian, Liaoning 116023
PR China
xtyuan@nmemc.gov.cn

Liping Zhang
238 of Songling Rd.
Qingdao, Shandong 266100
PR China
ocean_climate_ping@yahoo.cn

Shufang Zhang
Linghe Street 42
Dalian, 116023
PR China
ixuetong@163.com

Xinjun Zhang
Rongcheng Fisheries Technique Extention Station
140 Guanhaidong Rd., Rongcheng City
Weihai, Shandong 264300
PR China
zxj2966@yahoo.com.cn

Xuelei Zhang
Center for Marine Ecology Research
First Institute of Oceanography, SOA
6 Xian-Xia Ling Rd., Hi-Tech Park, LaoShan District
Qingdao, Shandong 266061
PR China
zhangxl@fio.org.cn

Dongmei Zhao
42 Linghe St., Shahekou District
Dalian 116023
PR China
dmzhao@nmemc.gov.cn

Liang Zhao
Physical Oceanography Laboratory
Ocean University of China
Songling road No. 238
Qingdao 266100
PR China
zhaoliang@ouc.edu.cn

Mingyuan Zhu
Key Lab for Marine Ecology
First Institute of Oceanography, SOA
6 Xian-Xia Ling Rd., Hi-Tech Park, LaoShan District
Qingdao, Shandong 266061
PR China
zhumingyuan@fio.org.cn

Xiaohua Zhu
State Key Lab. of Satellite Ocean Environment Dynamics
Second Institute of Oceanography, SOA
36 Baochu Bei Rd.
Hangzhou 310012
PR China
xhzhu01@yahoo.co.jp

Philippines

Maria Rebecca Alviar Campos
Southeast Asian Regional Center for Graduate Studies and Research in Agriculture
10996 Campos Compound
Faculty Village
College, Laguna 4031
Philippines
cmaribec@yahoo.com

Republic of Korea

Heui Chun An
Dept. Fisheries Engineering
National Fisheries R&D Institute (NFRDI)
152-1 Haean-ro, Gijang-up, Gijang-gun
Busan 619-705
R Korea
anhc1@nfrdi.go.kr

Yong-Rock An
Cetacean Research Institute
National Fisheries R&D Institute (NFRDI)
139-29 Maeam-dong, Nam-gu
Ulsan 680-050
R Korea
rock@nfrdi.go.kr

Hea Ja Baek
Marine Biotechnology Dept.
Dae-yeon 3 dong, Nam Gu
Busan 608-737
R Korea
hjbaek@pknu.ac.kr

Seung Ho Baek
South Sea Environment Research Dept.
Korea Ocean R&D Institute (KORDI)
391 Jangmok-ri Jangmok-myon
Geoje, Kyungsangnam 656-830
R Korea
baeksh@kordi.re.kr

Sang-Shin Byun
School of Earth and Environmental Sciences
Seoul National University
599 Gwanangno, Gwanak-gu
Seoul 151-742
R Korea
sangsin@snu.ac.kr

Soo-Jung Chang
Marine Ecology Research Div.
National Fisheries R&D Institute (NFRDI)
408-1 Sirang-ri, Kijang
Pusan 619-902
R Korea
sjchang@nfrdi.go.kr

In soon Choi
RIS, Industry-Academic Cooperation Foundation
Silla University
San 1-1, Gwaebop-Dong, Sasang-gu
Busan 617-736
R Korea
sg3ym@hanmail.net

Jae-Suk Choi
RIS, Industry-Academic Cooperation Foundation
Silla University
San 1-1, Gwaebop-Dong, Sasang-gu
Busan 617-736
R Korea
bioengchoi@korea.com

Joong-Ki Choi
Dept. Oceanography
Inha University
253 Yonghyun-dong, Nam-gu
Incheon 402-751
R Korea
jkchoi@inha.ac.kr

Jung Hwa Choi
National Fisheries R&D Institute (NFRDI)
151-1 Haean-ro, Gijang-up, Gijang-gun
Busan 619-705
R Korea
choijh@nfrdi.go.kr

Yoon seok Choi
Environment Research Div.
National Fisheries R&D Institute (NFRDI)
151-1 Haean-ro, Gijang-up, Gijang-gun
Busan 619-705
R Korea
grcys@nfrdi.go.kr

Ik-Kyo Chung
Earth Environmental System Div.
Pusan National University
San 30, Jangjun-dong, Geumjung-gu
Busan 609-735
R Korea
ikchung@pusan.ac.kr

Kee Hun Do
RIS, Industry-Academic Cooperation Foundation
Silla University
San 1-1, Gwaebop-Dong, Sasang-gu
Busan 617-736
R Korea
tkh3515@hanmail.net

Guo-Ying Du
Dept. Marine Science
Pusan National University
Changjeon-dong, Keumjeong-ku
Busan 609-735
R Korea
dgydou@yahoo.com.cn

Yu-Mi Ha
RIS, Industry-Academic Cooperation Foundation
Silla University
San 1-1, Gwaebop-Dong, Sasang-gu
Busan, 617-736
R Korea
gkdbal4@naver.com

Changhoon Han
National Fisheries R&D Institute (NFRDI)
408-1 Shirang-ri, Kijang-up, Kijang-gun
Busan 619-705
R Korea
chhan@nfrdi.go.kr

Hyoungsum Han
Marine Biotechnology Dept.
Soonchunhyang University
646 Eupnae-ri, Shingchang-Myeon
Ansan, Chungcheongnam-do 336-745
R Korea
stoyman@naver.com

In-Seong Han
Ecology and Oceanography Div.
National Fisheries R&D Institute (NFRDI)
152-1 Haean-ro, Gijang-up, Gijang-gun
Busan 619-705
R Korea
hanis@nfrdi.go.kr

In Joon Hwang
Dept. Marine Biology
Pukyong National University
599-1 Daeyeon 3-dong, Nam-gu
Busan 608-737
R Korea
fire-joon@hanmail.net

Jea-Dong Hwang
Ecology and Oceanography Div.
National Fisheries R&D Institute (NFRDI)
152-1 Haean-ro, Gijang-up, Gijang-gun
Busan 619-705
R Korea
jdhwang@nfrdi.go.kr

Bonggil Hyun
Southern Coastal Environmental Research Dept.
Korea Ocean R&D Institute (KORDI)
391 Jangmok-ri Jangmok-myon
Geoje, Kyungsangnam 656-830
R Korea
bghyun@kordi.re.kr

Chan Joo Jang
Korea Ocean R&D Institute (KORDI)
1270 sa-dong
Ansan, Gyeonggi-do 426-170
R Korea
cjjang@kordi.re.kr

Pung-Guk Jang
Dept. Marine Science
Korea Ocean R&D Institute (KORDI)
391 Jangmok-ri Jangmok-myon
Koje-shi, Kyungsangnam 656-830
R Korea
pgjang@kordi.re.kr

Chun-Ok Jo
School of Earth and Environmental Sciences
Seoul National University
599 Gwanangno, Gwanak-gu
Seoul 151-747
R Korea
cojoo100@snu.ac.kr

Qtae Jo
Aquaculture Research Team
East Sea Fisheries Research Institute, NFRDI
30-6 Dongdeok-ri, Yeongok-myon
Gangneung, Gangwon 210 861
R Korea
qtjo@nfrdi.go.kr

Se-Jong Ju
Marine Resources Research Dept.
Korea Ocean R&D Institute (KORDI)
P.O. Box 29
Seoul 425-600
R Korea
sjju@kordi.re.kr

Yu-Mi Jun
Fisheries Research and Environment Div.
National Fisheries R&D Institute (NFRDI)
483 Sachon haean-ro, Yeongok-myon
Gangneung, Gangwon 210-861
R Korea
j830218@nfrdi.go.kr

Kwang Young Jung
Oceanography & Ocean Environmental Sciences
Chungnam National University
220 Gung-dong, Yuseong-gu
Daejeon 305-764
R Korea
kyjung@cnu.ac.kr

Seung Won Jung
South Sea Environment Research Dept.
Korea Ocean R&D Institute (KORDI)
391 Jangmok-ri Jangmok-myon
Geoje, Kyungsangnam 656-830
R Korea
diatoms@kordi.re.kr

Sukgeun Jung
Fisheries Resources Research Team
National Fisheries R&D Institute (NFRDI)
408-1 Shirang-ri, Kijang-up, Kijang-gun
Busan 619-705
R Korea
sukgeun.jung@gmail.com

Hyung-Ku Kang
Marine Living Resources Research Dept.
Korea Ocean R&D Institute (KORDI)
P.O. Box 29
Seoul 425-600
R Korea
kanghk@kordi.re.kr

Hyunjung Kang
National Fisheries R&D Institute (NFRDI)
152-1 Haean-ro, Gijang-up, Gijang-gun
Busan 619-705
R Korea
khj0214@nfrdi.go.kr

Jung-Hoon Kang
South Sea Environment Research Dept.
South Sea Institute/Korea Ocean R&D Institute (KORDI)
391 Jangmok-ri Jangmok-myon
Kyungnam, Kyungsangnam 656-830
R Korea
jhkang@kordi.re.kr

Miri Kang
Dohwadong, Mapo-gu
Seoul
R Korea
kmiri@tisb.ac.in

Sukyung Kang
Fisheries Resources Research Div.
National Fisheries R&D Institute (NFRDI)
151-1 Haean-ro, Gijang-up, Gijang-gun
Busan 619-705
R Korea
kangsk@nfrdi.go.kr

Young-Shil Kang
Marine Ecology Research Team
National Fisheries R&D Institute (NFRDI)
408-1 Shirang-ri, Kijang-up, Kijang-gun
Busan 619-705
R Korea
yskang@nfrdi.go.kr

Dohoon Kim
Management and Economic Policy
National Fisheries R&D Institute (NFRDI)
152-1 Haean-ro, Gijang-up, Gijang-gun
Busan 619705
R Korea
delaware310@nfrdi.go.kr

Eunhye Kim
Environmental Marine Sciences
Hanyang University
1271 sa-3-dong sangrokgu
Ansan, Gyeonggi-do 426-791
R Korea
ehkim@hanyang.ac.kr

Hak-Gyoon Kim
Dept. Oceanography
Pukyong National University
Lotte Castle Marine Apt. 102 Dong, 1405 Ho, Jung-1-dong
Busan 612-870
R Korea
hgkim7592@yahoo.co.kr

Heeyong Kim
Fisheries Resources and Environment Div.
South Sea Fisheries Research Institute, NFRDI
16 Dangmuri-Gil Hwayang-myon
Yeosu 556-823
R Korea
heeyongkim@nfrdi.go.kr

Hye Seon Kim
Deep-Sea & Marine Georesources Research Dept.
Korea Ocean R&D Institute (KORDI)
P.O. Box 29
Ansan, Gyeonggi-do 425-600
R Korea
khs99@kordi.re.kr

Hyun Woo Kim
Cetacean Research Institute
139-29 Maeam-dong, Nam-gu
Ulsan 680 050
R Korea
orcinus@pknu.ac.kr

Hyung Chul Kim
Marine Environment Research Div.
National Fisheries R&D Institute (NFRDI)
152-1 Haean-ro, Gijang-up, Gijang-gun
Busan 619-705
R Korea
hckim@nfrdi.go.kr

Jeonghwa Kim
Marine Territory and Development Div.
Ministry of Land, Transport, and Maritime Affairs (MLTM)
88 Gwanmun-ro
Gwacheon-City, Gyeonggi-do 427-712
R Korea
goodpo@mltm.go.kr

Ji Yeon Kim
Marine Biotechnology Dept.
Soonchunhyang University
646 Eupnae-ri, Shingchang-Myeon
Ansan, Chungcheongnam-do 336-745
R Korea
kjy8122@naver.com

Kuh Kim
Environmental Science and Engineering Dept.
Pohang University of Science and Technology
Hyoja-dong, Nam-gu
Pohang, Kyungsang-bukdo 790-784
R Korea
kuhkim@postech.ac.kr

Myung Sook Kim
Dept. Biology
Jeju National University
66 Jejudaehakno
Jeju-si, Jeju-do 690-756
R Korea
myungskim@jejunu.ac.kr

Seong Cheol Kim
Ministry for Food Agriculture, Forestry and Fisheries
Jeju Fisheries Research Institute, NFRDI
1928 Oeodo 2-dong
Jeju, Jeju-do 690-192
R Korea
sckim@nfrdi.go.kr

Seong Hun Kim
Fisheries Engineering Div.
National Fisheries R&D Institute (NFRDI)
152-1 Haean-ro, Gijang-Up, Gijang-gun
Busan 619-705
R Korea
seba@nfrdi.go.kr

Seong-Gil Kim
Environment Research Div.
National Fisheries R&D Institute (NFRDI)
408-1 Shirang-ri, Kijang-up, Kijang-gun
Busan 619-900
R Korea
cosmas@nfrdi.go.kr

Suam Kim
Dept. Marine Biology
Pukyong National University
599-1 Daeyeon 3-dong, Nam-gu
Busan 608-737
R Korea
suamkim@pknu.ac.kr

Tae-Wook Kim
31 San, Room 313, Environ. Bldg.
Postech, Hyoja-dong, N
Pohang, Kyoungbuk 790-784
R Korea
ktwtw@postech.ac.kr

Yonghae Kim
Marine Production Technology
Gyeongsang University
445 Inpyeong-dong
Tongyoung, Keognam 650-160
R Korea
yonghae@gnu.kr

Young-Ok Kim
South Sea Environment Research Dept.
Korea Ocean R&D Institute (KORDI)
391 Jangmok-ri Jangmok-myon
Geoje, Kyungsangnam 656-830
R Korea
yokim@kordi.re.kr

Ah-Ra Ko
Environmental Marine Sciences
Hanyang University
1271 sa-3-dong sangrokgu
Ansan, Gyeonggi-do 426-791
R Korea
scrooge85@kordi.re.kr

Ji-Woong Ko
Artificial Reef Research Team
Jeju Fisheries Research Institute, NFRDI
1928, Wedo 2-dong
Jeju, Jeju-do 690191
R Korea
mohansiddhu@gmail.com

Ji-Woong Ko
National Fisheries R&D Institute (NFRDI)
1928 Oedo 2-dong
Jeju-si, Jeju-do 690-192
R Korea
nyhc555@naver.com

Hyeok Chan Kwon
Fisheries Physics Dept.
Pukyong National University
599-1 Daeyeon 3-dong, Nam-gu
Busan 608-737
R Korea
hckwon98@pknu.ac.kr

Oh Youn Kwon
Southern Coastal Environment Research Dept.
Korea Ocean R&D Institute (KORDI)
391 Jangmok-ri Jangmok-myon
Geoje, Kyungsangnam 656-830
R Korea
koy00@kordi.re.kr

You Jung Kwon
Pukyong National University
599-1 Daeyeon 3-dong, Nam-gu
Busan 608-737
R Korea
youjungkwon@gmail.com

Bo-Bae Lee
RIS, Industry-Academic Cooperation Foundation
Silla University
San 1-1, Gwaebop-Dong, Sasang-gu
Busan 617-736
R Korea
bobae79@hanmail.net

Chung Il Lee
Faculty of Marine Bioscience & Technology
Kangnung-Wonju National University
120 Gangneung Daehangno
Gangneung, Gangwon 210-702
R Korea
leeci@nukw.ac.kr

Eunhui Lee
Fisheries Resource Research Dept.
National Fisheries R&D Institute (NFRDI)
152-1 Haean-ro, Gijang-up, Gijang-gun
Busan 619-705
R Korea
ehlee83@nfrdi.go.kr

HaeWon Lee
Dokdo Fisheries Research Center
National Fisheries R&D Institute (NFRDI)
393 Samho-ro, Buk-gu
Pohang, Gyeongbuk 791-110
R Korea
roundsea@nfrdi.go.kr

Hwa-Hyun Lee
Biology Education
Pukyong National University
559-1 Daeyeon-3-dong, Nam-gu
Busan 608-737
R Korea
proxima07@hanmail.net

Jae-Bong Lee
Fisheries Resource Research
National Fisheries R&D Institute (NFRDI)
408-1 Shirang-ri, Kijang-up, Kijang-gun
Busan 619-905
R Korea
leejb@nfrdi.go.kr

Ji Hyun Lee
Aquaculture Research Team
East Sea Fisheries Research Institute, NFRDI
30-6 Dongdeok-ri, Yeongok-myon
Gangneung, Gangwon 210 861
R Korea
thinkdi@gmail.com

Jin Ae Lee
School of Environmental Science & Engineering
Inje University
607 Obang-dong
Gimhae, Gyeongnam 621-749
R Korea
envjal@inje.ac.kr

Jong Hee Lee
Marine Production Management
Pukyong National University
599-1 Daeyeon 3-dong, Nam-gu
Busan 608-737
R Korea
francis@pknu.ac.kr

Joon-Soo Lee
Ecology and Oceanography Div.
National Fisheries R&D Institute (NFRDI)
152-1 Haean-ro, Gijang-up, Gijang-gun
Busan 619-705
R Korea
leejoonsoo@nfrdi.go.kr

Kyounghoon Lee
Fisheries Engineering Div.
National Fisheries R&D Institute (NFRDI)
152-1 Haean-ro, Gijang-Up, Gijang-gun
Busan 619-705
R Korea
khlee71@nfrdi.go.kr

Sang Yong Lee
Seaweed Research Institute
National Fisheries R&D Institute (NFRDI)
1101 Okam-dong
Mokpo, 530-831
R Korea
seagrass1@nfrdi.go.kr

Yonghwa Lee
Fisheries Resources and Environment Div.
East Sea Fisheries Research Institute, NFRDI
482 Sacheonhaean-ro, Yeongok
Gangneung, Gangwon 210-861
R Korea
dragon@nfrdi.go.kr

Youngju Lee
Dept. Oceanography
Inha University
#253, Nam-gu, Yonghyun-dong
Incheon-City 402-751
R Korea
yjulee38@gmail.com

Jung Hyun Lim
Marine Production System Management
Pukyong National University
599-1 Daeyeon 3-dong, Nam-gu
Busan 608-737
R Korea
ljh1113@hanmail.net

Jang Min-Chul
South Sea Environment Research Dept.
Korea Ocean R&D Institute (KORDI)
391 Jangmok-ri Jangmok-myon
Geoje, Kyungsangnam 656-830
R Korea
mcjang@kordi.re.kr

Lee Moonsuk
Marine Policy Research Divisioin
Korea Ocean R&D Institute (KORDI)
454 Haeanro
Ansan, Kyunggi-do 426-744
R Korea
leems@kordi.re.kr

Hanna Na
School of Earth and Environmental Sciences
Seoul National University
56-1 San, Sillim-dong, Gwanak-gu
Seoul 151-742
R Korea
hanna.ocean@gmail.com

Jong-Hun Na
Marine Production Management
Pukyong National University
599-1 Daeyeon 3-dong, Nam-gu
Busan 608-737
R Korea
jhna@pknu.ac.kr

Jungyul Na
Environmental Marine Sciences
Hanyang University
1271 sa-3-dong sangrokgu
Ansan, Gyeonggi-do 426-791
R Korea
najy0252@hanyang.ac.kr

Taehee Na
Earth Environmental System Div.
Pusan National University
Chemical Oceanography Lab.
Busan 609-735
R Korea
ocean95@pusan.ac.kr

Jaehoon Noh
Marine Living Resources Res. Dept.
Korea Ocean R&D Institute (KORDI)
1270 sa-2-dong sangnokgu
Ansan, Kyunggi-do 426-744
R Korea
jhnoh@kordi.re.kr

Hyun-Ju Oh
Fisheries Resources and Environment Div.
South Sea Fisheries Research Institute, NFRDI
347 Anpo-ri, Hwayang-myon
Yeosu, Chollanam-do 556-820
R Korea
hjoh@nfrdi.go.kr

Jai-Ho Oh
Environmental Atmospheric Sciences
Pukyong National University
559-1 Daeyeon-3-dong, Nam-gu
Busan 608-737
R Korea
jhoh@pknu.ac.kr

Yun Ah Oh
san 31, Hyoja-dong, Nam-gu,
Pohang 790-784
R Korea
yuna0002@postech.ac.kr

Bum-Soo Park
Natural College, Dept. Biology
Hanyang University
528 Ho, Hae-dang-dong, Sung-dong-gu
Seoul 133791
R Korea
parkbs@hanyang.ac.kr

Hee Won Park
Marine Production Management
Pukyong National Uinversity
559-1 Daeyeon 3-dong, Nam-gu
Busan 608-737
R Korea
hwpark@pknu.ac.kr

Hye Min Park
Dept. Marine Biology
Pukyong National University
599-1 Daeyeon 3-dong, Nam-gu
Pusan 608-737
R Korea
shrimppark@gmail.com

Jae Young Park
Biotechnology Dept.
Dongseo University
69-1 San, Churye-2-dong, Sasang-gu
Busan 617-716
R Korea
nflover@hanmail.net

Kwang-Seok Park
Environment Research Dept.
Research Institute of Industrial Science & Technology
32 San, Hyoja-dong, Nam-gu
Pohang, Gyeongbuk 790-330
R Korea
kspark@rist.re.kr

Kwang-Soon Park
Climate Change & Coastal Disaster Research Dept.
Korea Ocean R&D Institute (KORDI)
1270 sa-dong
Ansan, Kyunggi-do 425-600
R Korea
kspark@kordi.re.kr

Kyum Joon Park
Cetacean Research Institute
139-29 Maeam-dong, Nam-gu
Ulsan 680-050
R Korea
awhitewhale@hotmail.com

Sang Rul Park
Biological Sciences
Pusan National University
Geumjeong-gu
Busan 609-735
R Korea
srv99park@pusan.ac.kr

Wongyu Park
Marine Biotechnology Dept.
Soonchunhyang University
646 Eupnae-ri, Shingchang-Myeon
Ansan, Chungcheongnam-do 336-745
R Korea
pwg09@hotmail.com

Young-Jae Ro
College of Natural Sciences
Chungnam National University
220 Gung-dong, Yuseong-gu
Daejeon 305-764
R Korea
royoungj@cnu.ac.kr

JeongHee Shim
Environment Research Div.
National Fisheries R&D Institute (NFRDI)
408-1 Shirang-ri, Kijang-up, Kijang-gun
Busan 619-705
R Korea
jshim@nfrdi.go.kr

Jeong Min Shim
Marine Biology
National Fisheries R&D Institute (NFRDI)
482 Sacheon Haean-ro
Gangneung 210-860
R Korea
jmshim@nfrdi.go.kr

Hyeon Ho Shin
Faculty of Marine Technology
Chonnam National University
96-1 San, Dundeok-dong
Yeosu, Chonnam 550-749
R Korea
shh961121@hotmail.com

Kyoung-Soon Shin
Southern Coastal Environment
Korea Ocean R&D Institute (KORDI)
391 Jangmok-ri Jangmok-myon
Geoje, Kyungsangnam 656-830
R Korea
ksshin@kordi.re.kr

Young Jae Shin
Fisheries Resources Research
National Fisheries R&D Institute (NFRDI)
408-1 Shirang-ri, Kijang-up, Kijang-gun
Busan 619-905
R Korea
syj5354@nfrdi.go.kr

Munho Sohn
Pegasus Int'l Inc.
161 Ma-Cheon dong
Jin-Hae, Kyungsangnam 645-450
R Korea
mhsohn77@yahoo.co.kr

Kyung-Jun Song
University-Research Institute
Interdisciplinary Program of Fisheries and Ocean.
Pukyong National University
599-1 Daeyeon 3-dong, Nam-gu
Busan 608-737
R Korea
kjsong329@hanmail.net

Hui Chih Wang
Biotechnology Dept.
Dongseo University
69-1 San, Churye-2-dong, Sasang-gu
Busan 617-716
R Korea
ckvirus@hotmail.com

Keiko Yamada
Ecology and Oceanography Div.
National Fisheries R&D Institute (NFRDI)
152-1 Haean-ro, Gijang-Up, Gijang-gun
Busan 619-705
R Korea
keiko@nfrdi.go.kr

Sang-Wook Yeh
Ocean Climate and Environment
Korea Ocean R&D Institute (KORDI)
P.O. Box 29
Ansan 425-600
R Korea
swyeh@kordi.re.kr

In-Ja Yeon
South Sea Fisheries Research Institute, NFRDI
16 Dangmuri-Gil Hwayang-myon
Yeosu 556-823
R Korea
ijyeon@nfrdi.go.kr

Sinjae Yoo*
Marine Living Resources Div.
Korea Ocean R&D Institute (KORDI)
1270 sa-dong
Ansan, Gyeonggi-do 426-170
R Korea
sjyoo@kordi.re.kr
*representative of IMBER

Jin-Hee Yoon
Climate Change & Coastal Disaster Research Dept.
Korea Ocean R&D Institute (KORDI)
P.O.Box 29
Gyunggi-do 425-600
R Korea
jiny.yoon@gmail.com

Hack-Churl You
Pegasus Int'l Inc.
7F, Platium Bldg., 889-51, Dae-Chi Dong, Kang-Nam-gu
Seoul 135-839
R Korea
pegasus1@pegasushomepage.com

Seok-Hyun Youn
Ecology and Oceanography Div.
National Fisheries R&D Institute (NFRDI)
152-1 Haean-ro, Gijang-Up, Gijang-gun
Busan 619-705
R Korea
shyoun@nfrdi.go.kr

Chang-Ik Zhang
Marine Production Management
Pukyong National University
599-1 Daeyeon 3-dong, Nam-gu
Busan 608-737
R Korea
cizhang@pknu.ac.kr

Russia

Anastasiya A. Abrosimova
General Oceanology
V.I. Il´ichev Pacific Oceanological Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
amber84@bk.ru

Andrey G. Andreev
V.I. Il´ichev Pacific Oceanological Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
andreev@poi.dvo.ru

Ivan S. Arzamastsev
The Center Landscapes and Ecological Researches
Pacific Geographical Institute, FEB RAS
7 Radio St.
Vladivostok, Primorsky Kray 690041
Russia
arz@tig.dvo.ru

Nadezhda L. Aseeva
Far-Eastern Seas Fisheries Resources
Pacific Research Institute of Fisheries and Oceanography
(TINRO-Center)
4 Shevchenko Alley
Vladivostok, Primorsky Kray 690950
Russia
aseeva_n@hotmail.com

Ludmila S. Belan
Oceanography and Marine Ecology
Far Eastern Regional
Hydrometeorological Research
Institute (FERHRI)
24 Fontannaya St.
Vladivostok, Primorsky Kray 690990
Russia
belan_t@mail.ru

Tatyana A. Belan
Oceanography and Marine Ecology
Far Eastern Regional Hyrdometeorological
Research Institute (FERHRI)
24 Fontannaya St.
Vladivostok, Primorsky Kray 690091
Russia
Tbelan@ferhri.ru

Galina Borisenko
Pacific Research Institute of Fisheries
and Oceanography (TINRO-Center)
4 Shevchenko Alley
Vladivostok, Primorsky Kray 690950
Russia
vera_borisenko@mail.ru

Victor Bugaev
Kamchatka Research Institute of
Fisheries and Oceanography
(KamchatNIRO)
18 Naberezhnaya St.
Petropavlovsk-Kamchatsky,
Kamchatka 683600
Russia
bugaevv@kamniro.ru

Alexey V. Bulanov
V.I. Il´ichev Pacific Oceanological
Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
lotar85@gmail.com

Oleg A. Bulatov
Lab. of Marine Fishes of Far East Seas
Russian Federal Research Institute of
Fisheries and Oceanography (VNIRO)
17 V. Krasnoselskaya St.
Moscow, 107140
Russia
obulatov@vniro.ru

Andrey Chernyaev
Lab. of Applied Ecology and
Ecotoxicology
Pacific Research Institute of Fisheries
and Oceanography (TINRO-Center)
4 Shevchenko Alley
Vladivostok, Primorsky Kray 690950
Russia
blizzard_01@mail.ru

Vladimir B. Darnitskiy
Dept. Oceanography
Pacific Research Institute of Fisheries
and Oceanography (TINRO-Centre)
96/4 Nekrasovskaya St., Apt.78
Vladivostok, Primorsky Kray 690014
Russia
laitik@mail.ru

Yurii P. Diakov
Kamchatka Research Institute of
Fisheries and Oceanography
(KamchatNIRO)
18 Naberezhnaya St.
Petropavlovsk-Kamchatsky
Kamchatka 683000
Russia
diakov@kamniro.ru

Elena V. Dmitrieva
V.I. Il´ichev Pacific Oceanological
Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
e_dmitrieva@poi.dvo.ru

Anastasia S. Dolganova
Lab. of Hydrobiology
Pacific Research Institute of Fisheries
and Oceanography (TINRO-Centre)
4 Shevchenko Alley
Vladivostok, Primorsky Kray 690950
Russia
acdolganova@yandex.ru

Liudmila S. Dolmatova
Dept. Biotechnology
V.I. Il´ichev Pacific Oceanological
Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
dolmatova@poi.dvo.ru

Elena P. Dulepova
Lab. of Applied Bioceonology
Pacific Research Institute of Fisheries
and Oceanography (TINRO-Center)
4 Shevchenko Alley
Vladivostok, Primorsky Kray 690950
Russia
dep@tinro.ru

Nadezda M. Dulova
V.I. Il´ichev Pacific Oceanological
Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
nadydul@poi.dvo.ru

Boris S. Dyakov
Lab. of Fisheries Oceanography
Pacific Research Institute of Fisheries
and Oceanography (TINRO-Center)
4 Shevchenko Alley
Vladivostok, Primorsky Kray 690950
Russia
djakov@tinro.ru

Valeriy I. Fadeev
Lab. of Ecology Shelf Communities
A.V. Zhirmunsky Institute of Marine
Biology, FEB RAS
17 Palchevskogo St.
Vladivostok, Primorsky Kray 690041
Russia
vfadeev@mail.primorye.ru

Natalia P. Fadeeva
Dept. Ecology
Far Eastern State University
27 Oktyabrskaya St., Room 404
Vladivostok, Primorsky Kray 690950
Russia
nfadeeva@mail.primorye.ru

Alexander Figurkin
Pacific Research Institute of Fisheries
and Oceanography (TINRO-Center)
4 Shevchenko Alley
Vladivostok, Primorsky Kray 690950
Russia
zhigalov@tinro.ru

Galina Gavrilova
Pacific Research Institute of Fisheries
and Oceanography (TINRO-Center)
4 Shevchenko Alley
Vladivostok, Primorsky Kray 690950
Russia
gavrilova@tinro.ru

Larissa A. Gayko
V.I. Il´ichev Pacific Oceanological
Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
gayko@yandex.ru

Elena V. Gritsay
Lab. of Walleye Pollock
Pacific Research Institute of Fisheries
and Oceanography (TINRO-Center)
4 Shevchenko Alley
Vladivostok, Primorsky Kray 690950
Russia
gritsay@tinro.ru

Svetlana A. Ireykina
Lab. of Ecosystem Research of Coastal Waters Bioresorses
Pacific Research Institute of Fisheries and Oceanography (TINRO-Center)
4 Shevchenko Alley
Vladivostok, Primorsky Kray 690950
Russia
ir_lana@live.ru

Maxim Ishchenko
V.I. Il´ichev Pacific Oceanological Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
maksim@poi.dvo.ru

Anatoly N. Kachur
Pollution Monitoring Regional Activity Center
Director, NOWPAP POMRAC
7 Radio St.
Vladivostok, Primorsky Kray 690041
Russia
akachur@mail.primorye.ru

Alexander M. Kaev
Federal Agency for Fisheries
Sakhalin Research Institute of Fisheries & Oceanography (SakhNIRO)
196 Komsomolskaya St.
Yuzhno-Sakhalinsk , Sakhalin 693023
Russia

Gennady A. Kantakov
Far-Eastern Ecological Center Ltd.
426 Mira Ave., Office 404
Yuzhno-Sakhalinsk, Sakhalin 693004
Russia
deco@sakhalin.ru

Dmitry D. Kaplunenko
Dept. Satellite Oceanology
V.I. Il´ichev Pacific Oceanological Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
dimkap@poi.dvo.ru

Oleg N. Katugin
Fisheries Resources of the Far Eastern Seas
Pacific Research Institute of Fisheries and Oceanography (TINRO-Center)
4 Shevchenko Alley
Vladivostok, Primorsky Kray 690950
Russia
katugin@tinro.ru

Fedor F. Khrapchenkov
V.I. Il´ichev Pacific Oceanological Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
fedi@poi.dvo.ru

Talgat R. Kilmatov
Pacific State Economics University
19 Okeansky Pr.
Vladivostok, Primorsky Kray 690950
Russia
talgat_k@mail.ru

Tatiana V. Konovalova
HSE (Health, Safety, Environment)
Sakhalin Energy Investment Company, Ltd.
35 Dzerzhinskogo St.
Yuzhno-Sakhalinsk, Sakhalin 693020
Russia
Tatyana.Konovalova@SakhalinEnergy.ru

Tatyana N. Krupnova
Pacific Research Institute of Fisheries and Oceanography (TINRO-Centre)
4 Shevchenko Alley
Vladivostok, Primorsky Kray 690950
Russia
krupnova@tinro.ru

Victor I. Kuzin
Mathematical Modeling of the Atmosphere and Ocean Physics
Siberian Division of the Russian Academy of Sciences
6 Lavrentieva Ave.
Novosibirsk, 630090
Russia
kuzin@sscc.ru

Vyacheslav S. Labay
Hidrobiological Lab.
Sakhalin Research Institute of Fisheries & Oceanography (SakhNIRO)
196 Komsomolskaya St.
Yuzhno-Sakhalinsk, Sakhalin 693023
Russia

Svetlana Y. Ladychenko
Dept. Physical Oceanology
V.I. Il´ichev Pacific Oceanological Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
svemos@poi.dvo.ru

Vyacheslav B. Lobanov
Deputy Director
V.I. Il´ichev Pacific Oceanological Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
lobanov@poi.dvo.ru

Olga N. Lukyanova
Lab. of Applied Ecology and Ecotoxicology
Pacific Research Institute of Fisheries and Oceanography (TINRO-Center)
4 Shevchenko Alley
Vladivostok, Primorsky Kray 690950
Russia
onlukyanova@tinro.ru

Natalya B. Luk'yanova
Lab. of Hydrological Processes and Climate, Dept. General Oceanology
V.I. Il´ichev Pacific Oceanological Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
natalook@poi.dvo.ru

Ferdenant A. Mkrtchyan
Informatics
Institute of Radioengineering and Electronics, RAS
1 Vvedensky Sq.
Fryazino, 141190
Russia
ferd47@mail.ru

Georgiy S. Moiseenko
Satellite Monitoring Systems Lab.
Russian Federal Research Institute of Fisheries and Oceanography (VNIRO)
17 V. Krasnoselskaya St.
Moscow, 107140
Russia
georgem@vniro.ru

Valentina V. Moroz
V.I. Il´ichev Pacific Oceanological Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
moroz@poi.dvo.ru

Tatiana V. Morozova
A.V. Zhirmunsky Institute of Marine Biology, FEB RAS
17 Palchevskogo St.
Vladivostok, Primorsky Kray 690041
Russia
tatiana_morozova@mail.ru

Alexei M. Orlov
International Fisheries Cooperation
Russian Federal Research Institute of Fisheries and Oceanography (VNIRO)
17 V. Krasnoselskaya St.
Moscow, 107140
Russia
orlov@vniro.ru

Tatiana Yu. Orlova
Dept. Hydrobiology
A.V. Zhirmunsky Institute of Marine Biology, FEB RAS
17 Palchevskogo St.
Vladivostok, Primorsky Kray 690041
Russia
torlova@whoi.edu

Alexandra Petrova
Institute of of Chemistry and Applied Ecology
Far Eastern National University
27 Oktyabrskaya St.
Vladivostok, Primorsky Kray 690950
Russia
petrovasasha@yandex.ru

Vladimir V. Plotnikov
Ice Research Lab.
V.I. Il´ichev Pacific Oceanological Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
vlad_plot@poi.dvo.ru

Antonina M. Polaykova
V.I. Il´ichev Pacific Oceanological Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
polyak@poi.dvo.ru

Vladimir I. Ponomarev
Physical Oceanography
V.I. Il´ichev Pacific Oceanological Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
pvi711@yandex.ru

Ekaterina Potalova
V.I. Il´ichev Pacific Oceanological Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
gata@poi.dvo.ru

Vasily Radashevsky
A.V. Zhirmunsky Institute of Marine Biology, FEB RAS
17 Palchevskogo St.
Vladivostok, Primorsky Kray 690041
Russia
radashevsky@mail.ru

Pavel Salyuk
V.I. Il´ichev Pacific Oceanological Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
pavel.salyuk@gmail.com

Eugene V. Samko
Cosmic Methods of Ocean Research Lab.
Pacific Research Institute of Fisheries and Oceanography (TINRO-Center)
4 Shevchenko Alley
Vladivostok, Primorsky Kray 690950
Russia
samko@tinro.ru

Marina S. Selina
A.V. Zhirmunsky Institute of Marine Biology, FEB RAS
17 Palchevskogo St.
Vladivostok, Primorsky Kray 690041
Russia
selinamar@km.ru

Svetlana P. Shkorba
Ice Research Lab.
V.I. Il´ichev Pacific Oceanological Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
sshkorba@yandex.ru

Natalia V. Shlyk
V.I. Il´ichev Pacific Oceanological Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
shl@poi.dvo.ru

Elena A. Shtraikhert
V.I. Il´ichev Pacific Oceanological Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
straj@poi.dvo.ru

Vladimir M. Shulkin
Pacific Geographical Institute
Far Eastern Branch of Russian Academy of Science (FEB RAS)
7 Radio St.
Vladivostok, Primorsky Kray 690041
Russia

Evgeniy A. Sigida
Dept. Ecology
Far Eastern National University
41, House 31a, Praporshika Komarova
Vladivostok, Primorsky Kray 690090
Russia
el-lobo@yandex.ru

Eduard Spivak
Lab. of Arctic Research
V.I. Il´ichev Pacific Oceanological Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
stilo@poi.dvo.ru

Mikhail Stepanenko
Pacific Research Institute of Fisheries and Oceanography (TINRO-Center)
4 Shevchenko Alley
Vladivostok, Primorsky Kray 690950
Russia
stepanenko@tinro.ru

Dmitry S. Strobykin
V.I. Il´ichev Pacific Oceanological Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
doom46@yandex.ru

Nadezhda Struppul
Lab. of Chemistry and Technology of Living Systems
Pacific State Economics University
19 Okeansky Pr.
Vladivostok, Primorsky Kray 690950
Russia
struppul@mail.ru

Evgeniya A. Tikhomirova
Dept. General Oceanology, Lab. of Hydrological Processes and Climate
V.I. Il´ichev Pacific Oceanological Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
tikhomirova@poi.dvo.ru

Eduard Titlyanov
A.V. Zhirmunsky Institute of Marine Biology, FEB RAS
17 Palchevskogo St.
Vladivostok, Primorsky Kray 690041
Russia
etitlyanov@mail.ru

Tamara Titlyanova
A.V. Zhirmunsky Institute of Marine Biology, FEB RAS
17 Palchevskogo St.
Vladivostok, Primorsky Kray 690041
Russia
titlyanova@inbox.ru

Tatyana I. Tolstyak
Kamchatka Research Institute of Fisheries and Oceanography (KamchatNIRO)
18 Naberezhnaya St.
Petropavlovsk-Kamchatsky, Kamchatka 683000
Russia
bugaevv@kamniro.ru

Olga O. Trusenkova
Lab. of Physical Oceanography
V.I. Il´ichev Pacific Oceanological Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
trolia@poi.dvo.ru

Olga Yu. Tyurneva
A.V. Zhirmunsky Institute of Marine Biology, FEB RAS
17 Palchevskogo St.
Vladivostok, Primorsky Kray 690002
Russia
olga-tyurneva@yandex.ru

Elena I. Ustinova
Lab. of Fisheries Oceanography
Pacific Research Institute of Fisheries and Oceanography (TINRO-Center)
4 Shevchenko Alley
Vladivostok, Primorsky Kray 690950
Russia
eustinova@mail.ru

Nadezda M. Vakulskaya
Ice Research Lab.
V.I. Il´ichev Pacific Oceanological Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
vakulskaya@poi.dvo.ru

Evgenia Vekhova
Invertebrates Ecology
A.V. Zhirmunsky Institute of Marine Biology, FEB RAS
17 Palchevskogo St.
Vladivostok, Primorsky Kray 690041
Russia
evechova@mail.ru

Anatoliy Velikanov
State Committe for Fisheries of the Russian Federation
Sakhalin Research Institute of Fisheries & Oceanography (SakhNIRO)
196 Komsomolskaya St.
Yuzhno-Sakhalinsk, Sakhalin 693023
Russia

Elena Vilyanskaya
Lab. of Hydrology Processes and Climate
V.I. Il´ichev Pacific Oceanological Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
vily05@mail.ru

Valeriy Vladimirov
Russian Federal Research Institute of Fisheries and Oceanography (VNIRO)
17 V. Krasnoselskaya St.
Moscow, 107140
Russia
vladimirov.vniro@gmail.com

Gleb S. Vlasov
Dept. Foreign Languages
V.V. Kuibyshev Far Eastern State Technical University
10 Pushiskaya St.
Vladivostok, Primorsky Kray 690950
Russia
vlasov_gleb83@mail.ru

Galina A. Vlasova
V.I. Il´ichev Pacific Oceanological Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
gavlasova@mail.ru

Gennady I. Yurasov
Lab. of Physical Oceanology
V.I. Il´ichev Pacific Oceanological Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
yug@poi.dvo.ru

Sergei P. Zakharkov
General Oceanology
V.I. Il´ichev Pacific Oceanological Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok, Primorsky Kray 690041
Russia
zakharkov@poi.dvo.ru

Yulia Zavertanova
V.I. Il´ichev Pacific Oceanological Institute (POI), FEB RAS
43 Baltiyskaya St.
Vladivostok,, Primorsky Kray 690041
Russia
zavertanova@poi.dvo.ru

Yury I. Zuenko
Japan Sea and North-West Pacific Oceanography
Pacific Research Institute of Fisheries and Oceanography (TINRO-Center)
4 Shevchenko Alley
Vladivostok, Primorsky Kray 690950
Russia
zuenko_yury@hotmail.com

Mikhail Zuev
Pacific Research Institute of Fisheries and Oceanography (TINRO-Center)
4 Shevchenko Alley
Vladivostok, Primorsky Kray 690950
Russia
maiklzusqd@mail.ru

Spain

Monica Lion
IOC-IEO Science and Communication Centre on Harmful Algae
Instituto Español de Oceanografia, Centro Oceanografico
Vigo, Pontevedra 36200
Spain

Graham J. Pierce
Programa ICES
Instituto Español de Oceanografia
Centro Oceanográfico de Vigo
P.O. Box 1552
Vigo, Pontevedra 36200
Spain
g.j.pierce@abdn.ac.uk

Maria Begoña Santos Vazquez
Centro Oceanografico de Vigo
Instituto Español de Oceanografia
P.O. Box 1552
Vigo, Pontevedra 36200
Spain
m.b.santos@vi.ieo.es

The Netherlands

Mark Dickey-Collas
Fisheries
Wageningen IMARES
Postbus 68
IJmuiden 1970AB
The Netherlands
mark.dickeycollas@wur.nl

Turkey

Bulent Acma
Economics
Anadolu University
Yunusemre Campus
Eskisehir 26470
Turkey
bacma@anadolu.edu.tr

U.S.A.

Michael A. Alexander
Earth System Research Lab.
National Oceanic and Atmospheric Administration (NOAA)
Physical Science Div., R/PSD1,
325 Broadway
Boulder, CO 80305-3328
U.S.A.
Michael.Alexander@noaa.gov

Vera Alexander*
School of Fisheries and Ocean Sciences
University of Alaska Fairbanks
P.O. Box 757220
Fairbanks, AK 99775-7220
U.S.A.
vera@sfos.uaf.edu
*representative of CoML

Kevin H. Amos
Aquaculture Program
NOAA Fisheries/NOAA Aquaculture Program
4921 Bend Dr. NE
Lacey, WA 98516
U.S.A.
kevin.amos@noaa.gov

Donald M. Anderson
Dept. Biology
Woods Hole Oceanographic Institution
MS 32, 266 Woods Hole Rd.
Woods Hole, MA 02543-1049
U.S.A.
danderson@whoi.edu

Jack A. Barth*
College of Oceanic and Atmospheric Sciences
Oregon State University
104 COAS Admin. Bldg.
Corvallis, OR 97331-5503
U.S.A.
barth@coas.oregonstate.edu
*representative of NaNOOS

Harold (Hal) P. Batchelder
College of Oceanic and Atmospheric Sciences
Oregon State University
104 COAS Admin. Bldg.
Corvallis, OR 97331-5503
U.S.A.
hbatchelder@coas.oregonstate.edu

Kelly Benoit-Bird
College of Oceanic and Atmospheric Sciences
Oregon State University
104 COAS Admin. Bldg.
Corvallis, OR 97331
U.S.A.
kbenoit@coas.oregonstate.edu

Brian Bill
Northwest Fisheries Science Center,
NMFS, NOAA
2725 Montlake Blvd. E
Seattle, WA 98112
U.S.A.
bdon91@hotmail.com

Bryan Black
Hatfield Marine Science Center
Oregon State University
2030 SE Marine Science Dr.
Newport, OR 97365
U.S.A.
bryan.black@oregonstate.edu

George W. Boehlert
Hatfield Marine Science Center
Oregon State University
2030 SE Marine Science Dr.
Newport, OR 97365-5296
U.S.A.
george.boehlert@oregonstate.edu

Catherine Boerner
Exxon Valdez Oil Spill Trustee Council
441 W. 5th Ave., Suite 500
Anchorage, AK 99501
U.S.A.
catherine.boerner@alaska.gov

Steven J. Bograd
Environmental Research Div.
Southwest Fisheries Science Center,
NMFS, NOAA
1352 Lighthouse Ave.
Pacific Grove, CA 93950
U.S.A.
steven.bograd@noaa.gov

Richard D. Brodeur
Fish Ecology Div., HMSC
National Marine Fisheries Service,
NOAA
2030 S Marine Science Dr.
Newport, OR 97365
U.S.A.
Rick.Brodeur@noaa.gov

Kenneth W. Bruland
Ocean Sciences
University of California at Santa Cruz
Earth and Marine Science Bldg.
Santa Cruz, CA 95064
U.S.A.
bruland@ucsc.edu

Fei Chai
School of Marine Sciences
University of Maine
5706 Aubert Hall
Orono, ME 04469
U.S.A.
fchai@maine.edu

David M. Checkley
Scripps Institution of Oceanography
University of California, San Diego
9500 Gilman Dr.
La Jolla, CA 92093-0218
U.S.A.
dcheckley@ucsd.edu

April N. Croxton
National Marine Fisheries Service
National Oceanic and Atmospheric Administration (NOAA)
Milford Laboratory, 212 Rogers Ave.
Milford, CT 06460
U.S.A.
april.croxton@noaa.gov

Enrique N. Curchitser
Institute for Marine and Coastal Sciences
Rutgers University
71 Dudley Rd.
New Brunswick, NJ 08901
U.S.A.
enrique@marine.rutgers.edu

Michael J. Dagg
Louisiana Universities Marine Consortium
8124 Hwy 56
Chauvin, LA 70344
U.S.A.
mdagg@lumcon.edu

Michael G. Dalton
Alaska Fisheries Science Center, NOAA
7600 Sand Point Way NE
Seattle, WA 98115
U.S.A.
michael.dalton@noaa.gov

Curtis Deutsch
Atmospheric and Oceanic Sciences
University of California, Los Angeles
405 Hilgard Ave.,
7125 Math Science Bldg.
Los Angeles, CA 90024
U.S.A.
cdeutsch@atmos.ucla.edu

Stephen J. DeVincent
Ocean and Polar Affairs
U.S. Department of State
2201 C St., NW
Washington, DC 20005
U.S.A.
devincentsj@state.gov

Emanuele Di Lorenzo
School of Earth and Atmospheric Sciences
Georgia Institute of Technology
311 Ferst Dr.
Atlanta, GA 30332
U.S.A.
edl@gatech.edu

Reka Domokos
Ecosystems and Oceanography
Pacific Islands Fisheries Science Center, NMFS, NOAA
2570 Dole St.
Honolulu, HI 96822-2396
U.S.A.
reka.domokos@noaa.gov

Miriam J. Doyle
Joint Institute for the Study of Atmosphere and Ocean (JISAO)
University of Washington
7600 Sand Point Way NE
Seattle, WA 98115
U.S.A.
miriam.doyle@noaa.gov

Brett Dumbauld
US Dept. of Agriculture, Agricultural Research Service
(USDA/ARS)
Forage Seed and Cereal Research Unit
2030 SE Marine Science Dr.
Newport, OR 97365
U.S.A.

Stephanie Dutkiewicz
EAPS
Massachusetts Institute of Technology
54-1412 MIT77 Massachusetts Ave
Cambridge, MA 02139
U.S.A.
stephd@mit.edu

Richard A. Feely
Ocean Climate Research Div.
NOAA/PMEL
Pacific Marine Environmental Laboratory/NOAA
7600 Sand Point Way NE
Seattle, WA 98115
U.S.A.
Richard.A.Feely@noaa.gov

Blake E. Feist
Environmental Conseration Div.
Northwest Fisheries Science Center, NMFS, NOAA
2725 Montlake Blvd. E
Seattle, WA 98112
U.S.A.
Blake.Feist@noaa.gov

John C. Field
Fisheries Ecology Div.
Southwest Fisheries Science Center, NMFS, NOAA
110 Shaffer Rd.
Santa Cruz, CA 95060
U.S.A.
John.Field@noaa.gov

David Foley
Joint Institute for Marine and Atmospheric Research
University of Hawaii at Manoa
1352 Lighthouse Ave.
Pacific Grove, CA 93950
U.S.A.
dave.foley@noaa.gov

Hernan Eduardo Garcia
Ocean Climate Lab.
NOAA-NODC
1315 East West Hwy, SSMC-III, E/OC5, Room 4230
Silver Spring, MD 20910-3282
U.S.A.
Hernan.Garcia@noaa.gov

Marsha L. Gear
University of California Dept 0232
California Sea Grant
9500 Gilman Dr., Dept. 0232
La Jolla, CA 92093-0232
U.S.A.
mgear@ucsd.edu

Lori Gustafson
US Dept. of Agriculture, Animal and Plant Health Inspection Service
National Surveillance Unit
2150 Centre Ave., Bldg. B, Mail Stop 2E6
Fort Collins, CO 80526-8117
U.S.A.
Lori.L.Gustafson@aphis.usda.gov

Anne B. Hollowed*
Alaska Fisheries Science Center, NMFS, NOAA
7600 Sand Point Way NE
Seattle, WA 98115-6349
U.S.A.
Anne.Hollowed@noaa.gov
*representative of BEST

George L. Hunt, Jr.*
School of Aquatic and Fishery Sciences
University of Washington
P.O. Box 355020
Seattle, WA 98195
U.S.A.
geohunt2@u.washington.edu
*representative of ESSAS

Saang-Yoon Hyun
Fishery Science
Columbia River Inter-Tribal Fish Commission
729 NE Oregon St. Suite 200
Portland, OR 97232
U.S.A.
hyus@critfc.org

Felix Jose
Coastal Studies Institute
Louisiana State University
CSI, How-Russell GeoSciences Complex
Baton Rouge, LA 70803
U.S.A.
felixjose@lsu.edu

Julie E. Keister
School of Oceanography
University of Washington
P.O. Box 357940
Seattle, WA 98195
U.S.A.
jkeister@u.washington.edu

Robert M. Key
AOS Program
Princeton University
300 Forrestal Rd., Sayre Hall
Princeton, NJ 08544
U.S.A.
key@princeton.edu

J. Anthony (Tony) Koslow
California Cooperative Oceanic Fisheries Investigations
Scripps Institution of Oceanography, UCSD
9500 Gilman Dr.
La Jolla, CA 92093-0218
U.S.A.
tkoslow@ucsd.edu

Alexander Kozyr
Carbon Dioxide Information Analysis Center (CDIAC)
Env. Sci. Div., Oak Ridge National Lab., U.S. Dept. of Energy
Bldg. 1509, MS 6335
Oak Ridge, TN 37831-6335
U.S.A.
kozyra@ornl.gov

Gordon H. Kruse
School of Fisheries and Ocean Sciences
University of Alaska Fairbanks
17109 Pt. Lena Loop Rd.
Juneau, AK 99801
U.S.A.
Gordon.Kruse@alaska.edu

Carol Ladd
Pacific Marine Environmental Lab.
National Oceanic and Atmospheric Administration (NOAA)
7600 Sand Point Way NE
Seattle, WA 98115
U.S.A.
Carol.Ladd@noaa.gov

Patricia Livingston
Alaska Fisheries Science Center, NMFS, NOAA
7600 Sand Point Way NE
Seattle, WA 98115-6349
U.S.A.
Pat.Livingston@noaa.gov

Elizabeth A. Logerwell
Resource Ecology and Fishery Management
Alaska Fisheries Science Center, NMFS, NOAA
P.O. Box 15700 F/AKC2
Seattle, WA 98115
U.S.A.
Libby.Logerwell@noaa.gov

Jonathan E. Matthews
Fishery Science
CRITFC
729 NE Oregon St., Suite 200
Portland, OR 97232
U.S.A.
edwm@critfc.org

Bernard A. Megrey
Alaska Fisheries Science Center, NMFS, NOAA
7600 Sand Point Way NE
Seattle, WA 98115-6349
U.S.A.
Bern.Megrey@noaa.gov

Arthur J. Miller
CASPO Div.
Scripps Institution of Oceanography, UCSD
Nierenberg Hall, Room 439, (SIO-UCSD 0224)
La Jolla, CA 92093-0224
U.S.A.
ajmiller@ucsd.edu

Franz J. Mueter
School of Fisheries and Ocean Sciences, Juneau Center
University of Alaska Fairbanks
17109 Pt. Lena Loop Rd.
Juneau, AK 99801
U.S.A.
fmueter@alaska.edu

Phillip Mundy*
NOAA Fisheries
17109 Pt. Lena Loop Rd.
Juneau, AK 99801
U.S.A.
Phil.mundy@noaa.gov
*representative of AOOS

Raghu G. Murtugudde
ESSIC/Meteorology
University of Maryland
5825 University Research Court
College Park, MD 20740
U.S.A.
ragu@essic.umd.edu

Sumant Nigam
Atmospheric and Oceanic Science, and ESSIC
University of Maryland
3419 Computer & Space Science Bldg.
College Park, MD 20742-2425
U.S.A.
nigam@atmos.umd.edu

Minling Pan
NOAA Fisheries
Pacific Islands Fisheries Science Center, NMFS, NOAA
2570 Dole St.
Honolulu, HI 96822
U.S.A.
Minling.Pan@noaa.gov

Frank A. Parrish
Pacific Islands Fisheries Science Center, NMFS, NOAA
2570 Dole St.
Honolulu, HI 96822
U.S.A.
Frank.Parrish@noaa.gov

William T. Peterson
Hatfield Marine Science Center
Oregon State University
2030 SE Marine Science Dr.
Newport, OR 97365
U.S.A.
Bill.Peterson@noaa.gov

Samuel G. Pooley
NOAA Fisheries
Pacific Islands Fisheries Science Center, NMFS, NOAA
2570 Dole St.
Honolulu, HI 96822-2396
U.S.A.
samuel.pooley@noaa.gov

Jennifer E. Purcell
Shannon Point Marine Center
Western Washington University
1900 Shannon Point Rd.
Anacortes, WA 98221
U.S.A.
purcelj3@wwu.edu

Rolf R. Ream
National Marine Mammal Lab.
Alaska Fisheries Science Center, NMFS, NOAA
7600 Sand Point Way NE
Seattle, WA 98115
U.S.A.
rolf.ream@noaa.gov

J.E. Jack Rensel
Rensel Associates Aquatic Sciences
4209 234th St. NE
Arlington, WA 98223
U.S.A.
jackrensel@att.net

Deborah Ann Reusser
USGS-Western Fisheries Research Center at Marine Hatfield Science Center
2111 SE Marine Science Dr.
Newport, OR 97365
U.S.A.
dreusser@usgs.gov

Keith B. Rodgers
AOS Program
Princeton University
300 Forrestal Rd., Sayre Hall
Princeton, NJ 08544-0710
U.S.A.
krodgers@princeton.edu

Jill B. Rolland
US Dept. of Agriculture, Animal and Plant Health Inspection Service
National Animal Health Programs
4700 River Rd., Unit 464B-04D
Riverdale, MD 20737-1231
U.S.A.
Jill.B.Rolland@aphis.usda.gov

Craig S. Rose
RACE Div., Conservation Engineering
Alaska Fisheries Science Center, NMFS, NOAA
7600 Sand Point Way NE, Bldg. 4
Seattle, WA 98115
U.S.A.
craig.rose@noaa.gov

Steve S. Rumrill
Dept. Biology
University of Oregon
63466 Boat Basin Dr.
Charleston, OR 97420
U.S.A.
Steve.Rumrill@state.or.us

Christopher L. Sabine*
Pacific Marine Environmental Lab.
National Oceanic and Atmospheric Administration (NOAA)
7600 Sand Point Way NE
Seattle, WA 98115-6349
U.S.A.
chris.sabine@noaa.gov
*representative of IOCCP

Jarrod Santora
Farallon Institute for Advanced Ecosystem Research
P.O. Box 750756
Petaluma, CA 10314
U.S.A.
jasantora@gmail.com

Niklas Schneider
International Pacific Research Center
University of Hawaii
1680 East West Rd.
Honolulu, HI 96822
U.S.A.
nschneid@hawaii.edu

Michael P. Seki
NOAA Fisheries
Pacific Islands Fisheries Science Center, NMFS, NOAA
2570 Dole St.
Honolulu, HI 96825
U.S.A.
Michael.Seki@noaa.gov

Chang Seung
US Dept. of Commerce
Alaska Fisheries Science Center, NMFS, NOAA
7600 Sand Point Way NE
Seattle, WA 98115
U.S.A.
Chang.Seung@noaa.gov

Rishi Sharma
Management/Science
Columbia River Inter-Tribal Fish Commission
Suite 200, 729 NE Oregon St.
Portland, OR 97232
U.S.A.
shar@critfc.org

C. Tracy Shaw
Cooperative Institute for Marine Resources Studies, HMSC
Oregon State University
2030 SE Marine Science Dr.
Newport, OR 97365
U.S.A.
tracy.shaw@noaa.gov

SeungHyun Son
NESDIS/STAR
National Oceanic and Atmospheric Administration (NOAA)
5200 Auth Rd., Room 102
Camp Springs, MD 20746
U.S.A.
seunghyun.son@noaa.gov

Yvette H. Spitz
College of Oceanic and Atmospheric Sciences
Oregon State University
104 COAS Admin. Bldg.
Corvallis, OR 97331
U.S.A.
yvette@coas.oregonstate.edu

John E. Stein
Northwest Fisheries Science Center, NMFS, NOAA
2725 Montlake Blvd. E
Seattle, WA 98112-2097
U.S.A.
John.E.Stein@noaa.gov

Andrei V. Suntsov
Integrative Oceanography Div.
Scripps Institution of Oceanography, UCSD
9500 Gilman Dr.
La Jolla, CA 92093
U.S.A.
asuntsov@mail.ru

William J. Sydeman
President/Senior Scientist
Farallon Institute for Advanced Ecosystem Research
P.O. Box 750756
Petaluma, CA 94975
U.S.A.
wsydeman@comcast.net

Kevin A. Thompson
Fisheries and Wildlife
Oregon State University
104 Nash Hall
Corvallis, OR 97330
U.S.A.
kevin.thompson@oregonstate.edu

Vera L. Trainer
Northwest Fisheries Science Center, NMFS, NOAA
2725 Montlake Blvd. E
Seattle, WA 98112
U.S.A.
Vera.L.Trainer@noaa.gov

Daniel J. Vimont
Atmospheric and Oceanic Sciences
University of Wisconsin - Madison
1225 W. Dayton St.
Madison, WI 53706
U.S.A.
dvimont@wisc.edu

Muyin Wang
Joint Institute for the Study of Atmosphere and Ocean (JISAO)
University of Washington
7600 Sand Point Way NE
Seattle, WA 98115
U.S.A.
muyin.wang@noaa.gov

Mark L. Wells
School of Marine Sciences
University of Maine
5741 Libby Hall
Orono, ME 04469
U.S.A.
mlwells@maine.edu

Gary H. Wikfors
Biotechnology Branch
212 Rogers Ave.
Milford, CT 06460
U.S.A.
Gary.Wikfors@noaa.gov

Stephani G. Zador
Pacific Marine Environmental Lab.
Alaska Fisheries Science Center,
NOAA
7600 Sand Point Way NE, Bldg. 4
Seattle, WA 98115
U.S.A.
stephani.zador@noaa.gov

Richard E. Zeebe
Oceanography
University of Hawaii at Manoa, SOEST
1000 Pope Rd., MSB 504
Honolulu, HI 96822
U.S.A.
zeebe@soest.hawaii.edu

United Kingdom

John K. Pinnegar
Centre for Environment, Fisheries &
Aquaculture Science (CEFAS)
Pakefield Rd.
Lowestoft, Suffolk NR33 0HT
United Kingdom

Organizations[1]

[1] Representatives or organizations who are primarily involved in PICES scientific activities are listed by country

AMAP / PAG

John Calder
Climate Program Office
National Oceanic and Atmospheric Administration
1100 Wayne Ave., Suite 1202
Silver Spring, MD 20910
U.S.A.
John.Calder@noaa.gov

AOOS

Phillip Mundy

Argo

Howard J. Freeland

BEST

Anne B. Hollowed

CLIVAR / WCRP

Bo Qiu
Dept. Oceanography
University of Hawaii at Manoa
1000 Pope Rd.
Honolulu, HI 96822
U.S.A.
bo@soest.hawaii.edu

CoML

Vera Alexander

ESSAS

George L. Hunt, Jr.

FAO

Yimin Ye
Fisheries and Aquaculture
FAO of the United Nations
Viale delle Terme de Caracalla 1
Rome 00153
Italy
yimin.ye@fao.org

GLOBEC

Manuel Barange
GLOBEC International Project Office
Plymouth Marine Laboratory
Prospect Place
Plymouth, Devon PL1 3DH
United Kingdom
m.barange@pml.ac.uk

ICES

Adolf K. Kellermann
Science Programme
International Council for the Exploration of the Sea (ICES)
H.C. Andersens Blvd. 44-46
Copenhagen V, DK-1553
Denmark
adi@ices.dk

Serge Labonté
Science Programme
ICES
H.C. Andersens Blvd. 44-46
Copenhagen V, 1553
Denmark
jytte@ices.dk

Michael Sinclair
Fisheries and Oceans Canada
Bedford Institute of Oceanography
Box 231 Central
Halifax, NS B3J 2M4
Canada
sinclairm@mar.dfo-mpo.gc.ca

IMBER

Sinjae Yoo

IMO / GESAMP

Peter Kershaw
International Maritime Organization
Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
4 Albert Embankment
London SE1 7SR
United Kingdom
msoderbe@imo.org

IOCCP

Christopher L. Sabine

IPHC

Juan Valero
School of Aquatic and Fishery Sciences
University of Washington
Box 355020
Seattle, WA 98195-5020
U.S.A.
juan@iphc.washington.edu

ISC

Gerard DiNardo
Pacific Islands Fisheries Science Center, NMFS, NOAA
2570 Dole St.
Honolulu, HI 96822
U.S.A.
Gerard.DiNardo@noaa.gov

IWC

Hidehiro Kato

NaNOOS

Jack A. Barth
College of Oceanic and Atmospheric Sciences
Oregon State University
104 COAS Admin. Bldg.
Corvallis, OR 97331-5503
U.S.A.
barth@coas.oregonstate.edu

NEAR-GOOS

Dong-Young Lee
Climate Change & Coastal Disaster Research
Korea Ocean R&D Institute (KORDI)
P.O. Box 29
Ansan, Gyeonggi-do 400-600
R Korea
dylee@kordi.re.kr

NOWPAP

Sangjin Lee
NOWPAP RCU
Northwest Pacific Action Plan (NOWPAP) of UNEP
152-1 Haean-ro, Gijang-Up, Gijang-gun
Busan, 930-0856
R Korea
sangjin.lee@nowpap.org

Alexander V. Tkalin
NOWPAP RCU
Northwest Pacific Action Plan (NOWPAP) of UNEP
152-1 Haean-ro, Gijang-Up, Gijang-gun
Busan, 930-0856
R Korea
Alexander.Tkalin@nowpap.org

NPAFC

Yukimasa Ishida

NPRB

Ian M. Dutton
Alaska SeaLife Center
301 Railway Ave., Box 1329
Seward, AK 99664-1329
U.S.A.
ian_dutton@alaskasealife.org

Clarence Pautzke
Executive Director
North Pacific Research Board (NPRB)
1007 W. 3rd Ave., Suite 100
Anchorage, AK 99501
U.S.A.
cpautzke@nprb.org

SAHFOS

Sonia D. Batten
Sir Alister Hardy Foundation for Ocean Science
c/o 4737 Vista View Crescent
Nanaimo, BC V9V 1N8
Canada
soba@sahfos.ac.uk

SCOR

Wolfgang Fennel
IOW
Seestr. 15
Rostock 18119
Germany
wolfgang.fennel@io-warnemuende.de

Edward Urban
College of Marine and Earth Studies
Scientific Committee on Oceanic Research
Robinson Hall, University of Delaware
Newark, DE 19716
U.S.A.
Ed.Urban@scor-int.org

SOLAS

Shigenobu Takeda

WESTPAC

Suchana A. Chavanich
Department of Marine Science
Chulalongkorn University
Faculty of Science
Department of Marine Science
Payat
Bangkok, Bangkok 10330
Thailand
suchana.c@chula.ac.th

WPFMC

Kevin C Weng
Pelagic Fisheries Research Program
University of Hawaii at Manoa
1000 Pope Rd.
Honolulu, Hawaii 96822
U.S.A.
kweng@hawaii.edu

PICES

Tokio Wada
PICES Chairman
Fisheries Research Agency
Queen's Tower B 15F
2-3-3 Minato Mirai, Nishi-ku
Yokohama 220-6115
Japan
wadat@affrc.go.jp

John E. Stein
Science Board Chairman
Northwest Fisheries Science Center
NMFS, NOAA
2725 Montlake Blvd. E
Seattle, WA 98112-2097
U.S.A.
John.E.Stein@noaa.gov

Alexander Bychkov
Executive Secretary
PICES Secretariat
P.O. Box 6000
Sidney, BC V8L 4B2
Canada
bychkov@pices.int

Christina Chiu
Deputy Executive Secretary on Administration
PICES Secretariat
P.O. Box 6000
Sidney, BC V8L 4B2
Canada
christina@pices.int

Stewart (Skip) M. McKinnell
Deputy Executive Secretary
PICES Secretariat
P.O. Box 6000
Sidney, BC V8L 4B2
Canada
mckinnell@pices.int

Rosalie Rutka
PICES Administrative Assistant
PICES Secretariat
P.O. Box 6000
Sidney, BC V8L 4B2
Canada
rrutka@pices.int

Julia Yazvenko
Database and Web Administrator
PICES Secretariat
P.O. Box 6000
Sidney, BC V8L 4B2
Canada
secretariat@pices.int

Yongling Zhu
PICES Intern
PICES Secretariat
P.O. Box 6000
Sidney, BC V8L 4B2
Canada
zhu@pices.int