North Pacific Marine Science Organization

PICES–2010
Program and Abstracts

October 22-31, 2010
Portland, OR, U.S.A.

PICES-2010

North Pacific Ecosystems Today, and Challenges in Understanding and Forecasting Change

North Pacific Marine Science Organization

PICES

October 22 – 31, 2010
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Notes for Guidance

This Annual Meeting is hosted by the Government of the United States of America, in coordination with the PICES Secretariat, and with logistical support provided by the Pacific States Marine Fisheries Commission.

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 26 (a.m.) until October 29 (a.m.). The Wine & Cheese Poster Session will be held from 18:00-20:30 on October 28 (Oregon Convention Center), when poster presenters are expected to be available to answer the questions. Posters must be removed in the morning of October 29.

Internet access

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

Social activities

October 25, Monday (18:30-22:00)

<u>Welcome Reception</u>

The Welcome Reception for all participants (and registered guests) will be held in the Multnomah Room of the Doubletree Hotel.

October 26, Tuesday (18:30-22:00)

<u>Sports Event</u>

This year's Sports Event will be bowling! We have chartered the Viking Game Room at the Portland State University for the night, there are 6 bowling lanes for our "tournament", plus there are 7 billiard tables and 4 video games also. Some snacks and drinks will be provided. Participation is strictly limited to 150 people, please sign up at the Registration Desk.

October 27, Wednesday (18:30-21:00)

<u>Extravaganza Dinner</u>

The Extravaganza Dinner at PICES 2010 will be at the Davis Street Tavern (http://www.davisstreettavern.com/). This restaurant is renowned for its modern American cuisine in a historic Old Town Portland landmark building. Some drinks will be paired with the courses. The ticket price of the dinner is CAD$100. The capacity of the restaurant is extremely limited.
Contact: Ms. Christina Chiu (Registration Desk)

October 28, Thursday (18:00-20:30)

<u>Wine & Cheese Poster Session Reception</u>

The Poster Session Reception be held in the Portland Ballroom Lobby (level 2) of the Oregon Convention Center, where all the posters are on display. Participants can roam around the poster displays and chat with poster presenters while nibbling on snacks and sipping beer.

Meeting Timetable

Friday, October 22

09:00 12:30	*SG-HD Meeting*	POC/BIO Workshop (W5), Day1	*AICE-AP Meeting*	*COVE-AP Meeting*	*SOFE-AP Meeting*
14:00 18:00			*Joint AICE/COVE/SOFE Meeting*		

Saturday, October 23

09:00 12:30	BIO Workshop (W1), Day1	POC/BIO Workshop (W5), Day2	*WG-21 Meeting*	MEQ Workshop (W3)	*MBM-AP Meeting*	*CREAMS-AP Meeting*
14:00 18:00					FIS Workshop (W2)	*CPR-AP Meeting*

Sunday, October 24

09:00 12:30	BIO Workshop (W1), Day2	*CC-S Meeting*	*WG-21 Meeting*	*HAB-S Meeting*	*WG-FCCIFS Meeting*	*WG-23 Meeting*
12:30 14:00	SB Lunch Meeting *					
14:00 18:00	BIO Workshop (W1), Day2	POC Workshop (W4)	WG-21 Meeting	*HAB-S Meeting*	*WG-22 Meeting*	*WG-24 Meeting*

Monday, October 25

09:00 10:00	**OPENING SESSION**
10:30 18:00	Science Board Symposium (S1) - PART I
18:30 22:00	Welcome Reception (Doubletree Hotel)

Tuesday, October 26

09:00 12:30	FIS Paper Session (I)	FIS/MEQ Topic Session (S7)	FIS/POC/BIO Topic Session (S8)	MEQ/FUTURE Topic Session (S12)
14:00 18:00	BIO Topic Session (S2)			

Wednesday, October 27

09:00 12:30	BIO Topic Session (S3)	FIS Topic Session (S5)	MEQ Topic Session (S9)	POC/MEQ/FUTURE Topic Session (S14)	*F&A Meeting* *

14:00 18:00	*BIO Meeting*	*FIS Meeting*	*MEQ Meeting*	*POC Meeting*	*TCODE Meeting*	*MONITOR Meeting*

Thursday, October 28

09:00 18:00	BIO Paper Session	FIS/BIO Topic Session (S6)	MONITOR Topic Session (S15)	POC Paper Session
18:00 20:30	**POSTER SESSION**			

Friday, October 29

09:00 12:30	MEQ/FIS Topic Session (S11)	BIO Topic Session (S4)	FIS Paper Session (II)	POC/BIO/MONITOR/ FUTURE Topic Session (S13)
14:00 17:30	Science Board Symposium (S1) - PART II			
17:30 18:30	**CLOSING SESSION ****			

Saturday, October 30		
09:00 18:00	*Science Board Meeting**	*Governing Council Meeting**
Sunday, October 31		
09:00 18:00	*Governing Council Meeting**	

*	Closed Session
**	Award-winning scientists (Best Oral/Poster presentations) will be announced during the Closing Session

Sessions/Workshops

S1	North Pacific Ecosystems Today, and Challenges in Understanding and Forecasting Change
S2	Understanding the role of iron in regulating biogeochemical cycles and ecosystem structures in the North Pacific Ocean
S3	The Practical Handbook at 50: A celebration of the life and career of Tim Parsons
S4	Census of Marine Life - Exploring ocean life: Past, present and future
S5	Oceanographic and demographic processes affecting the reproductive biology of exploited marine stocks
S6	Observations of ecosystem mixing under climate change
S7	Economic relation between marine aquaculture and wild capture fisheries
S8	Impact of climate variability on marine ecosystems: Understanding functional responses to facilitate forecasting
S9	Conceptual and numerical models of HAB dynamics
S11	Identifying vulnerable marine ecosystems in the North Pacific
S12	Anthropogenic forcing in North Pacific coastal ecosystems: Understanding changes in ecosystem structure and function
S13	Comparing the two major gyres of the subarctic North Pacific - Seasonal and interannual variability and its predictability
S14	Marine renewable energy development in coastal and estuarine environments around the North Pacific
S15	Development and use of ocean observing and forecasting systems in coastal and marine management
BIO-P	BIO Paper Session
FIS-P	FIS Paper Session
POC-P	POC Paper Session
E-Poster	Monitoring and Ocean Observing Systems
W1	Marine ecosystem model inter-comparisons (III)
W2	Beyond Lagrangian: Modeling migratory fish behavior in Global Circulation Models
W3	New technologies and methods in HAB detection: I. HAB species detection
W4	PICES Working Group on Evaluations of Climate Change Projections: Progress and FUTURE
W5	Carbon data synthesis (III)

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**
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-HD	Study Group on "Human Dimensions" (*belongs to Science Board*)
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-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 25, 10:30

Observing change in the Northeast Pacific: Past, present and FUTURE

John A. **Barth**

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Observing the fundamental physical and chemical properties of the coastal and adjacent deep ocean is critical to assessing the impacts of changing ocean conditions on marine ecosystems. One important quantity is the amount of dissolved oxygen available for coastal marine ecosystems. Through a combination of moorings, autonomous underwater gliders and ship-based sampling, we have been measuring dissolved oxygen with increasing temporal and spatial coverage in the northeast Pacific off the coast of Oregon and Washington, U.S.A. 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 9 years, including the appearance of anoxia in summer 2006. Near-bottom, inner-shelf hypoxia is driven by upwelling of low-oxygen, nutrient-rich source water onto the continental shelf, followed by the decay of organic matter raining down from surface phytoplankton blooms. Data returned in near real-time from moorings and gliders have helped guide additional sampling to assess the impact of low-oxygen on marine organisms, for example on larval and adult fish and invertebrates. Data from the expanding observatory are used in a regression model to link observed inner-shelf, near-bottom oxygen levels with offshore source water dissolved oxygen content and wind forcing. The decreasing oxygen content of the offshore source waters for upwelling is documented from a 50-year time series off central Oregon and is in agreement with observations to the north (Vancouver Island) and south (Southern California Bight) in the California Current. Indeed, decreasing oxygen levels in the oxygen minimum zone (OMZ) appears to be a global phenomenon with a hypothesized connection to global warming.

We are collaborating with other Pacific Northwest measurement programs, in particular the National Oceanic and Atmospheric Administration (NOAA) groundfish and hake surveys, to make maps of the extent of hypoxia over the Oregon and Washington shelves (~43-48N) from September 2006 to the present. Minimum near-bottom oxygen values are often found over the mid to inner shelf (50-100 m water depth), with oxygen levels increasing closer to shore and farther offshore toward the permanent OMZ. This reflects the shelf respiration contribution to lowering dissolved oxygen. The size of the near-bottom hypoxia zone increases with time during the upwelling season, reaching its maximum extent in mid to late summer. In July 2007, the area of hypoxic water inshore of the 200-m isobath covered nearly 18,000 square kilometers, slightly less than the size of New Jersey and on par with the size of the Mississippi River plume hypoxia region. The percent of shelf waters inshore of the 200-m isobath occupied by hypoxic waters varies from 30% early in the season (May) to nearly 80% in the late summer-early fall (Sep), and tracks the cumulative amount of seasonal upwelling-favorable wind stress.

Given the connection of coastal marine ecosystems to basin-scale oceanographic processes, it is imperative to maintain ocean observing systems on both coastal and basin scales. Measurements of physical, and an increasing number of chemical and bio-optical properties, are being accomplished on both the Argo float array and underwater gliders. In the next few years, the Ocean Observatories Initiative in the United States will construct a multi-element ocean observing array off Oregon and Washington, joining its partner NEPTUNE Canada in laying the long-term foundation for observing change in the Northeast Pacific. Maintaining and expanding these observing systems, in particular to increase the number of biological measurements, will be key for the FUTURE (**F**orecasting and **U**nderstanding **T**rends, **U**ncertainty and **R**esponses of North Pacific Marine **E**cosystems).

Schedules
and
Abstracts

S1 Science Board Symposium
North Pacific Ecosystems Today, and Challenges in Understanding and Forecasting Change

Co-Convenors: John Stein (SB), Michael Dagg (BIO), Mikhail Stepanenko (FIS), Steven Rumrill (MEQ), Hiroya Sugisaki (MONITOR), Michael G. Foreman (POC), Bernard Megrey (TCODE), Thomas W. Therriault (AICE), Hiroaki Saito (COVE), Robin Brown (SOFE), Fangli Qiao (China) and Sinjae Yoo (Korea)

Climate change and increasing development of coastal areas and their watersheds are two of the most serious threats to marine ecosystems in the North Pacific. It is probable that interactions between these stressors will be complex and consequences unknown and difficult to predict. Knowledge of the sensitivity and adaptability of natural and managed ecosystems to climate change is limited and confounded by the interaction of climate change with additional stressors such as fishing, habitat loss, and pollution. While inter-annual and decadal variability are dominant sources of climate variability in the North Pacific, global warming is expected to contribute significantly to future climate change. To improve our understanding of marine ecosystems of the North Pacific, it is imperative we identify the contribution of climate change to overall ecosystem change, and to strengthen our ability to forecast how marine and coastal ecosystems will adjust or respond to ongoing stresses from climate change and other human activities.

This symposium will focus on a series of major issues that are affecting North Pacific marine ecosystems including, but not limited to: changes in cycling of carbon and other elements, increasing acidification, decreasing oxygen concentrations, eutrophication, chemical and biological pollution, changing patterns of oceanic circulation, changes in the productivity and distribution of species (including shifts in migratory routes), shifts in species interactions, increased sea-level rise, and coastal erosion. Ideally, the contribution of climate change to ecosystem characteristics can be quantified and the information made available to the 5th assessment of the Intergovernmental Panel on Climate Change scheduled for 2013-2014.

Monday, October 25 (11:10-18:15), Day 1

10:30 **John A. Barth (Keynote)**
Observing change in the Northeast Pacific: Past, present and FUTURE

11:10 **Enrique N. Curchitser (Invited)**
Modeling the Earth System: Are we ready? (S1-6770)

11:35 **Yasuhiro Yamanaka, Takeshi Okunishi, Taketo Hashioka, Hiroshi Sumata and Shin-ichi Ito (Invited)**
Predicting marine ecosystem responses to climate change by a 3-D high-resolution ecosystem model (S1-6813)

12:00 **Neil S. Banas**
Limits on predictability in a diversity-resolving plankton model: A strategy for ensemble ecosystem forecasting (S1-6442)

12:20 **Evan A. Howell, Jeffrey J. Polovina and John Dunne**
Modeling the central North Pacific ecosystem response to predicted climate variations and fishery management scenarios (S1-6846)

12:40 ***Lunch***

14:00 **Minhan Dai (Invited)**
Coastal ocean carbon cycling – Current understanding and challenges (S1-6584)

14:25 **James C. Orr (Invited)**
Chemical potential for impacts of ocean acidification on Pacific Ocean ecosystems (S1-6853)

14:50	**Jeffrey J. Polovina, John Dunne, Phoebe Woodworth and Evan A. Howell** Projected expansion of the subtropical biome and contraction of the temperate and equatorial upwelling biomes in the North Pacific under global warming (S1-6441)
15:10	**Kenneth O. Coyle, Sarah Hinckley, Wei Cheng, Georgina Gibson, Albert J. Hermann and Kate Hedstrom** Production on the Gulf of Alaska shelf: Spatial-temporal expansion of GLOBEC field measurements using an ecosystem model embedded in a circulation model (S1-6658)
15:30	**Emanuele Di Lorenzo, Julie E. Keister, Sanae Chiba, Vincent Combes, Andrew C. Thomas, P. Ted Strub, Harold Batchelder, Steven J. Bograd, Peter J.S. Franks and William T. Peterson** The Pacific Boundary Ecosystems and Climate Study (POBEX) (S1-6757)
15:50	***Coffee/Tea Break***
16:10	**Albert J. Hermann, Kerim Aydin, Nicholas A. Bond, Wei Cheng, Enrique N. Curchitser, Georgina A. Gibson, Kate Hedstrom, Ivonne Ortiz, Muyin Wang and Phyllis J. Stabeno (Invited)** Modes of biophysical variability on the Bering Sea shelf (S1-6689)
16:35	**Michael A. Litzow and Franz J. Mueter** Hare and Mantua updated: Four decades of climate-biology covariation in the Northeast Pacific (S1-6491)
16:55	**Muyin Wang, James E. Overland and Nicholas A. Bond** Contributions of episodic events in decadal climate variation of the Bering Sea (S1-6544)
17:15	**George L. Hunt, Jr., Kenneth O. Coyle, Lisa Eisner, Edward V. Farley, Ron Heintz, Franz J. Mueter, Jeffrey M. Napp, James E. Overland, Patrick Ressler, Sigrid Salo and Phyllis J. Stabeno** Climate impacts on eastern Bering Sea food webs: A synthesis of new data and an assessment of the Oscillating Control Hypothesis (S1-6590)
17:35	**Hiroaki Saito, Shin-ichi Ito, Atsushi Kawabata, Mitsutaku Makino, Shoshiro Minobe, Masami Nonaka, Takeshi Okunishi, Kazutaka Takahashi and Ichiro Yasuda** Forecasting fish species alternation: Results of the SUPRFISH programme and remaining issues (S1-6704)
17:55	**Shin-ichi Ito, Takeshi Okunishi, Michio J. Kishi and Muyin Wang** Projection of Pacific saury response to future climate change (S1-6660)
18:15	***Session ends***

Friday, October 29 (14:00-17:30), Day 2

14:00	**Frank Whitney, Steven Bograd and Tsuneo Ono (Invited)** How does expanding hypoxia affect the nutrient budget of the subarctic Pacific? (S1-6575)
14:25	**Tsuneo Ono** Oxygen decline in the continental slope waters off-Japan and its potential influence on groundfishes (S1-6561)
14:45	**Steven J. Bograd, Carmen G. Castro, Francisco P. Chavez, Curtis A. Collins, Vincent Combes, Emanuele Di Lorenzo, Mark Ohman, Ryan Rykaczewski and Frank Whitney** The California Undercurrent: 1949–2009 and beyond (S1-6798)
15:05	**J. Anthony Koslow, Ralf Goericke and William Watson** Climate and fish assemblages of the southern California Current, 1951–2008 (S1-6633)

15:25 **William W.L. Cheung, Thomas A. Okey and Richard D. Brodeur**
Projecting future changes in distributions of pelagic nekton along the west coast of North America (S1-6640)

15:45 ***Coffee/Tea Break***

16:05 **Mingjiang Zhou (Invited)**
Understanding harmful algal blooms in eutrophic coastal waters: Necessity of end-to-end studies (S1-6724)

16:30 **Xuelei Zhang, ZL. Wang, JH. Liu, QS. Wei, SL. Fan, MZ. Fu, Y. Li, P. Sun, P. Liu, QZ. Xu, RX. Li and MY. Zhu**
Benthic records indicate increasing nutrient availability and primary production in the Yellow Sea (S1-6426)

16:50 **Jun-ya Shibata, Ryu Isonaka, Hideki Hamaoka, Kazumasa Matsumoto, Tetsuya Nanko, Todd W. Miller, Hidejiro Onishi, Tadao Kunihiro and Koji Omori**
Relationship between food web structure of a lower trophic level community and transfer efficiency in a coastal sea (S1-6471)

17:10 **Sophia C. Johannessen and Robie W. Macdonald**
Effects of local and global change on an inland sea: The Strait of Georgia, Canada (S1-6539)

17:30 ***Session ends***

S1 Posters

S1-6424 **Babagana Abubakar**
The impacts of human activities in Africa and the North and South Pole Regions on the Global Climate Change

S1-6437 **Alexey V. Vakatov, Valeriy I. Michailov and Andrey A. Smirnov**
The present condition of the ecosystem in Taui Bay in the Sea of Okhotsk

S1-6454 **Svetlana Monakhtina**
Skillfish (*Erilepis zonifer*): Traits of biology from a fishery near the Emperor Seamounts in the north-west Pacific Ocean

S1-6501 **Jianxin Ma, Zhenhu Zheng and Maojian Wang**
The distribution characteristics of phytoplankton in Laizhou Bay

S1-6527 **Fu-xin Sun, Ying Wang and Zhi-hong Wu**
Study on bioaccumulation and elimination of *Chlamys farreri* to copper

S1-6530 **Daoji Li, Haixia Liu and Ping Wang**
Formation of summer hypoxia in the Yangtze River Estuary of China: "cold pool" and "thermal barrier" effects

S1-6550 **Sayaka Matsumura, Hiroya Sugisaki, Hiroaki Saito, Yuji Okazaki and Tomohiko Kikuchi**
Spatio-temporal changes in species diversity and assemblage structure of Euphausiids (Oyashio to Oyashio-Kuroshio Transition Region in the western north Pacific)

S1-6551 **Kaoru Aoki, Kazuya Takeda, Satoshi Yamada, Takayoshi Yamashita and Tomohiko Kikuchi**
Spatial–temporal distribution of *Aurelia aurita* in Mikawa Bay inferred from net sampling with a fish finder

S1-6630 **Vladimir F. Krapivin and Ferdinand A. Mkrtchyan**
Development of the simulation model of pollutant propagation in the Arctic Basin

S1-6645 **Donhyug Kang, Hyungbeen Lee, Hye seon Kim, Woongseo Kim and Se-Jong Ju**
Vertical signatures in acoustic estimates of zooplankton around the Yellow Sea Bottom Cold Water, Korea

S1-6651 **Jeffery M. Napp, Carin Ashjian, Rodger Harvey, Mike Lomas, Mike Sigler and Phyllis Stabeno**
Understanding ecosystem processes in the Bering Sea

S1-6807 **Nora Deans, Thomas Van Pelt, Francis Wiese and Carolyn Rosner**
Communicating ecosystem science: The Bering Sea Project

S1 Session Oral Presentations, Day 1

25 October, 11:10 (S1-6770), Invited

Modeling the Earth System: Are we ready?

Enrique N. **Curchitser**

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E-mail: enrique@marine.rutgers.edu

Ecosystem services in coastal regions (*e.g.*, energy, fisheries, tourism, health, *etc.*) are particularly vulnerable to climate change. Changes in climate will cause shifts in the location of temperature fronts, upwelling characteristics, water masses and associated biogeographic boundaries and ground water distribution directly affecting the ecosystem's structure and the associated resources. Understanding and the quantitative projection of credible future scenarios will require sustained observations of the natural system as well as models that represent the numerous Earth System components, the feedbacks between them, and resolve the scales important to variability within each sub-system.

In this presentation, we describe on-going work to develop a unified modeling framework for studying global change in the Earth System, including human activity models, allowing for scale interactions (up/down-scaling) and explicitly modeled dynamic feedbacks between the sub-components. We describe a model that couples multi-scale ocean, atmosphere, watershed, biogeochemistry and human system models. We present examples from work in the northeast Pacific climate and ecosystems and describe remaining challenges in the context of Earth System predictions.

25 October, 11:35 (S1-6813), Invited

Predicting marine ecosystem responses to climate change by a 3-D high-resolution ecosystem model

Yasuhiro **Yamanaka**[1,2], Takeshi Okunishi[3], Taketo Hashioka[4], Hiroshi Sumata[1] and Shin-ichi Ito[5]

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3 National Research Institute of Fisheries Science, Fisheries Research Agency, 2-12-4 Fukuura, Yokohama, 236-8648, Japan
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5 Tohoku National Fisheries Research Institute, Fisheries Research Agency, 3-27-5 Shinhama-cho, Shiogama, 985-0001, Japan

I would like mainly to introduce the results of our recently developed integrated ocean model: a 3-D high-resolution ecosystem model, COCO-NEMURO, and an individual-based model coupled with bioenergetics for small pelagic fish. We evaluated the impact of global warming on the ecosystem in two 10-year scenarios: a control experiment (present climate state), and a double CO_2 experiment (gradually increasing atmospheric CO_2 by +1% per year from the present to approximately double by the 70^{th}–80^{th} year). In the double CO_2 scenario, the spring bloom occurs 10–20 days earlier than under the present climate in both the transition and subarctic regions. The signal of global warming is statistically significant at the 95% level, relative to natural variability (both inter-annual and fluctuations due to the meso-scale eddies). In present High Nutrient Low Chlorophyll (HNLC) regions, the biomass maximum associated with the spring bloom increases because the positive effect of increased temperature on the growth rate overwhelms the negative effect of reduced nutrient supply from deep water.

The timing of the spring bloom and the subarctic–subtropical transition region are essential for growth and survival of small pelagic fish. Global warming might significantly decrease the abundance of fish resources. In future projections for Japanese sardine, the spawning period in winter near the south coast of Japan shortens by about two months, and the growth rate decreases for the juvenile stage, which reduces their survival rate. However, the size of adult fish remains the same due to the temperature dependence of their growth rate.

25 October, 12:00 (S1-6442)

Limits on predictability in a diversity-resolving plankton model: A strategy for ensemble ecosystem forecasting

Neil S. **Banas**

Applied Physics Laboratory, University of Washington, Campus Box 355640, Seattle, WA, 98195, USA. E-mail: neil@apl.washington.edu

This talk uses an idealized model of complex planktonic predator-prey interactions in an upwelling zone to suggest a strategy for ensemble forecasting, uncertainty estimation, and improved representation of biological diversity patterns in marine ecosystem models. Usually, ensemble forecasting in ecosystem models (if it is attempted at all) is discussed in terms of varying a number of uncertain free parameters that control the solution. Here I suggest an alternate strategy much closer to the way ensemble forecasting is done in physical modeling, where the model itself is complex enough to allow rich, realistically chaotic dynamics, parameters are chosen by broad empirical averages and not varied, and only initial conditions vary among ensemble members. The model is NPZ (nutrient-phytoplankton-zooplankton) style, with 40 size classes of phytoplankton and zooplankton. Empirical allometric relationships are used to parameterize not just vital rates but also—crucially—the optimal prey size and size selectivity for each grazer class. This inclusion of complex prey preferences yields a system with 1) emergent diversity patterns consistent with global observations (*e.g.* a parabolic relationship between phytoplankton diversity and biomass) and 2) significant chaotic time evolution, in terms of both total biomass and community composition, on timescales from days to months. When a simple annual cycle in nutrient supply is repeated exactly for ten years, spring bloom magnitude varies by a factor of two among years, an intrinsic level of unpredictability, related to the grazer size selectivity, which compares well with observations from the northern California Current System.

25 October, 12:20 (S1-6846)

Modeling the central North Pacific ecosystem response to predicted climate variations and fishery management scenarios

Evan A. **Howell**[1], Jeffrey J. Polovina[1] and John Dunne[2]

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The Ecopath with Ecosim (EwE) model framework was used to understand ecosystem dynamics in the central North Pacific (CNP) under projected climate and fishery management scenarios. Model runs were done from 2000 through the year 2100 with climate-based bottom up forcing under three different fishery management scenarios. Climate-based bottom-up forcing during model runs was approximated by replacing the Ecosim-derived phytoplankton groups with phytoplankton biomass values taken from the NOAA Geophysical Fluid Dynamics Laboratory's Earth System Model (ESM2.1) run under the A2 scenario. Three fishery management scenarios were run using equal, double, and half the level of present day effort held constant through the year 2100. The results from these scenarios show dynamic changes in this ecosystem driven by both predicted climate variability and possible fisheries management measures. Projected decreases in biomass across most species in the ecosystem from climate-based biomass forcing are compounded by fishing pressure. However, at levels either equal to or greater than the level observed in 2008, there is a shift in species composition with an observed decrease in the biomass of higher trophic level species concomitant with an increase in the biomass of mid-trophic level species. The consequences on future fishery composition and target species availability will be discussed, as well as possible fishery management recommendations, to adapt to this possible changing ecosystem scenario.

25 October, 14:00 (S1-6584), Invited

Coastal ocean carbon cycling – Current understanding and challenges

Minhan **Dai**

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The open ocean, coastal ocean and terrestrial ecosystems are three major components modulating atmospheric CO_2 and thereby the Earth climate system. The complexity of carbon cycling in the coastal ocean under the impact of both land input and dynamic exchanges with the open ocean makes it a huge challenge to be included in any realistic prognostic climate simulations.

This presentation will start with our current understanding of the carbon fluxes and their controls in the global ocean margins. We will attempt to examine the spatial and temporal variability of carbon at different time scales, spanning from diurnal changes to decadal changes, and in different biogeochemical domains such as river plumes, upwelling, and meso-scale eddies in the western Pacific margins. Emphasis will be given to the carbon connection between riverine input, its response on the shelf system and export into the open ocean interior. Also examined in this presentation will be the interactions of carbon cycling with other biogenic elements such as nitrogen and silicate in the coastal ocean. This presentation will end with outlooks to the potential future changes of coastal ocean carbon biogeochemistry under the influence of both climate change and various anthropogenic forcing.

25 October, 14:25 (S1-6853), Invited

Chemical potential for impacts of ocean acidification on Pacific Ocean ecosystems

James C. **Orr**

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As atmospheric CO_2 increases, the surface ocean is responding by taking up more of this gas, which reacts with water, reducing surface ocean pH and carbonate ion concentrations. Pacific studies show that these chemical changes are already measurable at the ALOHA time series station and along the P16 meridional section first sampled during WOCE in 1991 and reoccupied during CLIVAR in 2006. Lower carbonate means reduced calcification for some marine calcifiers. Yet a severe chemical threshold has already been reached in some surface waters. Aggravated by invading anthropogenic CO_2, spring upwelling of CO_2-rich subsurface waters is already exposing Oregon shelf communities to waters that are corrosive to aragonite shell and skeletal material. Similarly, bottom waters on the Alaska shelf and slope have become corrosive to aragonite, partly from invasion of anthropogenic CO_2. This CO_2 invasion is causing a general shoaling of the aragonite and calcite saturation horizons (ASH and CSH), each of which separates supersaturated waters (above) from undersaturated waters (below), *i.e.*, with respect to each mineral. The North Pacific has the shallowest saturation horizons in the world and they are becoming shallower, exposing Pacific cold-water coral communities to waters that may be corrosive to their skeletal material. Here, I will summarize projected chemical changes in the North Pacific based on simulations with multiple earth system models forced under different future scenarios, all of which are participating in a European consortium, aimed at eventually addressing not only geochemical responses but also biological responses to ocean acidification (ecosystem structure, dynamics, shifts, adaptation).

25 October, 14:50 (S1-6441)

Projected expansion of the subtropical biome and contraction of the temperate and equatorial upwelling biomes in the North Pacific under global warming

Jeffrey J. **Polovina**[1], John Dunne[2], Phoebe Woodworth[1] and Evan A. Howell[1]

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A climate model that includes a coupled ocean biogeochemistry model is used to define large oceanic biomes in the North Pacific Ocean and describe their changes over the 21st Century in response to the IPCC SRES A2 future atmospheric CO_2 emissions scenario. Driven by enhanced stratification and a northward shift in the mid-latitude westerlies under climate change, model projections show that between 2000 and 2100, the area of subtropical biome expands by about 30% by 2100, while the area of temperate and equatorial upwelling biomes decrease by about 34 and 28% respectively by 2100. Over the century, the total biome primary production and fish catch is projected to increase by 26% in the subtropical biome and decrease by 38 and 15% in the temperate and equatorial biomes, respectively. Two areas where the subtropical biome boundary exhibits the greatest movement is in the Northeast Pacific where it moves northward by as much as 1000 km/100 yrs and at the equator in the central Pacific where it moves eastward by 2000 km/100 yrs. Lastly, by the end of the century there are projected to be over 25 million square kilometers of water with a mean SST of 31°C in the subtropical and equatorial upwelling biomes representing a new thermal habitat. The projected trends in biome carrying capacity and fish catch suggest resource managers may need to address long-term trends in fishing capacity and quota levels.

25 October, 15:10 (S1-6658)

Production on the Gulf of Alaska shelf: Spatial-temporal expansion of GLOBEC field measurements using an ecosystem model embedded in a circulation model

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The Gulf of Alaska shelf is commonly referred to as highly productive. Consistent long-term phytoplankton production measurements along the Seward Line between 2000 and 2004, as part of the GLOBEC program, indicate annual production of about 130 g C m^{-2} y^{-1}. However, the GOA shelf is subject to intense currents, eddies and meanders which move water back and forth across the shelf, mixing the iron-limited small-cell oceanic communities with the nitrate-limited large-cell coastal communities, complicating temporal-spatial interpretation of observational data. To aid in the spatial-temporal interpretation of GLOBEC production-biomass data, an ecosystem model was developed, parameterized using GLOBEC data and embedded in a Regional Ocean Modeling System (ROMS) circulation model to link production-biomass to circulation along the shelf. ROMS was modified to add iron with freshwater runoff to generate shelf iron concentrations similar to field observations. Simulations using field measurements of extinction coefficients and light-production curves suggest that timing of the spring bloom on the inner shelf may follow the Behrenfeld production-predation model more closely than the Sverdups critical depth model. Bloom timing on the outer shelf may be related to the position and intensity of shelf-break eddies. Simulated production for 2001–2003 varied from about 100 to over 300 g C m^{-2} y^{-1}, depending on location and year.

S1

25 October, 15:30 (S1-6757)

The Pacific Boundary Ecosystems and Climate Study (POBEX)

Emanuele Di Lorenzo[1], Julie E. **Keister**[2], Sanae Chiba[3], Vincent Combes[1], Andrew C. Thomas[4], P. Ted Strub[5], Harold P. Batchelder[5], Steven J. Bograd[6], Peter J.S. Franks[7] and William T. Peterson[8]

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The main objectives of POBEX are to understand and quantify how low-frequency changes in regional ocean processes (*e.g.*, upwelling, horizontal transport dynamics, mixing and mesoscale structure) at each Pacific boundary control lower trophic level ecosystem dynamics, and to explore the range of uncertainties associated with the ocean responses to climate change. Using a series of high-resolution (10 km) regional ocean models for the Gulf of Alaska, California Current, Peru-Chile Current and Kuroshio Oyashio Extension regions, POBEX has generated an ensemble of historical ocean hindcasts covering the period 1950–present. These hindcasts are used to assemble long-term statistics of horizontal and vertical ocean transport. Indices of transport variability inferred from the model simulations are combined with existing ecosystem observations to test the degree to which lower-trophic variability can be explained by changes in physical variability (bottom-up control).

In this talk we report on some of the challenges of conducting comparative analyses and forecasts of the upwelling and mesoscale transport dynamics in the two major eastern boundary upwelling systems of the Pacific Ocean, and the Kuroshio Oyashio Extension region. We also discuss how specific hypotheses of the dynamics that control zooplankton abundance and species diversity can be tested using model-derived transport statistics. This approach will provide better constraints on the key processes of physical-biological interaction so that future investigations (and specifically those of FUTURE) can integrate process-based understanding into model-based assessments and forecasts.

25 October, 16:10 (S1-6689), Invited

Modes of biophysical variability on the Bering Sea shelf

Albert J. **Hermann**[1], Kerim Y. Aydin[2], Nicholas A. Bond[1], Wei Cheng[1], Enrique N. Curchitser[3], Georgina A. Gibson[4], Kate Hedstrom[5], Ivonne Ortiz[2], Muyin Wang[1] and Phyllis J. Stabeno[6]

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The term “climate change” denotes spatially correlated changes in both atmospheric and oceanic properties; these are expected to drive spatially correlated changes in ecosystem structure. Coupled physical–biological models can be used to downscale broad-scale climate patterns to the regional level. These coupled models, while imperfect, can be used to explore both bottom-up and top-down effects on the spatial restructuring of ecosystems driven by climate change. Of special interest are the emergent properties of these coupled simulations, and how they compare with the observed system. In this presentation we describe the use of multivariate Empirical Orthogonal Functions to examine the covariance structure of predicted physical–biological modes from coupled models of the North Pacific. In particular, we examine the predicted effects of climate change on pelagic vs. benthic food webs on the Bering Sea shelf, and their dependence on ice cover. This type of analysis should help to quantify the greater predictability of spatially and trophically averaged quantities, as compared to univariate time series from a single fixed location.

25 October, 16:35 (S1-6491)

Hare and Mantua updated: Four decades of climate-biology covariation in the Northeast Pacific

Michael A. **Litzow**[1,2] and Franz J. Mueter[3]

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We updated a well-known set of northeast Pacific ecosystem indicators (31 climate, 67 biology, Baja California to the Bering Sea, 1965-2007) in order to assess current ecosystem status, and to use historical examples of climate forcing to better understand the potential effects of future climate change. Our specific goals were to: 1) detect recent ecosystem shifts in order to better inform fisheries management; 2) test hypotheses about the role of different climate mechanisms in structuring ecosystems; and 3) use patterns of past climate-biology covariation to inform attempts to predict the nature of future ecosystem shifts.

Goal 1. Summarized time series showed evidence of two previously unrecognized statistical shifts in ecosystem organization: a shift in biology indicators from the entire region in the early 1990s, indicating an intensification of post-1976-1977 ecological conditions, and a 2001-2002 shift in Alaskan biology indicators representing a reversal of a previous shift in 1988-1989. We found no similar early-2000s shift in data from the rest of the study area (British Columbia, Washington, Oregon and California).

Goal 2. Preliminary analysis of climate-biology correlations suggested that global warming may in some instances have an effect on northeast Pacific ecosystems as strong as, or stronger than, indices that capture decadal or shorter-term variability (*e.g.*, PDO, NPGO, ENSO).

Goal 3. Finally, we tested climate-biology covariation for the threshold responses that are suggested by alternate stable state theory. Such threshold relationships would suggest fundamental difficulties in using data from current and past ecosystem states to make inferences about the future.

25 October, 16:55 (S1-6544)

Contributions of episodic events in decadal climate variation of the Bering Sea

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In the first decade of the 21st century, the southeast Bering Sea spring experienced a warm period from 2000-2005, followed by a cold period from 2006 -2010. Although warm temperatures previously favored Pollock over Arctic species, the recent poor food during the warm period, more predators and then cold temperatures resulted in a biomass loss of 30%. As the large marine ecosystem responds to shifts in climate, we investigate the changes of eastern Bering Sea SAT, SST, SLP and sea ice extent on time scales from seasonal to interannual to decadal. Decomposing the time series of St. Paul's surface temperature by EEMD (Ensemble Empirical Mode Decomposition) to characterize the Bering Sea climate change identified signatures from the regime shift and from stochastic processes. Accompanying extremes in this time series for the period from 1915 to the present there are several 5-yr warm/cold events. Multi-year Bering Sea climate memory is related to ocean heat storage. The atmospheric circulation patterns associated with these events are identified in the reanalysis and climate models. Projections from climate models show annual to decadal changes due to natural variability are comparable to global warming over the next 50 years.

25 October, 17:15 (S1-6590)

Climate impacts on eastern Bering Sea food webs: A synthesis of new data and an assessment of the Oscillating Control Hypothesis

George L. **Hunt, Jr.**, Kenneth O. Coyle, Lisa Eisner, Edward V. Farley, Ron Heintz, Franz J. Mueter, Jeffrey M. Napp, James E. Overland, Patrick Ressler, Sigrid Salo and Phyllis J. Stabeno

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Walleye pollock (*Theragra chalcogramma*) is an important component of the eastern Bering Sea ecosystem and subject to major fisheries. The Oscillating Control Hypothesis (OCH) predicted that recruitment of pollock year-classes should be greatest in years with early ice retreat and late blooms in warm water because more energy would flow into the pelagic (*vs.* benthic) community. The OCH further predicted that, with pollock population growth, there should be a shift from bottom-up to top-down regulation. New data support the predictions that, in years with early ice retreat, more primary production accrues to the pelagic compartment, and that high numbers of age-0 pollock survive to summer. However, in these years production of large crustacean zooplankton is reduced, depriving age-0 pollock of lipid-rich prey in summer and fall. Consequently, age-0 pollock energy reserves (depot lipids) are low and predation on them is increased. A disconnect between the number of age-0 pollock in their first summer and the number of age-1 recruits the following year results. A revised OCH indicates bottom-up constraints on pollock recruitment in very warm periods. Prolonged warm periods with decreased ice cover will likely cause diminished pollock recruitment and catches relative to recent values.

25 October, 17:35 (S1-6704)

Forecasting fish species alternation: Results of the SUPRFISH programme and remaining issues

Hiroaki **Saito**[1], Shin-ichi Ito[1], Atsushi Kawabata[2], Mitsutaku Makino[2], Shoshiro Minobe[3], Masami Nonaka[4], Takeshi Okunishi[2], Kazutaka Takahashi[1] and Ichiro Yasuda[5]

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Fish species alternation (FSA) between sardine and anchovy is a drastic phenomenon of the ecosystem regime shift responding to climate change. Most FSAs are observed in upwelling zones in the eastern part of oceans. The exception is the Kuroshio-Oyashio ecosystem off Japan in the western boundary current system of the North Pacific. In order to understand the mechanism of FSA and to forecast the future FSA in the Kuroshio-Oyashio ecosystem, we started the SUPRFISH (Studies on Prediction and Application of Fish Species Alternation) programme in 2007. After 3-years of progress, we found that the physical and ecological shift in the Kuroshio Extension (KEX) region was responsible for the recruitment failure of Japanese sardine in late 1980s. The KEX system shifted upon reaching the sea surface height (SSH) anomaly which was propagated by Rossby waves from the central North Pacific. Monitoring the SSH anomaly and its westward propagation is useful as a basic technique to forecast the FSA 3–4 years in advance. At the same time, it clarifies the remaining issues to be resolved in forecasting FSA. We will present the results of the SUPRFISH programme after 3 years, and the on-going activities to resolve the remaining issues.

25 October, 17:55 (S1-6660)

Projection of Pacific saury response to future climate change

Shin-ichi **Ito**[1], Takeshi Okunishi[2], Michio J. Kishi[3,4] and Muyin Wang[5]

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An ecosystem based bioenergetics model NEMURO.FISH (North Pacific Ecosystem Model for Understanding Regional Oceanography. For Including Saury and Herring) was developed and successfully reproduced realistic growth of Pacific saury with parameters mainly determined based on field observations. The model is composed of three ocean domain boxes and saury is assumed to migrate between those boxes. This model was used to investigate responses of Pacific saury to global warming using the sea surface temperature (SST) of a global warming condition generated by MIROC3.2 coupled atmospheric–ocean model output with the A2 emission scenario. The saury showed a decrease in both wet weight and body length under global warming because of less prey plankton density. The migration pattern was modified by increased SST and reduced size of saury. Higher SST in the mixed water region under global warming prevented southern migration of saury in the first winter and delayed it in the second winter. As a result, egg production was enhanced by higher availability of prey plankton in the mixed water region. To evaluate the robustness of the result, an ensemble projection was conducted with SST outputs from 12 climate models. The results showed considerable uncertainty of the Pacific saury response. We conducted a case study to separate direct temperature effects with those through prey plankton. Model results suggested an SST increase (especially in the mixed water region) directly reduces juvenile growth while a prey plankton density decrease has an influence on the growth of adults and migration pattern, hence egg production.

S1 Session Oral Presentations, Day 2

29 October, 14:00 (S1-6575), Invited

How does expanding hypoxia affect the nutrient budget of the subarctic Pacific?

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Declining oxygen in the interior waters of the subarctic Pacific over the past 25–50 years has been widely reported as being caused by weakening ocean ventilation along the Asian coast. The impact of reduced ventilation will be twofold. Firstly, the amount of oxygenated habitat must decline, causing biological communities to compress into a shallower layer or to migrate into better oxygenated regions. Some evidence of this problem will be shown for the North American coast. Secondly, as ventilation weakens so does the transport of nutrients to the surface ocean which results in greater storage at depth over time. This has been previously reported for nitrate at Ocean Station P (OSP, 50°N, 145°W). However, this appears to be a widespread occurrence in waters around OSP, as well as off the coasts of northern Japan and southern California. It is not yet evident which surface waters will see reduced nutrient supply as a consequence of increased storage at depth, although declines have been reported in the Oyashio region near Japan.

S1

29 October, 14:25 (S1-6561)

Oxygen decline in the continental slope waters off-Japan and its potential influence on groundfishes

Tsuneo **Ono**

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It is well known that the oxygen content of subsurface waters has decreased in wide areas of the North Pacific. In eastern coast regions of the North Pacific, such oxygen decrease has caused severe impacts on the habitat of groundfishes (*e.g.*, Grantham *et al.*, 2004; Bograd *et al.*, 2008). In the western coast of the North Pacific, the hypoxia boundary (depth with < 1.4 ml/l of oxygen) is no shallower than 500 m and hence the "hypoxia problem" attracts less social attention than in the case of the Pacific eastern coast. However, our recent analysis showed that the hypoxia boundary on the continental slope off Japan has shoaled at the rate of 20-35 m/decade, or almost the same rate as the eastern Pacific case. This phenomenon may have had some impacts on the habitat size of groundfish communities off Japan. Pacific cod has a particularly low tolerance to low-oxygen content. D'Amours (1993) estimated that Atlantic cod starts to escape at the oxygen content of <2.4 ml/l. If we assume that Pacific cod has the same tolerance level to oxygen content, their escape boundary has shoaled from 480 m in 1950 to 420 m at present on the continental slope off Japan because of the observed subsurface oxygen decrease. This corresponds to ~20% loss of their habitat on continental margins off Japan.

29 October, 14:45 (S1-6798)

The California Undercurrent: 1949–2009 and beyond

Steven J. **Bograd**[1], Carmen G. Castro[2], Francisco P. Chavez[3], Curtis A. Collins[4], Vincent Combes[5], Emanuele Di Lorenzo[5], Mark Ohman[6], Ryan Rykaczewski[7] and Frank Whitney[8]

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We use historical hydrographic data from the California Cooperative Oceanic Fisheries Investigations (CalCOFI) program to explore the temporal variability of physical and chemical properties of slope waters impacted by the California Undercurrent (CUC) over the period 1949–2009. We describe seasonal to interannual variability and long-term property trends, including recent declines in dissolved oxygen, a consequent shoaling of the hypoxic boundary, increases in inorganic nutrient content, and large changes in Redfield ratios. We explore the causes of these trends, both in terms of local biological processes and changes in source waters to the region. Significant changes in the oxygen content and nutrient composition of CUC waters, which are upwelled upstream, could have important implications for the California Current ecosystem. Similarly, expansion of the oxygen minimum layer could lead to cascading effects on benthic and pelagic ecosystems, including habitat compression and community reorganization. We compare these observations to model studies of transport dynamics in the California Current, using an ensemble of passive tracer releases in the Regional Ocean Modeling System (ROMS) to quantify advection and mixing pathways. We also investigate potential changes in source waters to the California Current under climate change scenarios.

29 October, 15:05 (S1-6633)

Climate and fish assemblages of the southern California Current, 1951–2008

J. Anthony **Koslow**[1], Ralf Goericke[1] and William Watson[2]

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We used principal component analysis (PCA) to examine patterns in the abundance of 86 common taxa of larval fishes in the southern California Current surveyed by CalCOFI, 1951–2008. The first three PCs explained 20.5, 12.4 and 6.8% of the variance of the data set (total: 39.7%). PC 1 was associated with the mesopelagic fauna, PC 2 with epipelagic and shallow-water fishes, and PC 3 with reef and coastal fishes. Despite the diversity of the data set, 48 taxa were significantly positively correlated with PC 1 and only three negatively with it, indicating a broad community response to regional environmental forcing. Twenty-three of the 25 taxa that loaded most highly on PC 1 (loadings ≥ 0.5) were mesopelagic fishes from eight families. PC 1 was most highly correlated with midwater oxygen concentration ($r=0.73$, $p<0.001$), as well as with the Multivariate ENSO Index, the Pacific Decadal Oscillation (PDO), and temperature at 200 m depth. Oxygen at 200–400 m depth and the PDO entered a stepwise regression significantly and together explained 65% of the variance of PC 1. PCs 2 and 3 were significantly correlated with mean sea surface temperature and the North Pacific Gyre Oscillation, respectively. The mesopelagic and shelf/slope demersal fish taxa that loaded significantly on PC 1 declined on average 57% from periods of high to low midwater oxygen concentration. Our results suggest that the mesopelagic fauna is highly sensitive to changes in deepwater oxygen, which is predicted to decline in the deep ocean as a consequence of global warming.

29 October, 15:25 (S1-6640)

Projecting future changes in distributions of pelagic nekton along the west coast of North America

William W.L. Cheung[1], Thomas A. Okey[2,3] and Richard D. **Brodeur**[4]

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Marine ecosystems are being affected by changing ocean conditions resulting from the effects of greenhouse gas emissions on the global atmosphere. Shifting spatial distributions of species is a predicted impact of these oceanographic changes, and this is expected to modify community structure in particular locations and regions. We used a dynamic bioclimatic envelope model to project shifting ranges of pelagic marine fish and invertebrates along the west coast of North America, from California to Alaska. We combined published survey data and expert knowledge to predict species distribution ranges for 30 pelagic nekton species along the west coast. Using projected ocean condition changes from NOAA's GFDL coupled model, we simulated changes in the spatial distribution of these species and show that this region may undergo considerable changes in pelagic community structure by 2055. Distributions of these species are projected to shift poleward 40 km decade^{-1} on average, resulting in range expansions into the Gulf of Alaska and northern Bering Sea. Rate of range retraction is highest in southern Bering Sea and coastal areas of British Columbia and Oregon. Also, we predict changes in relative abundance of species along the west coast of North America, with increasing dominance of warmer water species at most stations. Such changes in species assemblages may have large ecological implications through spatial and temporal mismatches of co-evolved species, trophic effects, and shifts in fishing grounds. The simulation results provided sets of alternative hypotheses of climate change impacts that can be tested using data collected by existing monitoring programs.

29 October, 16:05 (S1-6724), Invited

Understanding harmful algal blooms in eutrophic coastal waters: Necessity of end-to-end studies

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Human activities, particularly the increasing production and use of synthetic fertilizer, have significantly changed the biogeochemical processes of the major nutrients, such as nitrogen (N) and phosphorus (P), and have led to nutrient over-enrichment and eutrophication in coastal waters. In many coastal regions, eutrophication has caused undesirable ecological changes and negative consequences, including massive algal blooms, anoxia/hypoxia, green tides, jellyfish blooms, and damages to fisheries and aquaculture, *etc.* Recent studies revealed that the phenomena of increased harmful algal blooms in eutrophic coastal waters had a close relationship with the change of the nutrient regime in seawater, and that the altered ratio of nutrient supply in some typical eutrophic waters had resulted in more nuisance or harmful blooms of flagellates. Meanwhile, many consequences of eutrophication, such as hypoxia and jellyfish blooms, could be intrinsically related to the massive harmful algal blooms or the substitution of dominant species in phytoplankton community, which causes the change of food webs in the area. Therefore, it was suggested that end-to-end studies from the source of nutrient overloading to the consequences of ecological changes be carried out in eutrophic coastal waters to understand the nature and impacts of harmful algal blooms, in which well designed comprehensive field investigations and an end-to-end modeling capability are prerequisites.

29 October, 16:30 (S1-6426)

Benthic records indicate increasing nutrient availability and primary production in the Yellow Sea

Xuelei **Zhang**, ZL. Wang, JH. Liu, QS. Wei, SL. Fan, MZ. Fu, Y. Li, P. Sun, P. Liu, QZ. Xu, RX. Li and MY. Zhu

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The Yellow Sea is a semi-enclosed shallow shelf that is vulnerable to eutrophication pressures from the neighboring lands. To date, it is difficult to resolve the history of eutrophication in the Yellow Sea, largely due to a lack of long term systematic observations in the region. We present an analysis of sediment records of the key bioactive elements C, N and P at three sites located in the north, middle and south of the Southern Yellow Sea. The sediment contents of total organic carbon (TOC), total nitrogen (TN) and total phosphorus (TP), all presented an overall increasing feature over the last century; the molar ratios C/N and C/P also presented significant increases since six decades ago. The low C/N ratios (<8) in the middle and north of the Southern Yellow Sea also indicated that the sediment organics were derived from the sea. The contents of TOC, TN and TP in the surface sediment were mostly positively correlated with the contents of these elements except for TP and primary productivity in the overlying water column of Southern Yellow Sea. The trends of historical changes of the sediment contents of TN and TP and N/P molar ratios were consistent with the observed increase of nutrients in the water column at 36°N in the Yellow Sea since the late 1970s/late 1980s and the trends of TOC and TN contents also paralleled the decadal increases of chlorophyll *a* content, zooplankton biomass and macrobenthic biomass. The results indicate that the Yellow Sea has received more nutrient inputs from the neighboring lands, which stimulated the sea's production toward a higher level through bottom-up effects.

29 October, 16:50 (S1-6471)

Relationship between food web structure of a lower trophic level community and transfer efficiency in a coastal sea

Jun-ya **Shibata**, Ryu Isonaka, Hideki Hamaoka, Kazumasa Matsumoto, Tetsuya Nanko, Todd W. Miller, Hidejiro Onishi, Tadao Kunihiro and Koji Omori

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Food web structure is a critical attribute in the material and energy flow of ecosystems and the number of trophic interactions can determine trophic efficiencies between primary production to higher consumers such as fishes or marine mammals. The Seto Inland Sea (SIS) of Japan is a coastal inland sea which is divided into subsystem basins connected by narrow channels. These sub-areas in the SIS express high environmental heterogeneity, and large differences occur in their trophic transfer efficiencies from primary production to large zooplankton (7%-37%). The purposes of our study were: 1) to assess the contribution of both the grazing link and the microbial food link to the lower trophic level food web from each sub-region by using stable isotope analysis of copepods, which represent large coastal zooplankton, and 2) to investigate the relationship between the transfer efficiency and the relative trophic level of copepods. Results showed a very strong positive relationship between the proportional importance of ciliates in the particulate organic matter fraction and trophic level of copepods. We furthermore observed a negative relationship between trophic transfer efficiency and copepod trophic level. These results underlie the importance of the microbial food web and lower trophic level interactions as a regulator for transfer of primary production to the ecosystem.

29 October, 17:10 (S1-6539)

Effects of local and global change on an inland sea: The Strait of Georgia, Canada

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Global changes manifest in coastal waters depending on local oceanography and ecosystems. Here we consider the Strait of Georgia, on the west coast of Canada, as a case study. After examining physical and chemical processes and trends, we discuss consequences of change on geochemical cycling and biota. Several components of the system are vulnerable. Declines in pH and O_2 of basin waters, partly imported from the shelf and partly supported by carbon cycling within the Strait, would reduce benthic and pelagic habitat. Sea-level rise and storms will interact with coastal development to place critical habitat, such as low-lying estuaries, intertidal zones and mudflats, at risk. The decrease and earlier peak in zooplankton biomass may lead to changes in the foodweb that cascade to higher trophic levels such as fish and birds. Anadromous fish, already showing declines, are vulnerable to ocean regime shifts, increasing river temperatures, habitat destruction, harvesting and contaminants. For southern resident killer whales, a species at risk, decline in Chinook salmon together with marine traffic and biomagnifying contaminants will lead to extirpation if no action is taken. Some stressors can be controlled only through international action to mitigate climate change. However, we have local control of fishing, habitat destruction, release of some contaminants and, to some extent, river flow and temperature. Acting to control these stressors will support resilience of biota in the face of inevitable global changes. Biogeochemical monitoring will help to provide plausible connections between physical forcing and biological effects.

S1 Session Posters

S1-6424

The impacts of human activities in Africa and the North and South Pole Regions on the Global Climate Change

Babagana **Abubakar**

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As a result of the rapid increase in petroleum exploration, industrial expansion, deforestation and other human activities going on within or around the Arctic and Antarctica ice caps, near or in the temperate region countries like Canada, Greenland, Russia, U.S.A. (Alaska), Iceland, Finland, Argentina, Tasmania and New Zealand among many others, plus the increase in deforestation activities in Tropical world countries like the Amazon of Brazil, The Tropical Rain forest of Nigeria, Zaire (Democratic Republic of Congo), Cote d'Ivoire, Indonesia *etc.*, in addition to the Sahara and the Kalahari desert expansions,, plus the uncontrolled disposal of broken refrigerators, air conditioners and propellants containing chlorofluorocarbon substances capable of destroying the Ozone layer in African refuse dumps (B. Abubakar, 2006), human factors are collectively becoming a threat to the world climate.

This explains why the volume of the Ocean keeps on rising, global temperature keeps ascending and the global climate has become abnormal since the beginning of the above mentioned activities in the above mentioned locations. It was in view of the above that this research was conducted and came up with the under listed suggestions/recommendations:

1. Temperate region countries like Canada, Russia, U.S.A, Argentina *etc.* should come up with polices restricting certain industries with the possibilities of causing environmental hazards from operating near the Ice Caps of the Arctic or Antarctica even in areas which the Ice was frozen thousands of years ago as the case with Greenland.
2. The research and exploration activities going on around or on the Arctic and the Antarctica regions should be carried out with utmost care and concern to the global climate.
3. The deforestation activities going on without control in most of the Tropical World Countries should be monitored by the United Nation's Specialized Agencies on forest and other related international organization in such a way that goals could be achieved without necessarily causing problems to the world climate.
4. The International Maritime Organization (IMO) should check and control the Ocean Pollutions caused as a result of the degreasing activities of the "QUAY APRONS" currently going on at the various African Sea Ports in order to protect the Ocean pollution with chemicals that can contribute to the World's ice melting.
5. The International Meteorological Organization should open its offices within each region of the six continents in order to have a closer monitoring of human activities that can influence the world's climate.
6. Organizing seminars, Conferences and Workshops on a regular basis by the United Nations and other related organizations can help in the areas of public enlightenment and the education of the rural populace who are also great contributors to the situation.
7. The UN should use its capacity to discourage the importation of fairly used refrigerators, air-conditioners and propellants to Africa and at the same time assist in the subsidy of the newer ones coming to Africa, so that the average African can afford to buy them

I believe that if the above listed suggestions/recommendations are adopted and implemented it will help in reducing these challenges threatening the entire world.

S1-6437

The present condition of the ecosystem in Taui Bay in the Sea of Okhotsk

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Taui Bay in the northern part of the Sea of Okhotsk has a great value as a traditional area for industry and the reproduction many kinds of fishes and crabs. In 2008-2009, complex scientific research was carried out from onboard the science vessel *Zodiac*. Comparisons between the condition of the Taui Bay ecosystem at the present stage with data over the last 80s years of 20th century has shown that the hydrological mode and structure of the planktonic community for last twenty years have undergone appreciable changes due to the reduction of ice level and a timing shift in the seasonality. This shift and the warming accompanying it causes an earlier blooming of phytoplankton and maturing of the principal types of zooplankton and larvae of Decapoda. A twenty year time series shows a change in the dominant zooplankton of Taui Bay: Copepoda have replaced Euphausiaceae. On two branches of the Jamsky current, the larvae of a pollock and herring have increased in Taui Bay. Our investigations have also shown a concentration of one of the reproductive kernels of the population of a Paralithodes platypus and dwelling zones of juveniles of Chionoecetes opilio. Climate and hydrological changes in last few years, and also structure transformations of phyto- and a zooplankton, undoubtedly, will result in changes in the higher trophic levels that will affect the number and structure of populations of fish and sea mammals living in this area.

S1-6454

Skillfish (*Erilepis zonifer*): Traits of biology from a fishery near the Emperor Seamounts in the north-west Pacific Ocean

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Skillfish is the principle object of the Russian long-line fishery at the Emperor Seamounts. Data on the distribution, fishery and biology of skillfish are extremely short.

In May-July 2009, two Russian long-line ships operated near four heights of the Emperor Seamounts, including Jingu, Ojin, Northern Koko and Koko. The catches varied from 0 to 914.7 kg per 1000 hooks. The maximal catch was recorded near the Northern Koko Mt. The length of skillfish varied from 59.0 to 188.0 cm. The minimal average length was recorded near the Koko Mt and the maximal one – near the Ojin Mt.

For today all methods of ageing for skilfish are imperfect. To our data, among the all age registering structures we have sampled (otholiths, scale and dorsal fin rays) the otholiths are the most authentic to be used for the age estimation. The maximal age estimated for the skillfish individual (117 cm) from the landing near the Koko Mt is 18 years. The minimal age of 6 years is estimated for the skillfish individual (86 cm) from the landing near the North Koko Mt.

S1-6501

The distribution characteristics of phytoplankton in Laizhou Bay

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Based on the data obtained in a survey in Laizhou Bay from 2000 to 2001, the distribution characteristics of phytoplankton are analysed and discussed in this paper. The results show that *Chaetoceros spp. and Rhizosolenia. stolterfothii Peragallo* are the dominant species in the dry season and *Chaet. spp., Skeletonema costatum* (Greville) Cleve, and *Thalassiothrix frauenfeldii* Grunow – dominate in the wet season. The total abundance of phytoplankton at each station varies significantly. The area of highest concentration is in the west near the shore in

the dry season but it expands to the middle of the bay in the wet season. The amount of phytoplankton is closely related to the inorganic nitrogen contained in the water. In near-shore water, the diversity index is lower in the dry season than in the wet season.

S1-6527

Study on bioaccumulation and elimination of *Chlamys farreri* to copper

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This paper studies the tolerance of *Chlamys farreri* to copper. *Chlamys farreri* was exposed to the copper test solution for 35 days and then transferred to natural seawater for 30 days. The copper content in the tissue of *Chlamys farreri* was measured over this time period. The tolerance test showed that *Chlamys farreri* is sensitive to the copper ion. The accumulation test showed that the content of copper in the tissue of *Chlamys farreri* is positively correlated with the copper ion concentration in the test solution. In the early days of the elimination period, the content of copper in the tissue of *Chlamys farreri* clearly decreased; its elimination was positively correlated with elimination time. Based on a two-compartment model, the kinetic parameters (accumulation rate constant k_1, elimination rate constant k_2, bio-concentration factor BCF, biological half life ($B_{1/2}$) and maximum equilibrium concentration (C_{Amax})) were obtained by non-linear regression. The two-compartment model was successfully used to study bioaccumulation and elimination of copper in *Chlamys farreri*. In addition, *Chlamys farreri* is a potential indicator of copper pollution.

S1-6530

Formation of summer hypoxia in the Yangtze River Estuary of China: "cold pool" and "thermal barrier" effects

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This paper studies the mechanisms leading to summer hypoxia in the Yangtze River Estuary of China, by analyzing the temperature, salinity and dissolved oxygen in the water column and bottom layer of the Yangtze River Estuary and its adjacent sea. The results show that: 1) the seasonal variation of temperature and salinity affect the formation of summer hypoxia in the Yangtze River Estuary by influencing dissolved oxygen saturation level, apparent oxygen utilization (AOU) and strength of stratification; negative correlations were found between temperature and salinity and dissolved oxygen (R=-0.730; R=-0.246. $P<0.05$); 2) estuarine, coastal and oceanic circulation including runoff from the Yangtze River, the Taiwan warm current and upwelling, enhance the formation of summer hypoxia in the Yangtze River Estuary by influencing the distribution of temperature and salinity, stratification strength, and water movement; 3) there is a "cold pool" (isolated, closed and stable waters with lower temperature under a 15-meter layer of warmer water) and a "thermal barrier" (water at the periphery of the cold pool with higher temperature that protects the stability of the cold pool and blocks the exchange of dissolved oxygen with surrounding waters) in summer hypoxia zones in the Yangtze River Estuary. Their existence greatly increases residence time of water in hypoxia zones, restricts exchange and migration of dissolved oxygen, provides necessary preconditions for the formation of summer hypoxia, and plays a key role in the formation of summer hypoxia off the Yangtze River Estuary.

S1-6550

Spatio-temporal changes in species diversity and assemblage structure of Euphausiids (Oyashio to Oyashio-Kuroshio Transition Region in the western north Pacific)

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The spatio-temporal changes in diversity and assemblage structure of the micronektonic euphausiids were analyzed with the physical oceanographic structure in the Oyashio to the Oyashio-Kuroshio Transition Region of the western north Pacific. All the specimens were collected by means of MOCNESS, and physical data were obtained from CTD sensors during eight cruises of the R/V "Wakataka-Maru" of the Fisheries Research Agency of Japan, from May 2004 to March 2006. In total, 40 species representing eight genera were identified from six fixed stations. A clear regional distinction of the euphausiid assemblage structure was observed, associated with temperature and salinity characteristics of water masses. However a seasonal pattern was hardly observed from the two-year survey, with some exceptions. Cluster and multi-dimensional scaling (MDS) ordination analyses based on the Bray-Curtis similarity index and its inverse analysis showed four distinct euphausiid assemblage groups. Group I consisted of the Arctic-Boreal, the Subarctic and the Subarctic-Transition species. Group II mainly consisted of the Subarctic and the Subarctic-Transition species. Group III consisted of the Subarctic-Transition, the Transition and the western Pacific coastal species. Group IV mainly consisted of the Central and the Central-Equatorial species. *Euphausia pacifica*, the only Subarctic-Transition species, was most abundant in Groups I, II and III. The results of this study suggest that a spatio-temporal change in the assemblage structure of euphausiids was controlled principally by physical factors rather than the seasonal variance in this area.

S1-6551

Spatial–temporal distribution of *Aurelia aurita* in Mikawa Bay inferred from net sampling with a fish finder

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The spatial—temporal distribution of swarms of *Aurelia aurita* were analyzed with nets and with fish finders in Mikawa Bay, Japan in June–September 2009. Six research cruises were conducted with 200 kHz and 50 kHz fish finders. Net sampling was also carried out when dense swarms of moon jellies were detected by fish finder, in order to estimate density, bell diameter and wet weight. 50 kHz fish finders could not detect moon jelly swarms. However, 200 kHz fish finders pick up clear images of moon jelly swarms. The results of the 200 kHz fish finder surveys and the net sampling showed that swarms were observed mainly in the eastern part of Mikawa Bay, and the highest density of the moon jelly swarms was 220.6 ind. m^{-3} in September. These results showed that the fish finders can detect swarms of *Aurelia aurita* effectively in a wide range of sea areas. Further studies of the population dynamics of this species are expected in the future.

S1-6630

Development of the simulation model of pollutant propagation in the Arctic Basin

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An attempt is made here to synthesize the accumulated knowledge in the form of a spatial simulation model of the dynamics of Arctic basin pollution (SSMAE) to estimate the distributions of pollutants over the Arctic seas. The boundary of this basin is determined from its maximum configuration, including the Norwegian and Bering Seas. The SSMAE block-scheme has biotic and hydrologic units. The Arctic Basin is divided by set of spatial cells that are used as the base for a balance equation. The ice–water ergocline and the community of algae accumulating in snow and ice play an important role in the formation of the biological productivity of the northern seas. The primary produce in the nutrient chains of the Arctic Basin's ecosystems is determined by phytoplankton productivity, whose formation is connected with the composition of complex variations of synoptic, hydrodynamic, geochemical and energetic parameters of water. The dynamics of water masses in the Arctic Basin with fluxes between the spatial cells is presented. The SSMAE pollution unit simulates the processes of the input of pollutants due to atmospheric transport, river and surface coastal runoffs, navigation, and other economic activity. The model can be used to study the dynamics of any pollutant in the ocean medium. As the base units, taking into account the specific features of pollutants, the model interaction of heavy metals, oil hydrocarbons and radionuclides with the components of the ecosystems of the Arctic waters, are considered. Some results of simulation experiments are given.

S1-6645

Vertical signatures in acoustic estimates of zooplankton around the Yellow Sea Bottom Cold Water, Korea

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The Yellow Sea Bottom Cold Water (≤ 10°C), one of the several water masses in the Yellow Sea, is formed during the winter, occupies the lower layer of the Yellow Sea's water body, and remains throughout the year until fall. This cold water mass directly affects the Yellow Sea ecosystem and marine living resources. Particularly, the population of *Euphausia pacifica*, known as one of the cold water euphausiid species and a key species in the Yellow Sea, could be significantly related with the dynamics of this cold water mass. In this study, vertical signatures in acoustic estimates of zooplankton are studied using data collected from the center of the Yellow Sea Bottom Cold Water with a two-frequency scientific echosounder (BioSonics DT-X series), combined with zooplankton net surveys. The acoustic-net surveys were done at 11 sampling stations (29~91 m depth) in April 2010. When acoustic signatures due to copepods were removed from acoustic data using the threshold level (–75 dB), diel patterns for major zooplankton species within the study area showed that the patches concentrate to the bottom or mid-depth during the day and move to the surface layer at night. Then, the upward and downward speed of the zooplankton patches was 0.74 and 0.87 m/s, respectively. Net surveys showed that, whereas nauplii and adult of *E. pacifica* and chaetognath randomly appeared at some station, *E. pacifica* eggs were abundantly distributed throughout all the stations. Zooplankton catch data showed that the major species of zooplankton having an influence on the acoustic signature were chaetognaths and *E. pacifica*.

S1-6651

Understanding ecosystem processes in the Bering Sea

Jeffrey M. **Napp**[1], Carin Ashjian[2], Rodger Harvey[3], Mike Lomas[4], Mike Sigler[5] and Phyllis Stabeno[6]

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The Bering Sea is one of the most productive marine ecosystems in the world, sustaining nearly half of US annual commercial fish landings and providing food and cultural value to thousands of coastal and island residents. In winter, the topography, latitude, atmosphere and ocean circulation combine to produce a sea-ice cover advance unmatched elsewhere in the northern hemisphere (ca. 1700 km). In the spring, the retreating ice, longer daylight hours, and nutrient-rich deep ocean waters forced up onto the shelf result in intense marine productivity. Pollock, cod, flatfish, halibut, crab, and salmon are abundant in the Bering Sea; whales, seals and seabirds migrate there every year. Seasonal ice cover acts as a major organizing driver of the Bering Sea and it is no surprise that this ecosystem is particularly sensitive to changes in climate and predicted changes in ice cover in the coming decades. In response, the North Pacific Research Board (NPRB) and the National Science Foundation (NSF) entered into a historic partnership in 2007 to support a comprehensive $52 million investigation to understand how climate change is affecting the Bering Sea ecosystem ranging from lower trophic levels (*e.g.* plankton) to fish, seabirds, marine mammals, and ultimately humans. This six-year study of the Bering Sea ecosystem links nearly a hundred principal scientists through a vertically-integrated program of field sampling and process studies, tied together with a fully integrated modeling program (http://bsierp.nprb.org/index.html). Here we highlight three overarching research themes and four key messages from the results so far.

S1-6807

Communicating ecosystem science: The Bering Sea Project

Nora Deans, Thomas **Van Pelt**, Francis Wiese and Carolyn Rosner

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The National Science Foundation and the North Pacific Research Board are supporting the "Bering Sea Project", a historic, six-year, $52 million integrated study of the Bering Sea marine ecosystem. More than 100 researchers from federal, state, university and private institutions are studying a range of issues from atmospheric forcing and physical oceanography to fisheries, traditional knowledge, and socio-economics, all within the context of a dynamic ecosystem mediated by changing sea-ice conditions as the climate changes. The communication strategy of public awareness, education, and outreach for this innovative integrated field science and ecosystem modeling partnership focuses on the vital importance of the dynamic Bering Sea ecosystem and the complex effects of climate change. In taking on the challenge of effectively communicating a multi-disciplinary ecosystem program, we have found the communication strategy must be as integrated yet multi-faceted as the study itself. We will share "lessons learned" about how to most effectively communicate with diverse audiences, including the scientific community, policymakers, commercial and subsistence users, coastal communities and the public. We will also present the communication and outreach plan that builds on partnerships and other ongoing efforts in communicating about research in Alaska's marine ecosystems. Finally, from our perspective at the midpoint of the Bering Sea Project, we will share highlights of researchers communicating from the field, through printed and multi-media materials, on the web, and in coastal communities.

S2 BIO Topic Session
Understanding the role of iron in regulating biogeochemical cycles and ecosystem structures in the North Pacific Ocean

Co-Sponsored by SOLAS

Co-Convenors: Angelica Peña (Canada), Toshi Saino (Japan) and Mark Wells (U.S.A.)

Iron plays a key role in regulating the biogeochemical cycles of carbon and nitrogen, and pelagic ecosystem structures in the North Pacific Ocean, yet our understanding of these effects remains limited. External sources of iron, such as Asian dust, rivers, sediments, and volcanoes, supply large amounts of iron to the North Pacific, while the physical processes of upwelling, meso-scale eddies, boundary currents, and tidal mixing transport deep waters with high iron concentration to the upper ocean. Biological uptake, zooplankton grazing, re-mineralization, and iron chemistry change the forms of iron and its distribution in the North Pacific Ocean. This session invites papers that address physical, biological and chemical processes controlling iron distribution and transformation, linkages between iron and ecosystem responses, and impacts on carbon and nitrogen cycles. Of special interest are papers that combine recent progress from field observations and modeling studies that relate iron cycling to ecosystem structures and carbon fluxes in the North Pacific Ocean.

Tuesday, October 26 (14:00-18:30)

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

14:05 **Jay T. Cullen and Maria T. Maldonado (Invited)**
Iron speciation and bioavailability: Insight gained from analytical chemistry and microbial physiology (S2-6818)

14:35 **Eric G. Roy and Mark L. Wells**
Evidence for regulation of Fe(II) Oxidation Rates by Organic Complexing Ligands in the Eastern Subarctic Pacific (S2-6840)

14:55 **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**
Mechanisms controlling dissolved iron distribution in the North Pacific: A model study (S2-6762)

15:15 **William Crawford**
Advection of deep-sea and coastal water into the HNLC region of the northeast Pacific Ocean (S2-6849)

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

15:55 **Huiwang Gao, Xiaohong Yao, Jinhui Shi and Jianhua Qi (Invited)**
Response of marine ecosystem to Asian dust fertilization from coastal sea to open ocean (S2-6622)

16:25 **Josiane Mélançon, Maurice Levasseur, Martine Lizotte, Jean-Éric Tremblay, Gui-Peng Yang, Marjolaine Blais, Guangyu Shi, Hui-Wang Gao, Michael Arychuk, Keith Johnson, Nes Sutherland, Marie Robert and Wendy Richardson**
Impact of Asian dust on plankton and DMS production in the Northeast Subarctic Pacific (S2-6850)

16:45 **Jun Nishioka, Tsuneo Ono, Hiroaki Saito, Keiichiro Sakaoka and Takeshi Yoshimura**
Oceanic iron supply mechanisms supporting the spring diatom bloom in the Oyashio region, western subarctic Pacific (S2-6707)

17:05	**Hiroaki Saito, Jun Nishioka, Atsushi Tsuda and Hiroaki Tatebe** The role of zooplankton in buffering geographical heterogeneity of primary productivity (S2-6859)
17:25	**Fei Chai, Peng Xiu, Huijie Xue, Lei Shi and Yi Chao** Modeling impacts of mesoscale eddies on iron cycle and biogeochemical processes in the Gulf of Alaska (S2-6649)
17:45	**Emilie Brévière** The international Surface Ocean - Lower Atmosphere Study (SOLAS) project and its mid-term strategy (S2-6862)
18:05	**Hong Chen, Jianbo Han and Xiaomeng Wang** A review of the influence of ocean fertilization on marine biodiversity (S2-6483)
18:25	***Summary by Convenors***
18:30	***Session ends***

S2 Session Oral Presentations

26 October, 14:05 (S2-6818), Invited

Iron speciation and bioavailability: Insight gained from analytical chemistry and microbial physiology

Jay T. **Cullen** and Maria T. Maldonado

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The marine geochemistry of Fe is inextricably linked with the cycle of growth, vertical transport and remineralization of marine microbes. The availability of Fe to vegetative cells can affect the species composition, ecological structure and productivity of the phytoplankton community. Indeed, we now recognize that phytoplankton affect: 1) the distribution of Fe through active cellular uptake and subsequent sinking of organic matter to depth, and 2) the physicochemical speciation of Fe through the production of strong complexing ligands. The marine biogeochemistry of Fe and C are thus intimately coupled, in that the supply of Fe to ocean surface waters regulates the synthesis of organic matter by phytoplankton, and, ultimately, the export of organic carbon from the surface to the ocean interior. However, our current understanding of the sources, sinks and chemical speciation of Fe, especially as it relates to bioavailability, in the upper ocean is incomplete. Here we will provide an overview of recent progress by chemists and microbial physiologists, sometimes working side by side, studying how the chemical form of Fe impacts its bioavailability. Insights provided by metal-metal interactions during microbial uptake between Fe and Cd and Fe and Cu in the north Pacific will also be summarized.

26 October, 14:35 (S2-6840)

Evidence for regulation of Fe(II) Oxidation Rates by Organic Complexing Ligands in the Eastern Subarctic Pacific

Eric G. Roy and Mark L. **Wells**

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Redox cycling of iron in natural seawater is an important process that can affect iron availability to marine phytoplankton, but one that often is overlooked in modelling iron effects on ocean ecosystems. We used luminol chemiluminescence to measure picomolar Fe(II) oxidation rates in continental shelf waters and surface (upper 200 m) waters of the iron-limited eastern subarctic Pacific. In both cases, Fe(II) oxidation rates were markedly faster in waters from the surface mixed layer and chlorophyll maximum depth than rates measured in UV oxidized seawater (UVOS). Conversely, Fe(II) oxidation rates measured in waters from below the mixed layer agreed well with UVOS rates. Even so, Fe(II) oxidation rates in surface and chlorophyll maximum waters slowed to converge with UVOS rates with stepwise Fe(II) and Fe(III) additions. These Fe titrations did not affect Fe(II) oxidation rates in waters from below the mixed layer. We hypothesize that excess concentrations of strong Fe(III)-complexing organic ligands known to occur in seawater accelerate Fe(II) oxidation at the surface and chlorophyll maximum; a process that we titrated away with stepwise Fe additions. Given that Fe(II) oxidation rates were enhanced only in the surface mixed layer, our findings suggest that the chemical nature, biological availability, and perhaps origin of natural Fe(III)-complexing organic ligands may differ in surface and deep waters.

26 October, 14:55 (S2-6762)

Mechanisms controlling dissolved iron distribution in the North Pacific: A model study

Kazuhiro **Misumi**[1,3], 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]

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Mechanisms controlling dissolved iron distribution in the North Pacific are examined by numerical simulation. We use the Biogeochemical Elemental Cycling (BEC) model with the resolution of roughly 1° in horizontal directions and 60 vertical levels. The model reproduces well the iron distribution in available field data: the surface concentrations are broadly below 0.2 nM; the concentrations increase with depth; and those in the lower thermocline are especially high in the northwestern region and off the coast of California. Furthermore, the simulated result is corresponds well to observed sections. Experiments changing scavenging regimes and external iron sources reveal that lateral transport of sedimentary iron into the open ocean causes the high concentrations in the northwestern region and off the coast of California. The penetration only appears under a scavenging regime where iron has a relatively long residence time at high concentrations, namely, the order of years. Sedimentary iron is intensively supplied around continental margins, resulting in locally high concentrations; the residence time with respect to scavenging determines the horizontal scale for plumes of elevated sedimentary iron. Budget analysis for iron reveals that the existence of offshore directed currents is essential for sedimentary iron transport to the open ocean.

26 October, 15:15 (S2-6849)

Advection of deep-sea and coastal water into the HNLC region of the northeast Pacific Ocean

William R. **Crawford**

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Much of the northeast Pacific Ocean is labeled high-nutrient (nitrate), low-chlorophyll (HNLC) based on years of sampling of ocean-surface nutrients by research vessels. Year-to-year changes in the shape and extent of this region are difficult to track, since there are few wide-area, ship-based surveys to sample nutrients over the region. It is now possible to track the movement of different water masses based on ocean-surface chlorophyll measured from satellite and on changes in currents determined by satellite-altimetry and Argo profilers. I will combine these measurements with ship-based sampling to reveal changes in the HNLC domain over the past decade.

26 October, 15:55 (S2-6622), Invited

Response of marine ecosystem to Asian dust fertilization from coastal sea to open ocean

Huiwang **Gao**, Xiaohong Yao, Jinhui Shi and Jianhua Qi

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Dust storm carries a large amount of aerosol particles, sweeps continents and exports to oceans. When these aerosol particles deposit in ocean, which provides abundant nutrients such as nitrogen and iron for ocean ecosystem, increases the primary production and induces algae bloom. Asian dust storm generates at a high latitude and a high elevation and is obvious a hemispheric scale phenomenon. Asian dust is unique not only in morphology, soil texture, and dust storm activities, but also mixing and capturing anthropogenic air pollutants on the transport pathway. Deposition of Asian dust substantially affects surface biological productivity. To improve

understandings of Asian dust and its effect on ocean ecosystem from the coastal sea to open ocean, ADOES (Asian Dust and Ocean EcoSystem) was proposed under the frame of international SOLAS (Surface Ocean-Lower Atmosphere Study).

A series of studies were performed in high- nutrient low-chlorophyll (HNLC), low-nutrient low-chlorophyll (LNLC) and eutrophication coastal regions of the Pacific Ocean. These studies provided evidence of biotic response to natural iron fertilization caused by Asian dust particles in the subarctic North Pacific and showed that dust storm episodes were significant in the initiation of spring blooms in the East China Sea. On-board incubations on the cruise in a LNLC region of the western Pacific at the southeast of Japan showed different responses of ocean ecosystem to nitrogen and dust fertilization. Correlation of the Asian dust storms with chlorophyll, primary productivity and algae blooms in the coastal seas of China from 1998 to 2008 were illustrated.

26 October, 16:25 (S2-6850)

Impact of Asian dust on plankton and DMS production in the Northeast Subarctic Pacific

Josiane **Mélançon**[1], Maurice Levasseur[1], Martine Lizotte[1], Jean-Éric Tremblay[1], Gui-Peng Yang[2], Marjolaine Blais[1], Guangyu Shi[3], Huiwang Gao[2], Michael Arychuk[4], Keith Johnson[4], Nes Sutherland[4], Marie Robert[4] and Wendy Richardson[4]

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3 Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, PR China
4 Institute of Ocean Science, Department of Fisheries and Ocean, Sidney, BC, Canada

The Alaskan Gyre is a High Nutrient Low Chlorophyll region (HNLC) characterized in summer by exceptionally high concentrations of dimethylsulfide (DMS), a biogenic gas with a potential cooling effect on climate. Surface waters in this region are sporadically replenished with Fe by aeolian dust wet deposition, events which can results in natural blooms. During the June 2009 and 2010 Line P cruises we conducted a series of onboard incubation experiments where surface water collected along Line P were enriched with dust samples from different Asian sources. Dust samples were added at concentrations of 0.12mg/L, 0.5mg/L and 2mg/L in 5L incubation bags. The incubations lasted between 48h and 96 h and the following variables were measured at T0, T24, T48 and T96: dissolved Fe, macronutrients, primary production, nitrogen fixation, chlorophyll *a*, phytoplankton and bacterial abundance, dimethylsulfoniopropionate (DMSP) and dimethylsulfide (DMS). Preliminary results will be presented and discussed in the context of reported impact of natural dust storm and artificial large scale fertilisation experiments.

26 October, 16:45 (S2-6707)

Oceanic iron supply mechanisms supporting the spring diatom bloom in the Oyashio region, western subarctic Pacific

Jun **Nishioka**[1], Tsuneo Ono[2], Hiroaki Saito[3], Keiichiro Sakaoka[4] and Takeshi Yoshimura[5]

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Multi-year (2003-2008) time series observations along the A-line provided information on the temporal variability of the dissolved iron (diss-Fe) concentration in the Oyashio region of the western subarctic Pacific and the data indicate that an annual cycle of surface diss-Fe occurs every year. Diss-Fe was supplied into the surface water in this region every winter and supports the spring phytoplankton bloom after development of the thermocline. The diss-Fe concentration was drawn down during the phytoplankton bloom period, and was depleted in summer in some water masses. Then diss-Fe increased from autumn to winter with the increasing depth of the surface mixed layer. The high diss-Fe concentrations in the surface layer in winter were controlled by mesoscale oceanic intrinsic processes, such as vertical winter mixing and horizontal Fe-rich intermediate water transport. Difference in magnitude of the winter mixing processes among different water masses caused the heterogeneous distribution of diss-Fe concentration in the surface layer. Substantially higher diss-Fe/NO_3 ratio in the winter surface layer

in the Oyashio region than that of the other HNLC region indicating that the winter surface water in the Oyashio region has a high potential to stimulate phytoplankton growth caused by the high Fe availability allowing high potential of macro-nutrients utilization. Dust events were rare in the period when the surface diss-Fe concentration increased, therefore, the consistently occurring spring diatom blooms in the Oyashio region are concluded to be fuelled by the oceanic Fe supply.

26 October, 17:05 (S2-6859)

The role of zooplankton in buffering geographical heterogeneity of primary productivity

Hiroaki **Saito**[1], Jun Nishioka[2], Atsushi Tsuda[3] and Hiroaki Tatebe[4]

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Iron is the most essential factor controlling the ecosystems structure and dynamics of the subarctic North Pacific (SNP). Iron limitation prevents nitrate uptake of phytoplankton in most oceanic regions of the SNP and maintains the nitrate concentration high. Eastward decrease in iron supply brings the contrast of the nitrate drawdown and phytoplankton composition between eastern and western subarctic gyres. In iron-replete region, such as Oyashio region, centric diatoms consume nitrate and form extensive bloom in spring. In spite of large regional difference in phytoplankton biomass and composition, regional difference in zooplankton composition is less distinct. Large calanoid copepods *Neocalanus* spp., *Eucalanus bungii* and *Metridia pacifica* are dominant throughout the SNP. Recent studies on the transportation of *Neocalanus* showed that a significant fraction of the population in a oceanic domain was passively transported to other ocean domains within a generation. This suggests zooplankton with long life cycle (months – 2 years) transfer primary production to higher trophic levels after smoothing the geographical heterogeneity of primary productivity. We will discuss the relationship between iron supply, passive transportation of zooplankton and biogeography of higher trophic levels.

26 October, 17:25 (S2-6649)

Modeling impacts of mesoscale eddies on iron cycle and biogeochemical processes in the Gulf of Alaska

Fei **Chai**[1], Peng Xiu[1], Huijie Xue[1], Lei Shi[1] and Yi Chao[2]

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Numerous mesoscale eddies occur each year in the Gulf of Alaska, but their statistical characteristics and impact on biogeochemical cycles have never been substantially investigated. A Pacific basin-wide three-dimensional coupled physical-biogeochemical model has been developed and the results for the Gulf of Alaska are used to quantify the eddy activities and the subsequent biogeochemical responses during the period of 1993-2009. Based on sea level anomaly (SLA), the Okubo-Weiss method is used to identify eddies and a connectivity algorithm is used to track eddies in this study. In order to evaluate the model performance, the modeled results are compared with the satellite derived SLA. The impacts of mesoscale eddies to the biogeochemical processes are evaluated with the model results. The iron transport from the coast to the Gulf will be estimated with the model results. The total nitrate and silicate uptake within the eddies each year are calculated. This study suggests that mesoscale eddies in the Gulf of Alaska are important sources of iron to the euphotic zone, which plays a significant role in regulating the biogeochemical cycle in the Gulf of Alaska.

26 October, 17:45 (S2-6862)

The international Surface Ocean - Lower Atmosphere Study (SOLAS) project and its mid-term strategy

Emilie **Brévière**

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The Surface Ocean - Lower Atmosphere Study (SOLAS) project is an international research initiative focusing on biogeochemical interactions at the air-sea interface and the immediately adjacent marine and atmospheric boundary layers. It is a co-sponsored project of SCOR (Scientific Committee on Oceanic Research), IGBP (International Geosphere-Biosphere Programme), WCRP (World Climate Research Programme) and iCACGP (Commission for Atmospheric Chemistry and Global Pollution), comprising over 1600 scientists in 25 countries. SOLAS science has developed and matured considerably since publication of its Science Plan and Implementation Strategy in 2004 and there have been a number of broad-based national SOLAS research programs and related projects. In 2008, pressing scientific issues and areas where progress can be accelerated significantly with the support of SOLAS were identified and referred to as the SOLAS mid-term strategy. These topics will be presented including the topic „Atmospheric control of nutrient cycling and production in the surface ocean" under which plans for iron-related work are being developed.

26 October, 18:05 (S2-6483)

A review of the influence of ocean fertilization on marine biodiversity

Hong **Chen**, Jianbo Han and Xiaomeng Wang

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Ocean fertilization may offer a potential strategy for removing CO_2 from the atmosphere by stimulating the growth of phytoplankton and thereby sequestering CO_2 in the form of particulate organic carbon. Scientific studies into the potential mechanisms for global climate modulation involving ocean fertilization activities have consistently demonstrated the stimulation of phytoplankton biomass through the addition of macro or micro nutrients in certain nutrient-deficient areas of the oceans. However, an incomplete understanding of the linkages and drivers within this complex system, introduces uncertainty in the extrapolation of experimental observations to the temporal and spatial scales proposed for carbon sequestration by commercial ocean fertilization. Based on available information, four key factors limiting research on ocean fertilization are highlighted in this review: 1) a dearth of baseline information in the areas suitable for fertilization restrict the accurate observation and monitoring of impacts to marine biodiversity resulting from the alteration of chemical and biological processes; 2) the influence of natural variability and fluctuations in biogeochemical processes within the oceans on sequestration efficiency is not clear; 3) the costs, benefits and shortcomings of ocean fertilization can not be accurately assessed; and 4) ocean fertilization, even carried out as legitimate scientific research, presents serious challenges for the law of the sea.

S3 BIO Topic Session
The Practical Handbook at 50: A celebration of the life and career of Tim Parsons

Co-Convenors: James Christian (Canada) and Tsuneo Ono (Japan)

The importance of Strickland and Parsons' *A Practical Handbook of Seawater Analysis* to the development of oceanographic science is difficult to overstate. The first version of the book, *A Manual of Sea Water Analysis*, was published by the Fisheries Research Board of Canada in 1960. Half a century on, we are in a position to examine the role that this manual and its descendants have played in the development of biological and chemical oceanography. This session invites papers on the role that the development and standardization of analytical methods has played in the evolution of oceanography, and the evolution of our understanding of planktonic ecosystems that methodological innovation has catalyzed.

Wednesday, October 27 (9:00-12:10)

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

9:05 ***Introduction by Tim Parsons***

9:15 **Yukihiro Nojiri (Invited)**
Good on board practice for ocean carbon measurement and efforts toward international collaboration (S3-6768)

9:40 **David L. Mackas (Invited)**
"You can learn a lot by looking": The importance of exploratory observation (and occasional surprise) in biological oceanographic discovery (S3-6657)

10:05 **Michio Aoyama and David J. Hydes (Invited)**
The new era of nutrients measurements in seawater with RM/CRM and the new manual: The joint IOC-ICES Study Group on Nutrient Standards (SGONS) and recent progress (S3-6547)

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

10:50 **James R. Christian**
Evolution of marine microbial ecology (S3-6568)

11:10 **K. Banse, S.W.A. Naqvi, J.R. Postel and P.V. Narvekar**
Twists in estimating temporal O_2 changes in oxygen minimum zones from old O_2 data (S3-6514)

11:30 **Frank Whitney and Janet Barwell-Clarke**
Challenges in observing long term trends in oxygen and nutrients: Ocean Station P as an example (S3-6863)

11:50 **Andrew G. Dickson**
Measuring pH in seawater: Prejudice, practice and pitfalls (S3-6868)

12:10 ***Session ends***

S3 Session Oral Presentations

27 October, 9:15 (S3-6768), Invited

Good on board practice for ocean carbon measurement and efforts toward international collaboration

Yukihiro **Nojiri**

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Ocean carbon measurement has a long history, from the GEOSECS era on. Because we require an understanding of the ocean as an important anthropogenic CO_2 sink, global data integration has been carried out under international collaboration. Nowadays many countries including PICES countries are involved in activities dating from the late 1980s. The first pioneer was the US global survey group with the analytical system SOMMA (Single-Operator Multiparameter Metabolic Analyzer) and seawater CRM (certified reference material). The procedure is well documented in the "Guide to Best Practices for Ocean CO_2 Measurement" distributed by CDIAC (Carbon Dioxide Information and Analysis Center). PICES inter-comparison campaigns for dissolved inorganic carbon (DIC) and alkalinity (A_T) were held in 1999 and 2000 included institutions from the US, Canada, Korea and Japan, and contributed to consensus on analytical practices on board or in the laboratory. The situation is different in the case of ocean surface pCO$_2$ measurement. Primary quality control can be done by use of CRM for DIC and A_T. However, calibrated standard gases can not give the necessary quality control for underway pCO$_2$ measurements. This is because the uncertainty in the pCO$_2$ measurement is not in the gas analysis but in equilibration from seawater. The global integration of surface pCO$_2$ data is very challenging and a group under IOCCP (International Ocean Carbon Coordination Project) has organized several chances on site inter-comparisons of ocean pCO$_2$ systems. Results of pCO$_2$ inter-comparisons organize by NIES and a summary of the present status of global data integration activity in ocean surface pCO$_2$ observation (SOCAT: Surface Ocean CO_2 Atlas) will be given.

S3

27 October, 9:40 (S3-6657), Invited

"You can learn a lot by looking": The importance of exploratory observation (and occasional surprise) in biological oceanographic discovery

David L. **Mackas**

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Dr. Timothy Parsons has given ocean science many key papers and several influential books. My talk today is going to focus on a view expressed in his recent book (*The Sea's Enthrall: Memoirs of an Oceanographer*). The basic idea is that many, perhaps most, big advances in biological oceanography have had their origin in observational surprises and fresh looks ("Gee, that's odd. What's going on?"), and not from step-by-step experimental tests of hypothesis. But what kinds and uses of ocean observations are most likely to yield rewarding "surprises"? Here are my candidates:

- New sensors/tools that let us resolve detailed patterns we simply couldn't see before. Established examples are the satellite images of mesoscale features in the ocean. New examples are the use of telemetered tags to reveal fish migration routes, and the use of genomics to sort out mixed populations or to reveal changes in gene expression.

- Merging of contemporary spatial data into multilayer maps. This is an approach I like and have used a lot. Examples are overlays of CUFES transect data (egg abundance of various small pelagic fish) onto satellite images of surface water properties and recent work on eddies in the subarctic Pacific.

- Use of computer tools to reanalyze historical data sets in new ways. Some of my favorite examples are from Beaugrand's work on CPR data from the North Atlantic. Most of our concepts (both sound and crazy) about North Pacific Ocean regimes have also come from this approach. Data mining is also a form of observation. Key characteristics of "mine-able" data are assured quality (so future users can be confident that a "surprise" is real, and not just bad data) and a fair amount of generality and internal diversity (the amount and type of sampling was not so narrowly optimized that the data are informative about only one question).

27 October, 10:05 (S3-6547), Invited

The new era of nutrients measurements in seawater with RM/CRM and the new manual: The joint IOC-ICES Study Group on Nutrient Standards (SGONS) and recent progress

Michio **Aoyama**[1] and David J. Hydes[2]

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Improved comparability and traceability of nutrient data in the world's oceans are needed to improve our knowledge of change in the deep oceans, and for studies of global change. In particular this is necessary to reliably investigate changes in the distribution of nutrient concentrations, and the coupling between the nitrogen, phosphorus and carbon cycles.

A key aim of the joint IOC-ICES Study Group on Nutrient Standards (SGONS) is to establish an "International Nutrients Scale System (INSS)" appropriate for improving the comparability and traceability of nutrient data in the world's oceans. Improvements will be based on the wide spread use of common Reference Materials for Nutrients in Seawater (RMNS).

SGONS also published "Determination of nutrients in seawater with high precision and inter-comparability using gas-segmented continuous flow analysers". This manual is a guide to best practice in performing nutrient measurements at sea. It provides detailed advice on laboratory practice for all of the procedures involved in use of gas-segmented continuous flow analysers (CFA) for the determination of dissolved nutrients (usually ammonium, nitrate, nitrite, phosphate and silicate) at sea. It discusses how RMNS solutions can be used to "track" the performance of a system during a cruise and between cruises. It also provides a format for metadata to be reported. Adoption of these standards will facilitate understanding of changes in ocean chemistry and biology by making data more readily comparable across laboratories.

27 October, 10:50 (S3-6568)

Evolution of marine microbial ecology

James R. **Christian**[1,2]

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The complexity of ocean biogeochemical cycles and the variety of microorganisms and microbial processes that catalyze them are understood today in way that could barely have been imagined a generation ago. New analytical methods for a variety of biogeochemical and microbiological parameters and processes have shown that key processes in the planktonic ecosystem are quite different than the 'classical' view. These biological processes have profound implications for the global biogeochemical cycles of carbon and other elements, and for the viability of ocean fertilization for geoengineering. Reliable measurements of iron and other trace element concentrations and the abundance and composition of dissolved organic matter, U-series nuclide tracers of particle flux, flow cytometry, and observations of marine viruses and of transformations of DMS/DMSP and related compounds are all examples of paradigm-changing methodologies that have emerged in the last 20-30 years. Our understanding of the role of marine microorganisms in global biogeochemical cycles has increased greatly as a result of application of these novel methodologies.

27 October, 11:10 (S3-6514)

Twists in estimating temporal O_2 changes in oxygen minimum zones from old O_2 data

K. **Banse**[1], S.W.A. Naqvi[2], J.R. Postel[1] and P.V. Narvekar[2]

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Our paper relates modifications of the Winkler method as in editions of Strickland and Parsons' handbook to the question of whether the three major open-sea oxygen minimum zones (OMZs) are currently intensifying and expanding. Accurate time series are required for the answer. While electrodes now routinely measure O_2 in the water column, calibration through Winkler titration of water samples is still needed. The end point of the titration used to be detected visually by adding starch as an indicator (Visual Endpoint Detection, VED). In the last two to three decades automated photometric, potentiometric, or amperometric approaches (Automated Endpoint Detection, AED) have become the norm, although VED is still used occasionally. We illustrate that the VED yields O_2 values higher than the AED by 0.05 to 0.10 mL L^{-1} (~ 2-5 mM), a large amount relative to the ambient O_2 concentrations in OMZs, which can be close to zero.

Oceanographic data centers, *e.g.*, the U.S. NODC, have not yet recognized the systematic error (bias), but have only removed variability (outliers, duplicates, *etc.*) by statistical analysis. The early O_2 values are not flagged. Therefore, when O_2 time series at very low O2 concentrations are extended back to 1960, bias in the VED observations from the 1960s onward may falsely make a decadal decline of O_2 appear as real. So, investigators looking into time series of O_2 need to forego averages and interpolations as they are the basis for climatology or the World Ocean Atlases issued by NOAA. The VED bias varies and its size cannot be assessed *post-hoc*. However, because denitrification is restricted to very low O_2 concentrations, VED values > 0.1 mL L^{-1} O_2 (AED, ~ 0.02 mL L^{-1}) accompanied by NO_2^- > 0.2 mM are faulty and should be eliminated.

S3

27 October, 11:30 (S3-6863)

Challenges in observing long term trends in oxygen and nutrients: Ocean Station P as an example

Frank **Whitney** and Janet Barwell-Clarke

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The interior waters of the subarctic Pacific have seen declining oxygen levels over the past several decades. One of the best data sets showing this change comes from Ocean Station P in the NE Pacific, a 54 year time series begun by the Pacific Oceanographic Group. Their establishment of reliable analytical procedures for routine measurements of water properties led to the publication of Strickland and Parsons' "A manual of sea water analysis". Oceanographers in our region naturally referenced this manual whenever procedures were being established for routine chemical or biological measurements.

If oxygen levels are declining, there should also be observable consequences in nutrients. We have 23 years of data from Ocean Station P which is internally consistent enough to show that nutrient storage in the interior waters of the NE Pacific is increasing. Because nutrient changes are much less than oxygen, constant attention to data accuracy is required through the use of standard operating procedures, reference materials and laboratory intercalibrations.

27 October, 11:50 (S3-6868)

Measuring pH in seawater: Prejudice, practice and pitfalls

Andrew G. **Dickson**

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The growing recognition of the potential importance of pH changes in the ocean that result from the dissolution of fossil-fuel derived CO_2 into seawater (ocean acidification) has led to an increasing emphasis on sea water pH measurements. Unfortunately, the field of pH scales and the study of acid-base reactions in sea water has become one of the more confused areas of marine chemistry with multiple different (and sometimes conflicting) approaches to measurement and interpretation co-existing in the literature of the last 25 years.

In this presentation, I shall review the current status of pH measurements in sea water, emphasizing - at least in part - why the current recommended approach is to infer hydrogen ion concentration from a spectrophotometric measurement of an acid-base indicator added to a sea water sample, rather than to measure the pH (hydrogen ion activity?) using a glass electrode cell and standard (NBS) buffers as had been the approach in the first Manual of Seawater Analyis. I shall also endeavor to clarify the likely uncertainty in such a measurement, and to indicate the hazards in overinterpreting existing pH data. In doing so, I will assess the extent to which the undoubted improvements in pH measurements over time have (or can) lead to improvements in our understanding of the oceanic carbon dioxide system overall.

S4 BIO Topic Session
Census of Marine Life - Exploring ocean life: Past, present and future

Co-Convenors: Michael Feldman, Clarence Pautzke, Andrew Rosenberg (U.S.A.) and Sinjae Yoo (Korea)

The Census of Marine Life (CoML) is a global scientific initiative to assess and explain the changing diversity, distribution, and abundance of marine species in the past and present, and to build the capacity to project future diversity. CoML is the initiative of unprecedented size and scope, engaging more than 2000 scientists and ocean professionals from over 80 countries with a common mission towards improving the understanding of life in the ocean. This session will summarize the past 10 years of results from the global CoML program, highlighting specific products and how CoML information and data can be used or applied. It will open with an overview of the entire program and its accomplishments, and then delve deeper into various program components with featured speakers representing Census activities in the Arctic, deep sea, tagging and tracking, HMAP, FMAP, NaGISA, corals, DNA barcoding, microbes, and other exciting projects. Contributors will discuss findings and discoveries with particular attention to the information released at the CoML "Decade of Discovery" events in London just weeks earlier. Discussion will also center on additional ways to apply the newly released CoML information to answer the growing global questions of ocean acidification and climate change, and the role of marine biodiversity information with managing through ecosystems approaches and marine spatial planning. The session will conclude with a consideration of lessons learned from CoML, exploring some of the most successful (and some not-so successful) aspects of the program in the context of developing any future coordinated marine biodiversity efforts.

Friday, October 29 (9:00-13:05)

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

9:05 **Vera Alexander, Patricia Miloslavich and Kristen Yarincik (Invited)**
The Census of Marine Life – Evolution of a decade of worldwide marine biodiversity research (S4-6680)

9:30 **Tim D. Smith (Invited)**
Confessions of a Convert: From fishery biology to historical marine ecology (S4-6845)

9:55 **John Dower**
A World Census of Marine Life on Seamounts (S4-6865)

10:15 **Jose Angel A. Perez, Andrey Gebruk, Alexei M. Orlov, Stanislav Kobyliansky and André Lima**
Surveying the patterns of life in the understudied depths of the South Atlantic: Continuing the legacy of the MAR-ECO project (CoML) into the southern mid-Atlantic ridge (S4-6781)

10:35 ***Coffee/Tea Break***

10:55 **Steven J. Bograd, Barbara A. Block and Daniel P. Costa**
Building a marine life observing system: Lessons from the Tagging of Pacific Pelagics (TOPP) (S4-6864)

11:15 **Elliott L. Hazen, Salvador Jorgensen, Ryan Rykaczewski, John Dunne, Steven Bograd, Dave Foley, Ian Jonsen, Arliss Winship, Daniel Costa and Barbara Block**
Potential habitat shifts in Pacific top predators in a changing climate (S4-6789)

11:35 **John C. Payne**
The future of POST (S4-6821)

11:55	**Reginald Beach, Daphne Fautin, J. Emmett Duffy, Heidi Sosik, John J. Stachowicz, Linda Amaral-Zettler, Tatiana Rynearson, Gustav Paulay and Hilary Goodwin** A national marine biodiversity observing network to inform ecosystem based management and science (S4-6679)
12:15	**Youn-Ho Lee, Sejin Pae, Sung Kim and Sung-Dae Kim** Marine biodiversity in Korea and CoML activities (S4-6869)
12:35	**Paul V.R. Snelgrove (Invited)** Marine biodiversity in the 21st century: Making ocean life count (S4-6842)
13:00	***Summary by Convenors***
13:05	***Session ends***

S4 Posters

S4-6516	**Hiroko Sasaki, Keiko Sekiguchi and Sei-Ichi Saitoh** Cetacean habitat distribution in the eastern Bering Sea and Chukch Sea
S4-6743	**Joon Sang Park, Jang-Seu Ki and Jin Hwan Lee** The genus *Thalassiosira* (Bacillariophyceae): The surface ultrastructures of marginal fultoportula and nuclear rDNA phylogenetic relationship
S4-6819	**Guang-xing Liu, Qiang Jiang, Yan-zhong Zhu and Hong-ju Chen** The taxonomic diversity of planktonic copepods in the North Yellow Sea

S4 Session Oral Presentations

29 October, 9:05 (S4-6680), Invited

The Census of Marine Life – Evolution of a decade of worldwide marine biodiversity research

Vera **Alexander**[1], Patricia Miloslavich[2] and Kristen Yarincik[3]

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3 CoML International Secretariat, Consortium for Ocean Leadership, Suite 420, 1201 New York Ave. NW, Washington, DC, 20005, USA

This paper discusses the origin and development of the ten-year Census of Marine Life, describing the way in which a visionary idea developed into an 80+-nation program. The time was ripe to engage in such a large-scale marine biodiversity incorporating the newest technology. We discuss the planning workshops, the development of the suite of projects as well as the management and support structures. The result was a program with distributed responsibilities, but supported by a strong Secretariat, and outreach and education program, and the database Ocean Biogeographic Information System. Currently in the synthesis stage, the program is expected to promote and influence biodiversity research for the long-term future.

29 October, 9:30 (S4-6845), Invited

Confessions of a Convert: From fishery biology to historical marine ecology

Tim D. **Smith**

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Herein the author confesses his journey from the effects of his early training in fishery biology through a study of the history of that field, and into the brave new world of historical marine ecology and environmental history. He speaks as one previously deluded by an ahistorical training in fisheries biology, then partially enlightened by seeking the history of that ahistorical science, and now more enlightened by historical marine ecology and environmental history. He also speaks as one afraid of what being fully enlightened might feel like, when the enormity of understanding that ahistorical fisheries biology is non-science settles on him. Afraid, but realizing that he had better get on with that task because time surely marches forward even as history struggles to keep up.

29 October, 9:55 (S4-6865)

A World Census of Marine Life on Seamounts

John **Dower**

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Seamounts are widespread features of the world's oceans and can support high levels of biodiversity; they can play an important role in patterns of marine biogeography. They can be highly productive ecosystems acting as feeding grounds for fishes, marine mammals, and seabirds. Seamounts are targeted for resource extraction such as fisheries and minerals exploration, but are ecologically vulnerable to exploitation. Beginning in 2005, the Global Census of Marine life on Seamounts programme (CenSeam) has facilitated a variety of seamount research and been instrumental in connecting, focusing, and collating the efforts of many international researchers. The result is a substantial reduction in the unknowns of seamount biodiversity, and many significant advances towards a global understanding of seamount ecosystems.

The programme has focused efforts on two primary research themes: Theme 1: What factors drive community composition and diversity on seamounts, including any differences between seamounts and other habitat types? And, recognizing the need to advise seamount managers and policy makers on potential fishing and mining impacts, Theme 2: What are the impacts of human activities on seamount community structure and function?

CenSeam results have had a significant positive influence on marine policy development at both national and international levels, leading to improved management of seamount resources and conservation of seamount habitats. This talk will examine the programme results over the past 5 years have, and explore how they have paved the way for the next era of seamount research.

29 October, 10:15 (S4-6781)

Surveying the patterns of life in the understudied depths of the South Atlantic: Continuing the legacy of the MAR-ECO project (CoML) into the southern mid-Atlantic ridge

Jose Angel A. Perez[1], Andrey Gebruk[2], Alexei M. **Orlov**[3], Stanislav Kobyliansky[2] and André Lima[1]

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Since 2006 a team of scientists leaded by South America and Africa, have collaborated on developing a strategy to extend the CoML's MAR-ECO project and scientific approach to the southern mid-Atlantic ridge and adjacent seamount chains (St. Peter's & St. Paul's Rocks, Rio Grande Rise and Walvis Ridge). In November 2009, a consortium established between the A.P. Sloan Foundation, the Shirshov Institute of Oceanology (IORAS - Russia) and the International Centre for Genetic Engineering and Biotechnology (ICGEB), provided the first opportunity for field activity as part of the annual South Atlantic voyage of the R/V Akademik Ioffe. During a 34-day trip that started in Gran Canaria (Spain) and ended in Cape Town (South Africa), a total of 63 sampling events were conducted down to 4700 m depths on the southern mid-Atlantic ridge and Walvis Ridge. Catches obtained by benthic and pelagic (plankton and micronekton) trawls included over 976 animals (mostly fish and cephalopods), currently being studied by taxonomists in Brazil, South Africa and Russia. Over 175 species of fish, 44 cephalopods and around 200 species of benthic invertebrates have been currently identified. Nearly 300 bacteria have been isolated from deep sediment and water samples, 50 of them showing potential for biotechnological uses. Continuous records of whales, birds and the distribution of the Deep Sound Scattering Layer (DSSL) were systematically obtained along the ship´s track and will provide information on the influence of the ridge system on the overlaying epipelagic habitats.

29 October, 10:55 (S4-6864)

Building a marine life observing system: Lessons from the Tagging of Pacific Pelagics (TOPP)

Steven J. **Bograd**[1], Barbara A. Block[2] and Daniel P. Costa[3]

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2 Hopkins Marine Station, Stanford University, Pacific Grove, CA, 93950, USA
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The Tagging of Pacific Pelagics (TOPP) program of the Census of Marine Life has developed the capacity to monitor the distribution, movement, and habitat usage of apex predators (sharks, tunas, seabirds, pinnipeds, cetaceans, turtles) in pelagic ecosystems of the North Pacific using the latest biologging technologies. With more than 4000 tag deployments to date on 23 species, encompassing several million water column profiles, TOPP scientists are pushing the frontiers of biologging science in areas of technological innovation, discovery, exploration, marine conservation and ocean observation. TOPP has provided nearly a decade of ecological and environmental observations from the North Pacific, demonstrating the capacity of large-scale biologging programs to play a critical role in global ocean observing systems. Future collection and assimilation of animal-derived data into circulation and ecosystem models will advance our understanding of how apex marine predators use their ocean environment, allowing predictions of distribution and behavioral changes associated with fisheries exploitation and a changing climate.

29 October, 11:15 (S4-6789)

Potential habitat shifts in Pacific top predators in a changing climate

Elliott L. **Hazen**[1], Salvador Jorgensen[2], Ryan Rykaczewski[3], John Dunne[3], Steven J. Bograd[1], David G. Foley[1], Ian Jonsen[4], Arliss Winship[4], Daniel P. Costa[5] and Barbara A. Block[2]

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As top predators in marine systems are globally in decline due to overfishing and other anthropogenic threats, it is import to assess which species are at greatest risk and which habitats are most important for conservation. Climate change scenarios have predicted an average rise from 1-6°C by 2100 which could effect the habitat and distribution of many marine species. The tagging of Pacific predators (TOPP) project has tagged 4300 animals resulting in 268,000 data-days. We used spatially explicit habitat models (*e.g.* generalized additive mixed models) to examine present-day distributions and foraging habitat of 23 top predator species in the Pacific from 2001-2009 as a function of fixed bathymetric variables, sea surface temperature, wind, Ekman pumping, mixed-layer depth, and chlorophyll *a*. Consequently we used high-resolution climate models from the Geophysical Fluid Dynamics Laboratory to predict potential habitat under future scenarios. We found changes in biodiversity, compression of habitat, and reduced home ranges throughout the Pacific highlighting a few important conservation corridors. While many top predators exhibit plasticity in behavior particularly with respect to temperature, the pelagic prey (*e.g.* deep scattering layers, schooling fish, krill) they feed upon are likely more sensitive to ocean changes and more closely linked to primary production. Increased frequency of El Niño / La Niña events and changes in timing and intensity of upwelling could further affect biodiversity and potential habitat in the north Pacific, particularly the critical habitat within the California current.

29 October, 11:35 (S4-6821)

The future of POST

John C. **Payne**

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The Pacific Ocean Shelf Tracking Program (POST), a field project of the Census of Marine Life, has spent the last decade developing a piece of long-lasting infrastructure: an acoustic tracking array that currently comprises 465 active underwater receivers deployed in lines across the continental shelf between SE Alaska and central California. The tracking array has been aptly called a "macroscope". It has been used for basic exploration of migration patterns of sturgeon, six-gill sharks, Humboldt squid and other species, and for testing hypotheses about survival of juvenile salmon, and about the causes of high mortality in returning adult salmon. New developments include testing with new species and smaller tags, deep-water deployments for tracking bottom-dwelling species, attachment of receivers to cabled ocean observatories and the integration of oceanographic data with tracking data. In addition, we are beginning to deploy mobile receivers on sea gliders and marine mammals in order to test the fixed array, extend the reach of the array into deeper water and more difficult areas, and enable flexible deployments to study animal use of temporary oceanographic features.

S4

29 October, 11:55 (S4-6679)

A national marine biodiversity observing network to inform ecosystem based management and science

Reginald **Beach**[1], Daphne Fautin[2], J. Emmett Duffy[3], Heidi Sosik[4], John J. Stachowicz[5], Linda Amaral-Zettler[6], Tatiana Rynearson[7], Gustav Paulay[8] and Hilary Goodwin[1]

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Experimental research suggests that biodiversity might be a "master variable" useful for determining the health and resiliency of ecosystems and the success of management efforts and objectives. Observations that monitor the status and trends of biodiversity may lead to the development of biodiversity-based, predictive ecosystem management tools to identify mitigation and adaptation responses to climate change and other stressors. A workshop on *Attaining Operational Marine Biodiversity Observations* was held 24-27 May 2010 in Washington, DC to identify the best options for implementing a national marine Biodiversity Observing Network (BON). The three-day workshop, which included 35 participants and seven sponsors, focused on priorities for taxonomic range and resolution, choice of target habitats, and identification of appropriate methodologies. An integrated BON is especially critical to achieve goals of data interoperability and access, standardized sampling approaches, and coordinated federal investment. This talk will address six recommendations that are necessary for the implementation of a national and global BON, including the recommendation to incorporate legacy data. In order for the BON to be comprehensive and monitor trends through time, the observations must be inclusive of and compatible with legacy data, *e.g.* federal, academic, and Census of Marine Life (CoML) studies. In addition to providing valuable data, the CoML fostered strong relationships, such as with the Barcode of Life initiative, which will serve as assets to the development of the BON. The CoML established a baseline of marine biodiversity, which can be built upon by the BON to inform ecosystem based management and science.

29 October, 12:15 (S4-6869)

Marine biodiversity in Korea and CoML activities

Youn-Ho **Lee**, Sejin Pae, Sung Kim and Sung-Dae Kim

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Korea has rich marine fauna and flora thanks to diverse habitats and both warm and cold currents occurring in the surrounding waters of the Korean peninsula which comprise marginal seas of the west Pacific. Activities to census the species in Korean waters were spurred by the enactment of the law 'Conservation and management of the marine ecosystem' in 2006 and have been carried out through several programs such as 'A general survey on marine ecosystem' (2006~2015), 'Marine biodiversity conservation program' (2006~2015), 'Assessment of fauna and flora of uninhabited islands', and 'Investigation on the mudflat ecosystem' (1999~2010). Up until now, approximately 9,700 marine species are reported and listed in Korea Marine Biodiversity Information System (KOMBIS). Bio-geographic information of the species is being filed in Korea Ocean Biogeographic Information System (KOBIS) which is being operated in connection with the CoML database, OBIS. The listed marine species include phytoplankton (diatoms, 1,835; dinoflagellates, 328; silicoflagellates, 6), marine algae (rhodophytes, 566; phaeophytes, 176; chlorophytes, 128), invertebrates (mollusks, 1,882; crustaceans, 1,387; annelids, 513; cnidarians, 324; poriferans, 267; echinoderms, 186), and fishes (1,121 species). It is expected that twenty thousands more species would be found in Korean waters. In addition to the census activities, DNA barcoding and high resolution photographing the Korean species are being carried out. The Korea CoML team help promote the Galatee *Oceans* film in Korea which is scheduled to be on screen in July 2010 as an effort to publicize the CoML activities as well as to enhance the public awareness on the need of marine life conservation.

29 October, 12:35 (S4-6842), Invited

Marine biodiversity in the 21st century: Making ocean life count

Paul V.R. **Snelgrove**

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The immense and opaque Planet Ocean supports one of the largest and poorest known species pools on Earth. The decade long Census of Marine Life program banded together a global network of over 2600 scientists from 80+ nations around the world, who engaged in over 500 research cruises across jurisdictional and disciplinary boundaries to learn what lives in the ocean, what lived in the ocean, and what will live in the future ocean. Census scientists discovered over 1500 new species and counting, scattered from the intertidal to the deep ocean and spanning microbes to fishes, but more importantly advanced our understanding of distribution, diversity and abundance of global ocean life. This novel collaboration utilized technologies from DNA barcoding that provides definitive identifications of even cryptic species, to sonar techniques that rapidly image schools of fish the size of Manhattan, to electronic tags on animals that log oceanographic data for remote regions, tell us where animals move, and how they see the ocean. The amalgamation of over 28 million+ data records from thousands of year ago to recent efforts encompasses all ocean habitats and shows blind spots in our taxonomic and biogeographic knowledge. We now know much more about what lives in the oceans, where they live, and why they live there. Importantly, we are better positioned to place this knowledge in the context of what has been lost, what we stand to lose, and identifying priorities for marine biodiversity research in the next decade.

S4 Session Posters

S4-6516

Cetacean habitat distribution in the eastern Bering Sea and Chukch Sea

Hiroko **Sasaki**[1], Keiko Sekiguchi[2] and Sei-Ichi Saitoh[1]

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Many Cetacean species are found in the eastern Bering Sea and they play the important role in the ecosystem; however, little study has been conducting for cetaceans and knowledge of their habitat is very limited. The objectives of this study are to clarify the distribution and the oceanographic condition of cetaceans in the eastern Bering Sea and then to construct suitable habitat area using satellite remote sensing. Cetacean distribution data is from the results of cetacean sighting surveys during the Hokuyo cruises 2003, 2005-2008 conducted by T/S Oshoro-Maru belongs to the Hokkaido University. From sighting surveys (2003, 2005-2008), we chose 7 species (4 species of baleen whales and 3 species of toothed whale) for this study. To understand spatial and temporal oceanographic characteristics of the cetacean sighting positions, MODIS/AQUA sea surface temperature (SST) and chlorophyll *a* concentration (Chl-*a*), and bathymetry data were analyzed. First we extracted oceanographic data at cetacean sighted positions from each satellite data. Next we cluster and overlay each data to clarify the cetacean distribution. To analysis and cluster each data, we use ArcGIS9.3. The extracted SST data doesn't show obvious species habitat, but overlaid each type of data shows their characteristic habitat. The result shows our analysis fit very well with the sighting result and may indicate pre-whaling cetacean distribution in the eastern Bering Sea.

S4-6743

The genus *Thalassiosira* (Bacillariophyceae): The surface ultrastructures of marginal fultoportula and nuclear rDNA phylogenetic relationship

Joon Sang **Park**, Jang-Seu Ki and Jin Hwan Lee

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The centric diatom genus *Thalassiosira* Cleve, 1873 is one of the most frequently occurred group in marine environments. To date, it is known to about 100 species in the world and many diatomists have suggested various characteristics (areolation, number and position of fultoportula, internal structure of fultoportula) to identify the each species. In the present study, we studied external ultrastructure of fultoportula from 15 species of *Thalassiosira* (e.g. *T. allenii, T. concaviuscula, T. curviseriata, T. eccentrica, T. lundiana, T. mala, T. minuscula, T. nordenskioeldii, T. oceanica, T. pacifica, T. pseudonana, T. punctigera, T. rotula, T. tenera,* and *T. weissflogii*) and their inter-specific relationship using the ribosomal DNA sequences. As a result, we observed similar forms of marginal fultoportula from the selected members of *Thalassiosira* and separated into 8 types based on the marginal fultoportula characteristic. The external tube of marginal fultoportula are more various and suitable characteristic for positive identification of each *Thalassiosira* species. Phylogenetic analyses showed that 18S rDNA tree patterns were compatible with those of 28S rDNA tree. Eighteen studied *Thalassiosira* were separated one another with moderate bootstrap support. Of them, *T. guillardii, T. pseudonana* and *T. weissflogii* were sister taxa, forming the earliest divergent group. Fultoportula-missing *Thalassiosira* (e.g. *T. mala, T. minuscule*, and *T. oceanica*) were widely distributed among clades. In addition, some other morphology-based grouping was not clearly matched with clustering of the rDNA phylogeny. This study expands our understandings on the surface morphological features and nuclear rDNA genetic relatedness regarding the diatom *Thalassiosira* in future.

S4-6819

The taxonomic diversity of planktonic copepods in the North Yellow Sea

Guang-xing **Liu**[1,2], Qiang Jiang[2], Yan-zhong Zhu[2] and Hong-ju Chen[2]

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Based on the data obtained from the four cruises carried out in the North Yellow Sea from 2006 to 2007, combined with previous studies, the planktonic copepod master species list in this area was established, its taxonomic diversity was analyzed, and the funnel plots with 95% confidence 1limits for both the average taxonomic distinctness (Δ^+) and the variation in taxonomic distinctness (Λ^+) of planktonic copepod master species list in the North Yellow Sea were established respectively. The results showed that 44 species of planktonic copepods have been recorded in the North Yellow Sea, they belong to 4 orders, 14 families and 21 genera. The theoretical mean value of the average taxonomic distinctness (Δ^+) based on the planktonic copepod master species list is 82.2. During the investigation, the taxonomic diversity (Δ) and taxonomic distinctness (Δ^*) were higher in Autumn and Winter than that in summer and spring, and the average taxonomic distinctness was higher in summer and spring than that in autumn and winter. The spatial distribution of the four indexes showed significant differences among sampling stations, however, the average taxonomic distinctness of the four seasons were all included in the funnel plots with 95% confidence limits.

S5 FIS Topic Session
Oceanographic and demographic processes affecting the reproductive biology of exploited marine stocks

Co-Convenors: Jin-Yeong Kim (Korea), Paul Spencer (U.S.A.) and Chang Ik Zhang (Korea)

Recent research has demonstrated several complexities in the reproductive processes of marine fish. First, for some cod and rockfish stocks there is evidence of a maternal effect upon larval quality such that larval viability increases with spawner age. Second, some iteroparous stocks show evidence of skipped spawning (i.e., not all mature fish spawn in each year) that is related to environmental conditions and the life-history of the stock. Third, temporal changes in age at reproduction have occurred for some exploited stocks, and researchers are attempting to attribute this pattern to some combination of (1) demographic changes in age and size structure; (2) plastic responses to a changing environment; or (3) evolutionary responses to selective pressures. These complexities indicate that the production of reproductive output of marine stocks may be more complex than typically assumed in population models, and researchers are beginning to more fully incorporate reproductive biology in assessment procedures. The purpose of this session is to review field, laboratory, and modeling studies that may reveal how oceanographic variability, life-history pattern, and fishing pressure may affect the reproductive biology for North Pacific fish stocks, and consider how reproductive biology can best be incorporated into fishery assessment and management.

Wednesday, October 27 (9:00-12:30)

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

9:05 **Edward A. Trippel (Invited)**
Demography, degrees and development of scientific advice for fisheries management (S5-6563)

9:30 **Doug Hay, Megan Moody, Bruce McCarter and Thomas W. Therriault**
Is climate change responsible for changes in the distribution, abundance and spawning of the anadromous eulachon (*Thaleichthys pacificus*) in the North Pacific? A synthesis of available information (S5-6722)

9:50 **Edward D. Weber and Sam McClatchie**
Effect of water-mass properties on the spawning location of Pacific Mackerel *Scomber japonicus* in the California Current (S5-6802)

10:10 **Steven J. Parker and Paul Grimes**
Oogenesis in Antarctic toothfish and implications for fisheries management (S5-6497)

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

10:50 **You Jung Kwon, Chang Ik Zhang and Hyeok Chan Kwon**
Estimation of biological parameters for rock bream, *Oplegnathus fasciatus,* in Jeju marine ranching area of Korea (S5-6613)

11:10 **Cindy J.G. van Damme, Mark Dickey-Collas, Olav S. Kjesbu and Adriaan D. Rijnsdorp**
Fecundity regulation mechanisms in fish with different spawning strategies (S5-6536)

11:30 **Edward J. Dick**
Modeling the reproductive potential of rockfishes (*Sebastes* spp.) (S5-6683)

11:50 **Joel B. Webb, Laura M. Slater, Ginny L. Eckert and Gordon H. Kruse**
Variability in reproductive potential of eastern Bering Sea snow crab, *Chionoecetes opilio*, demographic and environmental effects (S5-6474)

12:10 **Peng Sun, Zhenlin Liang, Wei Yan and Huaming Yu**
Chief cause for the change of fish phenotypic traits: Fishing gear selectivity (S5-6451)

12:30 ***Session ends***

S5 Posters

S5-6508 **Miriam J. Doyle and Kathryn L. Mier**
Species life history patterns and early life ecology as indicators of vulnerability and response of fish populations to climate change in the Gulf of Alaska

S5-6509 **Jie Zheng, Gordon H. Kruse and Bill Bechtol**
Temporal changes in size at maturity and their impacts on stock assessment and fishery management for eastern Bering Sea Tanner crab

S5-6521 **Laura M. Slater, Joel B. Webb, Kirsten A. MacTavish and Douglas Pengilly**
Preliminary analysis of demographic and geographic processes influencing Tanner crab fecundity in the eastern Bering Sea

S5-6632 **Paul Spencer, Sarah Kraak and Edward A. Trippel**
Evaluation of closed areas for fish stocks with maternal effects in larval survival

S5-6634 **Rui-Jing Wan, Feng Zhou and Xiujuan Shan**
Impacts of temperature and salinity on species composition of ichthyoplankton and distribution of fish spawning ground in the Changjiang River estuary and its adjacent waters

S5-6656 **Susanne F. McDermott, Daniel W. Cooper, Jared L. Guthridge, Ingrid B. Spies, Mike F. Canino, Pamela Woods and Nicola Hillgruber**
Effects of maternal growth on fecundity and egg quality of wild and captive Atka mackerel (*Pleurogrammus monopteyrius*)

S5-6713 **Sukgeun Jung and Il Su Choi**
Size-dependent mortality of Pacific cod (*Gadus macrocephalus*) based on their reproduction and growth

S5-6767 (*Cancelled*) **Linsey Arnold, Selina Heppell, Wade Smith and Scott A. Heppell**
Maternal effects in a long-lived, deep-dwelling rockfish, *Sebastes alutus*: Evidence and management implications

S5-6797 **Sandi Neidetcher**
Temporal and spatial patterns of Pacific cod spawning in the Bering Sea between 2005 and 2007; A comparison of spawning patterns between warm and cold years

S5 Session Oral Presentations

27 October, 9:05 (S5-6563), Invited

Demography, degrees and development of scientific advice for fisheries management

Edward A. **Trippel**

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Advancements in our understanding of reproductive and early life processes of marine fishes have been slow to become integrated into stock assessment advice. Factors such as age-based spawning periodicity, nutritional-based indices of gamete quality, and viability of eggs and larvae as a function of spawner experience have been experimentally demonstrated for a number of fish species with medium to extended longevity. A number of experimental and modelling approaches will be summarized that highlight the discrepancies that arise when not accounting for these recent scientific advancements. The significance of building up and maintaining a balanced age structure over decades is critical to sustaining long-term recruitment during periods of environmental uncertainty. Common harvest practices of setting total annual allowable catches often fail to recognize the underlying damage done by size-selective cropping of long-lived species. A greater appreciation for the full suite of biological traits of individuals is required for the conservation and sustainability of fishery resources. Oceanographic changes including temperature variation are also of obvious importance to reproduction. Examples of significant temperature effects and their relative magnitude to age-based effects on timing of spawning, egg size and match-mismatch of larval-prey resources will be given.

Fishery managers are in a position to influence stock biomass and age structure but have no influence over ocean environmental conditions. The inter-play of these factors and capacity for science to assist in resource management will be discussed.

27 October, 9:30 (S5-6722)

Is climate change responsible for changes in the distribution, abundance and spawning of the anadromous eulachon (*Thaleichthys pacificus*) in the North Pacific? A synthesis of available information

Doug **Hay**[1], Megan Moody[2], Bruce McCarter[1] and Thomas W. Therriault[1]

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Eulachons are small (< 25 cm), short-lived anadromous smelt that live in the north-east Pacific, from northern California to the southern Bering Sea. Their spawning habitats are limited to relatively few rivers, probably less than 100 throughout their range. Detailed assessments of abundance are scarce but it is clear that spawning runs have declined precipitously during last two decades, especially in southern rivers. In contrast to their apparent decline in spawning rivers independent offshore surveys in Canada and the USA indicate that eulachon are relatively abundant in some marine areas – with assessments from swept-volume trawl surveys that are one or two orders of magnitude greater than their apparent abundances in major rivers. Several other trends are: (i) the size (length) of spawning fish has declined in the last two decades; (ii) the extent of upstream spawning decreased, with spawning concentrated closer to river mouths; (iii) the timing of spawning is becoming earlier in recent years. Spawn timing is complex. When compared among different rivers in coastal British Columbia, eulachon spawning runs are earlier in many northern rivers. An explanation for this is that eulachon are basically a marine species with larvae that are flushed in to marine waters, often within minutes but probably never more than a few days after hatching. In some northern BC rivers spawning may occur in very cold water, sometimes under ice, but in southern rivers spawning may occur in waters of 10°C or higher. In all areas, however, eulachon larvae enter marine waters approximately during the spring bloom. It follows that the timing of spawning must be earlier in colder waters because of a longer incubation period in the colder water. It also follows that warming of marine waters might deleterious impact the optimal timing of the entry of eulachon larvae in to the sea. Climate change could affect other aspects of eulachon biology. Size of spawning fish has declined in recent years and may reflect

changes in marine trophic conditions, with smaller fish less able to penetrate into upstream spawning habitats. There is also limited evidence that eulachon may now use different spawning habitats, especially small coastal streams where they were not previously noted. If so, such undocumented spawning may explain the apparent discrepancy between the observations of reduced spawning in nearly all traditional rivers.

27 October, 9:50 (S5-6802)

Effect of water-mass properties on the spawning location of Pacific Mackerel *Scomber japonicus* in the California Current

Edward D. **Weber** and Sam McClatchie

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Egg and larval surveys often provide the only fishery-independent data available for assessing stocks of coastal pelagic species such as the Pacific Mackerel *Scomber japonicus*. An important assumption of such assessments is that the entire spawning area has been surveyed. We fit a generalized additive logistic model to explain the probability of capturing mackerel larvae, a proxy for spawning habitat, in the California Current for most years 1951-2009. The probability of capturing mackerel larvae could be explained using water temperature, salinity, and depth at which maximum oxygen concentration occurred. The model indicated conditions were unusually good for mackerel spawning in the Southern California Bight during the 1980s. However, the best habitat for mackerel spawning occurred in Mexican waters near Punta Eugenia in most years. These results indicate spawning grounds in Mexico and the U.S. must be surveyed if the data are to be used in an unbiased assessment.

27 October, 10:10 (S5-6497)

Oogenesis in Antarctic toothfish and implications for fisheries management

Steven J. **Parker**[1] and Paul Grimes[2]

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Histological characterisation of oogenesis in Antarctic toothfish *Dissostichus mawsoni* shows that once development begins, oocytes grow and accumulate at the cortical alveoli stage for at least a year; a feature thought to be atypical in many temperate marine fishes. Individual oocytes are then recruited into the vitellogenic phase over an additional 6–12 month period, resulting in a developed group of oocytes accumulating at the final maturation stage by approximately May each year. Spawning takes place in the austral winter and has not been observed. Evidence of skip spawning was observed for females, resulting in a flatter, right-shifted ogive, increasing the functional difference between male and female ogives. This two-year developmental process and skip spawning means that the age at 50% spawning for females on the Ross Sea slope region is older than the previous estimate of 10 years, occurring at 16.6 years or 133.2 cm. With data available, males show no evidence of skip spawning and on average have a steeper spawning ogive, with an age at 50% spawning of 12.8 years or 120.4 cm.

27 October, 10:50 (S5-6613)

Estimation of biological parameters for rock bream, *Oplegnathus fasciatus,* in Jeju marine ranching area of Korea

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Rock bream, *Oplegnathus fasciatus*, inhabits in the Korean coastal waters, especially, southern sea of Korea and is caught by pole-and-line or gillnet fisheries. This species has a good sale and expensive for sliced raw fish, however, any biological studies for stock assessment and management have not been reported in Korea, yet. Release of fly of rock bream has been conducted to improve biomass in Jeju marine ranching area of Korea. In this study, we estimated biological parameters, such as relationship between length and weight, gonadosomatic index (GSI), growth parameters and *etc.*, for stock assessment and fisheries management using sampled 457 fishes from

August, 2009 to July, 2010. Age character was selected sagittal otolith. Otoliths were mounted and embedded in resin and hardner and cut into ≈0.3 mm sections. Next, they were etched with 0.5% HCl for ≈10–80 seconds and microscopically examined using transmitted light. To analyze the homogeneity of growth rate between left otolith and right otolith from same fish, we selected 30 fishes, randomly, and analyzed simple t-test.

27 October, 11:10 (S5-6536)

Fecundity regulation mechanisms in fish with different spawning strategies

Cindy J.G. van **Damme**[1], Mark Dickey-Collas[1], Olav S. Kjesbu[2] and Adriaan D. Rijnsdorp[1,3]

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Fish show different spawning strategies. On the one hand, capital spawners use energy reserves build up prior to the spawning period to support reproduction, whereas income spawners utilise food resources during the spawning season to support their reproduction. The energy allocation pattern is expected to be related to the mechanism of fecundity regulation, *e.g.* determinate and indeterminate spawning.

This study compares fecundity regulating mechanisms of three fish species – herring, plaice and horse mackerel - in relation to their pattern of energy intake and allocation of energy over somatic growth and reproduction, using empirical information from histological analysis. We show that the capital spawning herring, which have the possibility to switch between spring, autumn and winter spawning, and plaice are determinate spawners, while the income spawner horse mackerel is an indeterminate spawner. The results are discussed against a literature review for other species to explore whether these fecundity regulating mechanisms are fixed at the species level or represent a plastic response to the environment through food availability and energy allocation.

27 October, 11:30 (S5-6683)

Modeling the reproductive potential of rockfishes (*Sebastes* spp.)

Edward J. **Dick**

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The development of sustainable harvest practices requires an understanding of the reproductive potential of exploited fish populations. Models that characterize female fecundity often assume that the number of eggs produced per unit body weight (relative fecundity) is independent of size or age. Relative fecundity in rockfishes (genus *Sebastes*) commonly increases with size, but to a varying degree among species. The reproductive biology of several rockfish species remains poorly understood, and advice is needed regarding proper characterization of fecundity to aid fisheries managers in the development of harvest guidelines. I develop Bayesian hierarchical models to predict fecundity of data-poor rockfish species. The models use information from closely related species to inform predictions of fecundity at size, quantify uncertainty about those predictions, and provide predictive distributions of model parameters for unobserved species. To better understand mechanisms that influence size-specific trends in relative fecundity, I consider state dependent life history models for optimal resource allocation. Patterns of growth, maturation and reproduction observed in rockfishes are consistent with the hypothesis of a trade-off between reproduction and natural mortality.

27 October, 11:50 (S5-6474)

Variability in reproductive potential of eastern Bering Sea snow crab, *Chionoecetes opilio*, demographic and environmental effects

Joel B. **Webb**[1], Laura M. Slater[2], Ginny L. Eckert[1] and Gordon H. Kruse[1]

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Biomass-based reference points currently used in management of the eastern Bering Sea snow crab, *Chionoecetes opilio*, may be insensitive to demographic and environmental variability that results in geographic or temporal variation in the annual production of viable embryos. For example, temperature has pervasive effects on snow crab history affecting female size-at-maturity and extending the duration of embryo incubation from annual to biennial at temperatures below ~1°C. To develop improved indices of reproductive potential, we measured fecundity of mature female snow collected during the U.S. eastern Bering Sea bottom trawl surveys in 2007 and 2008. Snow crab fecundity increased significantly with female size and model-estimated mean fecundities varied between 2007 and 2008. Fecundity was higher in 2008 compared to 2007 for primiparous (brooding first egg clutch) females and lower in 2008 compared to 2007 for multiparous (brooding second or subsequent egg clutch) females. Among multiparous females, fecundity also decreased with increasing age, as inferred from shell condition. Patterns of variation in indices of egg clutch fullness collected during stock assessment surveys from 1978 and 2008 reinforce our findings and suggest large temporal variation in egg production. The mechanisms underlying interannual variability in egg production are not well known; but our ongoing studies will investigate the potential role of variability in spawning stock demography and environmental factors.

27 October, 12:10 (S5-6451)

Chief cause for the change of fish phenotypic traits: Fishing gear selectivity

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Recently, great changes are taking place in the phenotypic traits of exploited fish, mostly referring to growth traits, such as smaller size-at-age and earlier age-at-sexual maturation. At present, analyses of the reasons for these phenotypic changes are not systematic or empirical, and such changes are merely considered to be the result of fish self-adaptation. Besides, it is believed that as long as the exploited fish could be confined the phenotypic traits of fish would restore. However, various environmental factors affect the growth of fish, besides, fishing gear has directed selectivity to fish populations and individuals, and such selectivity which has long-term effect on fish population is the major reason for the irreversible change of fish phenotypic traits.

S5 Session Posters

S5-6508

Species life history patterns and early life ecology as indicators of vulnerability and response of fish populations to climate change in the Gulf of Alaska

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Time-series of fisheries, biological, oceanographic and climate data have been accumulated for decades in the Gulf of Alaska (GOA) and contribute substantially to our knowledge of species reproductive and recruitment processes, and environmental forcing on fish abundance. Synthesis of an ongoing GOA ichthyoplankton time-series, and concurrent climate and ocean data, reveal synchronies and similarities in abundance trends and links to environmental variables that reflect life history variation among species, particularly in early life history characteristics. Similarities in response to environmental forcing are apparent when there are similarities in early life history exposure to the environment. This exposure-response coupling suggests that species life history groups may represent "functional assemblages" that have common vulnerabilities, resilience, and potential response to climate change. It also emphasizes the value of multi-species (and multiple life stage) synthesis of biological and ecological patterns in informing our mechanistic understanding of fish species response to climate change. A pilot project is underway that includes: 1) the delineation of species groups by ordination or numerical classification of a species x life history traits matrix; 2) the ecological characterization of these species groups and examination of within group synchrony in species abundance metrics; 3) the investigation of links between time-series of species abundance metrics and suites of environmental variables; and 4) the evaluation of species life history groups as potential proxies for common functional responses to environmental change. Preliminary results from this pilot project will be presented.

S5-6509

Temporal changes in size at maturity and their impacts on stock assessment and fishery management for eastern Bering Sea Tanner crab

Jie **Zheng**[1], Gordon H. Kruse[2] and Bill Bechtol[3]

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Tanner crabs (Chionoecetes bairdi) in the eastern Bering Sea are primarily distributed in the Bristol Bay and around the Pribilof Islands. Summer trawl survey data in these two areas were used to estimate mean sizes at maturity for female Tanner crab from 1975 to 2010 and sizes at 50% morphometric maturity for male Tanner crab from 1990 to 2010. Estimated mean sizes at maturity for females showed a statistically significant downward trend in both areas. Sizes at 50% morphometric maturity for males have declined significantly since 1990, in the Bristol Bay only. In the Bristol Bay, the distribution centers of female Tanner crab have shifted southwest over time and the decrease in female mean size at maturity was significantly related to changes in longitude and bottom depths. Declines in size of maturity have some potential negative biological consequences: 1) large-growing males experience disproportionately higher fishing mortality rates than small-growing males that mature at sublegal sizes; 2) small-sized mature females are less fecund and 3) a smaller proportion of males grow to legal size and handling mortality of sublegal males increases as the proportion of legal to sublegal males declines. With the recent maturity at smaller sizes, reduction of the current harvest rates and size limit while maintaining current fishing gear requirements will result in higher yield and higher male spawning biomass per recruit than those under the current harvest strategy.

S5-6521

Preliminary analysis of demographic and geographic processes influencing Tanner crab fecundity in the eastern Bering Sea

Laura M. **Slater**[1], Joel B. Webb[2], Kirsten A. MacTavish[3] and Douglas Pengilly[1]

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Tanner crab (*Chionoecetes bairdi*) are a commercially important species in the eastern Bering Sea, where males of a minimum legal size are harvested. A commercial fishery began in 1965 and the domestic harvest of mature male crabs peaked during the 1977/78 season at 30,232 metric tones (t). The mature male biomass and harvest has been highly variable and the stock was declared overfished in 1999. Under a rebuilding plan, Tanner crab abundance rebounded, and the stock was subsequently declared rebuilt allowing for a commercial fishery to resume in two management areas divided by 166°W longitude. However, in recent years, abundance has declined and the stock was declared overfished again in 2009. While a threshold of mature female biomass is required to open this fishery, harvest is based on male biomass. The effect of a males-only fishery on female reproductive output and subsequent recruitment patterns is still largely unknown. An index of female reproductive potential, clutch fullness score, is determined annually during a stock assessment survey, and we have developed relationships between clutch fullness score, clutch volume and fecundity, which we will present here. The utility of the clutch fullness score method of estimating female reproductive output will be discussed and variability among female crab in fecundity and egg size will be analyzed relative to female size, age post terminal molt (using shell condition as a proxy), and location (based on the two management areas).

S5-6632

Evaluation of closed areas for fish stocks with maternal effects in larval survival

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Recent studies have indicated that the viability of larvae for some species, including Pacific rockfish (genus *Sebastes*) and Atlantic cod (*Gadus morhua*), may depend upon spawner age. These maternal effects imply that the age structure of the spawning population is a management consideration, as older fish would be expected to contribute disproportionately to the reproductive output. Because even moderate amounts of fishing mortality can dramatically affect spawner age structure, closed areas have been proposed as a management tool that would allow old spawners to accumulate. However, the efficacy of closed areas in meeting management goals for stocks with maternal effects has not been evaluated. In this study, a management strategy evaluation (MSE) was developed to evaluate closed areas for simulated "rockfish-like" and "cod-like" populations with maternal effects in larval survival. The MSE includes options for characterizing how density dependence may occur across spatial areas, the linkage of recruitment variability between areas, and the degree of adult movement between closed and open areas. Closed area management was compared to a spatially-aggregated harvest control policy with respect to performance metrics such as yield, relative biomass, and relative error in estimated reference points such as F_{msy} (the fishing rate producing maximum sustained yield). Additionally, the effects of longevity and adult movement, which differed substantially between the simulated "rockfish-like" and "cod-like" populations, upon the performance of closed areas were also evaluated.

S5-6634

Impacts of temperature and salinity on species composition of ichthyoplankton and distribution of fish spawning ground in the Changjiang River estuary and its adjacent waters

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During June, August and October 2006, there were 3 multi-disciplinary surveys carried out in the Changjiang River estuary and its adjacent waters (122°00′–125°00′E, 27°50′–34°00′N) by R/V Beidou to study the species composition and abundance of ichthyoplankton (including fish eggs, larvae and juveniles), the spatial distribution of fish spawning ground and their relationship with habitat factors. 29, 29 and 25 grid stations were sampled in June, August and October, respectively. The ichthyoplankton samples were collected by horizontally towing with a macro-plankton net (mouth diameter 80 cm, length 270 cm, mesh size 0.50 mm) at the sea surface, and the towing speed was 3.0 n mile/h at each sampling station. The towing was lasted for 10 minutes. After hauling for each station, habitat factors including temperature and salinity were measured by SeaBird-25 CTD. Samples were preserved in 5% formaldehyde solution immediately after sampling for analysis in laboratory. In fact, the trawl speed could not be accurately evaluated due to the effects of ocean current and wind wave, so the amount of ichthyoplankton was evaluated by actual number of the sampling haul in each station. Ichthyoplankton collected were divided into dominant species, important species and main species by index of relative importance (*IRI*). The results were as follows: 71 species (1 200 fish eggs and 2 575 fish larvae and juveniles) were collected during 3 cruises, 59 species were correctly identified to species level, and which belonged to 50 genera, 37 families and 9 orders; 5 species only could be identified to genera level, 1 species only identified to family level and 6 species identified to order level. 59 species identified to species level and 5 species identified to genera level were divided into three ecological patterns, i.e., brackish water species, neritic water species and coastal water species. Warm water species were 34 species in 59 species identified to species level, accounting for 57.63%, warm temperature species were 25 species, accounting for 42.37%. According to the analysis of *IRI*, the dominant species were *Engraulis japonicus* (in June and August, that was important species in October), *Scomber japonicus* (in August), and *Johnius grypotus* (in October) during the survey; important species were *Cynoglossus joyneri* (in June and August), *Trichiurus lepturus* (in June, August and October), *Gonorhynchus abbreviatus* (in August), *Stolephorus commersonii* (in October), *Saurida undosquamis* (in October) and *Saurida elongate* (in October), and main species were 12 species in June, 9 species in August and 10 species in October respectively. The amount of fish eggs and larvae of the dominant species, important species and main species (28 species) were 97.50% and 97.13% of the total amount of fish eggs and larvae, respectively, which were the important composition of fish eggs and larvae in the Changjiang River estuary and its adjacent waters.

In June and August of 2006, when compared with that in corresponding months in 1986, the habitat factors of temperature and salinity in the Changjiang River estuary was greatly changed as follows: high salinity water in outer sea was closing to gaining upon coastal area, sea surface salinity obviously increasing; sea surface temperature obviously decreased in June, but significantly high in August. The run-off of the Changjiang River greatly reduced for long-term drought in summer 2006, which was responsible for the great changes of habitat factors in the Changjiang River estuary and its adjacent waters. The habitat of the Changjiang River estuary was greatly changed, and significantly influenced spawning, breeding and the spatial distribution of spawning ground of neritic water species, such as *Sardinella zunasi*, *Thryssa kammalensis*, *Thryssa mystax*, *Setipinna taty* and *Stolephorus commersonii* ect, and coastal water species, such as *Ilisha elongate* and *Konosirus punctatus* ect.

S5-6656

Effects of maternal growth on fecundity and egg quality of wild and captive Atka mackerel (*Pleurogrammus monopteyrius*)

Susanne F. **McDermott**[1], Daniel W. Cooper[1], Jared L. Guthridge[2,3], Ingrid B. Spies[1], Mike F. Canino[1], Pamela Woods[1] and Nicola Hillgruber[3]

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Tradeoffs in energy allocation between growth and reproduction can result in variation of the reproductive potential in fish with differing growth patterns. Spawning biomass is often used as a proxy for reproductive potential, based on the assumption that fecundity is directly proportional to body weight. We examined variation in the reproductive potential of Atka mackerel (*Pleurogrammus monopterygius*) by studying the effect of differential growth and condition patterns on fecundity, atresia, and egg energy. Fecundity and egg energy were determined from two geographic areas in the Aleutian Islands, Alaska: Seguam Pass and Amchitka Island, and compared to those of fish held in captivity. Atka mackerel showed distinct growth and condition differences with weight at length and length at age being the highest for captive fish, intermediate at Seguam Pass, and smallest at Amchitka Island. For wild fish, potential and realized fecundity at length or age were significantly higher at Seguam Pass than at Amchitka whereas the fecundity at weight, atresia, and batch fecundity did not differ by area. Egg dry weight of captive fish was higher than for wild fish, whereas batch order did not significantly affect egg dry weight. Increased potential fecundity, realized fecundity, and egg quality in Atka mackerel females was strongly related to body size, indicating that growth differences and maternal feeding success impact fecundity and egg quality of Atka mackerel. Therefore changes in growth and condition patterns need to be taken into account to accurately estimate reproductive potential for this species.

S5-6713

Size-dependent mortality of Pacific cod (*Gadus macrocephalus*) based on their reproduction and growth

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We introduce a matrix projection method to estimate size-dependent instantaneous rates of natural mortality (M) for Pacific cod (*Gadus macrocephalus*) based on their fecundity and growth. The parameters of the first row of the Leslie matrix, which represent fecundity, was estimated by combining a von Bertalanffy growth equation covering all life stages, a logistic equation of maturity with body size, and a relationship between body size and fecundity, which were derived from otolith and gonad analyses of cods collected from the East Sea of Korea from 2003 to 2007. For survival rates in the Leslie matrix, we derived a theoretical mortality curve after assuming M as an inverse function of total length and long-term equilibrium status of stock. The estimates of age-specific M ranged from 9.1 yr^{-1} for age-0 cod to 0.49 yr-1 for age-8 cod, on average for age-1 to 8 yr, 0.82 yr^{-1} which is greater by a factor of 4 than the estimate derived by Pauly's equation, 0.2 yr^{-1}. Our estimate of q is sensitive to the embryonic survival rate, which could vary greatly depending on water temperature, but we assumed as a constant of 10%. However, sensitivity analyses showed that, except age 0, derived age-specific M is robust with varying embryonic survival rate from 1% to 100%. Moreover, comparisons of the length frequencies derived from our Leslie matrix with those derived from catch data suggested that our theoretically-derived M is reliable enough for the purpose of stock assessment.

S5-6767 (*Cancelled*)

Maternal effects in a long-lived, deep-dwelling rockfish, *Sebastes alutus*: Evidence and management implications

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Research on nearshore rockfish species (*Sebastes* spp.) has shown positive relationships between maternal age and measures of offspring quality, including volume of the oil globule, time to starvation and growth rate. Females of different age classes also spawn at different times; increasing the probability that larvae will encounter favorable environmental conditions over the reproductive lifespan of the female. Combined with evidence of fishing-induced population age truncation, age-related maternal benefits on offspring survival highlight an important concept in life history evolution that ties to fisheries management: the importance of age structure to spawning stock population dynamics, and the potential impact of management strategies based solely on average biomass. Our investigation into age-specific reproductive characteristics of Pacific Ocean perch (POP), *Sebastes alutus*, confirm a significant relationship between maternal age and offspring quality as well as differential timing of larval release in this long-lived, deep-dwelling rockfish. We also evaluated the management implications of maternal effects in this and other *Sebastes* species by comparing the traditional biomass-based management strategy to a proposed age structure-based management strategy. Preliminary results of the management strategy evaluation indicate that management for age structure, in addition to biomass, may be more precautionary in species with limited assessment data, triggering intervention before large reductions in catch are required to sustain the population. Considering age structure reference points in fisheries management may present one avenue towards reconciling biomass-based fisheries management with the ecology of exploited populations.

S5-6797

Temporal and spatial patterns of Pacific cod spawning in the Bering Sea between 2005 and 2007; A comparison of spawning patterns between warm and cold years

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Knowledge of the timing and location of spawning is often important in making fishery management decisions, in assessing changes in abundance and distribution, and in designing future studies. Pacific cod are an important commercial and ecological species in the Bering Sea though, with semi-demersal eggs that elude plankton survey nets, little is known about the distribution of eggs and early larval stages. Laboratory experiments have identified thermal sensitivity of eggs, larvae, and juvenile Pacific cod (Laurel *et al.*, 2008) while in the Bering Sea, climate conditions have been linked to oceanographic regimes shifts which occur at varying scales (Hollowed *et al.*, 2001.) Between 2003 and 2005 members of the Fisheries Interaction Team with the Alaska Fisheries Science Center worked to develop a visual maturity key for Pacific cod. The visual maturity key had been deployed with Fisheries Monitoring and Analysis Division groundfish observers working on commercial vessels in the Bering Sea since 2004. Observer collected maturity data are being analyzed to identify patterns of Pacific cod spawning phenology and to map Pacific cod spawning locations. Data collected between a warm year (2005) and a cold year (2007) are compared to assess variability in spawning patterns for these years.

S6 FIS/BIO Topic Session
Observations of ecosystem mixing under climate change

Co-Convenors: Sanae Chiba (Japan), John Field (U.S.A.), Jin-Yeong Kim (Korea), Franz J. Mueter (U.S.A.) and Laura Richards (Canada)

As the ocean environment changes, we expect species to respond by changing their distribution. Species could expand into habitats newly made available to them and avoid or shrink their abundance in habitats that are no longer viable. Because species respond to these environmental changes at different rates, previously isolated species now interact. We coin the term "ecosystem mixing" to describe the pulling apart and re-mixing of ecosystems and species interactions in a changing environment. For example, Humboldt squid, expanded their range northward along the west coast of North America in 2009, encountering new prey species, potentially including important stocks of juvenile salmon. In this session, we consider the consequences of ecosystem mixing. Papers are invited that describe case studies of ecosystem mixing from a physical, biological and/or socio-economic perspective, especially as they impact the predators and/or prey of key species (such as those important for fishery harvests). Selected oral and poster presentations will be considered for publication in a peer-reviewed journal.

Thursday, October 28 (9:00-18:00)

9:00	***Introduction by Convenors***
9:10	**Hjálmar Hátún (Invited)** Large-scale shifts in the North Atlantic bio-geography forced by the subpolar gyre (S6-6628)
9:50	**Solfrid Sætre Hjøllo, Geir Huse, Morten D. Skogen and Einar Svendsen** Modeling secondary production in the Norwegian Sea with a fully coupled physical-primary-secondary production model system (S6-6604)
10:10	**Jürgen Alheit and Carola Wagner** Impact of Atlantic Multidecadal Oscillation (AMO) on NE Atlantic ecosystems (S6-6843)
10:30	***Coffee/Tea Break***
10:50	**Lorenzo Ciannelli and Mary Hunsicker (Invited)** Predator-prey spatial distribution patterns and spatial overlap in relation to climate driven environmental variability (S6-6593)
11:30	**Jin Yeong Kim, Heeyong Kim and Il Su Choi** Variation in occurrence of warm and cold water species in response to climate changes off Korea (S6-6827)
11:50	**Robinson Mugo, Sei-Ichi Saitoh, Akira Nihira, Tadaaki Kuroyama, Takahiro Toyoda, Shuhei Masuda, Hiromichi Igarashi, Toshiyuki Awaji** and **Yoichi Ishikawa** Potential impact of global warming on skipjack tuna habitat in the western North Pacific (S6-6635)
12:10	**Luke D. Whitman, Neal E. McIntosh, Scott A. Heppell and Kelly J. Benoit-Bird** Variation in the distribution and energy density of juvenile walleye pollock in the southeastern Bering Sea (S6-6513)
12:30	***Lunch***
14:00	**William Gilly and Unai Markaida (Invited)** Adaptability and plasticity of Humboldt squid, *Dosidicus gigas*, in conjunction with environmental perturbation (S6-6832)

14:40 **John C. Field, Ken A. Baltz, William Matsubu, Graham E. Gillespie, Julia S. Stewart, William F. Gilly and William A. Walker**
Foraging ecology of the Humboldt squid in the California Current (S6-6787)

15:00 **Gregory Kowalke, David L. Mackas and Julie Keister**
Do circulation patterns make the eastern North Pacific especially susceptible to zoogeographic shifts? (S6-6791)

15:20 **Vladimir Kulik**
The role of mesopelagic fishes in ecosystem vertical mixing in the north western Pacific (S6-6860)

15:40 ***Coffee/Tea Break***

16:00 **Trond Kristiansen, Charles Stock, Ken Drinkwater and Enrique N. Curchitser**
Effects of climate change on the phenology of spring blooms and consequences for the survival of larval cod (S6-6559)

16:20 **Alexei I. Pinchuk and Kenneth O. Coyle**
Emergence of the Arctic hyperiid *Themisto libellula* on the southeastern Bering Sea shelf as a result of the recent cooling and their potential impact on pelagic food web (S6-6573)

16:40 **Sonia Batten and Anthony Walne**
Variability in northwards extension of warm water copepods in the NE Pacific (S6-6564)

17:00 **Harald Loeng, Hjálmar Hátún, Jens Christian Holst, Mark Payne and Aril Slotte**
The rise and fall of the northern blue whiting stock (S6-6532)

17:20 **Aimee Keller, Victor Simon, W. Waldo Wakefield, Keith Bosley, M. Elizabeth Clarke, John A. Barth and Stephen D. Pierce**
Expansion and shoaling of the oxygen minimum zone off the U.S. west coast in relation to demersal fish distribution and biomass (S6-6814)

17:40 **Rong-shuo Cai, Hongjian Tan, Qing-liang Yang and Ji-long Chen**
The response of sea surface temperature in the offshore area of China to variations in the East Asian Monsoon under global warming and its marine ecological effects (S6-6507)

18:00 ***Session ends***

S6 Session Oral Presentations

28 October, 9:10 (S6-6628), Invited

Large-scale shifts in the North Atlantic bio-geography forced by the subpolar gyre

Hjálmar **Hátún**

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The biologically productive North Atlantic Ocean, including adjacent seas, hosts some of the largest fish stocks and thus fisheries, in the world. Large subarctic-subtropical water-mass exchanges in the NE Atlantic, related to the strength of the subpolar gyre, enforce a bottom-up control of the open-ocean marine ecosystem, which is characterized by a highly variable influence of the Arctic-boreal and Lusitanian-boreal faunas in this area. This has been demonstrated using four trophically connected levels in the food chain - phytoplankton, zooplankton, blue whiting, and pilot whales. A very long record on pilot whale catches in the Faroe Islands and relevant environmental indicators reveal that the coherent bio-physical fluctuations have persisted for at least 300 years. Deep water formation in the Labrador-Irminger Seas regulates the size and circulation strength of the subpolar gyre on inter-decadal time-scales, but the regional wind driven Sverdrup transport in the NE Atlantic is important for the characteristic sub-decadal variability. This short-term variability is reflected in the shelf ecosystems around the NE Atlantic and possible basin-shelf exchanges will be discussed. Although the presence of strong meridional overturning circulation (MOC) distinguishes the high-latitude Atlantic from the Pacific, there are parallels between the subpolar-subtropical gyre interactions in both oceans.

28 October, 9:50 (S6-6604)

Modeling secondary production in the Norwegian Sea with a fully coupled physical-primary-secondary production model system

Solfrid Sætre Hjøllo, Geir **Huse**, Morten D. Skogen and Einar Svendsen

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The copepod *Calanus finmarchicus* is the dominant species of the mesoplankton in the Norwegian Sea, and constitutes an important link between the phytoplankton to the higher trophic levels in the Norwegian Sea food chain. An individual-based model for *C. finmarchicus*, based on superindividuals and evolving traits for behavior, stages *etc.*, are two-way coupled to a physical-biological model system. One year of modeled *C. finmarchicus* spatial distribution, production and biomass are compared to point-wise and integrated observations, and found to represent these satisfactory. Sensitivity tests of model setup (i.e. no of superindividuals, initial values of traits for behavior and food preferences) show that the modeling system is robust and provides a valuable tool for studies of ecosystem responses to causative forces such as fish predation or climate change. From a longer simulation, interannaul variability and regional differences in biomass and production are studied.

28 October, 10:10 (S6-6843)

Impact of Atlantic Multidecadal Oscillation (AMO) on NE Atlantic ecosystems

Jürgen **Alheit** and Carola Wagner

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The AMO is a mode of multi-decadal climate variability whereby warm and cold periods alternate over large parts of the northern hemisphere. Anecdotal records since the late 19th century and long-term time series since the early 20th century indicate that multi-decadal changes in sea surface temperature associated with the dynamics of the AMO have impacted on dynamics of zooplankton, intertidal benthos and fish populations of NE Atlantic ecosystems . During the warm periods (i) in the late 19th century, (ii) from about 1930-1960 and (iii) since the 1990s, many zooplankton, benthos and fish species have extended their northern boundaries. Southern species

have been observed in the North and Baltic Seas during these times, but were not recorded in the intervening periods. Examples for these apparently climatically driven changes in species distribution and abundance will be presented and comparisons will be made to similar phenomena in the North Pacific.

28 October, 10:50 (S6-6593), Invited

Predator-prey spatial distribution patterns and spatial overlap in relation to climate driven environmental variability

Lorenzo **Ciannelli** and Mary Hunsicker

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There is a growing interest both in general ecology and in management to understand the links between predator-prey interactions and environmental variability. Marine predators are opportunistic in their feeding habits, compared to many terrestrial species. It follows that changes in marine species distribution patterns can cause the establishment of new trophic interactions or reinforce existing ones, due to shifts in predator-prey spatial overlap. Identifying how predator-prey spatial overlaps may change and the potential consequences requires knowledge of species' spatial dynamics. This is a complex task, as species can shift their distribution due to a variety of interacting and scale-dependent processes, broadly grouped as density-independent, due to environmental variability, and as density-dependent, due to variation in their own abundance. In this talk we will present three case studies, collectively focusing on how climate and demography affect the spatial distributions of important predator-prey species, and on the relative impacts that these changes have on species spatial overlap and trophic interactions. The three case studies include: 1) juvenile and adult Atlantic cod (*Gadus morhua*) in the Barents Sea; 2) capelin (*Mallotus villosus*) and Pacific cod (*Gadus macrocephalus*) in the Bering Sea; and 3) arrowtooth flounder (*Atheresthes stomias*) and juvenile pollock (*Theragra chalcogramma*) in the Gulf of Alaska. All three case studies are from sub-arctic regions, which over the last several decades have been the stage for high climate-related habitat variability with effects on species temporal and spatial dynamics.

28 October, 11:30 (S6-6827)

Variation in occurrence of warm and cold water species in response to climate changes off Korea

Jin Yeong **Kim**[1], Heeyong Kim[1] and Il Su Choi[2]

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Annual cycles of the major commercial fisheries landings show temporal variability and detectable changes in the magnitude of catches and in the timing of first occurrence of the fisheries resource. We examined seasonal and regional variability in the occurrence of fisheries resources in the eastern, western and southern waters of Korea in response to climate change and global warming. Monthly and regional landings data for anchovy (*Engraulis japonicus*), Pacific herring (*Clupea pallasii*), Paralichthidae, Pleuronectidae and Pacific cod (*Gadus macrocephalus*) during 1990-2009 were examined to compare changes in representative small pelagics and flatfish in warm water and demersal fish in the cold water area. Anchovy landings during the winter season have increased above 20% of the yearly total catch after 2000 because warming sea surface temperatures have resulted in the northward movement of wintering grounds into waters along the southern coast of Korea. Pacific herring have shown an increasing trend with the southward extension of their range from the eastern waters of Korea since 2000, and have also extended their seasonal occurrence into spring. Landings of Paralichthidae and Pleuronectidae decreased regionally in the southern area and their major distribution areas moved to the western and eastern areas, respectively, with the restricted seasonality during spring. Pacific cod landings increased recently and extended seasonally from winter into summer and autumn in the mid-western and southeastern area, where cold bottom waters expanded. Monthly and regional appearance for each species demonstrated a significant difference between the early 1990s and the late 2000s. Changes in the area of distribution and in the seasonality of each species reflect different habitat preferences of fisheries resources in terms of bottom and surface water temperatures. These changes make the Korean fishery vulnerable to continued climate change.

28 October, 11:50 (S6-6635)

Potential impact of global warming on skipjack tuna habitat in the western North Pacific

Robinson **Mugo**[1,2], Sei-Ichi Saitoh[1], Akira Nihira[3], Tadaaki Kuroyama[3], Takahiro Toyoda[4], Shuhei Masuda[4], Hiromichi Igarashi[5], Toshiyuki Awaji[5,6] and Yoichi Ishikawa[6]

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The potential impact of global warming on skipjack tuna habitat in the western North Pacific was studied using satellite remotely sensed and 4-dimensional variational (4D-VAR) data. Fishery presence-only monthly resolved data (March-November, 2004; February-June, 2005) for skipjack tuna were used. Sea surface temperatures (SST), chlorophyll *a* (CHL-*a*), diffuse attenuation coefficient (K490), sea surface heights (SSH) and surface wind speed (WS) were used as skipjack tuna habitat indicators. Based on IPCC projections, we simulated global warming by raising SSTs by 1°C, 2°C and 4°C. The 2004-2005 skipjack tuna and environment data layers were used to make ecological niche factor analysis (ENFA) models and generate habitat suitability indices (HSI) from February-November. ENFA models were used to predict HSI from 2006-2009 and also based on simulated SSTs. Comparisons between HSIs generated by base models and those from models using simulated SSTs were made using empirical cumulative distribution function and the Kolmogorov-Smirnov test. Distributions of mixed layer depths (MLD) derived from a 4-dimensional variational (4D-VAR) ocean data assimilation system were also examined. Results indicate global warming is likely to expand suitable habitats of skipjack tuna northwards, from February-June. We found significant changes in habitats, associated with rise in SST in this period. After July, SST rise had a negative or marginal impact on HSI. Skipjack tuna habitats were consistent with declining MLDs from February to November.

28 October, 12:10 (S6-6513)

Variation in the distribution and energy density of juvenile walleye pollock in the southeastern Bering Sea

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Juvenile walleye pollock (*Theragra chalcogramma*) are one of the primary prey items for bird and mammal predators in the Bering Sea, while the adults support a major commercial fishery. An understanding of the environmental factors that determine juvenile pollock distribution and energy density is needed to estimate the effects that climate variation may have on pollock and their predators. During the summers of 2008 and 2009, transect surveys were conducted near the Pribilof Islands in the southeastern Bering Sea to collect forage fishes and environmental data while seabirds and fur seals were rearing their young on the islands. In 2008, juvenile pollock were found primarily near the islands and catches were dominated by age-0 individuals. In 2009, juvenile pollock were significantly more abundant although both age-0 and age-1 fish were caught farther from the islands. Age-0 pollock caught in 2009 were larger and had higher energy density than those caught in 2008. However, the relationship between size and energy density was the same during the two years, suggesting that age-0 pollock hatched sooner in 2009. The energy density of individual pollock from both years varied spatially, suggesting that juvenile pollock abundance, numerical density, and individual quality as prey are all affected by variation in the environment. In addition, pollock with higher energy density were usually found in the densest aggregations of prey fishes. All of these factors are likely to affect habitat use by predators seeking to optimize their use of this important prey resource.

28 October, 14:00 (S6-6832), Invited

Adaptability and plasticity of Humboldt squid, *Dosidicus gigas*, in conjunction with environmental perturbation

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Dosidicus gigas became established off central California after the 1997-98 El Nino and has since invaded waters of the Pacific Northwest where it may exert significant impacts on important fish species. Reasons for the California invasion or subsequent range expansion are not well understood, but environmental change is probably an important factor. El Niño is a powerful environmental perturbation in the eastern Pacific where *Dosidicus* is endemic. During the strong 1997-98 El Niño, the commercial fishery in the Gulf of California collapsed, because squid abandoned the traditional fishing grounds off Santa Rosalia and Guaymas. An El Niño for 2010 was predicted in late 2009, and a warm anomaly affected the upper water column in the Gulf during the early months of 2010. But by late spring it was evident that the El Niño-like event was dissipating. We carried out extensive field work in the Gulf during May-June 2010 focused on the ecology of *Dosidicus gigas*. Large squid were absent from the Guaymas Basin, and they were replaced by much smaller squid that were sexually mature. Large squid had moved north into the midriff islands region where they were commercially harvested for the first time. Tidal upwelling and mixing in this productive region may thus provide a refuge from El Niño. A variety of data will be presented that illustrate the adaptability and reproductive plasticity of *Dosidicus* in conjunction with the 2010 El Niño-like event. We propose that these factors are also important for the pulsatile migrations and range expansion of this species.

28 October, 14:40 (S6-6787)

Foraging ecology of the Humboldt squid in the California Current

John C. **Field**[1], Ken A. Baltz[1], William Matsubu[2], Graham E. Gillespie[3], Julia S. Stewart[4], William F. Gilly[4] and William A. Walker[5]

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Since 2002 the typically subtropical Humboldt squid (*Dosidicus gigas*) has been regularly encountered in large numbers throughout the California Current. The distribution of squid throughout this ecosystem appears to follow a consistent pattern, with indications of a strong seasonal movement from either southern or offshore waters to the northern California current in summer and fall, and back down to California and likely Baja California in the winter. The magnitude and extent of their distribution, as well as their abundance, varies from year to year in response to interannual changes in ocean conditions. Although the magnitude of ecosystem impacts is dependent on the local abundance of squid in time and space, there is little doubt that these animals play a major role in structuring their ecosystems wherever they occur. Humboldt squid typically feed on small mesopelagic fishes and squids in the eastern tropical and subtropical Pacific, however in the California Current they also feed on many larger, commercially important species, such as Pacific hake, Pacific sardine, market squid, several species of semi-pelagic rockfish and infrequently on salmon and sablefish. As the impacts to populations and ecosystems are likely to be associated with the distribution and movement patterns, we will discuss over five years (2005-2010) of food habits data collected from over 1200 squid in the context of temporal and spatial distribution patterns, to better assess the potential consequences of the ongoing range expansion to coastal ecosystems and fisheries.

28 October, 15:00 (S6-6791)

Do circulation patterns make the eastern North Pacific especially susceptible to zoogeographic shifts?

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Meridional displacements of animal and plant distribution ranges are recognized as a likely consequence of climate change in both terrestrial and aquatic environments. Many of the recent reports of large poleward shifts of marine plankton and nekton zoogeographic patterns have come from the mid-latitude eastern margins of the Pacific and Atlantic Oceans. Does this high incidence rate simply reflect the high density of historical observations in these regions, or is it caused by real differences in susceptibility to invasion that are linked to regional oceanography? Compared to western ocean margins, the eastern margins have weaker latitudinal gradients in water properties. This suggests that animals moved poleward by transient flowfield anomalies will encounter environmental conditions that are changed only slightly and gradually from the conditions in their core home range. Mid-latitude eastern ocean boundaries are also characterized by meridional divergence of the large scale alongshore transport, plus strong seasonal and interannual modulation of current speed and/or direction. This means that transient perturbations of alongshore position are likely to occur frequently, and that any initial alongshore advective displacement will increase the probability of subsequent additional advective displacement in the same direction. We explore these issues using case histories from the California Current system, and also with mathematical models.

28 October, 15:20 (S6-6860)

The role of mesopelagic fishes in ecosystem vertical mixing in the north western Pacific

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Every night mesopelagic fishes come into the upper pelagic layer to feed. Thus, they are involved in trophic relationships with epipelagic species almost half of their life. Being guests, competitors and victims for hosts at the same time mesopelagic fishes may influence directly and indirectly on the structure of ichthyocen in the upper pelagic layer. We estimated the percentage of the total fish abundance and the average biomass concentration (kg/km^2) of 30 species from 5 families (*Myctophidae, Bathylagidae, Nemichthyidae, Notosudidae* and *Lampridae*) in the upper pelagic layer (0-50 m) at night for the last 29 years. Data selection included 231, 542 and 1329 trawl stations in the Bering Sea (BS) and the Sea of Okhotsk (OS) in autumn, and the northwestern Pacific (NWP) in summer, respectively. The most stable region is NWP with a biomass concentration of 462±39SD kg/km^2. There are no have noticeable shifts in the interannual dynamic, but anomalous variations occurred in 1997-2001 and 2005. In comparison to total fish abundance in the same time-spatial locations during 1980-1984 and 1998, in 2003 the percentage of mesopelagic fishes was extremely low (less than 10%) compared to its average value of 23% to 26% (0.95 confidence interval). The total abundance of fishes, biomass density of mesopelagic fishes and their percentage of total abundance all had similar values of about 33% before 1993 and below 13% after in the BS. In the OS, percentage and biomass concentration have an inverse pattern until the beginning of the 1990‘s when they become synchronous. Since 2005, biomass concentration of mesopelagic fishes in the OS has risen towards its historical maximum in 1998 (454 kg/km^2). It is now almost equal to the biomass concentration in the NPW, but still represents much less than 35-40% of the ichthyocen, the level in 1991 and 1998.

28 October, 16:00 (S6-6559)

Effects of climate change on the phenology of spring blooms and consequences for the survival of larval cod

Trond **Kristiansen**[1], Charles Stock[2], Ken Drinkwater[1] and Enrique N. Curchitser[3]

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Understanding how climate change may impact important commercial fisheries is critical for developing sustainable fisheries management strategies. In this study, we used simulations from an Earth System Model (NOAA GFDL ESM2.1) to assess how future temperature and primary production will control the metabolic needs and growth potential of larval Atlantic cod. The physical and environmental data were incorporated into a mechanistic individual-based model used to simulate the critical early phases in the life of larval fish (*e.g.* cod) in a changing environment. A mechanistic approach allowed us to disentangle the key processes that regulate growth and survival of larval fish, and to identify how these processes operate in a nonlinear fashion. We also determined if future potential recruitment of Atlantic cod will differ strongly among populations in the North Atlantic because of differences in temperature and productivity. Local cod populations will be regulated by their physiological temperature limits and the predicted levels of prey abundance. We also analyze how climate change may affect the timing and production of phytoplankton, which we use to develop indices of timing of zooplankton, the main prey item for larval fish. Model simulations allow us to generate scenarios of survival for Atlantic cod across the North Atlantic to the year 2100. Together, these analyses will provide detailed predictions on the survival of larval cod in the North Atlantic under climate change.

28 October, 16:20 (S6-6573)

Emergence of the Arctic hyperiid *Themisto libellula* on the southeastern Bering Sea shelf as a result of the recent cooling and their potential impact on pelagic food web

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The eastern Bering Sea shelf has been experiencing a sequence of extremely cold years marked by intense ice coverage and late ice retreat since 2008. Spatial and temporal variability in zooplankton communities during these conditions was investigated as a part of the collaborative BEST-BSIERP program. An increasing presence of the arctic hyperiid *Themisto libellula* (by an order of magnitude between 2008 and 2009), which had not been recorded in the study area since the 1970s, was observed on the middle shelf, indicating a developing structural shift in the zooplankton community in response to continuous cold conditions. Simultaneously, *T. libellula* became an increasingly dominant prey in salmon and seabird diets, suggesting the important role of the species in the pelagic food web. A voracious predator, *T. libellula* has been shown to be capable of controlling copepod populations; thus it may serve as a potential contributor to top-down regulation of the growing *Calanus* spp. population on the Bering Sea middle shelf during the recent cooling event.

28 October, 16:40 (S6-6564)

Variability in northwards extension of warm water copepods in the NE Pacific

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The Continuous Plankton Recorder has been deployed in the NE Pacific multiple times per year on two intersecting transects since 2000. Many deployments have included a temperature sensor providing in situ temperature data for each sample to supplement the species abundance data obtained from the microscopic analysis of ~1250 samples. Thirty copepod taxa (mostly species level) were sufficiently abundant to examine their temperature-related distributions. Groups of warm- and cold-water species were identified, with overlapping distributions

between 48° and 58°N. The recent fluctuations in ocean climate of the NE Pacific, from the warmest year on record in 2005 to one of the coldest in over 50 years in 2008, provided ideal conditions to observe temperature-related interannual variability. The abundance and northward extension of warm water species were significantly positively correlated with mean annual temperature and the Pacific Decadal Oscillation, although there was no relationship with the strength of the North Pacific and Alaska Currents. The cold water species showed no correlations with either temperature or the PDO. We speculate that this is because the CPR is sampling the northern limit of the warm water copepods, therefore interannual changes in distribution and abundance are clear, but not the southern limit of the cold water copepods. Under warm ocean conditions the range-overlap of the two groups is therefore likely to increase as warm water species extend northwards, leading to an increase in copepod diversity in this region of the NE Pacific. Since warm water species are generally smaller and nutritionally poorer this has implications for higher trophic levels.

28 October, 17:00 (S6-6532)

The rise and fall of the northern blue whiting stock

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The northern blue whiting (*Micromesistius poutassou*) is a pelagic gadoid occupying mainly the waters between the spawning grounds west of the British Isles and the feeding areas in the Norwegian Sea and adjacent waters. The spawning stock of blue whiting increased dramatically in the late 1990s due to a succession of eight strong or extremely strong year classes. However, after 2005 the recruitment went back to the pre-1995 recruitment. Since 2005 the blue whiting stock has dropped quickly due to the collapse in recruitment and a large fishery. The sub polar gyre may influence the spawning distribution. The challenges are to explain how the changeable spawning distribution might influence recruitment to the blue whiting stock. It is hypothesised that mackerel may feed on the eggs and larvae of blue whiting, thus affecting blue whiting recruitment negatively. The overlap in the spawning distribution of blue whiting with mackerel varies with the conditions in the sub polar gyre. Larvae and young blue whiting are feeding on zooplankton in the Norwegian Sea. The biomass of zooplankton in the Norwegian Sea and adjacent areas has steadily decreased during the last fifteen years. In parallel the biomass of pelagic fish (blue whiting, mackerel and Norwegian spring spawning herring) has increased. We hypothesise that variations in physical conditions explain changes in distribution, while variations in predation by mackerel on eggs and larvae is the most likely direct causal effect on recruitment. Variations in feeding conditions in the nursery area may have secondary effects.

28 October, 17:20 (S6-6814)

Expansion and shoaling of the oxygen minimum zone off the U.S. west coast in relation to demersal fish distribution and biomass

Aimee **Keller**[1], Victor Simon[1], W. Waldo Wakefield[2], Keith Bosley[2], M. Elizabeth Clarke[1], John A. Barth[3] and Stephen D. Pierce[3]

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Understanding the relationship between environmental variables and fish distribution and abundance has long been a goal of fisheries biologists. Since 2002, hypoxic conditions have been observed on the continental shelf off the coast of the Pacific Northwest in a region not previously characterized by hypoxic conditions. In addition, major declines in dissolved oxygen have been observed in the oxygen minimum zone (OMZ) of the southern California Current as well as a shoaling of the OMZ. Despite these recent increases in frequency, duration, and spatial extent of hypoxia and the recognition of hypoxia as a threat to worldwide fish production, little is known about its effects on upper trophic levels. In 2007, the Northwest Fisheries Science Center (NWFSC) initiated studies on the extent of hypoxic conditions on the continental shelf and slope along the west coast and the influence

of hypoxia on demersal fishes and invertebrates, including commercially important groundfish. This project was developed as an extension of the NWFSC West Coast Groundfish Bottom Trawl Survey. Studies in 2007 and 2008 focused on a segment of the Oregon coast – an established area for ongoing interdisciplinary studies on hypoxia. In 2009, working with oceanographers at Oregon State University, the NWFSC expanded its hypoxia research by incorporating an oceanographic sensor package into the NMFS coast-wide bottom trawl survey. Here we describe the recent distribution of low oxygen waters off the U.S. west coast and preliminary findings relating low oxygen to demersal fish distribution and abundance based on survey results.

28 October, 17:40 (S6-6507)

The response of sea surface temperature in the offshore area of China to variations in the East Asian Monsoon under global warming and its marine ecological effects

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Based on HadISST and ERA-40 reanalysis data, the response of Sea Surface Temperature (SST) in the offshore area of China (OAC) to variations in the East Asian Monsoon (EAM) in winter and summer are analyzed using Empirical Orthogonal Function and Linear Regression analysis methods. The results show, first, that the SST in OAC exhibits inter-annual and inter-decadal variations with a rising trend, and experienced a climate shift in the mid-1980s. The areas with the strongest increase in SST are located in the East China Sea (ECS) in winter and in the Yellow Sea in summer. Second, EAM displays distinct inter-annual and inter-decadal variations with a weakening trend since the end of the 1980s in winter, and since the end of the 1970s in summer. Third, the response of SST to EAM in winter on inter-decadal timescales was greater than that on inter-annual timescales. The weakening trend in the EAM in winter contributed to the rise in SST in the ECS. Moreover, the response area of SST on inter-annual timescales to the EAM in summer is located in the SCS, and the response in winter is much more obvious than that in summer. Meanwhile, the abundance and occurrence of warm water species of plankton and fish in the ECS increased, and that of temperate water species decreased in the past decades. No less than 14 kinds of tropical fish species have had their first recorded occurrence in the subtropical area. It is therefore suggested that the warming trend may greatly affect marine species composition and biogeographic distribution, especially for tropical fish expanding their range northward into the subtropical area.

S7 FIS/MEQ Topic Session Economic relation between marine aquaculture and wild capture fisheries

Co-Convenors: Ingrid Burgetz (Canada), Dohoon Kim (Korea), Minling Pan (U.S.A.) and Qingyin Wang (China)

Past activities of PICES have mainly focused on physical and biological sciences, such as ecology, ecosystems, fisheries, oceanography, and biogeochemistry, *etc.* While humans are essential parts of marine ecosystems, it is important to consider impacts from human activities/uses upon marine living resources and economic and social science research within the PICES region. Indeed, the new FUTURE science program endeavors to provide a greater role for social and economic scientists in PICES. This session is convened in direct response to this objective and is intended to be a step toward enhancing research and management of marine living resources from a socio-economic perspective.

Considering the growing role of marine aquaculture in both seafood production and consumption as well as the close relationship between marine aquaculture and wild ocean capture fisheries, this session will focus on the relationships of marine aquaculture to capture fisheries with respect to economics, such as (1) marine aquaculture products as a substitute and/or complement for wild caught products owing to consumer preference, price, and availability; (2) the synergies between aquaculture and fishing (use of fish processing trimmings, resilient coastal communities and maintaining working waterfronts), and (3) economic considerations regarding potential environmental effects (positive and negative) interactions between captured fisheries and marine aquaculture (*e.g.*, feed inputs in marine aquaculture derived from captured fisheries, aquaculture stock enhancement, aquaculture structures as fish aggregating devices, *etc.*). Selected oral and poster presentations will be considered for publication in a specials issue of a peer-reviewed journal such as *Aquaculture Economics and Management, Aquaculture, Reviews in Aquaculture, or Fishery Research*.

Tuesday, October 26 (9:00-17:20)

9:00	***Introduction by Convenors***
9:05	**Michael C. <u>Rubino</u> (Invited)** Potential economic effects on wild capture fisheries from an expansion of marine aquaculture in the United States (S7-6782)
9:40	**Di <u>Jin</u> (Invited)** Aquaculture and capture fisheries: An integrated economic-ecological analysis (S7-6445)
10:05	**Yajie <u>Liu</u>, Ola Diserud, Kjetil Hindar and Anders Skonhoft (Invited)** An ecological-economic model of genetic interaction between farmed and wild Salmon (S7-6848)
10:25	***Coffee/Tea Break***
10:50	**Masahito <u>Hirota</u> and Yoshinobu Kosaka** The TASC (Total Allowable Scallop Culture) in Japan: An approach for the issue on the overproduction in Yezo giant scallop cultivation in Mutsu Bay (S7-6674)
11:10	**Heedong <u>Pyo</u>** Analyzing recovered effects of marine contaminated sediment cleanup project on wild capture fisheries in Korea (S7-6502)
11:30	**Galina S. <u>Gavrilova</u>** Capture fisheries and mariculture of the marine invertebrates in Peter the Great Bay (Japan Sea) (S7-6655)

11:50 **Toyomitsu Horii**
Impacts on fishery products of the Tiger Puffer, *Takifugu rubripes*, by stock enhancement (S7-6817)

12:10 ***Lunch***

14:15 **Shang Chen, Li Wang, Tao Xia, Guoying Du and Dachuan Ren (Invited)**
Quantification of maricultural effects on coastal ecosystems services: Sanggou Bay case from China (S7-6553)

14:40 **Seong-Kwae Park and Dong-Woo Lee (Invited)**
Economic relation between marine aquaculture and wild capture fisheries: Case of Korea (S7-6691)

15:05 **Hisashi Kurokura, Akira Takagi, Yutaro Sakai and Nobuyuki Yagi (Invited)**
Tuna goes around the world on sushi (S7-6695)

15:30 ***Coffee/Tea Break***

15:50 **Chen Sun (Invited)**
The influence of marine aquaculture to the fishery industry chain in China (S7-6430)

16:15 **Kelly Davidson and Minling Pan (Invited)**
Consumers' willingness to pay for aquaculture fish products *vs.* wild-caught seafood – A case study in Hawaii (S7-6594)

16:40 ***Discussion and Summary by Convenors***

17:20 ***Session ends***

S7 Session Oral Presentations

26 October, 9:05 (S7-6782), Invited

Potential economic effects on wild capture fisheries from an expansion of marine aquaculture in the United States

Michael C. **Rubino**

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This paper outlines the economic issues and research needs raised in the United States by the potential expansion of domestic marine aquaculture, and in particular, the potential economic effects of marine aquaculture on capture fisheries. Although the focus of the paper is the United States, similar effects have been noted in other countries. The economic ramifications of expanding aquaculture in the United States, along with environmental and food safety concerns, are the subject of much debate and widely differing views. Aquaculture may be a way to substantially increase domestic seafood production. Hatchery-based stock replenishment may be a way to restore depleted commercial and recreational fisheries. Associated economic benefits of these aquaculture activities may include the creation of jobs from coastal communities to the agricultural heartland, maintenance of working waterfronts, and synergies with commercial fishing such as use of fish processing trimmings. But concerns have been raised that domestic aquaculture may compete with domestic wild fisheries depressing prices for wild caught fish. Additional concerns include the economic consequences of potential environmental and social effects of aquaculture on wild capture fisheries and traditional fishing communities.

26 October, 9:40 (S7-6445), Invited

Aquaculture and capture fisheries: An integrated economic-ecological analysis

Di **Jin**

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It is now widely recognized in the field of marine policy that the management of single commercial fish stocks may be short-sighted, wasteful, and ineffective. Marine ecosystems are known to comprise species that exhibit biological interactions (competitive, mutualistic, predator-prey, or other). The exclusive harvest of one species may lead to significant effects on the stocks and flows of other species, the stability of the larger ecosystem, and on other human uses and passive values. The large degree of uncertainty regarding the combined influences of the environment and human harvests operating within the context of incompletely known or variable ecological linkages increases the likelihood that a single-species focus may be misguided and potentially detrimental to the larger ecosystem. The prospect of a broader ecosystem-based management (EBM) of marine fisheries has begun to emerge as the logical alternative to ineffective single-species management.

Ecosystem-based management is an integrated approach to management that considers the entire ecosystem, including humans. According to Pikitch *et al.* (2004), the objectives of ecosystem-based fishery management are (1) to avoid degradation of ecosystems as measured by indicators of environmental quality and system status; and (2) to account for the requirements of other ecosystem components (*e.g.*, nontarget species, protected species, habitat considerations, and various trophic interactions). The implementation of EBM requires the development of new analytic tools to integrate different environmental, ecological, and socio-economic data from various sources, to capture explicitly interactions among different components in the entire ecosystem, to simulate and assess the effects of different management options.

To help assess the implementation of ecosystem-based fisheries management (EBFM) in New England, we have developed an integrated economic-ecological framework by linking a computable general equilibrium (CGE) model of a coastal economy to an end-to-end (E2E) model of a marine food web for Georges Bank (Collie et al., 2009). The basic version of the integrated model utilizes coastal county economic data for a restricted set of industry sectors and marine ecological data for three top level trophic feeding guilds: planktivores, benthivores, and piscivores. The model can be used to estimate the welfare effects of changes in alternative combinations of yields from feeding guilds and alternative manifestations of biological productivity.

This study extends our basic model of the economic and ecological systems in coastal New England by incorporating an aquaculture sector in the CGE model and by examining the forage fish and aquaculture link in a marine food web context. Specifically, the extended CGE model of the New England coastal economy includes six sectors: aquaculture, commercial fishing, seafood processing, agriculture, manufacturing, and all other sectors combined. A marine food web model is used to simulate the effects on various food web components of different management options for forage fish (*e.g.*, as prey for commercially harvested species or feed for aquaculture) and for commercial fisheries. The resulting economic impacts and social welfare effects are calculated using the extended CGE model. We discuss other possible applications of and modifications and limitations to the framework.

26 October, 10:05 (S7-6848), Invited

An ecological-economic model of genetic interaction between farmed and wild Salmon

Yajie **Liu**[1], Ola Diserud[2], Kjetil Hindar[2] and Anders Skonhoft[1]

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The paper aims to explore the ecological and economic impacts of genetic interaction between farmed and wild salmon over generations. An age- and stage-structured bioeconomic model is developed. The biological part of the model includes age-specific life history traits such as survival rate, fecundity, spawning success for both wild and farmed salmon and their hybrids, while the economic part takes account of use and non-use values of fish stock. The model is constructed based on the Atlantic salmon fishery and salmon farming in Norway. The social welfare are derived from harvest and wild salmon while the economic benefits of fishing comprise both sea and river fisheries. The results reveal that the wild salmon stock is gradually replaced with farmed origin ones, while the total social welfare and economic benefit vary, but not as dramatically as the wild salmon stock.

26 October, 10:50 (S7-6674)

The TASC (Total Allowable Scallop Culture) in Japan: An approach for the issue on the overproduction in Yezo giant scallop cultivation in Mutsu Bay

Masahito **Hirota**[1] and Yoshinobu Kosaka[2]

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The Mutsu Bay is located in Aomori prefecture, the northern part of Japan. This region is one of the main aquaculture areas of Yezo giant scallop (*Patinopecten yessoensis*). In recent years, the over production in Yezo giant scallop cultivation has became a serious issue. The incomes of fishers have become unstable or fluctuated sharply because of low quality and the high mortality of the scallop. This unstableness accelerates further over production. This caused a vicious circle. Additionally, the long working hours and an increase in labor cost make the business environment much worse than before. Under such conditions, we estimated the allowable volume of scallop cultivation based on the feed environment in Mutsu Bay (*i.e.*, environmental capacity), and calculated the total incomes. Furthermore, we set the best cultivation volume which can achieve the stability in cultivation volume and the maximum income for fishers. We called it the TASC (Total Allowable Scallop Culture) system. The prefectural government coordinated repeated discussions with researchers and fishers to reach agreement on the TASC, and finally it was formally authorized by all the fisheries cooperative association in the Mutsu Bay in 2009. This will be one of the successful cases of fisheries co-management in Japan, in which the local government, researchers, and fishers cooperatively solve the issue on the over production in cultivation.

26 October, 11:10 (S7-6502)

Analyzing recovered effects of marine contaminated sediment cleanup project on wild capture fisheries in Korea

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There are various types of predictable economic benefits to restoring beneficial uses from contaminated marine sediment cleanup. These benefits can be derived from reduction in aquatic animals died or infected, increase in their consumption recovery, increase in tourism including recreational fishing, reduction in human health risk, increase in amenity and aesthetics, increase in ecosystem integrity, and so on. The paper focuses on estimating the net increase in value for producers and consumers from producing and consuming those fish due to the pollution reduction of marine contaminated cleanup project. Almost Ideal Demand System (AIDS) is employed for estimate of the demand for fish, and the production cost function for fish are determined using market data. The result shows 10.8 billion won per year for economic surplus to the net increase for producers and consumers.

26 October, 11:30 (S7-6655)

Capture fisheries and mariculture of the marine invertebrates in Peter the Great Bay (Japan Sea)

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Wild capture fisheries are not large-scale nearest coastal Primorye. According the forecasts the condition of stocks will allow increasing the capture fisheries by not more than 70 thousand tons in 2010. The share of the invertebrate's fisheries is insignificant in Total Allowable Catch (TAC). Capture fisheries of such value species as king crab, sea cucumber and scallop are prohibited during many years. Some species, for example, *Mytilus trossulus*, do not accumulate commercial populations near the Primorye coasts.

In Primorye mariculture development is actually not only a possibility and necessity of putting the large volume of production but also a necessity of social-economic development of the coastal region. Recently commercial production of the sea cucumber, scallop and mussel is located on mariculture plantations only. Annual mollusk aquaculture production is up to 2 thousands ton. It is 7 times of TAC of the scallops and mussel wild populations.

The value of the mariculture area is increasing as mariculture production is being developed. A valuation was conducted for ecosystem service in Sukhodol Bight. By Costanza et al. method (1997) total value of the mariculture area in Sukhodol Bight is $1013 thousand. The bioresources value, taking into account that the mariculture production is 63% of the value annual ecosystem services, without mariculture production is 4% only. However the value of annual ecosystem services of Peter the Great Bay is 10 time of bioresources value.

26 October, 11:50 (S7-6817)

Impacts on fishery products of the Tiger Puffer, *Takifugu rubripes*, by stock enhancement

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T. rubripes inhabiting in the waters around Tokai area, Pacific coast of Honshu, is one of the main targeted species by trawl net and long line fisheries, and the amount of landed fish were 80 to 550 metric tons a year. For stock enhancement, 700,000 artificially produced seeds have been released a year, meanwhile the stock abundance had been widely fluctuated according to the irregular superior year-class recruits. The yearly changes of the stock size and the recruits were evaluated by the virtual population analysis by use of the monthly catches data in 1993-2008 that were obtained by the measurement of landed fish. As the results, the numbers of newly recruits of six-month-

olds have been widely fluctuated; the calculated recruits were ranged from 107 thousands to 1,454 thousands. The yearly survival rates of released juveniles to the recruits were evaluated to be from 5% to 9%, and the rates were gradually ascendant because the releasing methodologies have been developed year by year. The ratios of released animals among landed were widely ranged from 2% to 30% because the yearly numbers of released animals were comparatively stable, whereas the wild recruits were widely fluctuated. The fishery productions under the two conditions of the releasing and the non-releasing were compared by a computer simulations. The average productions were calculated to be 215 tons and 241 tons, and the values were fall under 200 tons in 24% and 43% of the time, respectively. Stock enhancement policy on the stock could help to stabilize the fishery productions.

26 October, 14:15 (S7-6553), Invited

Quantification of maricultural effects on coastal ecosystems services: Sanggou Bay case from China

Shang **Chen**[1], Li Wang[1], Tao Xia[1], Guoying Du[2] and Dachuan Ren[2]

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Food production through mariculture is one of main services provided by coastal ecosystem. The rapidly developed mariculture has been significantly changed the structure and function of coastal ecosystem, therefore highly changed the coastal ecosystem services to human. By using Expert Survey Method, a Mariculture Effect Index (MEI) was developed to quantify the positive and negative effects of different mariculture models on 14 services of coastal ecosystem. Considering the weight of each service, the MEI, and baseline value of each ecosystem service together, the change value of each service and all services of coastal ecosystem can be calculated. Sanggou Bay is a typical mariculture bay in the coastal Yellow Sea in which shellfish-kelp polyculture is the main human activity. This mariculture model improves the value of 12 ecosystem services i.e. food production, material production, scientific service, nutrient cycling, primary production, oxygen production, biological control, waste treatment, climate regulation, disturbance regulation, cultural usage and recreational service. The model reduces the value of 2 ecosystem services i.e. provision of genetic resources and species diversity maintenance. The total increment of ecosystem service value caused by large-scale kelp-shellfish polyculture was 556.43 million RMB yuan. Food production service value increased 523.11 million yuan, material production service value increased 2.09 million RMB yuan, oxygen production service value increased 11.07 million RMB yuan, climate regulation service value increased 14.54 million RMB yuan, waste treatment service value increased 2.00 million RMB yuan, scientific service value increased 3.62 million yuan. The main increment was from food production which accounts 94% of total. The shellfish- kelp polyculture is a friendly ecological mariculture model to use ecosystem services. Totally it can improve most of ecosystem services. However, this polyculture has adverse impacts to local biodiversity and genetic resources of native species. Therefore, selection of mariculture area should except the key habitats such as spawning and overwintering grounds of wild species and avoid the impact from mariculture activities on them.

26 October, 14:40 (S7-6691), Invited

Economic relation between marine aquaculture and wild capture fisheries: Case of Korea

Seong-Kwae **Park** and Dong-Woo Lee

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Most fish species in Korea have been overexploited over the last three decades and fish stocks have continued to decline over time. To deal with fishery resource depletion, from 1994 to 2007 the buyback (or structural adjustment) programs were introduced and implemented in two ways: one was a general buyback program and the other was an international one. In 1994, the initial year of the program 54 vessels were decommissioned and in 1999, 730 boasts were reduced in a large scale under both of the general and the international buyback programs. The ultimate goal of Korea's fisheries structural adjustment policy (i.e. buyback programs) is to have ecosystem-

based, environmentally-sustainable fishery resource management and to utilize of Korean marine ecosystem by reducing fisheries development stress and promoting sustainable exploitation of the ecosystem from a densely populated, heavily urbanized, and industrialized semi-enclosed seas.

Regarding the stock status, the assessment results suggest that (i) red fish, monkfish, anchovy, sea bass, yellow tail, pen shell, and Spanish, and mackerel are not in overexploitation/overcapacity, (ii) hair tail and skate ray are in overexploitation but in non-overcapacity, and (iii) yellow croaker and flounders are in non-overexploitation but in overcapacity. However, considering stock fluctuations and assessment uncertainties, the average optimal fishing effort over the last three years (2005-2007) on E_{NSY} and $2/3E_{MSY}$ criteria was evaluated at 73.4 – 90.2%. This result suggests that the current level of total fishing capacity be reduced by 9.8 – 26.6%.

Considering the limited natural capacity of ocean's wild fish reproduction and at the same time technological advancement of marine aquaculture, the cost of farmed fish production would be getting lower and then farmed fish prices would be lower than prices of captured fish. Thus, farmed fish may replace wild fish gradually, not rapidly, over time. However, there is uncertainty in predicting how much farmed fish can replace captured fish without marine-environmental cost. Past and present experiences tell us that there is an apparent economic trade-off between costs of sacrificing marine environmental quality and benefits from mari-culture expansion.

Following the national low-carbon/green growth initiative and the international plans of action for sustainable responsible fisheries, the central and provincial governments should be able to develop green fishery policies linked together, including buyback, resource enhancement, subsidy reorientation, off-shore aquaculture development, self (or co)-management programs, off-fisheries income promotion, and seafood safety regulations. Also, such package program should be supported by a new R&D system that is focused on enhancing and maintaining the Korean marine environment and ecosystem. This will require significantly closer cooperative work among South/North Koreas, China, Japan and related international bodies.

26 October, 15:05 (S7-6695), Invited

Tuna goes around the world on sushi

Hisashi **Kurokura**, Akira Takagi, Yutaro Sakai and Nobuyuki Yagi

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Sushi and sashimi are traditional Japanese dishes eaten to celebrate of special events in the lives of Japanese citizen prior to the economic development of Japan. Raw diet of fresh fish was popularized and sushi became daily meal among Japanese citizens, as a result of development of cold chain in system since 1960s. However, fatty tuna sushi was still considered a luxury food served in higher class sushi bars, because the ratio of fatty meat in the body muscle of wild tuna is less than 10%. Conveyor belt sushi bars (sushi-go-round restaurants) were rapidly popularized in the late 1990s in Japan. Even in these lower priced sushi bars, fatty tuna was an absolutely necessary menu item. As seventy percent of body muscle of cultured tuna is fatty meat, cultured tuna was used as relatively low priced substitute for fatty tuna sushi. Tuna culture industry was developed in the late 90s in Japan and the import of cultured tuna increased in same period. It could be said that the popularization of conveyor belt sushi bars pushed up the consumption of cultured tuna. Sushi bars became more and more common worldwide, and many new types of sushi are created every year. For example, salmon was not served as a raw food item 20 years ago. The development of aquaculture and freezing technology enabled eating raw salmon to be eaten raw. Conveyor belt sushi bars are places where new food cultures are born. It is necessary to observe people who are eating in conveyor belt sushi bar to consider future of aquaculture and fisheries.

26 October, 15:50 (S7-6430), Invited

The influence of marine aquaculture to the fishery industry chain in China

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In the mid-term of 1980's, China established a policy to support the development of aquaculture. This talk will address the influence of marine aquaculture to the fishery industry chain in China.

Firstly, not only the scale of the output of seafood increased significantly, but also the structure of the output of seafood changed greatly. In 2008, the output of seafood had reached 26 million tons, among which more than 50% was aquaculture products. Secondly, notable changes occurred in the seafood processing industry. Not only the scale of seafood processing enlarged greatly, but also the varieties of processed seafood enriched. Surimi and its products began and increased continuously. Simultaneously, the sanitation standards were extensively heightened. Thirdly, with the circulation channel improvements, the circulation occupation has been diversified. Some new occupations appear. Lots of new wholesale markets were built. Fourthly, there were also obvious changes in seafood trade. The quantity and value of exports increased rapidly, and has surpassed 3 million tons and $ 10 billion respectively. Aquaculture seafood and its products contributed more and more in trade. Fifth, there were changes in seafood consumption. Consumers can enjoy more and more chilled or fresh seafood now than before. Moreover, consumers also adjusted their preferences, eating different species of seafood at different times of the year. Simultaneously, the price of seafood fluctuated less than other products such as meat, egg and milk.

The rapid development of fisheries and the stable abundant market supply of seafood during these years is owed to the marine aquaculture in China. However, there were certainly some negative effects accompanying such rapid development, such as the environment and resources issues and these will be discussed in later presentations.

26 October, 16:15 (S7-6594), Invited

Consumers' willingness to pay for aquaculture fish products *vs.* wild-caught seafood – A case study in Hawaii

Kelly **Davidson** and Minling Pan

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The U.S. ranks third in seafood consumption behind China and Japan, and U.S. seafood consumption is projected to continue to increase. To meet the growing demand, 84 % of seafood is imported from foreign sources. Yet over half of imported seafood is farm-raised, as aquaculture production is rising and wild catch remains stable globally. The objective of this study is to examine consumer preferences for farm-raised vs. wild-caught fish. A survey was conducted and implemented in Hawaii to investigate consumer perceptions and preferences including consumer awareness concerning production methods (farm-raised *vs.* wild-caught), seafood labeling, and environmental issues. The survey also addresses food safety and nutrition, cultural traditions, consumption patterns, and taste and product form preferences. Using conjoint analysis across four different fish species, tuna, salmon, tilapia and moi (Pacific threadfin), this study aims to determine species-specific attributes that affect consumers' willingness to pay and make purchasing decisions. Stakeholders will be able to use the research results to better target appropriate markets and facilitate policy decisions aimed at promoting and developing the aquaculture and seafood industry. In addition, the study will allow us to compare the survey results and demographic profiles derived from two survey approaches, since questionnaires were administered both in-person and online.

S8 FIS/POC/BIO Topic Session
Impact of climate variability on marine ecosystems: Understanding functional responses to facilitate forecasting

Co-Sponsored by ICES

Co-Convenors: Jürgen Alheit (Germany), Suam Kim (Korea), Harald Loeng (Norway), James Overland (U.S.A.) and Yasunori Sakurai (Japan)

Understanding the role of natural variability, occurring over a variety of temporal and spatial scales is essential for effective management of marine ecosystems in the wake of predicted global change. Evidence suggests that climate variability can trigger regime shifts in marine ecosystems. Regime shifts are characterized by a re-organization of marine communities, species dominance, and tropho-dynamic relationships. Often, synchronous shifts occur in aquatic ecosystems that are separated by thousands of kilometers. This finding suggests that atmospheric teleconnections are mediating regional system changes. We postulate that comparative studies of ecosystems that have experienced regime shifts will provide insights into the expected responses of marine organisms to climate change. Papers are invited that go beyond simple pattern matching. The primary focus will be on understanding shifts in the pelagic realm, including phytoplankton, zooplankton, small pelagic fishes, gadids, and squids. Preference will be given to research that provides evidence of the functional responses and relationships that underlie regime shifts, and to statistical or modeling studies that successfully simulate observed shifts.

Tuesday, October 26 (9:00-18:05)

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

9:05 **Hans O. Pörtner (Invited)**
Oxygen and capacity limited thermal tolerance (OCLT): Linking climate to ecosystem change (S8-6606)

9:30 **Julie E. Keister, Emanuele Di Lorenzo, Sanae Chiba, Vincent Combes, Cheryl A. Morgan and William T. Peterson**
Climate-related changes in ocean transport control zooplankton biogeography around the North Pacific basin (S8-6686)

9:50 **Yury Zuenko, Ludmila Chernoivanova, Alexander Vdovin and Elena I. Ustinova**
Saffron cod fluctuations in the Japan Sea: An evidence of match/mismatch hypothesis (S8-6816)

10:10 **William R. Crawford and James R. Irvine**
Climate variability and ecosystem response in Pacific Canadian coastal waters (S8-6778)

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

10:50 **Kazuaki Tadokoro, Yuji Okazaki, Tsuneo Ono and Hiroya Sugisaki (Invited)**
Geographical comparison of the decadal-scale variations in marine ecosystems in the North Pacific Ocean (S8-6611)

11:15 **Ken Drinkwater, Glen Harrison, Erica Head, Padmini Dalpadado, Jim Carscadden and George Lilly**
Comparison of the ecosystem responses to climate forcing and fishing between the Labrador Sea and the Norwegian/Barents seas (S8-6753)

11:35 **Jürgen Alheit, Michele Casini, Wulff Greve, Thomas Pohlmann, Anne Sell, Ralf Vorberg and Carola Wagner**
Climate variability drives anchovies and sardines into North and Baltic Seas (S8-6844)

11:55	**Joachim P. Gröger, Gordon H. Kruse and Norbert Rohlf** Climate cycles and population dynamics of North Sea herring (S8-6427)
12:15	**Anne B. Hollowed, Steven Barbeaux, Ned Cokelet, Stan Kotwicki, Patrick Ressler and Christopher Wilson** Effects of climate change on pelagic ocean habitats and their potential role in structuring Bering Sea and Gulf of Alaska ecosystems (S8-6841)
12:35	***Lunch***
14:00	**Shin-ichi Ito, Takeshi Okunishi, Atsushi Kawabata, Hiroshi Kubota, Akinori Takasuka, Taketo Hashioka, Hiroshi Sumata and Yasuhiro Yamanaka (Invited)** Multi-trophic level ecosystem modeling for understanding the mechanism of small pelagic fish species alternation associated with climate regime shifts (S8-6661)
14:25	**Richard D. Brodeur, James J. Ruzicka and John H. Steele** Investigating alternate trophic pathways through gelatinous zooplankton, krill, and planktivorous fishes in an upwelling ecosystem using end-to-end models (S8-6641)
14:45	**William J. Sydeman, Jarrod A. Santora, Sarah Ann Thompson, Kyra L. Mills, John C. Field, Brian K. Wells, Baldo Marinovic and Bryan A. Black** Numerical responses of krill predators to variation in krill abundance and spatial organization (S8-6790)
15:05	**Seokjin Yoon, Hiroya Abe and Michio J. Kishi** Variance estimation of the growth and food sources of the Manila clam by global warming in a subarctic lagoon, Japan (S8-6822)
15:25	**Harald Loeng** Impacts of climate change on the Arctic Ocean and adjacent seas (S8-6600)
15:45	***Coffee/Tea Break***
16:05	**Franz J. Mueter (Invited)** Long-term forecasts of walleye pollock dynamics in the eastern Bering Sea based on estimated responses of recruitment and growth to climate variability (S8-6805)
16:25	**Oleg Bulatov** Climate fluctuations and walleye pollock biomass dynamics (S8-6444)
16:45	**Thomas E. Helser, Bryan A. Black and Vanessa R. von Biela** Empirical evidence for biophysical coupling: Short and long term effects of climate variability on the growth rates of marine organisms across diverse taxa (S8-6473)
17:05	**Masahide Kaeriyama, Hideaki Kudo, Hideki Kaeriyama and Katherine W. Myers** Spacio-temporal changes in the feeding pattern of Pacific salmon, *Oncorhynchus* spp., in the North Pacific Ocean ecosystems during 1958–2009 (S8-6526)
17:25	**Melissa A. Haltuch and André E. Punt** On the promises and pitfalls of including decadal-scale climate forcing of recruitment in demersal fish stock assessment (S8-6572)
17:45	**Yongjun Tian, Hideaki Kidokoro and Tsuneo Goto** Long-term changes in the condition factor of small pelagic fishes in the Japan Sea and the impact of the late 1980s regime shift (S8-6500)
18:05	***Session ends***

S8 Posters

S8-6439 **Andrey A. Smirnov and Alexey V. Vakatov**
Change of the migration scheme of larval herring in connection with transformation of directions and forces of the currents caused by climatic factors in the northern Sea of Okhotsk

S8-6449 **Vanessa R. von Biela, Christian E. Zimmerman, Thomas E. Helser, Bryan Black and David C. Douglas**
Terrestrial and marine correlates to black rockfish (*Sebastes melanops*) growth in the California and Alaska Coastal Currents

S8-6492 **Michael A. Litzow, Franz J. Mueter and Dan Urban**
Can rising variance predict sudden shifts in populations and ecosystems? A test using Alaskan crustacean data

S8-6499 **Elena A. Shtraikhert, Sergey P. Zakharkov and Tatyana N. Gordeychuk**
Inter-annual variability of the spring chlorophyll *a* concentration maximum in the Peter-the-Great Bay (Sea of Japan) in 1998-2010

S8-6504 **Se-Jong Ju, Chang-Rae Lee and Ah-Ra Ko**
Latitudinal variation of lipid contents and compositions in copepods, *Euchaeta* and *Pleuromamma* spp., from the Northwest Pacific Ocean: Its implication in feeding ecology

S8-6541 **Bryan A. Black, Isaac D. Schroeder, William J. Sydeman, Steven J. Bograd and Brian K. Wells**
Winter and summer upwelling modes and their biological relevance in the California Current Ecosystem

S8-6595 **James J. Ruzicka, Thomas C. Wainwright, Richard D. Brodeur, Jeannette Zamon, Elizabeth Daly, Cheryl A. Morgan and Robert L. Emmett**
Interannual variability in the Northern California Current food web structure: Inferring trophic pressures upon juvenile salmon

S8-6627 **Suam Kim, Sangwook Yeh, Chung-Il Lee, Sukyung Kang, Hyunwoo Kang, Jin-Hee Yoon, Jung Jin Kim and Sinjae Yoo**
Forecasting practice on the common squid (*Todarodes pacificus*) population responding to climate/oceanographic changes

S8-6684 **Sarah Ann Thompson, William J. Sydeman, Jarrod A. Santora, Robert M. Suryan, Bryan A. Black, William T. Peterson and John Calambokidis**
Comparing pathways of functional response of top predators to seasonality of upwelling in the California Current

S8-6690 **Miguel Ñiquen, Cecilia Peña and Marilú Bouchon**
Overview of the main pelagic species stocks in Peru during 1950–2009

S8-6692 **Jun Shoji, Syun-ichi Toshito, Ken-ichiro Mizuno and Yasuhiro Kamimura**
Possible effects of global warming on fish early life stages: Shift in spawning season and latitudinal distribution can alter growth of juvenile fishes through the changes in daytime length

S8-6725 **Chan Joo Jang and Sinjae Yoo**
Variability of mixed layer depth and its relation with chlorophyll concentration in the North Pacific Ocean

S8-6727 **Ken-ichiro Mizuno, Yasuhiro Kamimura and Jun Shoji**
Effect of temperature on growth of black rockfish *Sebastes cheni* juveniles in seagrass and macroalgae beds

S8-6749 **Hee Dong Jeong, Sang-Woo Kim, Yong Kyu Choi, Jeong Min Shim and Kee Young Kwon**
A striking difference of coastal SST related to climate change in the eastern coast of Korea

S8-6758 **Jackie R. King, Vera N. Agostini, Chris J. Harvey, Gordon A. McFarlane, Michael G. Foreman, James E. Overland, Nicholas A. Bond and Kerim Y. Aydin**
Climate forcing and the California Current ecosystem

S8-6820 **Ann E. Edwards and Shannon Fitzgerald**
Predicting resilience to ecosystem change in a far-ranging, pelagic, generalist forager

S8-6835 **Oleg N. Katugin, Konstantin A. Karyakin and Alexander A. Nikitin**
Contrasting distribution patterns of the common squid (*Todarodes pacificus*) in Peter the Great Bay (Japan/East Sea) in 2008 and 2009

S8-6837 **Mikhail A. Zuev and Oleg N. Katugin**
Distribution patterns of the gonatid squids (Gonatidae, Oegopsina) in the northern Sea of Okhotsk in 1990-2008

S8 Session Oral Presentations

26 October, 9:05 (S8-6606), Invited

Oxygen and capacity limited thermal tolerance (OCLT): Linking climate to ecosystem change

Hans O. **Pörtner**

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Climate warming emphasizes the need for a common understanding of thermal limitation by physiologists and ecologists. The whole organism responses to warming or cooling link to ecosystem response (Science 322, 690, 2008) and build on a suite of tissue, cellular, molecular and genomic events, in a systemic to molecular hierarchy of limitation (CBP 132A, 739, 2002). All of these are involved in setting limits to tolerance, shaping a species-specific, limited budget of tolerance over time beyond pejus limits. The limiting mechanisms are also the targets of processes shaping acclimatisation and evolutionary adaptation. The concept of oxygen and capacity limitation of thermal tolerance (OCLT) was proposed as a matrix integrating the levels of biological organisation and the synergistic effects of environmental stressors (JEB 213, 881, 2010). Recent work has emphasized its role in heat tolerance. Here, capacity and oxygen limitation go hand in hand. A mismatch in oxygen supply versus demand causes a limitation in aerobic scope and finally transition to anaerobic metabolism, paralleled by the development of molecular stress events. The respective picture is less clear during cold exposure, partly related to the climate regime. In fact, functional characters in polar species may reflect adaptation to excess oxygen availability rather than limitation (Deep Sea Res. II 53, 1071, 2006). Reduced metabolic rates and excess ambient oxygen will alleviate oxygen limitation in the cold such that cold limitation by an overall loss in functional capacity is more stringent than by reduced oxygen supply.

26 October, 9:30 (S8-6686)

Climate-related changes in ocean transport control zooplankton biogeography around the North Pacific basin

Julie E. **Keister**[1], Emanuele Di Lorenzo[2], Sanae Chiba[3], Vincent Combes[2], Cheryl A. Morgan[4] and William T. Peterson[5]

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North Pacific boundary ecosystems are strongly impacted by climate-related physical variability, but direct tests of the mechanistic links between climate and the biological structure are rare. The Pacific Boundary Ecosystems and Climate Study (POBEX) is exploring the role that large-scale ocean transport plays in bottom-up control of Pacific boundary ecosystems. Using passive tracer experiments in a Regional Ocean Modeling System (ROMS), we are exploring the variability observed in zooplankton time series in the Northern California Current (NCC) and Kuroshio/Oyashio (KO) region. In the NCC, where zooplankton communities shift between cold-water species dominance and warm-water species dominance on seasonal and multi-year cycles, we find that horizontal transport varies with the phase of the Pacific Decadal Oscillation (PDO), and that the low-frequency component of the advection strongly correlates with the regional variance in species composition ($R>0.9$). Hindcasts of the community composition reveal 6-7 year cycles of species dominance over the 1950–2008 model domain, and a shift toward warm-water communities following the 1976 'regime shift'. In the KO region, where changes in ocean transport that occurred after the 1976 regime shift corresponded with shifts in zooplankton biogeography, we will directly test the degree to which PDO-related changes in surface currents controlled the transport of zooplankton into the region. That both the NCC and KO regions are influenced by PDO-indexed variability indicates that atmospheric forcings associated with the Aleutian Low (the driver of the PDO) downscale to influence local and regional ecosystem structure around the boundaries of the North Pacific.

26 October, 9:50 (S8-6816)

Saffron cod fluctuations in the Japan Sea: An evidence of match/mismatch hypothesis

Yury **Zuenko**, Ludmila Chernoivanova, Alexander Vdovin and Elena I. Ustinova

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The mechanism of the saffron cod *Eleginus gracilis* population fluctuations in Peter the Great Bay (Japan Sea) is investigated, in particular, the reasons for its catch decreasing in the early 1990s and its recent restoration. The spawning of this winter-spawning species occurred earlier after the winter regime shift to warming in the late 1980s, which was unfavourable for its year-classes strength because of the longer period from the peak of spawning to the beginning of the zooplankton spring bloom. Relatively cold winters in the 2000s caused later spawning and shorter time to the spring bloom which was favourable for larvae survival. A simple model based on the resonance function is proposed for estimation of the saffron cod year-classes strength. The optimal length of the period from spawning to spring blooming of zooplankton is determined as 90 days. Similar dependence on decadal-scale changes of winter conditions at spawning grounds is possible for Japanese sardine, as well, though its main spawning grounds are located far from Peter the Great Bay. The nature of these changes is explained; their relationship to the Arctic oscillation is shown.

26 October, 10:10 (S8-6778)

Climate variability and ecosystem response in Pacific Canadian coastal waters

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

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Ocean temperatures and marine life in Canadian waters of the northeast Pacific Ocean respond quickly to changes in seasonal winds. Seasonal winds, in turn, are sensitive to El Niño and La Niña events. These changes have been noted over the past decade in the annual State of the Ocean Reports prepared by members of the Fisheries and Oceanography Working Group in the Canadian Pacific region. An especially sudden shift in winds and ocean temperatures took place in early 2010 as the winter storms of the northeast Pacific Ocean responded to the 2009–2010 El Niño. We will show details of how the ocean and its marine life responded to the 2009–2010 event, and how previous warm and cool regimes in Canadian west coast waters have impacted marine life.

26 October, 10:50 (S8-6611), Invited

Geographical comparison of the decadal-scale variations in marine ecosystems in the North Pacific Ocean

Kazuaki **Tadokoro**[1], Yuji Okazaki[1], Tsuneo Ono[2] and Hiroya Sugisaki[3]

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The Intergovernmental Panel on Climate Change (IPCC) AR4 reported trends in decreasing salinity and increasing temperature in the surface layer of the North Pacific Ocean during the recent half century, and global warming is the speculated cause of the changes. The change in oceanographic conditions would enhance the stratification in the upper layer of the North Pacific Ocean. A decreasing trend in nutrients was observed in the surface layer of the Gulf of Alaska, Oyashio waters, Kuroshio-Oyashio Transition waters, Kuroshio, western subtropical waters, and East China Sea and an increasing trend in nutrients was observed in the intermediate water in the Oyashio and Kuroshio-Oyashio Transition waters. Nutrients are basically supplied from the subsurface to surface layer in the offshore waters. Therefore, the inverse trends imply a diminishing of water exchange between the two layers. Chl-*a* concentration and zooplankton biomass also represented a significant decreasing trend in the waters. These suggest that global warming decreases the productivity of the lower ecosystems simultaneously among the regions. On the other hand, it was reported that the effects of the climatic regime shift to the oceanographic conditions

and marine ecosystems is different among the regions. Therefore, it is important to classify the effects of global warming and regime shift to consider the mechanism of geographical variation of decadal-scale variations in marine ecosystems in the North Pacific Ocean.

26 October, 11:15 (S8-6753)

Comparison of the ecosystem responses to climate forcing and fishing between the Labrador Sea and the Norwegian/Barents seas

Ken F. **Drinkwater**[1], Glen Harrison[2], Erica Head[2], Padmini Dalpadado[3], Jim Carscadden[4] and George Lilly[4]

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The NORway-CANada comparative study of marine ecosystems (NORCAN) project examined the ecological responses to both climate and fishing in the Labrador Sea and the Norwegian/Barents seas. The traditional out-of-phase temperature and sea ice conditions between the regions due to their opposite response to the North Atlantic Oscillation (NAO) changed in the mid-1990s with strong warming and reduced ice coverage in both regions due to a weakening of the NAO pattern. Observations and modelling suggest this has resulted in the timing of the spring bloom and peak seasonal productivity to occur progressively earlier in the year in both regions and there is evidence of changing phytoplankton community structure, i.e., increasing role of small forms (picoeukaryotes). Within and among areas in both seas, *Calanus finmarchicus* started to reproduce earlier and the new generation developed faster. Capelin, the dominant forage fish, have exhibited large distributional changes since the 1990s in the Labrador /Newfoundland area but much less variability in the Barents Sea. Diet analysis shows that in recent years there have been poorer feeding conditions for Newfoundland capelin compared to the Barents Sea capelin. The large contrasts in the cod abundance over the past two decades from collapse in the Labrador/Newfoundland region to near high abundance in the Barents Sea are described, including the role of climate and fishing on these changes. Finally, the question of whether these recent changes constitute a regime shift or not is addressed.

26 October, 11:35 (S8-6844)

Climate variability drives anchovies and sardines into North and Baltic Seas

Jürgen **Alheit**[1], Michele Casini[2], Wulff Greve[3], Thomas Pohlmann[4], Anne Sell[5], Ralf Vorberg[6] and Carola Wagner[1]

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European anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) are southern, Lusitanian species needing temperatures warmer than boreal ones. After about 40 years of absence, they were observed again in increasing quantities in the North and Baltic Seas. Surprisingly, the population rise did not start in the late 1980s, when SSTs increased conspicuously in association with the increase of the North Atlantic Oscillation index. Instead, increasing numbers of eggs, larvae, juveniles and adults of both species were recorded since the mid-1990s, indicating that temperature was not the only factor triggering their re-appearance and spawning in more northern waters. Apparently, climate variability drives anchovies and sardines into North and Baltic Seas. We will discuss which atmospheric (*e.g.*, Atlantic Multidecadal Oscillation, East Atlantic Pattern) and oceanographic (*e.g.*, contraction of subpolar gyre) drivers might be responsible for the occurrence of anchovies and sardines in North and Baltic Seas and other changes in plankton, intertidal benthos and fish, observed at the same time. Comparisons to similar northward migrations of anchovies and sardines in the North Pacific will be made.

26 October, 11:55 (S8-6427)

Climate cycles and population dynamics of North Sea herring

Joachim P. Gröger[1], Gordon H. **Kruse**[2] and Norbert Rohlf[1]

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Understanding the causes of variability in the recruitment of marine fish stocks has been the "holy grail" of fisheries scientists for more than 100 years. Currently, debate is ongoing about the functionality and performance of traditional stock–recruitment functions used during stock assessments. Additionally, the European Commission requires European fishery scientists to apply the ecosystem approach to fisheries, in part, by integrating environmental knowledge into stock assessments and forecasts. Motivated to better understand recent years of reproductive failures of commercially valuable North Sea herring, we studied large-scale climate changes in the North Atlantic Ocean and their potential effects on stock productivity. Applying traffic light plots and time-series analyses, it was possible not only to explain the most recent reproductive failures, but also to reconstruct the full time series of recruitment from climate cycles, indexed by the North Atlantic Oscillation and the Atlantic Multidecadal Oscillation. A prognostic model was developed to provide predictions of herring stock changes several years in advance, allowing recruitment forecasts to be incorporated easily into risk assessments and management strategy evaluations for the long-term sustainability of this valuable commercial fishery. Also, insights gained from the analysis permit reinterpretation of the sharp decline in the North Sea herring stocks in the 1970s in terms of a combination of climate-driven effects and overfishing.

26 October, 12:15 (S8-6841)

Effects of climate change on pelagic ocean habitats and their potential role in structuring Bering Sea and Gulf of Alaska ecosystems

Anne B. **Hollowed**[1], Steven Barbeaux[1], Ned Cokelet[2], Stan Kotwicki[1], Patrick Ressler[1] and Christopher Wilson[1]

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Theoretical ecology suggests that competition between species and predator-prey interactions are modulated by the quality and quantity of suitable habitat. This paper examines whether climate variations influence the boundaries of suitable pelagic habitat, and whether these changes affect the spatial distribution and interactions between dominant pelagic fish species (forage fish) in the Bering Sea and Gulf of Alaska. We hypothesize that climate conditions form physical gateways that structure the summer distributions of forage fish (age-0 and age-1 walleye pollock (*Theragra chalcogramma*), and capelin, (*Mallotus villous*)). The strength of these physical gateways differs in warm and cold regimes. We examine this hypothesis using data collected during summer acoustic and bottom trawl surveys conducted as part of the NOAA groundfish trawl and acoustic surveys in the Bering Sea in 2003–2008, and the NOAA Fishery Interaction Team experiments in the Gulf of Alaska conducted in 2000–2006. We compare the responses of age-0 and age-1 walleye pollock, and capelin to climate induced shifts in pelagic habitats in the Bering Sea and Gulf of Alaska ecosystems. Habitat boundaries are defined using key explanatory variables including: forage fish density, predator distribution, depth, bottom temperature, surface temperature, and surface chlorophyll *a*. General Additive Models are developed to predict the spatial distribution of age-0 pollock, age-1 pollock and capelin in both regions. Comparison of the responses of three classes of forage fish in different ecosystems helps to better understand their expected responses to climate forcing. A framework is presented for integrating relationships between climate variability, pelagic ocean habitats, and forage fish distributions into stock projection models to permit simulations of regime shifts.

26 October, 14:00 (S8-6661), Invited

Multi-trophic level ecosystem modeling for understanding the mechanism of small pelagic fish species alternation associated with climate regime shifts

Shin-ichi **Ito**[1], Takeshi Okunishi[2], Atsushi Kawabata[2], Hiroshi Kubota[2], Akinori Takasuka[2], Taketo Hashioka[3,4], Hiroshi Sumata[5] and Yasuhiro Yamanaka[3,4,5]

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A multi-trophic level ecosystem model including Japanese sardine (*Sardinops melanostictus*) that coupling physical, biochemical-plankton (NEMURO: North Pacific Ecosystem Model for Understanding Regional Oceanography) and fish models was developed and then applied to the western North Pacific to elucidate the mechanism of fish species alternation, such as sardine and anchovy, associated with climate regime shifts. An individual-based modeling technique was used in the fish model, and fish movement is assumed to be controlled by feeding and spawning migrations with passive transport by simulated ocean currents. While feeding migration was assumed to be governed by search for local optimal habitats, spawning migration was modeled by an artificial neural network (ANN) with five environmental inputs (surface temperature, temperature change experienced, current speed, day length and distance from land) and ANN parameters were adjusted by genetic algorithm. To test the density-dependent effects on Japanese sardine, the model was integrated with higher and lower stock scenarios. The model reasonably reproduced weight decrease of sardine during the higher stock period. Moreover, the model reproduced expansion of the habitat area and decrease of prey plankton during the period. A hindcast simulation was also conducted for the earlier life stages, with mortality based on three different hypotheses; "bigger is better", "growth mortality", and "predatory pressure". The model results revealed that both "bigger is better" and "growth mortality" are insufficient to explain the large fluctuation of the Japanese sardine and at least another mechanism, such as "predatory pressure" is needed to realize it.

26 October, 14:25 (S8-6641)

Investigating alternate trophic pathways through gelatinous zooplankton, krill, and planktivorous fishes in an upwelling ecosystem using end-to-end models

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Interannual changes in the Northern California Current (NCC) food web structure were examined using both documentary and alternate scenario strategies. Spring and summer hydrographic, plankton, pelagic fish, and seabird surveys conducted off Oregon and Washington provide data on pelagic community composition from three oceanographically-contrasting years (2003, 2005 and 2007). This dataset is used to synthesize independent, top-down mass-balanced food web models upon the ECOPATH platform. Evidence is accumulating that gelatinous zooplankton populations have increased recently in many regions of the world. Jellyfish are generally detrimental to fisheries because they feed on zooplankton and ichthyoplankton, and so are both predators and potential competitors of fish. Jellyfish populations are opportunistic, responding quickly to environmental changes by increased feeding, growth, and reproduction of medusae in good conditions; therefore, jellyfish have been suggested as key indicator species of changing climate conditions. In the upwelling region of the NCC, jellyfish are extremely abundant and can often comprise the majority of biomass in the pelagic ecosystem. Both empirical and modeling studies suggest that jellyfish can negatively impact many pelagic fishes through resource competition. Our hypothesis is that climate-induced changes in ocean biotic and abiotic conditions caused variations in the jellyfish population in the NCC by affecting the reproduction, survival, and growth of large

jellyfish. Using top-down (Ecopath) and bottom-up (End-to-End) models, we examine interannual variability in the transfer of energy through alternate planktivore (jellyfish, krill and small fish) pathways and use this to project possible climate-induced changes in the food web in the coming decades.

26 October, 14:45 (S8-6790)

Numerical responses of krill predators to variation in krill abundance and spatial organization

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Climate variability can affect marine top predator populations via changes in predator-prey interactions. In previous studies of marine fish and seabirds, investigations of numerical responses have shown that fish and bird population parameters are related to prey abundance in a log-linear fashion. However, few studies used a comparative format including both marine fish and birds simultaneously. Here, we test the hypothesis that the relative abundance and spatial organization of euphausiid crustaceans in the central-northern California Current is related to seabird breeding success, the growth and productivity of rockfish and salmon, and the escapement of salmon, with appropriate lags. To test this hypothesis, we developed a series of indices of euphausiid prey availability for a 10-year period, 2000–2009, and tested the numerical responses of these predators using generalized liner and additive models. We found many significant relationships that explained most (~50–90%) of the variation in predator growth, productivity and escapement (as a proxy for survival). Owing to the length of the time series examined, we could not distinguish between linear and non-linear relationships, but most suggested non-linearity and threshold responses. Establishing the numerical responses of these krill predators to variation in krill population parameters provides a better understanding of how climate variability and change could be linked to regime shifts and other apparent changes in the bio-physical "state" of the California Current, with implications for other marine ecosystems where krill comprise an important prey field for top-level consumers.

26 October, 15:05 (S8-6822)

Variance estimation of the growth and food sources of the Manila clam by global warming in a subarctic lagoon, Japan

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Akkeshi Lake (35km^2), a subarctic lagoon, is located in the eastern part of Hokkaido, the northern island of Japan. It is semi-closed and connected to Akkeshi Bay, which is open to the North Pacific via only a narrow channel. It is covered by ice in winter. The water depth is usually less than 2 meters and the lake is covered with eelgrass, specifically *Zostera marina*. The Manila clam, *Ruditapes philippinarum*, is cultured in the intertidal sand flats, and the oyster, *Crassostera gigas*, is cultured throughout the lake except for the intertidal zones. In order to estimate variances of the growth and food sources of the Manila clam by global warming, we developed an ecosystem model with seven components, which are phytoplankton, zooplankton, eelgrass, epiphytic algae, benthic algae, oyster and the Manila clam. The model was coupled with a three-dimensional physical model and run for nine months. We estimated the time-dependent features of the growth of the Manila clam according to food sources, as well as the biomass of each compartment. The phytoplankton and suspended benthic algae are the main food sources for the Manila clam in Akkeshi Lake. When water temperature increased by global warming, chemical oxygen demand (COD) increases and dissolved oxygen (DO) decreases. Also, because of the enhanced stratification, the supply of benthic DO does not work smoothly and the biomass of benthic algae decreases in consequence. As a result, the growth of the Manila clam worsens as the food source of the Manila clam decreases.

26 October, 15:25 (S8-6600)

Impacts of climate change on the Arctic Ocean and adjacent seas

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Physical factors that make arctic marine ecosystems unique are a very high proportion of shallow continental shelves, dramatic seasonal change, low temperature, extensive permanent and seasonal ice-cover, and a large supply of freshwater from rivers and melting ice. Because of these conditions, many of which are challenging for marine biota, arctic marine ecosystems have a large number of specialists, many of which are not found elsewhere. These organisms have, through time, been able to adapt to the environment, but they are still challenged by extreme inter-annual variations.

The possible pathways by which climate variability may affect ecological processes are many and vary across a broad range of temporal and spatial scales. Climate variability affects fish both directly through physiology, including metabolic and reproductive processes, as well as through affecting their biological environment (predators, prey, species interactions) and abiotic environment (habitat type and structure). Furthermore, ecological responses to climatic variation may be immediate or lagged, linear or nonlinear, and may result from interactions between climate and other sources of variability.

The presentation will focus on physical and biological characteristics of Arctic Ocean and adjacent seas, and how ecosystems interact. There is ample evidence of the effects of climate variability on the marine ecosystems, *e.g.* the response of the abundance and distribution of fish species associated with long-term temperature changes. These occur as direct physiological responses as well as indirectly through effects on the prey, predators or competitors. However, many aspects of the interaction between the atmosphere and the ocean, and between climate and the marine ecosystem require a better understanding before the high levels of uncertainty associated with present predicted responses to climate change can be significantly reduced. This understanding can only be achieved through monitoring and research. The latter should include comparisons between and among other sub-arctic and arctic regions.

26 October, 16:05 (S8-6805), Invited

Long-term forecasts of walleye pollock dynamics in the eastern Bering Sea based on estimated responses of recruitment and growth to climate variability

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Reliable projections of future variability in fish populations requires (1) an understanding of the mechanisms that drive recruitment and growth, (2) future scenarios for key environmental drivers, (3) functional relationships linking recruitment and growth to these drivers, (4) a biologically defensible stock projection model, and (5) an understanding of the key uncertainties in important parameters and input variables. Recent advances in our understanding of the role of climate variability in regulating lower trophic levels in the eastern Bering Sea support a dome-shaped relationship between the recruitment of walleye pollock and surface temperatures during late summer. Although warm years appear to be conducive to the survival of early larvae, recent field studies suggest that unusually warm years, which are expected to increase in frequency, are unfavorable for late larval and early juvenile pollock. However, two potentially compensating mechanisms suggest that future recruitment may not be reduced as much as the temperature relationship alone would suggest. First, as walleye pollock abundance declines, cannibalism on larval and early juvenile stages is reduced and their survival increases. Second, warmer temperatures are associated with larger size-at-age of older juveniles and adults, which is likely to increase reproductive output. These relationships are further complicated by the presence of other important predators, in particular arrowtooth flounder. Future population trajectories under a variety of plausible temperature, predation, and fishing scenarios suggest a high probability that walleye pollock in the eastern Bering Sea will experience population declines over the coming decades.

26 October, 16:25 (S8-6444)

Climate fluctuations and walleye pollock biomass dynamics

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The relationship between climate variations and dynamics of walleye pollock (*Theragra chalcogramma*) biomass is studied. The Pacific Decadal Oscillation (PDO) shows common cyclic dynamics of 60- to 65-year periods with peaks in the 1940s and 2000s and a minimum in the 1960s–1970s. Walleye pollock biomass dynamics marked some high and low levels in the Bering Sea and in the Sea of Okhotsk. The comparative analysis of walleye pollock biomass changes and PDO index show a positive correlation. The historical maximum of the total biomass of walleye pollock in the Bering Sea and in the Sea of Okhotsk was observed in the mid 1980s, which was followed by a notable decline in biomass. Studies show that the periods of high biomass occurred during years of PDO positive anomalies, and had a duration between peaks of around 10–12 years. Minimum levels of biomass were generally observed in periods of PDO negative anomalies. Projected cooling is expected for the next 2–3 decades (Easterbrook, 2010), based on past PDO patterns of the past century. Expected global cooling for next several decades will change the total biomass of walleye pollock in the North Pacific in 2020–2030.

26 October, 16:45 (S8-6473)

Empirical evidence for biophysical coupling: Short and long term effects of climate variability on the growth rates of marine organisms across diverse taxa

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Dendrochronology methods of crossdating growth zones formed in calcareous structures of long lived marine organisms has been used as a tool for paleoenvironmental reconstruction. Annual growth-increment widths provide an integrated measure of an animal's growth rate over its life span that when related to environmental variability reveal evidence for a biophysical response. Evidence for a functional response between climate variability and animal growth is strengthened when such a response is seen across diverse taxa under the influence of physical processes in a given ecosystem. In this study, we evaluated the functional response between short- and long-term climate variability on the growth rates of long lived bivalves (*Panopea abrupta*) and rockfish (*Sebastes* spp.) in the North Pacific Ocean. Exactly dated growth increment data, which spanned nearly 100 years, was analyzed using a nonlinear mixed effects model that included covariates such as age, annual sea surface temperature (SST), upwelling and the Pacific Decadal Oscillation (PDO). Both SST and PDO were entered in the model as covariates, explaining significant variability in growth across both bivalves and rockfish. Once the effects of age on growth-increment data were removed, growth variability correlated positively with SST on an inter-annual basis while PDO accounted for longer term growth rate trends that were particularly evident between the 1940–1950 warm-cold and 1970–1985 cold-warm regime transitions. Accounting for PDO and SST greatly improved model skill in reconstructing climate conditions prior to the instrumental record. Our results indicate that biophysical coupling likely occurs at several temporal scales.

26 October, 17:05 (S8-6526)

Spacio-temporal changes in the feeding pattern of Pacific salmon, *Oncorhynchus* spp., in the North Pacific Ocean ecosystems during 1958–2009

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We surveyed the feeding habits of Pacific salmon (*Oncorhynchus* spp.) collected by surface trawl and gill nets in the North Pacific Ocean and the Bering Sea during 1994–2009, and compared them with the Gulf of Alaska in 1958 (LeBrasseur 1966) and 1980–1985 (Pearcy et al. 1988). Chum salmon (*O. keta*) collected in the Bering Sea in the summer 2009 fed on: 1) diverse prey-animals in the wider area; predominantly on 2) nekton in the coastal waters of the Aleutian Islands; 3) pteropods in middle waters, and 4) pteropods and copepods in the northern part of the sea. Chum salmon showed an increase in food diversity with increased CPUE. These results show that chum salmon have a high plasticity in their feeding, shifting their diets from dominant to more diverse prey-animals with increased salmon population density. In the Gulf of Alaska, Gonatid squids (mainly *Berryteuthis anonychus*) were the predominant prey of all Pacific salmon, except for chum salmon. However, squids showed a decreasing trend in diet of Pacific salmon in ENSO event years (*e.g.*, 1982–84, 1997, 1999, and 2004). These results suggest that Pacific salmon adapt feeding pattern to climate-induced changes in their prey resources and intra-specific interaction by switching their diets.

26 October, 17:25 (S8-6572)

On the promises and pitfalls of including decadal-scale climate forcing of recruitment in demersal fish stock assessment

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Concurrent declines in demersal fish stock abundances and shifts in long-term average environmental conditions in the Pacific have been well documented. Furthermore, highly variable stock-recruitment curves indicate environmental or other factors affect recruitment to fisheries. Thus, management advice that ignores environmental forcing of recruitment may cause stocks to be over- or under-harvested. The efficacy of including environmental forcing on recruitment in management models is important if stock assessment methods and forecasts are to consider ecosystem interactions. Simulation testing is used to determine the statistical power of currently-used stock assessment methods to correctly identify long-term decadal-scale environmental forcing of recruitment, and the impact on the ability to estimate biological reference points, when the duration of the fisheries time series is equal to or less than the period of the environmental cycle. Assessment methods most commonly used in practice tend to lead to lower total type I and type II error rates. High type I failure rates are, in many cases, due to fishing producing declines in spawning biomass and recruitment that often coincide with directional environmental change. These results are discussed in the context of the biological reference points typically used to make management decisions.

26 October, 17:45 (S8-6500)

Long-term changes in the condition factor of small pelagic fishes in the Japan Sea and the impact of the late 1980s regime shift

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A climatic regime shift, indicated as an abrupt change from cooling to warming in the Tsushima Warm Current (TWC), and identified in the late 1980s in the Japan Sea, has a large impact on the ecosystem of the TWC. Small pelagic fishes termed "wasp-waist" species are dominant but changed largely with the late 1980s regime shift in the Japan Sea. Using historical observation data, we examined the impact of the late 1980s regime shift on the long-term changes in the condition factor (CF) of five small pelagic fishes (Japanese sardine, anchovy, round herring, jack mackerel and chub mackerel). CFs of 20,000–900,000 fishes for the five species were calculated for the period since 1950s. CFs of all five species changing around the late 1980s with an increase (decrease) in the 1990s (1970s–1980s), corresponded well with the variation pattern in the water temperature. Significant negative (positive) correlations were found between the CFs and catches for Japanese sardine and chub mackerel (anchovy and jack mackerel), indicating that the CFs of Japanese sardine and chub mackerel (anchovy and jack mackerel) increased with a decrease (increase) in the abundance during the warm regime. These results strongly suggested that the late 1980s regime shift had a large impact not only on the abundance but also on the CFs for the small pelagic fishes.

S8 Session Posters

S8-6439

Change of the migration scheme of larval herring in connection with transformation of directions and forces of the currents caused by climatic factors in the northern Sea of Okhotsk

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Some researchers have found a separate grouping of herring spawning in Taui Bay, which is the intermediate spawning area of Okhotsk and the Gizhiga-Kamchatka herring. In June 2009, aggregations of larval herring were found in Taui Bay and the frequency of their occurrence in the eastern part of area was 45.5%. In 2009, new features occurred in the dynamics of currents. In particular, in the eastern part of the Bay, along with the conventional anticyclonic circulation, cyclonic circulation was observed. In 2009, the formation of cyclonic circulation in Olsky estuary interfered with the advection of larvae from the spawning areas of Taui herring in the central part of Taui Bay. In addition, the waters of the Jamsky current showed an intensification in Bay. Thus, the configuration and character of currents in 2009 interfered with the penetration of larvae from spawning areas of Taui herring in the eastern part of Taui Bay, which contradicts the data received by us on their distribution. It is possible that the larvae we found were brought by a branch of the Jamsky current in Taui Bay from the western spawning areas of the Gizhiga-Kamchatka herring. Thus, the global warming observed in recent years, including in northern part of the Sea of Okhotsk, obviously has led to change in direction and strength of both stationary and local currents in this area that, in turn, has changed the scheme of migrations of larval herring and, probably, promotes the redistribution of spawning sites of various populations of herring.

S8-6449

Terrestrial and marine correlates to black rockfish (*Sebastes melanops*) growth in the California and Alaska Coastal Currents

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Nearshore productivity is influenced by terrestrial and marine inputs, with some regions influenced more heavily by one input source rather than the other. Productivity in the California Current has been closely related to marine indices, but in the Alaska Coastal Current terrestrial inputs from rivers and glaciers may play a larger role. Annual growth records in otoliths can provide an opportunity to compare the relative influence of marine and terrestrial sources on fish productivity across both currents. We examined black rockfish otoliths from the California Current (Arcata/Eureka, CA; collected by NOAA) and the Alaska Coastal Current (Sitka, AK; collected by Alaska Department of Fish and Game and USGS). Otoliths were thin-sectioned, photographed, and visually crossdated. Annual increment widths were then measured and crossdating statistically verified. Next, each measurement time series (individual fish) was detrended to remove age-related variation and then averaged to generate a growth chronology. Growth chronologies were compared with monthly values of sea surface temperature as an index of marine influence and river discharge as an index of terrestrial influence. For the California Current, otoliths provided a growth chronology that spanned almost 40 years (1972–2006) and positively correlated with winter upwelling (P=0.0096; r=0.39) and negatively correlated with winter SST (P=0.05–0.0024; r=0.40–0.57), but did not relate to Klamath River discharge. At least in the California Current, nearshore growth was coupled with marine variables such that upwelling and the productivity it enables were positively associated with the black rockfish chronology. Results for the Sitka samples are presently under preparation.

S8-6492

Can rising variance predict sudden shifts in populations and ecosystems? A test using Alaskan crustacean data

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Marine ecosystems may respond to external forcing with abrupt reorganizations that are economically and socially devastating to fishing communities. There is currently no method allowing early warning of these reorganization events. However, recent developments in ecosystem modeling suggest a novel approach to this problem: using the *variance* of key parameters to monitor ecosystem status, rather than the mean. This “variance tracking” approach has been validated by empirical observations in the Gulf of Alaska and North Atlantic, suggesting that it may have real world management utility. We are conducting an extensive evaluation of the variance tracking method, using commercially important Alaskan crustacean populations as a model system for developing parameter variance as an indicator of resilience in both ecosystems and individual fisheries. Using retrospective analysis of extensive fisheries-derived and fisheries-independent data sets, we are testing key parameters for increases in spatial variance prior to the collapse of crustacean fisheries associated with ecological reorganization in Alaskan waters during the 1970s and 1980s. We are also testing for “false positives” in situations where fisheries did not collapse, and we are comparing the ability of fisheries-derived and fisheries-independent parameters to forecast historical fisheries collapses. Current forcing of Alaskan ecosystems by climate change may make ecological reorganization more likely, and could rapidly change the ecological state in which fisheries management operates. Our study may contribute to an eventual tool for early warning of ecological reorganizations, and could also suggest an approach (preventing variance increases) for maintaining ecosystem resilience.

S8-6499

Inter-annual variability of the spring chlorophyll *a* concentration maximum in the Peter-the-Great Bay (Sea of Japan) in 1998-2010

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According to the monthly SeaWiFS scanner estimates averaged for Peter-the-Great Bay (PGB), the spring chlorophyll *a* concentration (Cchl-*a*) maximum in 1998, 1999, 2001–2003, 2007–2010 was in April, and in 2000, 2004 – in May. In 2005, the maximum was observed in April–May. In 2006, two small maxima, in March and in May, were registered. The objective of this work is to elucidate the reason for the shift of the spring Cchl-*a* maximum in PGB by studying the chlorophyll *a* distribution and its relationship with hydrological features of area. Monthly spring estimates of the Cchl-*a*, photosynthetically available radiation (PAR) from SeaWiFS, sea surface temperature (SST) from MODIS-Aqua for 2003–2010 (obtained by means of the Giovanni System), sea-surface wind distribution from QuikScat and SSM/I (obtained from http://www.ssmi.com) were analyzed. For 2000–2002, the daily SST distributions from NOAA satellite data (obtained via the Center for Satellite Monitoring of IACP FEB RAS) were considered. Regarding Cchl-*a* for the spring months, it was possible to distinguish 3 basic zones of phytoplankton growth: 1) coastal; 2) the zone stretching from the north-eastern to south-western part of PGB; 3) southern zone. For the situations with a relatively high satellite Cchl-*a* estimate averaged for PGB, the predominance of the second zone was typical. The negative coefficients of correlation between Cchl-*a* and SST, Cchl-*a* and (SST × PAR) for this zone, and SST distributions for the northern part of the Sea of Japan, show the influence of water from the melting ice of the northern part of the Tatar Strait through the Primorye Current on Cchl-*a* distribution in PGB. According to the SST and sea-surface wind distributions, it was revealed that the development of this zone depends on the water temperature, wind speed, and border of spreading for warmer and saltier water from the Tsushima Current in the northern part of the Sea of Japan. Values of these characteristics were estimated.

S8-6504

Latitudinal variation of lipid contents and compositions in copepods, *Euchaeta* and *Pleuromamma* spp., from the Northwest Pacific Ocean: Its implication in feeding ecology

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In order to understand the latitudinal variation of lipid contents and compositions in copepods, we collected two copepod species, *Euchaeta* and *Pleuromamma* spp., from low to mid latitudes in the Northwest Pacific Ocean. Total lipid contents of *Pleuromamma* spp. were about 10 $\mu g \cdot ind^{-1}$ with little latitudinal variation, whereas *Euchaeta* spp. showed slightly higher lipid content ($\approx 17 \mu g \cdot ind^{-1}$) than *Pleuromamma* spp. with the latitudinal gradient (low at sub-tropic and high at temperate). Wax esters, known as the major storage lipid classes, were found to be the dominant lipid classes (≥35% of total lipids) in *Euchaeta* spp., whereas in *Pleuromamma* spp., phospholipids, known as the membrane components, were the dominant lipid classes, with an exception of specimens from warm pool regions, showing the dominance of storage lipids as a form of triacylglycerols. Among fatty acids, polyunsaturated fatty acids, especially docosahexaenoic acid (DHA: 22:6(n-3)), were most abundant in *Euchaeta* spp., while saturated fatty acids, especially hexadecanoic acid (16:0), were most abundant in *Pleuromamma* spp. Among the neutral fraction of lipids, phytol, originating from the side chain of chlorophyll, was found in all samples which could indicate feeding activity on phytoplankton. While only trace amounts of short-chain fatty alcohols were found in *Pleuromamma* spp., significant amounts of long-chain monounsaturated fatty alcohols (20:1 and 22:1), generally known to be found in cold water copepod species, were found in *Euchaeta* spp. The latitudinal variation of trophic lipid markers in these copepods could be significantly related with *in-situ* food availability and species-specific diet preference.

S8-6541

Winter and summer upwelling modes and their biological relevance in the California Current Ecosystem

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The seasonal structure of coastal upwelling in the California Current Ecosystem (CCE) is explored and two dominant modes of variability are described: the first reflects peak upwelling during the summer months while the second reflects wintertime ocean conditions. The "summer mode" is dominated by low-frequency processes including long-term increases within the central CCE, while the "winter mode" is dominated by higher-frequency, interannual variability associated with the El Niño Southern Oscillation. Both are biologically relevant to the ecosystem. Multidecadal time series of splitnose rockfish (*Sebastes diploproa*) and yelloweye rockfish (*S. ruberrimus*) otolith growth, Chinook salmon (*Oncorhynchus tshawytscha*) scale growth, and reproductive success of common murre (*Uria aalge*) and Cassin's auklet (*Ptychoramphus aleuticus*) in the CCE respond to one or the other of these modes, though the majority most closely relate to winter-mode upwelling. Years with above-average upwelling, especially in the winter months, are associated with vigorous rockfish and salmon growth as well as high seabird reproductive success. Relationships are non-linear and indicate threshold responses. Overall, this study illustrates the importance of upwelling seasonality to the physical and biological structure of the CCE, including that of the winter months during which upwelling intensity levels are low or dominated by downwelling processes.

S8-6595

Interannual variability in the Northern California Current food web structure: Inferring trophic pressures upon juvenile salmon

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Interannual variability in the ocean survival of juvenile salmon within the Northern California Current has been attributed to both lower trophic-level productivity and predator abundance. Both top-down and bottom-up processes may regulate juvenile salmon survival, but the strength and relative importance of these processes vary among years with coastal upwelling strength, the arrival of migratory predators, and climate-scale physical processes. Hydrographic, plankton, seabird, and fish surveys conducted from 2003–2008 provide time-series data on pelagic community composition. We synthesize this dataset into a series of independent, mass-balanced food web models from which we infer interannual changes in both direct and indirect top-down and bottom-up pressures acting upon juvenile coho (*Oncorhynchus kisutch*). While major potential predators (hake, sooty shearwaters) were no more abundant in 2005 than in 2003 and 2007, both juvenile salmon and alternative forage fish prey were less abundant in 2005. Thus the inferred predation pressure was greater in 2005. Seasonal meso-zooplankton production was also low in 2005 due to late onset of coastal upwelling. Given this information and the high predation pressure of 2005, this could have been an especially poor survival year. However, indices of hatchery coho survival were not much different between 2003, 2005, and 2007. Accounting for total ecosystem demand on meso-zooplankton production, the 2005 demand is shown to be the lower of these years. Variation in trophic pathways enhance or reduce energy available for growth, and conditions for growth in 2005 may have been better than inferred directly from gross zooplankton production.

S8-6627

Forecasting practice on the common squid (*Todarodes pacificus*) population responding to climate/oceanographic changes

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The common squid, *Todarodes pacificus*, has a one-year life cycle, and is currently the most abundant fishery resource in Korean waters as a single species. It has been known that its biomass generally fluctuates in accordance with the changes in ocean temperature. In addition to seawater temperature, however, the mixed layer depth of the spawning grounds and the volume transport through the Korea Strait seem to be related to the future success in recruitment of common squid in the following season. We speculated on the changes in squid resources based on retrospective analysis with past observations, as well as model results using the MPI model under the climate change scenario SRES A1B. Model results indicate that the warming rates of seawater in spawning areas seem to be accelerated in the first half of the 21st century. The tendency of warming is higher in winter (0.28~0.30°C/decade) than in autumn (0.17~0.20°C/decade). The peak of catch used to be in autumn when spawning intensity is high. However, it tends to be delayed until winter as winter temperatures rise in the future. Furthermore, the area of preferred temperature range for hatchling squid will be expanded in the Japan/East Sea, while decreasing in the Yellow Sea.

S8-6684

Comparing pathways of functional response of top predators to seasonality of upwelling in the California Current

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Upwelling is an important driver of coastal productivity and an essential mechanism to predator-prey interactions in eastern boundary current systems worldwide. Along the west coast of North America, nutrients supplied by upwelling processes support abundant phytoplankton and zooplankton communities that serve as the basis for trophic interactions leading to upper trophic level marine predators. We hypothesized that 1) predator productivity is indirectly affected by upwelling through intermediate trophic levels, and 2) different upper level predators would show different pathways of response. We tested these hypotheses using path analysis from upwelling (divided into winter and summer seasons) through intermediate trophic levels to the productivity and relative abundance of two species of seabirds (common murre and Cassin's auklet), chinook salmon, rockfish, and humpback whales. Intermediate levels included phytoplankton, proxied by chlorophyll *a* concentrations, and mid-trophic level prey, indexed by measurements of copepod biomass and community structure and proxies of euphausiid and juvenile rockfish abundance based on seabird diets. Results confirmed indirect effects and variation in the pathways of response for different predators. Multiple intermediate trophic levels were important to include in the path models, and predators had specific key prey. Contrasting the differential pathways of response of predators to upwelling and intermediate trophic levels enhances understanding of fundamental ecosystem dynamics and mechanisms.

S8-6690

Overview of the main pelagic species stocks in Peru during 1950–2009

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Landings and biomass of main pelagic species in Peru during 1950–2009 registered three remarkable periods in order of their species composition: 1) dominance of Peruvian anchovy (*Engraulis ringens*) in the sixties, 2) abundance of other pelagic species such as sardine (*Sardinops sagax*) and jack mackerel (*Trachurus murphyi*) during the seventies and eighties and 3) again, dominance of anchovy, mainly after the warm El Niño event of 1997–98, a situation that in other similar ecosystems has not been clearly observed.

In this period differences were observed in the time and pattern of the declines of the stocks of pelagic species. For example, landings of Peruvian anchovy at the beginning of the seventies drastically dropped in only 4 years related to a combined effect of environmental variability and strong fishing pressure. Sardine landings decreased during the nineties but was moderate, lasting about ten years. Jack mackerel landings decreased during the present decade with a trend similar to sardine and also lasting about ten years. The decreases of both species were associated more with environmental long-term changes.

A new contribution to these changes is related to the impact of climatic variability on the distribution and concentration of dominant species off Peru, as in the case of anchovy in the coastal zone and vinciguerria (*Vinciguerria lucetia*)/jumbo squid (*Dosidicus gigas*) in the ocean area.

S8-6692

Possible effects of global warming on fish early life stages: Shift in spawning season and latitudinal distribution can alter growth of juvenile fishes through the changes in daytime length

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Changes in growth rates, shifts in spawning season and grounds (latitude) of fish are expected after an increase in sea temperature due to global warming. Fish can avoid higher temperatures by undergoing a poleward shift of spawning ground and temporal shift in spawning timing. However, these shifts will induce changes in daytime length experienced during their early life stages. In order to comprehensively understand the possible effects of global warming on fish recruitment, effects of temperature and daytime length on growth, daily ration and growth efficiency of juvenile black rockfish, a dominant species in coastal waters of the western North Pacific, were examined under wild and laboratory conditions. The growth rate of wild black rockfish juveniles collected in seagrass beds was back-calculated by the use of otolith daily rings based on the biological intercept method. Mean growth rate ranged between 0.1–0.7 mm d^{-1} and was higher at higher temperatures. Gross growth efficiency was highest at 16°C (24.2%) and lowest at 18°C (17.1%). The effect of photoperiod on growth was also significant with fast growth at longer daytime length. The effect of shifts of spawning season and grounds would differ among fish species and spawning season. These shifts provide fish early life stages with changes in daytime length in different ways. Changes in daytime length due to a northward shift of spawning ground will have opposite effects between summer- and winter-growing fish early life stages, and are more prominent at higher latitudes.

S8-6725

Variability of mixed layer depth and its relation with chlorophyll concentration in the North Pacific Ocean

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Mixed layer depth (MLD) affects phytoplankton dynamics through controlling the availability of nutrients and light in the upper ocean. This study investigates variability of MLD and its relation with chlorophyll (CHL) in the North Pacific Ocean on seasonal to year-to-year timescales. The North Pacific MLD field was calculated from

SODA (Simple Ocean Data Assimilation) version 2.1.6 covering 51 years from January 1958 to December 2008. MLD was defined as the depth at which the potential density takes the reference depth (10 m) salinity value and the temperature value which is 0.2 degree centigrade lower than the reference value. The variability of maximum MLD is well correlated with CHL variability in some regions in the North Pacific Ocean, including the Kuroshio Extension (KE). For example, increased maximum MLDs in the years of 2003–2007 compared with values in the years of 1998–2002 correspond to enhanced CHLs in the KE. The good correspondence between MLD and CHL suggests that increased maximum MLD helps to entrain deep nutrients into the upper ocean and thus to maintain high CHL in the KE. Changes in primary production based on nutrient entrainment by wind mixing at selected locations in the North Pacific also will be given and compared with observation.

S8-6727

Effect of temperature on growth of black rockfish *Sebastes cheni* juveniles in seagrass and macroalgae beds

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Seagrass (*Zostera marina*) and macroalgae (*Sargrassum* spp.) beds are important nurseries for fish and support high fish production. The black rockfish *Sebastes cheni* are widely distributed and commercially and recreationally important fisheries resources in coastal waters of the western North Pacific. Their larvae and juveniles dominate the fish community in seagrass and macroalgae beds of the temperate and sub-arctic waters from late winter through summer. Temperature of the juvenile habitats fluctuate temporally and spatially from ca. 7.0ºC in March in northern Japan and >20.0ºC in June in both northern and southern Japan. In the present study, the relationship between juvenile growth rate and ambient temperature was analyzed in seagrass beds in temperate coastal waters of Japan where juvenile rockfish are abundant. Fish collection was conducted at more than 15 sampling sites in Japan from March 2009 to July 2010. Otolith microstructures were used for back-calculation of growth rate from extrusion to capture based on the biological intercept method. Mean daily growth rate of juvenile black rockfish ranged between 0.1 and 0.7 mm/d and was high at higher temperatures. Other environmental conditions (seagrass shoot density and leaf length, salinity, prey concentration and biomass) did not have a significant effect on the variability in juvenile growth rate. Ambient temperature was considered to be one of the most important determinants for the growth of juvenile black rockfish.

S8-6749

A striking difference of coastal SST related to climate change in the eastern coast of Korea

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The variation of ten days' SST during 40 years (1970–2009) at 3 stations (Ulgi: 35°29´30.44″N, 129°26´34.64″E; Jukbyon: 37°03´27.25″N, 129°25´49.09″E and Sokcho: 38°12´54.04″N 128°35´56.23″E) on the eastern coast of Korea was studied on the basis of time series data from KODC (Korea Oceanographic Data Center). During the studied period, in Jukbyon, the lowest SST was below 5℃ at the beginning of February in 1981 and the highest was about 24℃ at the beginning of August in 1991. SST lower than 10℃ was recorded at the beginning of April until 1986 but disappeared after 1998. In Sokcho, the lowest SST was below 1℃ at the beginning of February in 1980 and the highest was about 25℃ at the end of July in 1994. SST lower than 5℃ was recorded at the end of April until 1986 but disappeared from 1987 when the collapse of the walleye pollock fishery started in Korea. However, low SST in Ulgi was about 12℃ which was nearly constant throughout the studied period. The 15℃ isopleth of Jukbyon SST was found around the end of May until 1993 but recently we can find it in the middle of March. Besides, warm SST higher than 20℃ appeared from the middle of July to the end of September until mid-1990s but afterwards it occurred from the first ten days of June to the first ten days of September. However, we cannot find a sharp difference in the main axis of the high SST period from the Sokcho and Ulgi SST time-series.

S8-6758

Climate forcing and the California Current ecosystem

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The Climate Forcing and Marine Ecosystems (CFAME) Task Team of PICES was formed to address climate forcing impacts on ecosystem structure and productivity of key species. For the California Current System, the Task Team described the physical processes, built an overview of species across trophic levels and described how the population dynamics of these species have changed overtime. Based on synthesis work, conceptual models were developed describing the potential mechanisms linking climate forcing, oceanography and species' responses. The resultant empirical data scenarios draw on ecosystem histories to provide a synopsis of expected change given global climate change. The multi-disciplinary team faced challenges and limitations in their attempt to draw connections between the outputs from Global Climate Models (GCM), the physical processes and the subsequent impacts on species via the identified mechanisms. To some degree there was a mismatch of variables that fisheries scientists identified as important in determining species' response to climate and physical forcing, and the variables that current GCMs are currently able to resolve at the regional level. These gaps will be important for researchers to consider as they begin to develop higher resolution climate and regional oceanographic models for forecasting changes in species' productivity.

S8-6820

Predicting resilience to ecosystem change in a far-ranging, pelagic, generalist forager

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The Laysan Albatross (*Phoebastria immutabilis*) is a far-ranging, generalist feeder that adjusts foraging location across the North Pacific by breeding status, season, and inter-annual variability in foraging conditions. Given the great breadth of foraging strategies among individuals and life-stages, how resilient is the population to changing ecosystem dynamics? We employed a standardized measure of "ecosystem use" or foraging strategy, namely, stable isotope ratios of nitrogen and carbon in feathers, across a broad range of sampling categories, to address questions that link foraging strategies with demographic responses and with century-long change in foraging opportunities. A clear pattern of optimal versus buffering strategies emerged. Optimal foraging strategies, defined by association with high reproductive success and early age of first reproduction, were narrowly defined, despite the great breadth of stable isotope values found across the sampled population as a whole, both currently and historically. Optimal strategies appear to have remained consistent over the last 100 years, despite large gains (fishing discards) and losses (based on stable isotope evidence) in foraging opportunities. Although a large proportion of the population currently appears to forage "sub-optimally", population size is relatively stable, demonstrating the adaptive significance of the generalist strategy. However, if climate change ultimately affects the narrowly-defined, optimal foraging base, the population may quickly lose resiliency to ecosystem change. Our approach, combining a standardized measure of ecosystem use with a diverse range of sampling categories can provide robust data for predictive models of functional response to ecosystem change.

S8-6835

Contrasting distribution patterns of the common squid (*Todarodes pacificus*) in Peter the Great Bay (Japan/East Sea) in 2008 and 2009

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The common squid (*Todarodes pacificus*) is widely distributed in the Japan/East Sea and off the Japanese islands in the Northwest Pacific Ocean and is a highly valued commercial species. Squid reproduce in the south of the species range, migrate northward to feed and grow and, as they mature, return to spawning areas. This species occur frequently during summer and fall in Peter the Great Bay (Japan/East Sea); however, the intensity of the squid migrations into the bay varies from year to year. We analyzed the distribution density (CPUE) of squid in Peter the Great Bay in 2008 and 2009 and compared those to differences in oceanographic patterns. It appeared that, in 2008, when warm water entered Peter the Great Bay in a narrow flow along the continental coast and the Primorye current was strong in the early summer, the common squid migrated into the bay early but migrations remained low in terms of numbers as the season progressed. In 2009, on the contrary, when warm water advection into Peter the Great Bay was broad (several anticyclonic gyres), the squid migrated into Peter the Great Bay later but, as the warm season progressed, squid occurred there in high densities until the late autumn.

S8-6837

Distribution patterns of the gonatid squids (Gonatidae, Oegopsina) in the northern Sea of Okhotsk in 1990-2008

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Three species of the family Gonatidae dominated pelagic cephalopod communities in the northern Sea of Okhotsk (north of 54°N): *Berryteuthis magister, Gonatus madokai* and *Boreoteuthis borealis*. In the epipelagic zone (0–200 m depth), investigations were conducted in all four seasons during 1990–2008. In winter, distribution density of all gonatid species varied from 0–117.9 kg/km^2, and juvenile *B. magister* were the most common squid (>72%). In spring, gonatid squid distribution density varied from 7.7–65.2 kg/km^2, and juvenile *G. madokai* were the most common squid (>54%). In summer, gonatid squid distribution density varied from 2.8–193.3 kg/km^2. In most years, either *B. magister* or *G. madokai* were dominant species. In the warm summer of 1997, when the counter-current along the east Kamchatka coast was weak, gonatid squid biomass was the highest, *G. madokai* and *B. borealis* accounting, respectively, for 60 and 32% of the total squid distribution density. In autumn, distribution density of the gonatids was the highest, from 65.9–602.2 kg/km^2. Two species, *B. magister* and *G. madokai*, occurred in similar quantities (together accounting for more than 80% of the biomass) when density of all gonatids was less than 115 kg/km^2; however, higher density was due to an increase in biomass (>75%) of *B. magister*. In the upper mesopelagic zone (200–500 m depth), surveys were performed in autumn, winter and spring during 1990-1998. At these depths, distribution density of the gonatids varied from 29.7 kg/km^2 in spring to 506.4 kg/km^2 in winter, and in all the three seasons, *B. magister* was the most common squid (>64%). In 2000–2002, when only spring surveys were conducted in the upper mesopelagic zone, squid density ranged from 58.2-140.5 kg/km^2, *G. madokai* and *B. magister* together accounting for more than 94% of the combined gonatid squid biomass.

S9 MEQ Topic Session
Conceptual and numerical models of HAB dynamics

Co-Convenors: William Cochlan (U.S.A.) and Shigeru Itakura (Japan)

Each PICES member country has conceptual models of harmful algal bloom (HAB) dynamics that link the physics, chemistry and biological aspects of bloom development and decay. The biology gives us information on ecosystem structure but also describes elements contributing to success of a particular species. The chemistry focuses on nutrient dynamics, ratios and preferences among species. Physical processes detail cell and nutrient delivery to the coast. While conceptual models are descriptions of HAB dynamics without numbers, numerical models include rate estimates. In theory, each of these would be supported with the same physical, chemical and ecological foundation, overlain with the unique considerations of different water types and second order ecosystem structure. However, these models vary widely between species and among countries. There have been no comprehensive inter-comparisons among these conceptual and numerical models to identify their similarities and differences. The focus of this session will be to seek commonalities among models and identify the unique second order aspects needed to describe the distribution and dynamics of HAB in different PICES regions. We encourage modelers and non-modelers alike to submit their papers.

Wednesday, October 27 (9:00-12:40)

9:00	***Introduction by Convenors***
9:05	**Wolfgang Fennel (Invited)** Construction of models with reference to HABs (S9-6871)
9:35	**Theodore J. Smayda (Invited)** Modeling harmful algal blooms: The need for a conceptual template harmonious with empirical evidence (S9-6464)
10:05	**Jenny Q. Lane, Peter T. Raimondi and Raphael M. Kudela** The development of toxigenic *Pseudo-nitzschia* bloom models in Monterey Bay, California, and their application at a single monitoring site within the model domain (S9-6484)
10:25	**Shigeru Itakura, Ichiro Imai, Satoshi Nagai and Mineo Yamaguchi** *Chattonella* (*antiqua/marina*) versus diatoms - Different seeding strategies and their bloom dynamics in enclosed embayments (S9-6739)
10:45	***Coffee/Tea Break***
11:05	**Tamiji Yamamoto and Ryoko Sakai (Invited)** Numerical modeling of the slow-growing, motile harmful alga *Gymnodinium catenatum* in Inokushi Bay, a small inlet in southern Japan (S9-6574)
11:35	**Donald M. Anderson, Dennis J. McGillicuddy, Jr., Bruce A. Keafer and Ruoying He** Bloom dynamics of the red tide dinoflagellate *Alexandrium fundyense* in the Gulf of Maine: A synthesis and progress towards a forecasting capability (S9-6755)
11:55	**J.E. Jack Rensel** Modeling fish-killing blooms of *Heterosigma akashiwo* in the Salish Sea (S9-6874)
12:15	**Angelica Peña and Michael G. Foreman** Phytoplankton bloom development in the Juan de Fuca Eddy: Insights from a simple biophysical model (S9-6788)
12:35	***Summary by Convenors***
12:40	***Session ends***

S9 Session Oral Presentations

27 October, 9:05 (S9-6871), Invited

Construction of models with reference to HABs

Wolfgang **Fennel**

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This talk presents theoretical approaches that provide ways to faciltate modeling of marine ecosystems with relevance to HABs. After addressing some aspects specific to HABs, the discussion covers the basic ingredients of models, such as choices of state variables, identfication of the process rates, interaction among and competition between organisms, life cycles and physical-biological interactions. There are several options to describe real systems with the aid of models, ranging from individual-based consideration to population models, and/or using equations for distribution functions. An analysis on the level of phase space is used to show that for systems with very many cells the individual-based models are virtually equivalent to distribution models that work with 'average individuals'. This assessment applies also to systems of other organisms as soon as very many, practically indistinguishable individuals are involved. The issue of coupling biological or biogeochemical models with three dimensional physical models is also addressed. The importance of consistent data sets for model development and validation is highlighted as a precondition for the development of predictive capacity of HAB models.

27 October, 9:35 (S9-6464), Invited

Modeling harmful algal blooms: The need for a conceptual template harmonious with empirical evidence

Theodore J. **Smayda**

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Empirical data must be combined with theory as a conceptual first step in developing numerical models to understand the complex organization, dynamics and interactive physical, chemical and biological regulation of harmful algal community assembly, species selection and blooms (HABs). Several key attributes of HAB ecophysiology must be recognized conceptually, but often are ignored in pursuing a universal, numerical HAB model. Data are presented to show that, conceptually, modelers need to reject the notion that HAB species have a common "ecological zone" and that a "Law of Ecophysiological Equvalence" applies. The empirical evidence suggests HAB species exhibit considerable diversity in "ecological zone" requirements and ecophysiology, and that a model developed for a given dinoflagellate species, locale or time will be more specific than general. The distinction between cellular, population and community growth modes; their differing role in bloom dynamics, and differences in their regulatory processes must be recognized and networked within numerical models to capture their interactive direct and indirect effects on bloom dynamics. The conceptual consequences to the modeling of HABs resulting from failure to recognize the marked contrasts in bloom and community behavior between dinoflagellates and diatoms are considered. Modelers must recognize that species selected to bloom are the result of a preceding hierarchical phylogenetic and generic selection process, and the rules of assembly governing those processes must be taken into account. The need to apply a conceptual biocomplexity model with elements more akin to insect ecology than to classical bloom behavior is discussed.

27 October, 10:05 (S9-6484)

The development of toxigenic *Pseudo-nitzschia* bloom models in Monterey Bay, California, and their application at a single monitoring site within the model domain

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Models of regional toxigenic *Pseudo-nitzschia* blooms have been developed and described for Monterey Bay, California. This modeling exercise provided valuable and useful insight into *Pseudo-nitzschia* bloom dynamics and the study of those dynamics, including: 1) which regional datasets could be applied towards model development and, more significantly, what factors disqualified the majority of available data; 2) identification of those bloom factors which were recurrent and possibly 'universal' (*i.e.*, shared among the Monterey Bay models and models previously described for the Santa Barbara Channel and from a laboratory dataset); and 3) the reconciliation of alternating hypotheses regarding bloom forcing (upwelling versus freshwater discharge) through the consideration of seasonality. Now, over two years after our development of the regional bloom models, we evaluate the applicability of these models towards a 'real-world' purpose for which they were not designed: the prediction of localized blooms at a single monitoring site within the model domain – the Santa Cruz Municipal Wharf (SCMW). Model predictions driven by SCMW environmental data will be presented in conjunction with traditional monitoring data (cell counts of toxigenic species, indexed *Pseudo-nitzschia* [genus] relative abundance, toxin quantification, and sentinel shellfish analysis) and data from a new phycotoxin monitoring tool - Solid Phase Adsorption Toxin Tracking (SPATT). Toxigenic *Pseudo-nitzschia* bloom events observed in autumn 2009 and spring 2010 are presented as case studies through which we consider the usefulness of model application at SCMW under the circumstances of an 'unusual' autumn bloom event (which, as an unusual event, was unanticipated from a regulatory standpoint) and a more 'classic' spring bloom event.

27 October, 10:25 (S9-6739)

Chattonella (*antiqua/marina*) versus diatoms - Different seeding strategies and their bloom dynamics in enclosed embayments

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Chattonella and diatoms (such as *Skeletonema* spp., *Chaetoceros* spp. and *Thalassiosira* spp.) are thought to be common rival phytoplankters in Japanese coastal environments. They are known to produce benthic resting stages (resting cysts/resting spores) in their respective life cycles. These benthic resting stages are considered to play an important role in their local (autochthonous) reoccurrence in enclosed embayments. Under fluctuating coastal environmental conditions, the timing of germination is a key factor in their seeding strategy. Newly-formed resting stages are in a state of endogenous dormancy. So, they need to be matured (i.e., relieved from their state of dormancy) prior to germination. However, even in matured, resting stage cells, germination is inhibited under unsuitable environmental conditions. Water temperature, light intensity and dissolved oxygen seem to have a decisive role in the germination of matured, resting stage cells. In general, diatom resting stages are able to germinate under a wider temperature range than *Chattonella* cysts, whereas *Chattonella* cysts are able to germinate under lower light intensity levels than diatom resting stages. In this talk, the different physiological responses to environmental factors within *Chattonella* and diatom resting stages will be examined, and the significance of different seeding strategies on their bloom dynamics will be discussed.

S9

27 October, 11:05 (S9-6574), Invited

Numerical modeling of the slow-growing, motile harmful alga *Gymnodinium catenatum* in Inokushi Bay, a small inlet in southern Japan

Tamiji **Yamamoto** and Ryoko Sakai

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The paralytic shellfish poisoning (PSP)-producing dinoflagellate, *Gymnodinium catenatum* often forms blooms in a small inlet, Inokushi Bay in Kyushu, Japan where it causes serious damage to the local cultured shellfish fishery. The maximum growth rate of the *G. catenatum* strain isolated from this area is only 0.31 d^{-1}, even during optimum conditions. This slow growth rate is common to such toxic dinoflagellate species. This raises the question, how do such slow-growing organisms form blooms when surrounded by many faster-growing phytoplankton species? One of the possible answers is their toxicity, which works as a factor to escape grazing. In our case study of Inokushi Bay, 'swimming' behavior was the key to forming blooms in the inlet, in addition to escaping grazing. In this area, there are no big rivers that control water movement. However, it was observed that surface cooling in the inner regions of this bay during the winter drives 'inverse estuarine circulation' with downward movement in the innermost regions. The numerical model revealed that *G. catenatum* couldn't form a bloom in the bay without such inverse estuarine circulation. It was concluded that the balance between the upward swimming movement of the species and the downward water movement is the most important factor to maintain and/or increase the population of *G. catenatum* in Inokushi Bay.

27 October, 11:35 (S9-6755)

Bloom dynamics of the red tide dinoflagellate *Alexandrium fundyense* in the Gulf of Maine: A synthesis and progress towards a forecasting capability

Donald M. **Anderson**[1], Dennis J. McGillicuddy, Jr.[1], Bruce A. Keafer[1] and Ruoying He[2]

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Blooms of the toxic dinoflagellate *Alexandrium fundyense*, commonly known as "red tides" have been a serious problem in the Gulf of Maine since 1972. The blooms are associated with the accumulation of potent neurotoxins in shellfish and some fish species, leading to Paralytic Shellfish Poisoning (PSP) in human consumers – a potentially fatal poisoning syndrome. This talk will summarize more than a decade of large-scale field and modeling activities in the nearshore waters of this region, leading to a conceptual model of bloom dynamics that is consistent with cruise observations, patterns of shellfish toxicity, and numerical models that are being used for weekly and seasonal forecasts. The long-term implications of the blooms and their deposition of dormant cysts will also be discussed, as there is good reason to believe that the western Gulf of Maine region will experience more frequent and more intense PSP outbreaks in upcoming years, compared to the previous decade. The challenges and potential for an operational red tide forecasting system in the Gulf of Maine will be discussed. We will also describe seasonal to interannual variability in *A. fundyense* blooms in Georges Bank, which appear to be decoupled from the near-coastal blooms, at least in terms of their initiation and development.

27 October, 11:55 (S9-6874)

Modeling fish-killing blooms of *Heterosigma akashiwo* in the Salish Sea

J.E. Jack **Rensel**

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Blooms of the harmful raphidophyte *Heterosigma akashiwo* have recently been linked to the two-decade decline of the Fraser River Sockeye salmon *Oncorhynchus nerka*, historically the most valuable west coast salmon fishery of the United States and Canada. New data show that other stocks of fish, particularly resident-marine fish such as herring and other salmon species also may be at risk. Therefore understanding *Heterosigma* bloom dynamics and the ecological effects of this raphidophye are important for future fisheries management and food-web mitigation actions. Factors that contribute to extensive blooms of this alga in the Salish Sea are known, and have led to development of a conceptual model that is useful over time scales of days to a week. The conceptual model relies on warm-weather effects and time of year, and to a lesser extent tidal-cycle timing. Here I discuss possible means to use monitoring, farmed-salmon mortality events, wild fish marine survival and tagging information, together with weather, water temperature, nutricline depth, tidal exchange and river discharge data to refine the conceptual model to the stage where a numerical model of bloom development and fish mortality in northern Puget Sound and the southern Strait of Georgia may be possible.

27 October, 12:15 (S9-6788)

Phytoplankton bloom development in the Juan de Fuca Eddy: Insights from a simple biophysical model

Angelica **Peña** and Michael G. Foreman

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Recent studies indicate that the Juan de Fuca Eddy, a summer nutrient-rich retentive feature off the entrance of Juan de Fuca Strait, is an initiation site for toxigenic *Pseudo-nitzschia* blooms that impact shellfish along the outer coast of Washington State. In this presentation, we describe a bio-physical ROMS model developed to study factors influencing phytoplankton bloom dynamics. The biological model includes two size-classes of phytoplankton and zooplankton, and the concentrations of nitrate, ammonium and silicate. Model results demonstrate the influence of the Juan de Fuca Eddy on the accumulation and retention of phytoplankton. Variations in the winds and tides are shown to not only change the location and intensity of this eddy, but also in some cases, to reduce the upwelling and transport of offshore water to the coast. In order to understand the environmental factors that make the Juan de Fuca Eddy more viable for the growth and sustenance of phytoplankton, we assessed the importance of different sources of nutrients (i.e., wind-driven upwelling, topographically-controlled upwelling, and the outflow from the Juan de Fuca Strait) on the growth of phytoplankton.

S11 MEQ/FIS Topic Session Identifying vulnerable marine ecosystems in the North Pacific

Co-Sponsored by NPFMC

Co-Convenors: R. Ian Perry (Canada) and Chang-Ik Zhang (Korea)

The Food and Agriculture Organization (FAO) and the Convention on Biological Diversity (CBD) have been encouraging the sustainable use of marine living resources by the identification of vulnerable marine ecosystems (VMEs) and ecologically and biological significant areas (EBSAs), in particular but not exclusively in international waters, and have developed criteria. The broad purpose for identifying such areas is to prevent significant adverse impacts and to protect the marine biodiversity and services that these ecosystems provide.

To achieve these objectives, researchers and managers must be able to identify areas where VMEs are known, or are likely, to occur. Outstanding questions related to VME identification include: (1) what characteristics should be used to classify these systems, (2) how can current information on VMEs and EBSAs be consolidated, and (3) how can models which predict the locations of such areas be developed and tested. PICES member countries are beginning to identify VMEs that meet a variety of biological and socio-economic objectives. However, no comprehensive comparison of the different methods or assessment of their performance against established ecological, social and economic objectives exists to provide guidance on the appropriate tools to be used. This session will bring together researchers and managers engaged in ecosystem-based management to address two objectives: (1) to compare current approaches and datasets used to identify VMEs/EBSA by different member countries in order to develop a list of appropriate tools and (2) to explore how the criteria for these areas (such as defined in the FAO Guidelines FIEP/R881 and CBD Resolution UNEP/CBD/COP/DEC/IX/20) can be used to identify VME/EBSA-type areas in the high-seas of the North Pacific Ocean. Both benthic/demersal and pelagic systems will be considered, as they may have different characteristics. Presentations and methods developed for shelf and coastal waters are welcome to the extent that they provide guidance and case studies for open ocean situations. This review of international experiences with applying approaches and data to identify VMEs and EBSAs will contribute to the international discussion and evaluation of these issues, and to the application of measures to protect these significant regions.

Friday, October 29 (9:00-12:45)

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

9:05 **Edward J. Gregr, Andrea Rambeau and R. Ian Perry**
Identifying ecologically and biologically sensitive areas in the eastern North Pacific (S11-6772)

9:25 **Doo-Nam Kim, Jae-Bong Lee, Kyu-Jin Seok and Dong Woo Lee**
Investigating Vulnerable Marine Ecosystems (VMEs) from Korean distant-water fisheries (S11-6829)

9:45 **Steven J. Parker and David A. Bowden**
Criteria to select benthic invertebrate taxa to monitor potential impacts to vulnerable marine ecosystems: Lessons from the Southern Ocean (S11-6496)

10:05 **Glen Jamieson**
Moving from EBSAs to a protected area network: Framework considerations and progress challenges in Canada's Pacific waters (S11-6702)

10:25 **Jessica L. Finney, Isabelle M. Côté, Randall M. Peterman and Edward J. Gregr**
Using the overlap of predicted cold-water coral habitat and bottom-contact fisheries to identify vulnerable marine ecosystems in British Columbia, Canada (S11-6571)

10:45 ***Coffee/Tea Break***

11:05 **Takeshi Hayashibara, Mai Miyamoto and Takashi Yanagimoto (Invited)**
Investigation of the cold-water corals in the Emperor Seamount Area by Fisheries Agency of Japan (S11-6603)

11:25 **Yukimasa Ishida, Kazuaki Tadokoro, Akihiko Yatsu and Mitsutaku Makino**
Japanese-type marine protected areas (MPAs) and their contributions to biodiversity and fisheries in Tosa Bay, southern Japan (S11-6560)

11:45 **Robert M. Suryan, Jarrod A. Santora and William J. Sydeman**
Biological "hotspots" of the California Current revealed by satellite imagery: Temporal and spatial variability and implications for biodiversity conservation (S11-6765)

12:05 **Jarrod A. Santora, William J. Sydeman, John Field, Robert M. Suryanand Stephen Ralston**
"Hot zones" of krill in the California Current: Application to marine spatial management? (S11-6703)

12:25 **Jaime Jahncke, Nadav Nur, Lance Morgan and Astrid Scholz**
Identifying vulnerable marine ecosystems in the California Current System (S11-6777)

12:45 ***Session ends***

S11 Session Oral Presentations

29 October, 9:05 (S11-6772)

Identifying ecologically and biologically sensitive areas in the eastern North Pacific

Edward J. **Gregr**, Andrea Rambeau and R. Ian Perry

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The classification of marine habitats is necessary for ecosystem-based marine management and to meet national commitments to the Convention on Biological Diversity (CBD). To determine the most suitable approach to classifying marine areas, we first compared criteria proposed by the CBD and the FAO (United Nations Food and Agriculture Organization) to the EBSA (Ecologically and Biologically Sensitive Areas) criteria. We concluded that EBSAs represent a parsimonious and encompassing marine classification approach suitable in either shelf or high-seas ecosystems. We then reviewed 18 classifications of the world's oceans, ranging from coastal regions to the high-seas to determine the most feasible approach to defining EBSAs in the eastern North Pacific. Approaches ranged from quantitative analyses to subjective interpretations, and differed in their treatment of the available data with some using only physical characteristics and others including various forms of biota, typically (though not exclusively) plankton. Most methods assumed that classified physical features were in some way deterministic of biological distributions. However, the only process explicitly represented is oceanographic concentration. Recent advances in data collection and analysis show how dynamic boundaries can be identified using remotely sensed data. However, no method provided an integrated classification suitable for management decisions. Methods for integrating a collection of individual EBSAs into a singular set of multi-attribute, place-based, significant areas taking the dynamics of spatial and temporal boundaries into consideration are discussed. We conclude by providing some guiding principles in the development of a classification system for coastal and high-seas regions of the eastern North Pacific.

29 October, 9:25 (S11-6829)

Investigating Vulnerable Marine Ecosystems (VMEs) from Korean distant-water fisheries

Doo-Nam Kim, Jae Bong **Lee**, Kyu-Jin Seok and Dong Woo Lee

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The term 'Vulnerable Marine Ecosystem' is subject to variable interpretation, potentially referring to populations of particular vulnerable taxa, entire benthic assemblages or communities, ecosystems and associated processes, particular species at the scale of the whole physical habitat features (*e.g.* seamounts) that may support vulnerable taxa (NAFO, 2008; Rogers *et al.*, 2008; Parker *et al.*, 2010). Criteria for identifying VMEs include uniqueness or rarity of species or habitats, their functional significance, fragility, and structural complexity as well as life histories that limit the probability of recovery. The definition of VME should incorporate the spatial extent of the disturbance process (*e.g.* fishing effort) and the expected ability of the ecosystem to recover, implying that the results of a completed impact assessment are a necessary prerequisite for defining a VME. Effort-impact information with regard to particular gear types used in different deep-sea habitats is also limited. However, the types and directions of impacts of fishing gears are well known from a global literature on the subject and significant damage to vulnerable communities are known from single impacts of mobile gear such as trawls (Freese *et al.* 1999), as well as static gear such as benthic longlines and traps (Krieger, 2001; Grehan *et al.*, 2004; Stone, 2006; Edinger et al., 2007). Such information could be used to predict and differentiate the potential for particular types of fishing operations to produce significant adverse impacts to VMEs. National Fisheries Research and Development Institute (NFRDI) trained and sent International Observer for on-board survey to the distant-water fisheries in the Southern Ocean and the North Pacific Ocean since 2009. They deployed catch report by every haul, complete with data for all by-catch species and total quantity of VME-indicator organisms, such as corals, sponges and benthos. Those will be contribute to develop the process to estimate the cumulative impact of fishing activity on individual vulnerable taxa in the deep-sea region. Results at each step are displayed in tabular form and combined to derive an estimate of total cumulative impact.

29 October, 9:45 (S11-6496)

Criteria to select benthic invertebrate taxa to monitor potential impacts to vulnerable marine ecosystems: Lessons from the Southern Ocean

Steven J. **Parker**[1] and David A. Bowden[2]

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Implementing measures to avoid significant adverse impacts to vulnerable marine ecosystems (VMEs) requires a specific list of the taxa that are considered vulnerable to the fishery and region being monitored and assessed. The taxa to be monitored may be selected depending on the local ecology, the taxonomic levels able to be identified reliably and the characteristics of the interactions with the particular gear types used. The rationale for including or excluding a taxonomic group can be described relative to intrinsic qualities of the group such as fragility, longevity, organism size, larval dispersal mechanisms, and spatial distribution. Additional considerations such as organism mobility, community diversity, endemism, taxonomic resolution and presence in fishery bycatch are also important considerations. Twenty-three taxa have been selected for monitoring in Southern Ocean bottom longline fisheries.

29 October, 10:05 (S11-6702)

Moving from EBSAs to a protected area network: Framework considerations and progress challenges in Canada's Pacific waters

Glen **Jamieson**

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A commitment to protect marine biodiversity by implementing a network of marine protected areas (mpas) requires specific considerations. Firstly, a network differs from a set or system by implying there is some level of connectivity among designated mpas within a region.

There are a series of identified steps in establishing a network of mpas which can be summarized in three phases. The first phase starts with the compilation of data necessary for mapping habitats and species distributions within a particular region. Completion of this phase results in maps of representative areas, distinctive areas and single species distributions, ie. identifying Ecologically and Biologically Significant Areas (EBSAs). The second phase is the selection of a set of areas of interest (AOIs), which together could constitute a mpa system. The third planning phase is then concerned with moving from a set of AOIs to determining boundaries for a logical and defensible mpa network. Canada has largely completed the first phase, and has yet to prioritise objectives for the second phase.

The second phase first focuses on determining highest priority ecological objectives and identifying the most relevant AOIs to achieving them. The latter involves identifying connectivity requirements among AOIs to the best extent possible with available data since to conserve marine biodiversity, biota must be both represented and able to persist. The third phase considers the weighting of socio-economic and cultural objectives to create an acceptable network of mpas that meet identified ecological goals whilst minimising disruption to socio-economic and cultural needs.

29 October, 10:25 (S11-6571)

Using the overlap of predicted cold-water coral habitat and bottom-contact fisheries to identify vulnerable marine ecosystems in British Columbia, Canada

Jessica L. **Finney**[1], Isabelle M. Côté[2], Randall M. Peterman[3] and Edward J. Gregr[4]

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In recent years there has been increased interest worldwide to protect vulnerable marine ecosystems (VMEs) from anthropogenic impacts. Cold-water corals (class Anthozoa) are of particular concern due to their role in providing biogenic habitat, as well as their limited capacity to recover from disturbance. Lack of information on the distribution of cold-water coral in British Columbia (BC) limits our ability to identify areas of coral habitat that are potentially vulnerable to fishing activity. In this paper, we predict suitable habitat for four orders of cold-water coral (Alcyonacea, Antipatharia, Pennatulacea, and Scleractinia) using the species distribution modelling tool *Maxent*. We identify potential VMEs by evaluating the overlap between the fishing footprints of three bottom-contact fisheries (groundfish trawl, sablefish longline, and sablefish trap) and predicted suitable coral habitat. Predictive modeling results are robust and predict coral habitat in many unsampled areas. Additionally, results correspond with previously identified ecologically and biologically significant areas (EBSAs) for corals and sponges that were identified using different data and methods. Depending on the taxonomic order, between 30.4 and 46.5% (range) of predicted suitable habitat may be vulnerable to fishing activity, with fishing effort being disproportionately concentrated in areas of predicted coral habitat. Results suggest that cold-water coral habitat in BC requires protection from fishing activity to guarantee the long-term viability of coral populations. This method of VME identification is widely applicable and particularly useful in areas with limited sampling, such as the high seas.

S11

29 October, 11:05 (S11-6603), Invited

Investigation of the cold-water corals in the Emperor Seamount Area by Fisheries Agency of Japan

Takeshi **Hayashibara**, Mai Miyamoto and Takashi Yanagimoto

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Appropriate management of the influence on deep sea ecosystems by bottom fisheries in the high seas region has become an urgent issue. In order to respond to UNGA Resolution 61/105, the Fisheries Agency of Japan has conducted research activities in the Emperor Seamount Area since 2006. Based on results of these investigations, especially the discovery of living precious corals (*Corallium* sp.), a provisional closed area was established as a preventive measure at the end of 2008. The Emperor Seamount Area has been known as an important fishing ground for precious corals, and 200 tons a year were caught in a peak period, however, the fishery has disappeared for about 20 years. The precious coral resources may have decreased. However, there is also the possibility that the disappearance of the coral fishery may be due to a decrease of the price rather than the exhaustion of coral resources. Many corals in addition to the precious corals have been observed in these investigations. Many were found in places where the influence of the fishery has been less intense, however, coral distributions are also determined by factors other than fishing pressure. In fact, some species, such as *Eleutherobia* sp. and *Flabellum* sp. appeared at relatively high densities in places which have received heavy influences of trawling. Therefore, it is important to understand the environmental factors which limit the distribution of corals for the design of an effective management strategy.

29 October, 11:25 (S11-6560)

Japanese-type marine protected areas (MPAs) and their contributions to biodiversity and fisheries in Tosa Bay, southern Japan

Yukimasa **Ishida**[1], Kazuaki Tadokoro[1], Akihiko Yatsu[2] and Mitsutaku Makino[2]

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Marine Protected Areas (MPAs) have been of global interest in recent years. Japanese-type MPAs, which aim for the coexistence of sustainable multiple fisheries and the conservation of biodiversity, are located in various areas in Japan. However, their contribution to fisheries resource conservation and maintenance of biodiversity are not well known. Catches by purse seine fisheries comprise about 50%, followed by trawl fisheries about 30% and set net fisheries about 10%. So, the MPAs for purse seine fisheries and trawl fisheries are important in Japan. In Kochi Prefecture, purse seine fisheries have been prohibited in Tosa Bay since the 1920s based on the official Fisheries Coordinating Regulations and other autonomous rules, in order to avoid conflicts with the set net and coastal fisheries. As a result, the spawning population of Japanese sardine in Tosa Bay is protected which allows for a large part of egg production in Japan during periods of low stock abundance. For trawl fisheries in Tosa Bay, no-take zones along the coast and several limited areas in the offshore are established by the Act on the Protection of Fishery Resources and autonomous agreements among the members of the Fishery Cooperative Associations (FCAs). Floating fish-aggregating devices, which are connected to the sea floor, are deployed for pole-and-line fisheries in Tosa Bay. They also act as Japanese-type MPAs to protect the natural resources from bottom trawl fisheries. Fish and shrimp species are abundant compared with other areas in Japan partly due to these Japanese-type MPAs and geographic variation in Tosa Bay. To promote Japanese-type MPAs, future research topics and additional measures are discussed.

29 October, 11:45 (S11-6765)

Biological “hotspots” of the California Current revealed by satellite imagery: Temporal and spatial variability and implications for biodiversity conservation

Robert M. **Suryan**[1], Jarrod A. Santora[2] and William J. Sydeman[2,3]

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Understanding variation in biological activity over large scales is critical for an ecosystem-based approach to management. Satellite imagery of chlorophyll *a* (Chl-*a*) concentrations can provide a holistic perspective on productivity in large marine ecosystems not available by other means, yet its value to predict mid-to-upper trophic level predator distribution and abundance has remained equivocal. We used a decade of satellite remotely-sensed Chl-*a* data and marine bird distributions at sea in one region to test the hypothesis that remotely sensed oceanographic data could be used to locate “hotspots” corresponding to elevated consumer densities the California Current System (CCS). “Hotspots” of co-varying primary productivity and consumer densities were best identified with a persistence metric of positive Chl-*a* anomalies in space and time that were likely caused by persistent upwelling fronts. In the central-northern California region (Point Sur to Point Arena), Chl-*a* persistence accounted for 96% of the variation in bird density, twice the variation explained by mean Chl-*a* alone. CCS-wide calculation showed high Chl-*a* persistence along much of the shelf break/slope, especially adjacent to wider portions of the shelf and associated with prominent bathymetric and topographic features, many of which are key habitats for many species of seabirds, marine mammals, and also targeted by commercial fisheries. Deriving new metrics from remotely sensed Chl-*a* that are more reliable indicators of trophic transfer and predator distribution is critical to identifying and monitoring ecologically important, yet vulnerable habitats in pelagic ecosystems.

29 October, 12:05 (S11-6703)

"Hot zones" of krill in the California Current: Application to marine spatial management?

Jarrod A. **Santora**[1], William J. Sydeman[1], John C. Field[2], Robert M. Suryan[3] and Stephen Ralston[2]

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Due to their abundance, high lipid content, and tendency to form dense patches, krill comprise an important prey field and component of the California Current System (CCS) food web. Many species of fish, birds, and marine mammals depend on krill directly or indirectly (through an intermediate trophic level) as key prey. Our objective is to develop a baseline record for investigating and tracking spatial and annual dynamics of krill populations in the CCS. We use a combination of hydroacoustics, nets, and visual observations of seabirds at sea to accomplish this task. We processed and compiled a geographic atlas of a decade (2000-2009) of hydroacoustic data collected during routine NOAA-NMFS Juvenile Rockfish ecosystem assessment surveys in May-June. Approximately 28,000 nautical miles were sampled for krill, resulting in one of the most comprehensive geo-spatial data sets on krill distribution in the CCS. One of our analytical objectives is to determine the location of krill "hot zones" by predicting locations of high abundance. A novel result of this data set is that it can be used to study complex spatial relationships between krill and their predators. We spatially linked remotely sensed cholorphyll-a, seabird, and mammal distributions (conducted via visual surveys) to krill "hot zones" to measure the spatial variability and associations of krill-predator interactions to identify biologically important regions. We found that seabirds co-vary with changes in krill spatial distribution and possible thresholds in krill abundance that are important for predicting the location of seabird aggregations. These results can yield important parameters for food web models, marine spatial planning, and provide a better understanding of ecological responses to changing ocean conditions in the CCS.

S11

29 October, 12:25 (S11-6777)

Identifying vulnerable marine ecosystems in the California Current System

Jaime **Jahncke**, Nadav Nur, Lance Morgan and Astrid Scholz

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We conducted analyses to identify vulnerable marine ecosystems in the California Current System (CCS). We developed habitat associations for 16 species of seabirds using information from at-sea surveys carried out over a 12-year period (1997-2008). Surveys extended from north of Vancouver Island to the US/Mexico border and out to 600 km from the coast. We related seabird abundance to bathymetric variables and satellite oceanographic data. Single-species predictive models were developed using a hierarchical, multivariate statistical procedure (bagged decision trees). Bathymetric variables were often important predictive variables. Oceanographic variables derived from remotely sensed data were generally less important. Model predictions were applied to the entire California Current for 4 months (February, May, July, October) as a proxy for seasons in each of 11 years. Single-species predictions were combined using three criteria (abundance, importance, and persistence) to identify potential ecologically and biological significant areas (EBSAs) of multi-species seabird aggregation. EBSAs occurred over the shelf of the continental U.S. and southern Canada and aligned well with current National Marine Sanctuary boundaries. Our analysis revealed gaps in protection, especially in the coastal area between Cape Mendocino (Northern California) to Heceta Head (Southern Oregon), where there are no federally protected marine reserves. We will use Zonation software for spatial conservation prioritization to integrate above findings with important benthic habitats (MCBI), California Ocean Use Atlas (MCBI and MPA Center) and fishing activity data (Ecotrust) to identify most vulnerable marine ecosystems along the California Current.

S12 MEQ/FUTURE Topic Session
Anthropogenic forcing in North Pacific coastal ecosystems: Understanding changes in ecosystem structure and function

Co-Sponsored by IMBER

Co-Convenors: Blake Feist (U.S.A.), Hiroshi Kawai (Japan), Olga Lukyanova (Russia), Steven Rumrill (U.S.A.) and Thomas Therriault (Canada)

The North Pacific marine environment has provided a diverse and valuable series of ecosystem services to coastal communities for many thousands of years. Ocean and land-based anthropogenic activities are now widely recognized to have a strong influence on ecological processes throughout the North Pacific marine ecosystem. Anthropogenic influences such as commercial fishing, aquaculture, pollution, and urbanization are particularly strong in coastal waters where they impose a wide variety of multiple stressors that can impact fundamental ecosystem functions, critical processes, and marine biodiversity. Changes in the physical and biological environment perturb native communities, often resulting in disruption of species interactions and trophic relationships that can negatively impact productivity and diminish ecosystem resilience. In addition, large scale processes such as regime shifts, ocean oscillations, and climate variability can alter near-shore processes. For example, introduced species can negatively impact native communities, and commercial shipping and recreational activities can be a powerful vector for changes in the geographic distribution of marine and estuarine species. Similarly, changing ocean conditions have facilitated the continued pole-ward range expansion of a number of marine organisms, often with unknown impacts on the ecosystems they are moving into. Recent range expansion (*e.g.*, Humboldt squid) and population eruptions (*e.g.*, jellyfish) on both sides of the Pacific have had negative consequences for native flora and fauna.

Application of an ecosystem-based approach to coastal management would provide a template to better understand multiple stressors in coastal systems. Continuing to study and manage these stressors independently as single problems must be replaced by examining multiple stressors within the context of the ecosystems they are altering. Further, global climate change is expected to have clear consequences with respect to future species introductions, establishment, and range expansion. Ignoring complex interactions will only hinder management efforts. Thus, integrating non-indigenous species invasions with existing anthropogenic stressors will facilitate a holistic approach to addressing the challenges facing our coastal marine ecosystems.

This session will explore the characterization, understanding, and forecasting of the influence of multiple anthropogenic stressors in North Pacific coastal ecosystems. For example, how do non-indigenous species interact with other anthropogenic stressors? Contributed papers will provide a higher-level overview of stressors in various North Pacific ecosystems (*e.g.*, overharvesting, urbanization, habitat alteration and loss, mariculture, HABs, pollution, non-indigenous species, *etc.*) and the types of impacts that have been observed, especially those linked to changes in biodiversity and productivity (*e.g.*, extinctions, species interactions, trophic cascades).

Tuesday, October 26 (8:55-18:00)

8:55	***Introduction by Convenors***
9:00	**John J. Stachowicz (Invited)** Changing biodiversity and the functioning of coastal marine ecosystems (S12-6677)
9:30	**Steven S. Rumrill, Alicia R. Helms and Adam S. DeMarzo** Potential influence of multiple anthropogenic stressors on restoration and recovery of native Olympia oysters (*Ostrea lurida*) in the Coos Bay estuary, Oregon, USA (S12-6510)
9:50	**Olga N. Lukyanova, Sergei A. Cherkashin and Mikhail V. Simokon** Multiple stressors impact on the ecosystem of Peter the Great Bay (Japan/East Sea) (S12-6624)

10:10	**L.I. Bendell** Influence of near bottom mariculture structures on intertidal diversity (S12-6597)
10:30	***Coffee/Tea Break***
10:50	**Thomas A. Okey, Andrew Day, Laura A. Loucks, Jennifer Spencer and Kathryn Wallace (Invited)** An application of Integrated Ecosystem Assessment in the marine areas of the West Coast of Vancouver Island to support integrated planning and management (S12-6643)
11:10	**Jameal F. Samhouri, Cameron H. Ainsworth, D. Shallin Busch, William L. Cheung and Thomas A. Okey** The importance of community interactions for predicting climate change impacts (S12-6759)
11:30	**D. Shallin Busch, Cameron H. Ainsworth, Jameal F. Samhouri, William L. Cheung, John Dunne and Thomas A. Okey** Evaluating uncertainty in estimates of how climate change may impact Northeast Pacific marine ecosystems (S12-6592)
11:50	**R. Ian Perry, Diane Masson, David L. Mackas and Gisele Magnusson** Developing ecosystem-based management in a human-dominated marine system: The Strait of Georgia, Canada (S12-6659)
12:10	**Lingbo Li, Tony Pitcher and Robert Devlin** Investigating potential ecological impacts of growth-hormone transgenic coho salmon using a marine ecosystem model (S12-6699)
12:30	***Lunch***
14:00	**Toshiyuki Yamaguchi, Yuu Ohshiro, Masashi Kiuchi, Michio Otani, Ikuo Ueda and Hiroshi Kawai (Invited)** The introduction of the Titan Barnacle, *Megabalanus coccopoma* (Darwin, 1854) (Cirripedia: Balanomorpha) to Japan (S12-6446)
14:20	**Vasily I. Radashevsky** World wide dispersal of mudworm *Boccardia proboscidea* Hartman, 1940 (Annelida, Spionidae) (S12-6667)
14:40	**Shang Chen, Tao Xia, Guoying Du, Huiyang Wang, Li Wang and Dachuan Ren** Quantification of influence of *Spartina* spp. invasion on coastal wetland ecosystem services: Yancheng case study, China (S12-6552)
15:00	**Thomas W. Therriault, Claudio DiBacco, Leif-Matthias Herborg and Graham E. Gillespie** The importance of scale for predicting impacts of stressors in nearshore environments: An example using European green crab (*Carcinus maenas*) invasions in British Columbia (S12-6678)
15:20	***Coffee/Tea Break***
15:40	**Peter S. Ross, Donna Cullon, Andrea Buckman and John K.B. Ford** Climate change may exacerbate pollution impacts in marine mammals of the North Pacific Ocean (S12-6681)
16:00	**Burke Hales, Jesse Vance, Sue Cudd, Mariona Segura, Wiley Evans and Alan Trimble** Changing carbonate chemistry and the future of oysters in the eastern North Pacific boundary system (S12-6538)

16:20	**Tatiana Yu. Orlova, Inna V. Stonik, O.G. Schevchenko and Vladimir I. Ponomarev** Long-term changes in phytoplankton communities in Amursky Bay (the north-western part of the East/Japan Sea) under eutrophic conditions (S12-6701)
16:40	**Elizabeth Logerwell, Mary Baker and Amy Merten** Natural resource damage assessment in Arctic waters (S12-6652)
17:00	**Xianshi Jin, Xiujuan Shan, Xiansen Li, Jun Wang, Yi Cui and Tao Zuo** Long-term variations of ecosystem structure in the Laizhou Bay, China (S12-6731)
17:20	**Vjacheslav. S. Labay** Variability of macrobenthos structure in coastal waters of northern Sakhalin Island (Okhotsk Sea) around oil- and gas extracting objects (S12-6465)
17:40	**TatianaV. Morozova, Tatiana Yu. Orlova, Boris A. Burov, Alexander Yu. Lazaryuk, Sergey P. Zakharkov and Vladimir I. Ponomarev** Dinoflagellate cysts as indicators of eutrophication in the Amursky Bay, Sea of Japan (East Sea) (S12-6576)
18:00	***Session ends***

S12 Posters

S12-6428	**Lailah G. Lartey-Antwi, Ayaa K. Armah and J. Laudien** Population dynamics and ecology of Surf Clam *Donax pulchellus* in Ghana
S12-6447	**Valentina V. Slobodskova, Evgeniya E. Solodova and Victor P. Chelomin** DNA strand breakage in aquatic organisms as a biomarker in environmental monitoring
S12-6466	**Vjacheslav. S. Labay** Malacostraca (*Crustacea*) – A new species in coastal waters of Aniva Bay (Okhotsk Sea, Sakhalin Island)
S12-6494	**Xiukai Song, Jianxin Ma, Yihao Liu, Lijuan Liu, Yuanqing Ma, Lihua Ren and Xianchun Tang** History and causes of *Alexandrium Tamarense* red tide blooms in the waters near Nanhuangcheng Island, China
S12-6533	**Takeo Kurihara, Hideki Takami, Takeharu Kosuge, Susumu Chiba, Masatsugu Iseda and Takenori Sasaki** Area-specific temporal changes of species composition and species-specific range shifts in rocky-shore molluscs associated with a warming Kuroshio Current
S12-6609	**Tao Yu, Bin Chen, Weiwei Yu, Wenhua Liu and Zhenghua Liu** Restoration of typical marine ecosystems in China
S12-6631	**Ferdinand A. Mkrtchyan, Vladimir F. Krapivin, V.I. Kovalev, V.V. Klimov** An adaptive system to identify pollutants on the water surface
S12-6665	**Alexandra S. Kondakova and Andrey P. Chernyaev** Anthropogenic hormone substances in coastal waters of Peter the Great Bay (Japan/East Sea)
S12-6666	**Andrey P. Chernyaev and Anna S. Vazhova** Oil pollution in Nakhodka Bay (Japan/East Sea)
S12-6711	**Yasuhiro Kamimura and Jun Shoji** Effects of environmental conditions on growth-selective survival of juvenile black rockfish *Sebastes cheni* in a vegetated habitat in the central Seto Inland Sea, Japan

S12-6719 **Yulia V. Koudryashova, Tatiana L. Chizhova, Evgeniya E. Solodova and Nina N. Belcheva**
Age-specific oxidative stress response to cadmium in the scallop *Mizuhopecten yessoensis*

S12-6720 **Alexander Sevastyanov, Anastasia Chernova and Tatyana Lishavskaya**
Results of long-term pollution monitoring in Peter the Great Bay (Sea of Japan)

S12-6721 **Takuma Morita, Yuji Iwamoto and Jun Shoji**
Significance of estuarine habitat as nursery for yellowfin sea bream *Acanthopagrus latus*: Comparison of feeding, growth and possible predators for larvae and juveniles in two habitats around Ohta River estuary northern Hiroshima Bay, Japan

S12-6723 **Young Shil Kang, Won-Chan Lee, Sok Jin Hong and Dong-Wook Kim**
Seasonal and spatial variability in the zooplankton community in Masan Bay, Korea

S12-6733 **Jung-Hoon Kang, Oh Youn Kwon, Kyoungsoon Shin and Man Chang**
Distribution of potentially risky heterotrophic *Noctiluca scintillans* and port specific capacity based on port baseline surveys in Korea

S12-6741 **T.V. Konovalova, T.A. Belan, A.V. Moshchenko, B.M. Borisov and L.S. Belan**
Distribution of macrobenthos around the LUN-A platform at the initial phase of Lunskoye field development (North-East Sakhalin Island Shelf)

S12-6745 **Guo Ying Du, Shang Chen, Tao Xia, Dachuan Ren, Li Wang and Min Wang**
Valuation of ecological capital in coastal area of Shandong province, China

S12-6794 **Ik Kyo Chung, Jung Hyun Oak, Sang-Rae Lee and Jeong Ha Kim**
Estimation of the seaweed biomass by the extensive field survey

S12-6812 **Hee Won Park, Jae Bong Lee , You Jung Kwon, Chang Ik Zhang and Sung Il Lee**
Estimating optimum size of stock enhancement in marine ranching ecosystem

S12-6856 **Sangjin Lee and Mark Walton**
Threats to marine and coastal biodiversity in the NOWPAP region

S12-6873 **Leslie H. Harris**
Is it or isn't it? Taxonomic proficiency of North Pacific NIS Polychaete assessments in the Northeast Pacific

S12 Session Oral Presentations

26 October, 9:00 (S12-6677), Invited

Changing biodiversity and the functioning of coastal marine ecosystems

John J. **Stachowicz**

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There is growing concern over changes in marine biodiversity for the structure and functioning of coastal ecosystems. Multiple stressors: habitat destruction, harvesting, climate change and pollution can all cause declines in resident species. At the same time new species are being introduced via shipping, aquaculture and other vectors. Our work in estuarine invertebrate communities shows that invasions can also interact with these other stressors to affect resident communities. While the net effect may be little change in total richness, a review of the documented extinctions and invasions in coastal communities in the U.S., Northern Europe and Australia shows that the characteristics of species present in these ecosystems has shifted. Extinctions occurred disproportionately at top trophic levels whereas invasions generally occur by species at the producer or primary consumer level. In this talk, I will consider the consequences of loss of top predator diversity vs. gain in lower trophic level diversity for the ecosystem functions such as primary production, water filtration, and temporal stability. I will draw on experiments we have conducted in a range of systems including communities of estuarine sessile filter feeding invertebrates, eelgrass beds, intertidal communities, and kelp forests.

26 October, 9:30 - *Change: Steven S. Rumrill (S12-6510) , p. 122*

Evaluating uncertainty in estimates of how climate change may impact Northeast Pacific marine ecosystems (S12-6592) - *Change: moved to 11:30*

D. Shallin **Busch**[1], Cameron H. Ainsworth[2], Jameal F. Samhouri[3], William W.L. Cheung[4], John Dunne[5] and Thomas A. Okey[6,7]

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Climate change will affect Earth's physical environment strongly and influence its biota in complex ways. While empirical studies provide valuable information on species' responses to environmental conditions, modeling exercises can be used to gain insights into the indirect and cascading effects of climate change on whole biological communities. Such modeling exercises can, however, contain a large number of uncertainties, all of which can influence their results. We present a study that addresses how uncertainty in both our knowledge of species responses to climate change (effect size and process uncertainty) and our ability to model them (model uncertainty) influences our understanding of the impacts of climate change. This work is an extension of a modeling exercise undertaken by Ainsworth *et al.* (in review), which attempts to predict the ecosystem-level impacts of climate change on Northeast Pacific shelf ecosystems using simulations with five Ecopath with Ecosim food web models. The Ainsworth et al. study applies five climate change impacts to these food web models: change in annual mean level of primary production, shifts in distribution of fish and invertebrates, alteration of the size structure of plankton communities, ocean acidification, and deoxygenation of surface waters. We consider and explore the effects of the three types of uncertainty using a variety of analytical techniques. Results of this study focus on data that are relevant to resource managers, namely, biomass of groups that provide important ecosystem services (*e.g.*, harvested species, forage fish) and measures of ecosystem health (*e.g.*, diversity, reorganization).

26 October, 9:50 (S12-6624)

Multiple stressors impact on the ecosystem of Peter the Great Bay (Japan/East Sea)

Olga N. **Lukyanova**, Sergei A. Cherkashin and Mikhail V. Simokon

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Peter the Great Bay is located in the northwestern part of the Japan/East Sea and provides diverse ecosystem services to local communities. The human population is at a maximum density compared to other regions of Russian Far East. Multiple stressors impact the functions and processes of the coastal ecosystem. Mean air and sea surface temperatures increased during the last century. Hypoxia and anoxia have increased in frequency, and elevated concentrations of heavy metals, and petroleum hydrocarbons and organochlorine pesticides occur in sea water and bottom sediments in ports, industrial engineering areas, river discharges, and other sites. Fish and shellfish accumulate high concentrations of contaminants, and bioassays with domestic species reveal acute toxicity of sea water and bottom sediments in the inner parts of the Bay, particularly in estuaries. The number of indigenous species of zooplankton has decreased, and more than 50 introduced species were identified over the last decade. Harmful algae blooms occur frequently in the summer season. Histopathological changes were observed in the skin and internal organs of fish and mollusks. Biochemical disturbances were discovered in the gills and digestive glands of fish, crustaceans, mollusks and echinoderms. Environmental risk assessment illustrates a moderate level of contamination of the coastal area with heavy pollution of industrial zones. However, the basic ecological relationships have not been disturbed. Overall commercial stock of bio-resources has remained stable over the last decade, and the total value of ecosystem services is 10 times greater than the cost of food production from commercial species.

26 October, 10:10 - ***Change: L.I. Bendell (S12-6597), p. 123***

Developing ecosystem-based management in a human-dominated marine system: The Strait of Georgia, Canada (S12-6659) - *Change: moved to 11:50*

R. Ian **Perry**[1], Diane Masson[2], David L. Mackas[2] and Gisele Magnusson[3]

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The Strait of Georgia is arguably the most human dominated marine ecosystem in Canada. It is surrounded by the 3rd, 15th, and 38th largest cities in Canada, is a location for active fishing, aquaculture, and marine transport and recreation, and is influenced by local and remote land use and climatic changes. It also has experienced recent high profile fish stock changes. This presentation describes a 4-yr pilot program by Fisheries and Oceans Canada to develop an ecosystem-based approach to managing marine ecosystems: the Strait of Georgia Ecosystem Research Initiative (ERI). Briefly, it describes the changes that have occurred in the Strait of Georgia and some of the preliminary key findings from the ERI program. It then focuses on the development of marine ecosystem indicators for the region, using a Driver-Pressure-State-Impact-Response framework. The use of a Bayesian Network model is demonstrated for integrating ecosystem indicators into a probabilistic prediction system for the region. 'End-of-chain' nodes such as seals or transient killer whales can serve as indicators of the entire ecosystem, as they integrate the productivity conditions that support them. However, their response times to perturbations may be slow, because of their longer life spans. Potential indicators of conditions and specific pathways within the ecosystem include 'central' nodes with multiple connections, for example the timing of the spring chlorophyll bloom or herring spawning biomass. Overall, Bayesian Network models show promise as tools to integrate ecosystem observations and to predict outcomes (with probabilities) that can be useful for ecosystem-based management.

26 October, 10:50 - *Change: Thomas A. Okey (S12-6643), p. 125*

Climate change may exacerbate pollution impacts in marine mammals of the North Pacific Ocean (S12-6681) - *Change: moved to 15:40*

Peter S. **Ross**[1], Donna Cullon[1], Andrea Buckman[1] and John K.B. Ford[2]

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Increasing sea surface temperatures may lead to diminished ocean productivity in some areas of the Pacific, raising the spectre of energetic stresses on some marine mammal populations. Since persistent organic pollutants (POPs) are fat-soluble contaminants that amplify in food webs, productivity-related reduction in lipids will concentrate POPs in the diminishing blubber stores of marine mammals. We highlight here evidence from our research in the NE Pacific that highlights this concern: 1) 'thinner' harbour seals (*Phoca vitulina*) have higher POP concentrations in fat; 2) high polychlorinated biphenyl (PCB) concentrations in Puget Sound (USA) harbour seals are only explained if they consume more fish to compensate for reduced fat content observed in prey; 3) high PCB concentrations in endangered southern resident killer whales (*Orcinus orca*) relative to their northern resident counterparts also appear to be explained by a higher consumption of salmon to compensate for reduced prey fat content; and 4) PCB-associated disruption of thyroid hormone physiology in contaminated seals and killer whales may increase metabolic turnover. Collectively, our research suggests that marine mammals consume more prey when it contains less fat and when PCBs disrupt thyroid physiology altering metabolism. In the former case, climate change-associated impacts on the nutritional quality of prey may increase POP exposure through increased consumption. In the latter, PCB-associated thyroid toxicity may be exacerbated by a climate-driven 'concentration effect' for toxic chemicals. We speculate that these two scenarios will act synergistically in a warming ocean to increase POP-related health risks in some high trophic level marine mammals.

26 October, 11:10 - *Change: Cameron H. Ainsworth (S12-6759), p. 125*

Changing carbonate chemistry and the future of oysters in the eastern North Pacific boundary system (S12-6538) - *Change: moved to 16:00*

Burke **Hales**[1], Jesse Vance[1], Sue Cudd[2], Mariona Segura[1], Wiley Evans[1] and Alan Trimble

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Upwelling along the eastern boundary of the North Pacific is the key process that has long driven high coastal biological productivity and large-amplitude biogeochemical variability. Although the length and quality of observational records is limiting, it appears that recent changes in the chemistry of upwelled source waters and/or the character of wind-driven circulation have led to a shift in the carbonate chemistry of shelf waters in the eastern North Pacific. Recent observations have confirmed the role of anthropogenic CO_2 in upwelled source waters, despite the apparent old age of these waters. While anthropogenic factors may be driving the circulation changes, the contribution of anthropogenic CO_2 to source waters can only be expected to increase in coming years. New observations of CO_2 chemistry in coastal bays at commercial shellfish hatchery facilities show clear intrusion of upwelled source water into shallow coastal bays, and strong negative correlation between larval oyster survival and elevated CO_2 concentrations in hatchery intake water. CO_2 levels are often high enough to make these waters corrosive to aragonitic calcium carbonate minerals. Direct causative mechanisms are unclear, but mortality is most often associated with the failure of pre-settlement larvae to form viable shell material, which strongly suggests that high CO_2 (and thus low-*p*H and low carbonate ion) waters inhibit shell formation. Some evidence of cyclical forcing in long records of wild *C. gigas* settlement success exists; however, the growing role of anthropogenic CO_2 in upwelled source waters suggests that future 'bad times' will continue to get worse.

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26 October, 11:30 - ***Change: D. Shallin Busch (S12-6592), p. 119***

Investigating potential ecological impacts of growth-hormone transgenic coho salmon using a marine ecosystem model (S12-6699) - *Change: moved to 12:10*

Lingbo **Li**[1], Tony Pitcher[1] and Robert Devlin[2]

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Growth hormone (GH) transgenic fishes have the potential to greatly increase productivity in aquaculture but may also pose environmental risks. GH transgenic salmonids can grow two- to three-fold faster than non-transgenic fish, mature earlier and have higher fecundity, and possess increased appetites and markedly enhanced feeding behaviour. However, significant concern exists about potential ecological harm that may occur in the event that transgenic fish escape into nature. Environmental risk assessment studies on transgenic fish are difficult because they are currently restricted to the laboratory, and data are limited to environmental complexities that may be established therein. An ecosystem model was used to investigate the stability and resilience of the Strait of Georgia ecosystem to the theoretical introduction of a growth hormone transgenic coho salmon. We evaluate potential long-term changes to the ecosystem using the Ecopath with Ecosim (EwE) modelling approach. We examined food competition among transgenic populations and wild and hatchery populations and the predation impacts on prey populations. We measure the resilience of the ecosystem at various rates of introduction (escape and self reproduction) of farmed transgenic coho salmon considering both chronic and catastrophic release events. We also determine the threshold level of escapes at which the functioning or structure of the ecosystem shifts to an alternative stable state. The sensitivity of model parameters is tested with a Monte Carlo approach. Our study contributes to evaluating risk assessment methodologies that may be applied to the regulation of transgenic fish should such technology be adopted in the future.

26 October, 11:50 - ***Change: R. Ian Perry (S12-6659), p. 120***

Potential influence of multiple anthropogenic stressors on restoration and recovery of native Olympia oysters (*Ostrea lurida*) in the Coos Bay estuary, Oregon, USA (S12-6510) *Change: moved to 9:30*

Steven S. **Rumrill**[1], Alicia R. Helms[2] and Adam S. DeMarzo[2] ***Change: moved to 9:30***

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Native Olympia oysters (*Ostrea lurida*) were once abundant and ecologically important members of estuarine communities throughout the Pacific Northwest (British Columbia to northern California). Beds of Olympia oysters historically occurred in the lower intertidal and shallow subtidal zone where they provided key ecosystem services including formation of heterogeneous benthic habitat, biofiltration of the water column, pelagic-benthic coupling, increased biodiversity, foraging areas for invertebrates, fish, and shorebirds, and an important source of food for indigenous people. Olympia oyster populations were decimated throughout the region over the past 150 years due to multiple environmental stressors including burial by fine sediments, overharvests, dredge-and-fill activities, and other types of habitat alteration. Multiple anthropogenic stressors including: 1) dredging of tidal channels; 2) shoreline alteration and addition of inappropriate substrata; 3) commercial mariculture operations; 4) eutrophication; 5) predation and competition by non-indigenous invertebrates; and 6) acidification of ocean waters, continue to pose potentially important hurdles to the restoration and recovery of Olympia oyster populations. Availability of shell-rubble habitat has been reduced substantially in the estuaries and presents a serious problem for larval settlement. Time-series measurements of water quality parameters indicate that ambient conditions are generally favorable for oyster recovery. However, datalogger records also reveal a long-term shift in estuary pH values that may be broadly indicative of localized eutrophication, changes in regional upwelling, and ocean acidification. In addition, larvae of *O. lurida* frequently settle and grow on shells of living Pacific oysters (*Crassostrea gigas*; a non-indigenous species) which are harvested after periods of 2-3 years.

26 October, 12:10 - *Change: Lingbo Li (S12-6699), p. 122*

Influence of near bottom mariculture structures on intertidal diversity (S12-6597)

L.I. **Bendell** ***Change: moved to 10:10***

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The intertidal regions of the Pacific Northwest are under ever increasing pressure for the purpose of near-bottom mariculture. In the Pacific Northwest of British Columbia (BC), mariculturepractices include seeding the foreshore with the non-indigenous Manila clam (*Venerupisphilippinarum*) followed by the application of anti-predator netting.Intertidal macroflora and macrofauna communities were compared among 8 farmed and 7 reference sites from 3 geographically distinct regions of BC. Results from the surveys demonstrate that mariculturepractices encourage growth and biofouling of the netted areas with *Ulva*spp. with a corresponding reduction in the density of macroinvertebrates on farmed versus reference sites. Ordination by non-metric multidimensional scaling (MDS) indicated that macroinvertebrate communities that inhabited the farmed sites were more regionally similar as compared to reference sites. These findings suggest that intertidal regions are becoming homogenized (where biotic homogenization is defined as the gradual replacement of native biotas by locally expanding non-natives) with the Manila clam becoming the dominant bivalve on both reference and farmed sites. Study outcomes do not support the idea that anti-predator netting serves as an artificial reef to enhance habitat by providing a three-dimensional structure in the intertidal zone; rather as applied in coastal BC,the netting is more analogous to structural pollution that results in habitat degradation.

26 October, 14:00 (S12-6446), Invited

The introduction of the Titan Barnacle, *Megabalanus coccopoma* (Darwin, 1854) (Cirripedia: Balanomorpha) to Japan

Toshiyuki **Yamaguchi**[1], Yuu Ohshiro[2], Masashi Kiuchi[2], Michio Otani[3], Ikuo Ueda[4] and Hiroshi Kawai[5]

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The Titan Acorn Barnacle, *Megabalanus coccopoma*, a native of the tropical eastern Pacific (Panama), has become established in the western Atlantic (Brazil and the northern Gulf of Mexico to the Carolinas), northwestern Europe and the western Indian Ocean (Mauritius), and exemplifying its dispersal capabilities. This study reports its introduction to Japan and confirms its occurrence in Australia. In an attempt to determine the source of this introduction, phylogenetic techniques, involving COI sequences, were utilized. No significant genetic differentiation or haplotype patterns between widely spread populations of *Megabalanus coccopoma* from Panama, Brazil, Australia, Japan, and bulk carrier between Japan and Australia were found. We will consider the lack of such differentiation in *M. coccopoma* at this meeting and also report on the present naturalization of *M. coccopoma* in the Japanese environment.

26 October, 14:20 (S12-6667)

World wide dispersal of mudworm *Boccardia proboscidea* Hartman, 1940 (Annelida, Spionidae)

Vasily I. **Radashevsky**

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Boccardia proboscidea Hartman, 1940 originally was described from California and later widely reported from the Pacific coast of North America from British Columbia south to California. Subsequent reports arose from Japan, Korea, China, Australia, Tasmania and New Zealand and in Australia it was considered an introduced species. During the last decade this species has been reported as an introduced species in Hawaii and South Africa

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and Radashevsky *et al.* (in prep.) suggest this species is invasive in the Bay of Biscay, northern Spain, England and Argentina. Adult worms inhabit mud tubes on soft bottom but also are able to bore into hard substrates such as sandstone and shells of various molluscs. In Argentina, population densities can reach 650,000 individuals per square meter, where this worm greatly affects native benthic communities. Dense populations of *B. proboscidea* were found in the intertidal zone off Dalian, China during the Rapid Assessment Survey provided by the PICES Working Group 21 in October 2008. The aggressive behavior of this species and its influence on local communities is discussed. Also, molecular analysis of different populations of *B. proboscidea* and some other invasive species is suggested as a potential means to reveal potential transport vectors.

26 October, 14:40 (S12-6552)

Quantification of influence of *Spartina* spp. invasion on coastal wetland ecosystem services: Yancheng case study, China

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Spartina spp., are cordgrasses endemic to coastal wetlands in North America and Europe, but have been widely introduced around the world. *Spartina* spp. invasions in China coastal wetlands have altered structure and services of these ecosystems. A *Spartina* Effect Index (SEI) was developed to quantify the positive and negative effects of different mariculture models on 14 services of coastal wetland ecosystem based on the Delphi Method. Considering the weight of each service, the SEI, and baseline value of each ecosystem service together, the change value of coastal wetland ecosystem services due to *Spartina* spp. invasion was calculated. Yancheng wetland, located on the western Yellow Sea, is essential for overwintering and feeding for many migratory birds and for mariculture production. The *Spartina* spp. invasion improves the value of 11 ecosystem services: material, primary and oxygen production; climate regulation; waste treatment; biological control; disturbance regulation; recreational and scientific services; cultural usage; and, nutrient cycling. It reduces the value of 3 ecosystem services: food production, provision of genetic resources and species diversity maintenance. The *Spartina* spp. invasion reduced overall Yancheng wetland ecosystem service value by 29.635 billion RMB yuan. Food production service value decreased by 31.968 billion RMB yuan, while oxygen production, climate regulation, and waste treatment service value increased by 0.675, 0.708, and 4.041 billion RMB yuan, respectively, and scientific and recreational service value increased by 13.0 and 11.0 million RMB yuan, respectively. The greatest impacts from *Spartina* spp. invasion was on food production, since it overlaps with most shellfish habitat.

26 October, 15:00 (S12-6678)

The importance of scale for predicting impacts of stressors in nearshore environments: An example using European green crab (*Carcinus maenas*) invasions in British Columbia

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It is recognized that invasions, like other stressors in marine environments, seldom are uniform and that some locations will have conditions amenable to supporting large populations of invaders while others will not. Since impacts are closely related to population sizes of many invasive species, it becomes important to identify the amount of habitat capable of supporting populations at an "invasive" level. Since European green crab (*Carcinus maenas*) was introduced to the west coast of North America in 1989, it has continued to spread northward, largely due to its prolonged planktonic larval stage. In order to characterize the potential distribution of this crab, we evaluated different types of environmental niche models. A genetic algorithm for rule-set prediction (GARP) environmental niche model based on documented occurrence points provided informative projections of the potential distribution but did not consider the invasion level. Field surveys provided measures of the relative density of green crab populations in Barkley Sound, British Columbia along with smaller-scale environmental

measures (temperature and salinity). We evaluated the relationship between the smaller-scale environmental measures and the larger-scale model predictions to identify locations with the potential to support large green crab populations. Additional field data were used to characterize population variability over time at sites along the west coast of Vancouver Island. For nearshore invaders, identification of the correct spatial (and likely temporal) scale to make predictions of is critical. Further, this approach has application to other types of stressors impacting nearshore marine ecosystems.

26 October, 15:40 - *Change: Peter S. Ross (S12-6681), p. 121*

An application of Integrated Ecosystem Assessment in the marine areas of the West Coast of Vancouver Island to support integrated planning and management (S12-6643), Invited *Change: moved to 10:50*

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West Coast of Vancouver Island ecosystems have supported human communities for millennia, and they have also been exposed to changing patterns of anthropogenic stressors. A coastal and ocean plan for the West Coast of Vancouver Island is currently being developed by West Coast Aquatic—a diverse and representative co-management board. West Coast Aquatic is taking a collaborative approach to plan development through its Tsawalk Partnership. An ultimate goal of the partnership and plan is the development of resilience-based planning and management frameworks that maximize the sustainability and health of the social-ecological systems of the West Coast of Vancouver Island in the context of climate change and more regional and local anthropogenic stressors. The interdisciplinary science program designed to support the development of this plan features Integrated Ecosystem Assessment as an approach to simplifying a complex assessment challenge. This approach involved the identification and collection of ecological, socio-economic, and cultural information with the practical goal of identifying useful indicators of ecological and socio-economic health. These were based on key elements of the social-ecological systems, the goals and objectives for those elements, sensitivity to the identified and ranked stressors of the social-ecological system, their information content, and other criteria. Different management options and strategies will be evaluated by monitoring these indicators, and potentially through more formal Management Strategy Evaluation modelling. Management decision support tools include the Marxan/Marzone approach for developing marine zoning options and an application of the marine InVEST tool for estimating changes in ecosystem services across the seascape.

26 October, 16:00 - *Change: Burke Hales (S12-6538), p.121*

The importance of community interactions for predicting climate change impacts (S12-6759) *Change: moved to 11:10*

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Climate change is altering the world's oceans. The direct impacts of projected changes on species are complex, but not completely unknown. Warmer, more acidic, and less oxygenated waters will alter metabolic processes, modify demographic rates such as survival and fecundity, and produce shifts in the biogeographic ranges of individual species. Less appreciated than these direct climate change impacts are the indirect consequences of climate change resulting from interactions among species. The objective of this study was to compare the predicted impacts of climate change induced range shifts, ocean acidification, and ocean deoxygenation on individual species to those predicted for the same species in a food web context. We used two approaches to simulate the impacts of each of these effects on marine species in five Northeast Pacific marine food webs. First, we simulated the impact

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of each climate change effect on each species individually. Second, we used Ecopath with Ecosim models to simulate the impact of each climate change effect on all species simultaneously, allowing for dynamic trophic interactions among the food web members. The difference between the biomass predicted for each species using the first and second approach highlights the relative importance of species interactions in determining the impact of climate change in these systems. As new information becomes available on how climate change affects species biology, modeling approaches such as this one will become increasingly valuable for understanding how species interactions shape community- and ecosystem-level responses to climate change.

26 October, 16:20 (S12-6701)

Long-term changes in phytoplankton communities in Amursky Bay (the north-western part of the East/Japan Sea) under eutrophic conditions

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The results of long-term changes in phytoplankton communities as well as analysis of HAB dynamics in Amursky Bay (East/Japan Sea) during the period 1970-2010 were summarized. This area is exposed to continuous anthropogenic influence due to input of urban and agricultural runoff. The revealed changes and trends in the composition and distribution of the phytoplankton are as follows: the species richness of phytoplankton increased; there are species-specific changes in the abundance and seasonal dynamic of HAB taxa; the total biomass of planktonic microalgae increased; a list of species causing blooms of water in the bay was expanded; the biomass of the non-diatom component of the phytoplankton increased. For the last two decades some species of harmful algae (*e.g.*, toxic dinoflagellates benefiting from land runoff and water column stratification, warm water benthic dinoflagellates responding to increased water temperatures) became more common. The oceanographic records show alternation between periods of relative warming and cooling at the time scale in this area. It is supposed that climate change combined with human activities, primarily through nutrient runoff, is important for the increase in HABs.

26 October, 16:40 (S12-6652)

Natural resource damage assessment in Arctic waters

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As required by the Oil Pollution Act of 1990, Natural Resource Damage Assessment (NRDA) is a process to determine what restoration actions are needed to compensate for harm to natural resources and their human uses that occur as a result of an oil spill. The process requires natural resource trustee agencies (NOAA, DOI, and state agencies) to assess the transport of oil from the release site, the exposure of natural resources to the oil, and its effects on the biota and human uses. Determining the amount of injury and appropriate restoration requires an understanding of the condition of the natural resources and human uses in the absence of the spill (baseline conditions). Loss of Arctic sea ice suggests that over the next 10–20 years ship activity will dramatically increase. Predictions of large reserves of oil and gas are increasing pressure for hydrocarbon exploration and production. One likely result will be the accidental release of petroleum into the Arctic marine environment, which would require an NRDA to be initiated. However, little NRDA work has been done in this region. On April 22, 2010, the Coastal Response Research Center (CRRC) and NOAA's Office of Response and Restoration completed a workshop on planning for NRDA in the Arctic. Attendees included natural resource trustees, industry representatives, non-governmental organizations, academic scientists, and Arctic community representatives. This presentation will describe the outcomes of the workshop, highlight challenges particular to the Arctic, and provide suggestions for future research in support of NRDA in the Arctic.

26 October, 17:00 (S12-6731)

Long-term variations of ecosystem structure in the Laizhou Bay, China

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The Yellow River, the major freshwater source entering Laizhou Bay of the Bohai Sea, has an important impact on the estuarine ecosystem. Based on long-term ecosystem surveys during the main spawning period (May) of most fishery species from 1959 to 2008, changes in the biomass and species composition of marine resources, zooplankton, phytoplankton and nutritive salts were analyzed. The estimated mean biomass of marine resources declined continuously from 423.6 kg h^{-1} in 1959 to 164.6 kg h^{-1} in 1982, 37.7 kg h^{-1} in 1993, and less than 8 kg h^{-1} in 1998-2008. Concurrently, the biomass of zooplankton showed an increasing trend from 1959 to 2006, but slightly declined in 2008. The abundance of phytoplankton increased from 1959 to 1982, then greatly decreased in 1993 and increased until 2004, but currently is at very low levels. The mole ratio of Dissolved Inorganic Nitrogen to Phosphate has increased, and Si:P and Si:DIN have declined to low levels during the same period. The variations of major nutrient salts and decreased runoff carrying sand from the Yellow River, influenced by climate changes and human activities, may have impacted seriously on the primary production, and on ecosystem structure and function. We concluded that a combination of top-down and bottom-up controls have caused the alterations in the Laizhou Bay ecosystem structure: the top-down effect was the major determinant through the first five decades due to the increasing fishing pressure whereas the bottom-up effect has increased in the past three decades owing to greater environmental variations.

26 October, 17:20 (S12-6465)

Variability of macrobenthos structure in coastal waters of northern Sakhalin Island (Okhotsk Sea) around oil- and gas extracting objects

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Faunal sampling in coastal waters off north Sakhalin Island, Okhotsk Sea, was done in August of 2001, 2002, 2007, 2008, 2009 in the Nevelskogo Strait and northeast of Sakhalin Island. In coastal zones the beltform distribution of macrobethos communities was observed. Variability in the structure of bottom communities was strongly correlated with two factors: interannual variability in temperature regime and hydrodynamic activity. Interannual variability of the temperature regime was correlated with abundance indicators (density and biomass) and with a shift in dominant species. The hydrodynamic factor was correlated with the distributions in an influence zone of a "hydrodynamic shade", and with appearance of new local communities, that were absent previosly. Near a waterway of Nevelskogo Strait, temporary communities of "*Saduria entomon*" and "*Upogebia major + Cistenides granulata*" were observed. In the shallow waters off the northeast Sakhalin Island near Chaivo Lagoon, a new benthic community of "Molgula" was discovered.

26 October, 17:40 (S12-6576)

Dinoflagellate cysts as indicators of eutrophication in the Amursky Bay, Sea of Japan (East Sea)

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Sediment cores of 30 cm in length were collected from two stations located in Amursky Bay (Peter the Great Bay), Sea of Japan (East Sea) in March 2010 to analyze the vertical distribution of dinoflagellate cysts. The sediment cores spanned the most important period of human population growth associated with industrial development of the region, from the mid-1900s to the present. We observed an increase in the trace metal content of the bottom sediments beginning in approximately 1945. However, a decrease in trace metal concentrations was observed in

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the 1990s, and may be related to the general economic recession in the region. In the present study, 36 different cyst morpohotypes representing 13 genera were identified. Cyst species richness varied from 8 to 27 species per core. The concentrations of living cysts varied from 45 to 3240 cysts per cubic centimeter of bottom sediments, and the concentrations were much higher in upper sediments. *Scrippsiella trochoidea* was the most dominant cyst type, which averaged 39% of the cyst assemblages. Changes in the cyst-flora were compared with the known history of eutrophication and also with geochemistry of the sediments, reflecting aspects of anthropogenic pollution.

S12 Session Posters

S12-6428

Population dynamics and ecology of Surf Clam *Donax pulchellus* in Ghana

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The population dynamics and ecology of surf clam, *D. pulchellus* inhabiting exposed sandy beaches of Ghana, were studied over 12 months period (August 2006 to July 2007). A total of 7,225 individuals of *D. pulchellus* were sampled. Two-way analysis of variance revealed a significant difference in the spatial (across-shore) and temporal distribution of the species ($p < 0.05$). The results of length -frequency distributions showed two recruitment periods (October–November 2006 and March 2007) for *D. pulchellu*s. Shell morphological analysis indicated that D. *pulchellus* attains first maturity at a mean length of 7.16±1.89 mm, and may reach a maximum size of around 11 mm. *D. pulchellus* is restricted to the dissipative La beach with predominantly fine sand (2.3 Φ), moderately well sorted (0.72 Φ) and near symmetrical (0.02 Φ) with mesokurtic distribution (1.09 Φ). The results revealed that temperature, salinity, nutrients and food availability did not influence the abundance of *D. pulchellus*. Overall, three factors-salinity, nitrate and grain size are apparently modulating growth in shell length of the species. As *D. pulchellus* species are regular inhabitants of Ghanaian sandy beaches, this species can be used as bio-indicators to assess pollution levels of near shore waters. Further research should focus on the early life history of *D. pulchellus* (reproduction cycle, duration of planktonic stage, larval biology) to bridge gaps in our understanding of the species biology and functioning of Ghanaian intertidal sandy beaches ecosystems.

S12-6447

DNA strand breakage in aquatic organisms as a biomarker in environmental monitoring

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The aquatic environment is often the ultimate recipient of increasing amounts and varieties of contaminants, a large proportion of which could be potentially genotoxic and carcinogenic. The assessment of DNA damage by the single cell gel electrophoresis or Comet assay has been described as a useful nonspecific general biomarker of stress in many marine organisms. *Mizuhopecten yessoensis* have been regarded as the most useful sentinel for chemical pollution studies in the aquatic environment because they accumulate the toxic pollutants in their tissues. The aim of our study is to estimate the influence of various environmental stressors on DNA damage in gill cells of *M. yessoensis.* We used the Comet assay to measure genotoxic damage, expressed as DNA strand breaks, in isolated gill cells from scallops that were collected from polluted and 'clean' areas in Peter the Great Bay. The level of DNA damage was assessed using an image analysis package expressed as % of DNA in Tail and Tail Moment. The results of our study showed significant amounts of DNA damage in the scallops collected from polluted sites. Unpolluted sites were described as having no or minimal DNA strand breaks. The data from the present study indicate that the Comet assay is a useful and relatively sensitive tool for detecting DNA damage in marine invertebrates exposed to anthropogenic contaminants.

S12-6466

Malacostraca (*Crustacea*) – A new species in coastal waters of Aniva Bay (Okhotsk Sea, Sakhalin Island)

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Faunal sampling at Aniva Bay, Okhotsk Sea, south of Sakhalin Island, was held in September 2009. Research has been conducted according to the Contract № Y04925 between «Sakhalin Energy Investment Company Ltd» and Sakhalin Research Institute of Fisheries and Oceanography.

A new amphipod species, *Metopa* cf. *glacialis* (Kröyer, 1842), was discovered in Aniva Bay at a depth of 20 m, attached to the bivalve mollusc *Musculus niger* (Gray, 1824). The total view and structure elements of founded species are present. The nominative species (junior synonym – *Metopa cariana* Gurjanova, 1929 (Guryanova, 1951)) is a conditional endemic of the Arctic basin, besides, the discovered individuals differ from the nominative species in some details of pereopods construction for I and II pairs. K. W. Ockelmann (1983) describes *Metopa glacialis* (definition of J. Just) from the coastal waters of Korea, where amphipods have been found in the bivalve *Musculus koraeanus*.

The crab-commensal *Sakaina* cf. *incisa* Sakai, 1969 was found at depth 15–20 m. The total view and structure elements of founded species are present. *Sakaina incisa* from coastal waters of Japan (Honshu Island) differs by lesser sizes and by the construction of the abdomen.

S12-6494

History and causes of *Alexandrium Tamarense* red tide blooms in the waters near Nanhuangcheng Island, China

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In September 2006, we investigated the red tide in the waters off the coast of Nanhuangcheng Island, which was the first record of red tide caused by *Alexandrium tamarense* in Yantai. The area of the red tide was about 2.37 square kilometers, and the highest cell abundance of *Alexandrium tamarense* reached 2.334×10^8 cells/l. The high density of *Alexandrium tamarense* depleted dissolved oxygen in the water column, which led to total mortality in nearby fish pen culture facilities. Nearly half of the *Haliotis discus* cultured nearshore died from Paralytic Shellfish Poisoning (PSP) secreted by *Alexandrium tamarense*. The suspected primary vector of *Alexandrium tamarense* initial introduction was ballast water discharge. Established populations were able to proliferate as eutrophication from land-based sources, nutrient salt ejected into the sea, and organic matter fallout of shellfish culture rafts fueled the organisms. Finally, hydrometeorological conditions provided a good physical environment for frequent red tide blooms.

S12-6533

Area-specific temporal changes of species composition and species-specific range shifts in rocky-shore molluscs associated with a warming Kuroshio Current

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Global warming is predicted to lead to the dominance of low-latitude species in local species assemblages and the poleward shift of species ranges. This prediction has, however, rarely been examined at large spatio-temporal scales for intertidal organisms. We examined how the species composition and range in rocky-shore molluscs changed during 1978-2006 in Japan (26.6–45.0°N). We ran seven quadrat surveys on 15 southern shores in the Kuroshio Current area and on 6 northern shores outside this area. Both of the annual mean air and sea-surface water temperatures gradually increased in only the Kuroshio Current area. Corresponding to this, the dominance of southern species in 114 species increased on 11 of 15 shores in the Kuroshio Current area but only 1 of 6 shores outside this area during the survey period. The latitude of center of the distribution range increased during the study period by 0.52°N on average across 43 dominant species. Yet, the latitudinal increase greatly varied among species (standard deviation: 1.57°N) and values were closer between closely related species. Although these results do not contradict global warming predictions, area-specific changes of species composition and species-specific range shifts call for careful interpretation.

S12-6609

Restoration of typical marine ecosystems in China

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In recent years, China has launched a series of restoration programs in order to preserve and restore the qualities of attractive marine ecosystems. Restoration of mangrove, coastal wetland and semi-enclosed bay ecosystems are current focal areas for research. In this paper, three case-histories of marine ecosystem restoration were evaluated. The results, together with the brief assessment of practices in other coastal areas, illustrates that marine ecosystem restoration in China is still at its initial stage in both scales and strategies. The following conclusions from rehabilitation experiences of typical marine ecosystem were made: (a) the procedure of marine ecosystem rehabilitation should include marine ecological surveys, degradation analysis, determination of ecosystem targets, rehabilitation techniques, monitoring, and a follow-up evaluation of management effectiveness; (b) given the mutual interaction between coastal and land ecosystems, marine ecosystem rehabilitation should be linked to the land ecosystem and seek to eliminate degradation caused by land sources; (c) conservation and improvement of habitat is very important. For coastal wetland ecosystem rehabilitation, improvement of hydrological condition is the key factor; (d) macroalgae culture is one of the best ways to mitigate eutrophication in semi-enclosed bays, which can not only absorb nitrogen and phosphorus, but also result in economic benefits; (e) cooperation among the local governments, scientists and communities can improve rehabilitation while follow-up management can help ensure rehabilitation effectiveness.

S12-6631

An adaptive system to identify pollutants on the water surface

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Detection and identification of water surface pollution, especially due to oil spills, is currently addressed by many scientists. An expert system for adaptive identification of the environmental parameters (ASAIEP) has been developed that includes a compact multi-channel spectro-polarimeter (MSP), an information interface with a computer, computer software (STW), and an extending database (EDB). The STW realizes a number of algorithms to process data fluxes from the MSP and provides for visualization and control of the regime of measurements. The EDB consists of standard spectral images of pollutants represented by points in the multi-dimensional vector space of indicators, pre-calculated on the basis of learning samples. The ASAIEP functions on the principle that changes in light flux are fixed at the MSP output, and they are transformed into a digital code. Further processing of data with respect to their efficiency is determined by the STW that contains various algorithms for recognition of 2D objects. The adaptability of the recognition procedure is determined by the level of accumulated knowledge about special features of intensity fluctuations and polarizing properties of light reflected from the water surface. The STW makes it possible, in the case of uncertain identification of the pollution spot, to reach an expert decision based on the visual analysis of its spectral image. This procedure is realized during dialogue with the ESAIEP, and if a decision is made, the operator can address any uncertainties in the database by establishment of a standard for subsequent situations that are similar in appearance.

S12-6665

Anthropogenic hormone substances in coastal waters of Peter the Great Bay (Japan/East Sea)

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Alkylphenol polyethoxylates (APE) have been shown to be endocrine disruptors. Nonylphenol is a degradation product of APE that is used in the world as nonionic surfactant and detergent in industrial and domestic applications. The toxic effect of these compounds is associated with their ability to mimic natural estrogens and disrupt the endocrine systems of marine organisms. The concentration of nonylphenol was determined in the waters and bottom sediments of Amursky Bay, Ussuriysky Bay, and their estuarine zones. Water samples were collected from 22 stations over the period of 2008-2009, and sediment samples were collected from 11 stations in 2008. The concentration of nonylphenol in seawater ranged from 0.012 to 1.24 μg/L, and the concentration in sediments was in the range of 0.002-0.003 μg/g dry wt. The levels of nonylphenol recorded in coastal waters were generally higher than in the outer part of the bays. This is due to discharge of effluents that contain large amounts of wastewater from Vladivostok City.

S12-6666

Oil pollution in Nakhodka Bay (Japan/East Sea)

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Determination of petroleum hydrocarbon (PH) concentrations in the waters of Nakhodka Bay indicate that oil levels in the bay pose a concern with regard to marine fisheries. In 2008-2009, studies demonstrated that the distribution of oil pollution in the bay over the past decade has changed significantly. PH content in Partisanskaya River water, which flows into the bay, during the 2007-2009, does not currently exceed 530 μg/L. However, during the early 1990's PH concentrations were frequently greater than 2500 μg/L. In 2004, pollution of the river waters was minimal from all of the rivers of the Nakhodka Bay, and the PH concentration was low at 120 μg/L. The decrease in PH concentrations may be indicative of a decrease in the release of industrial effluents. In 2008, the average concentration of oil in the waters of the Primorye shipyard declined to 300 μg/L in comparison to

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2006. PH concentration in the east coast waters ranged from 400 to 500 μg/L. Coastal waters of the western bay are not equally contaminated: for example, the PH concentration near Cape Astaf'eva was measured at 570 μg/L. However, the PH concentration in the Musatova Bay area increased to 600 μg/L. During 2007 - 2009 significant PH concentrations were detected in the Kozmina Bay (up to 700 μg/L). A new oil terminal is under construction in Kozmina Bay, and a new oil refinery is planned for the western part of the bay. These new developments will undoubtedly have negative impacts on the environment in the future.

S12-6711

Effects of environmental conditions on growth-selective survival of juvenile black rockfish *Sebastes cheni* in a vegetated habitat in the central Seto Inland Sea, Japan

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Juvenile black rockfish *Sebastes cheni* are the most dominant member of fish fauna in vegetated habitats (*Sargassum* spp. and *Zostera marina*) during spring in the Seto Inlnad Sea, southwestern Japan. They immigrate into vegetated habitats from late February to early April at a total length of about 20 mm and grow to about 60 mm by early summer. Variability in vegetation has been suggested to significantly influence predation rate of juvenile black rockfish. Anthropogenic effects such as increase in sea level and temperature may alter mortality and recruitment of fish early life stages through the effects on their habitat and predation rates. In the present study, growth trajectories of juveniles were compared between the original population (OP) captured in early April and survivors (SV) captured in May over three years (2008-2010). Rockfish juveniles were collected with seine net (5 mm mesh) at one- or two-weeks intervals from March to May from 2008 to 2010. Growth trajectory was back-calculated for individual fish using otolith microstructures. Mean daily growth rates of juveniles following immigration into the vegetated habitat (over 20 mm in total length) of SV were significantly higher than those of OP in all years. It was concluded that in this study area, black rockfish juveniles experienced growth-selective mortality, and fish with high growth rates had a greater chance to survive through the post-immigration period. Variability in vegetation was one of the most important determinants for black rockfish survival through affecting their accumulative mortality under the growth-selective survival.

S12-6719

Age-specific oxidative stress response to cadmium in the scallop *Mizuhopecten yessoensis*

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The heavy metal cadmium (Cd) is widely distributed in the estuarine and coastal environments as a result of natural and anthropogenic activities. Cd can cause adverse effects in bivalves by inducing the formation of free oxygen radicals that lead to oxidative stress. The scallop *Mizuhopecten yessoyensis* is an important commercial marine bivalve cultured in the Far East. To examine the stress response of scallops, two different ages (1.5 years – immature, 3.5 years – sexually mature) were exposed to a concentration of cadmium at 300 $\mu g l^{-1}$ for a period of 4 days. The following biochemical parameters were measured in the gills: (1) activity of antioxidant system enzymes: superoxide dismutase (SOD), catalase (CAT), glutathione-reductase (GSR); and (2) malondialdehyde (MDA) as a product of membrane lipid peroxidation. The results demonstrated the age-related differences of the antioxidant enzyme activities of the control animals: SOD activity was lower whereas CAT and GSR activity was significantly higher in the gills of the 3.5 yr scallops in comparison to the 1.5 yr animals. After Cd exposure in 3.5 yr scallop the activity of three antioxidant enzymes significantly decreased in relation to control animal, while in the 1.5 yr animal CAT and GSR activity was enhanced along with reduction of SOD activity. The MDA content increased 1.4-fold and 4-fold in the 1.5 yr and 3.5 yr scallops, respectively. These findings indicate that adult scallops are more susceptible to oxidative stress, but additional research is needed to clarify the antioxidant potential for animals of different ages.

S12-6720

Results of long-term pollution monitoring in Peter the Great Bay (Sea of Japan)

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Vessel-based monitoring for hydrological and hydrochemical signals as well as sea water and bottom sediment pollution has been ongoing for 40 years in offshore shelf waters in the Sea of Japan (Peter the Great Bay). Here we examine environmental conditions and track changes due to natural or human disturbances, such as sewage disposal (including untreated sewage), transport of suspended solids, petroleum hydrocarbons and trace metals. Samples were collected from 2004 to 2008 to characterize priority pollutants (petroleum hydrocarbons, organochlorine pesticides, lead, copper, zinc, cadmium) in water and sediment samples. Patterns of these pollutants were revealed. Gold Horn Bay was the most polluted location in Peter the Great Bay, where almost all analyzed contaminants considerably exceeded maximum permissible concentrations (MPC) established for commercial fishing waters in Russia. Maximal concentrations were generally one order of magnitude greater than similar sites in Amur and Ussury Bays. Bottom sediment pollutant exceeded threshold Effects Range-Low (ERL) values, when reduced benthos abundance and species diversity begins. Amur Bay, especially the Razdol'naya River estuary and the central area of the bay, had moderate levels of petroleum hydrocarbon (TPH) and pesticide pollution in sea water and TPH in bottom sediments. The open area of Amur Bay is generally clean. Similarly, Ussury Bay had low levels of TPH and pesticide pollution in sea water and bottom sediments.

S12-6721

Significance of estuarine habitat as nursery for yellowfin sea bream *Acanthopagrus latus*: Comparison of feeding, growth and possible predators for larvae and juveniles in two habitats around Ohta River estuary northern Hiroshima Bay, Japan

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Fish early life stages will be exposed to a variety of changes in environmental conditions in their coastal and estuarine habitats due to future global warming. Estuarine habitats are considered good nursery areas for fish due to elevated prey concentrations and lower vulnerability to predation. Yellowfin sea bream *Acanthopagrus latus* are widely distributed and are an important fisheries resource in temperate coastal waters of the Indian Ocean and western Pacific Ocean. Larval yellowfin sea bream immigrate from coastal waters into shallow waters such as surf zones and tidal rivers in winter and during their juvenile stage inhabit the Seto Inland Sea, southwestern Japan. Environmental conditions, growth rate and stomach content of larvae and juveniles were compared between two habitats around the Ohta River estuary: surf zone of northern Hiroshima Bay (HB) and tidal river (Ohta River channel: OR). Fish collections and environmental surveys were conducted at sea and river stations from November to December 2009. Stomach contents and weight of yellowfin sea bream larvae and juveniles were higher in OR. Contrastingly, recent growth rates of larvae and juveniles, which was back-calculated using otolith microstructures based on the biological intercept method, were higher in HB. Possible predators (piscivorous fish) were more abundant in HB. Thus, there seems to be a trade-off between growth and survival during the early life of yellowfin sea bream: larvae and juveniles grow faster in HB due to higher temperatures while vulnerability to predation is lower in OR.

S12-6723

Seasonal and spatial variability in the zooplankton community in Masan Bay, Korea

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We investigated the variability in the zooplankton community in Masan Bay to determine how anthropogenic forces influence community structure. Masan Bay, located on the southern coast of Korea, has been under significant anthropogenic influences since 1970.

Its inner area is highly eutrophicated compared to its mouth and adjacent open ocean area, but zooplankton densities were very high in the inner Bay. Seasonality of zooplankton abundance in Masan Bay differed from the typical pattern of two peaks in spring and fall, which is generally observed in other temperate seas. Aggregated zooplankton abundance in the Bay showed a peak in February (2,186.7 ind./m^3), and was lowest in May (213.0 ind./m^3). The numerically-dominant species were *Acartia* spp., in particular *Acartia omorii*, Cladocera and Chaetognatha. Species diversity was lowest in February and highest in May, because a single group of copepod predominated in February but several groups (Appendicularia, Copepoda, Cladocera and *Noctiluca scintillans*) were equally dominant in May. Herbivores and omnivorous zooplankton were dominant in February and May whereas a carnivorous zooplankton group, Chaetognatha, predominated in August. We speculate that anthropogenic forces might have caused the anomalously high zooplankton biomass dominated by one or two species and the correspondingly low species diversity. We are currently analyzing the possible relationships of the seasonal variability in zooplankton community structure and biomass with variability of primary productivity in Masan Bay.

S12-6733

Distribution of potentially risky heterotrophic *Noctiluca scintillans* and port specific capacity based on port baseline surveys in Korea

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Vulnerability of port environments to ship's ballast water urged us to conduct baseline surveys at the busiest ports in Korea (Incheon, Gwangyang and Ulsan) to inform decisions about controlling the introduction of unwanted species. We surveyed for potentially harmful zooplankton (>200µm) and related environmental factors which are critical to the development of ballast water management methods in Korea. The red-tide heterotrophic *Noctiluca scintillans*, recognized as a blooming species causing hypoxia, frequently occurred at the ports from February 2007 to November 2009. Each port has distinctive coastal structure and is located in different bioregions of the Large Marine Ecosystems (LME) region. This species appeared consistently at all ports during the study period, indicating that it is eurythermal and euryhaline (1.97-28.00°C, 21.09-34.54 psu). Abundances of *N. scintillans* over 10,000 inds per m^{-3} were observed within the range of harbor limits at the three ports in spring and Gwangyang port in winter, coinciding with high concentrations of chlorophyll *a* (~6.58 µg L^{-1}). Maximum abundances of the species generally occurred at the outer stations of Incheon port, at the inner stations of Ulsan port and at all stations of Gwangyang port. Results indicated that Gwangyang port in spring is the most suitable environment for the introduction and reproduction of *N. scintillans* transferred outside the bioregion. Conversely, uptake of ballast water at the same time and place is likely to provide an opportunity to transfer and introduce this species to the other coastal ecosystems.

S12-6741

Distribution of macrobenthos around the LUN-A platform at the initial phase of Lunskoye field development (North-East Sakhalin Island Shelf)

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Monitoring of the LUN-A area has shown that the composition, structure and community abundance pattern has not changed over a long period of time, suggesting this community is relatively stable. Our study found high quantitative and structural values for characteristics of these benthic communities. Comparisons of post construction phase communities of the LUN-A platform (2006-2009), and those conducted pre-construction in 2001-2004, showed that the benthos was similar before and after the platform installation. Also, a stable community of fine and silty sands has been observed around the LUN-A platform over several years. Before development of the Lunskoye field (2001, 2004) and during the post construction phase (2006-2009), the community biomass was dominated by: bivalves *S. groenlandica*, *C. ciliatum*, polychaete *A. proboscidea*, cumacean *D. bidentata,* and sea anemone *Halcampoides purpurea.* The most frequently encountered species (P≥80%) included: *D. bidentat, H. purpurea,* and amphipod crustaceans *Orchomenella minuta, Protomedeia epimerata.* The species composition and quantitative parameters of the benthic communities around the LUN-A platform are typical for marine areas not affected by anthropogenic impacts.

S12-6745

Valuation of ecological capital in coastal area of Shandong province, China

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Based on the Guidelines for Marine Ecological Capital of China, the ecological capital was valuated in the coastal area of Shandong province, China. In its approximately 35,900 km^2 of coastal area, this area contains nearly 334.27 billion m^3 of sea water, 11.54 billion ton sea sands, and more than 1.02 million ton economical bio-resources. In 2007, these ecological resources supplied total ecosystem service values of ¥201.45 billion, including the values of provisioning, regulating, cultural and supporting services: ¥111.75, ¥5.40, ¥83.99 and ¥0.31 billion per year, respectively. The provisioning and cultural services contributed the most to the whole ecosystem services; 55.47% and 41.68%. Variation in individual administrative regions revealed differences owing to diverse ecosystem and anthropogenic utilization. The results of our research will be applied to improve utilization and loss evaluation of marine ecosystems. Furthermore, this research will contribute to optimization of the exploitation mode of costal ecosystems, facilitate ecosystem-based marine management, and determine sustainable services of marine ecosystems.

S12-6794

Estimation of the seaweed biomass by the extensive field survey

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Seaweeds make up the majority of the biomass in coastal marine ecosystems. They are economically and ecologically very important. Currently the economic usefulness of seaweeds as biofuel and carbon sequestration is an emerging topic in the era of sustainable development. The availability of natural seaweed biomass is fundamental to estimate the usefulness of seaweeds in coastal ecosystems. To estimate seaweed biomass we investigated a total of 62 sites along the coastline of South Korea from July 2006 to April 2008. Non-destructive, seasonal samples were collected from three intertidal zones (upper, middle and lower) and three subtidal depths

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(1, 5 and 10 m). The seaweed biomass ranged from 176 g wet wt m^{-2} to 3,238 g wet wt m^{-2}, showing rich standing crop in Jeju Island. The total seaweed biomass along the 6,000 km of coastal line of South Korea was putatively estimated at approximately 580,000 wet wt tones.

S12-6812

Estimating optimum size of stock enhancement in marine ranching ecosystem

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An integrated fisheries risk assessment, forecasting and management for ecosystem (IFRAME) was introduced to manage fisheries resources in recent years and we applied this IFRAME to estimate the optimal size of stock enhancement in a marine ranching ecosystem. We estimated the optimum size of stock enhancement using two different approaches: one population-based and the other ecosystem-based. To estimate optimum size at the population level, we used Berverton-Holt model parameters, such as theoretical maximum weight, growth coefficient, instantaneous natural mortality, instantaneous fishing mortality, and age of recruit. To estimate optimum size at the ecosystem level, we forecasted impacts of stock enhancement. We estimated the optimal size of stock enhancement using the integrated fisheries risk assessment, forecasting and management for ecosystem (IFRAME) tool, which considers four management objectives: sustainability, biodiversity, habitat, and socio-economic benefits.

S12-6856

Threats to marine and coastal biodiversity in the NOWPAP region

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The Northwest Pacific features coastal and island ecosystems with spectacular marine life and commercially important fishing resources. The region is also one of the most densely populated parts of the world, with enormous pressures and demands on the environment, including marine and coastal biodiversity. This work includes information on biodiversity threats in the region covered by the UNEP Northwest Pacific Action Plan (NOWPAP). Information on trends in fish catches, sea surface temperature and nutrient loads is provided. The range and extent of protected areas in the NOWPAP region is encouraging for the future conservation of biodiversity in the region. Although the marine biodiversity loss is increasingly affecting the ocean's capacity to provide food, yet available data suggest that the trend is still reversible. It is also important to note that at stake is not just the biodiversity, but a substantial part of the economy and the livelihoods that depend on it.

S12-6873

Is it or isn't it? Taxonomic proficiency of North Pacific NIS Polychaete assessments in the Northeast Pacific

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All non-indignous species (NIS) programs rest on the bedrock of species identifications for the assessments of their native, cryptogenic, or non-indigenous origins. Millions of dollars are spent on detection, prevention, control, and eradication programs. The economic damage of wide spread invasive species is likely to reach into the billions of dollars. While large, charismatic marine invertebrates, such as green crabs, European fan worms, lionfish, and tunicates are readily identified, the smaller and more diverse species such as polychaetes that can also exert great ecosystem effects are often poorly identified if at all. Examples include well-established NIS that are at first mis-identified as natives or cryptogenic species before closer examination. The reverse is also true - poorly identified natives or cryptogenic species are mistaken for NIS. These problems stem from poor access to taxonomic training, inadequate literature, lack of support, and poor communication between taxonomists. What's needed is enhanced exchange of information between regional and international taxonomists, both morphological and molecular methods of identification for cryptic species, and a greater reliance on previously verified specimens. Voucher collections are essential as is their being made accessible by museum deposition with their locations included as part of the ecological literature.

S13 POC/BIO/MONITOR/FUTURE Topic Session Comparing the two major gyres of the subarctic North Pacific - Seasonal and interannual variability and its predictability

Co-Convenors: James Christian (Canada), Emanuele Di Lorenzo (U.S.A.), Shin-ichi Ito (Japan), David L. Mackas (Canada), Vyacheslav B. Lobanov (Russia) and Atsushi Tsuda (Japan)

In the North Pacific, there are two major gyres; the western subarctic gyre and the Alaskan gyre. Although severe winter conditions have limited observational activity, recent progress in observational networks, including satellites, drifters and Argo floats, have improved our understandings of the two gyres. Both gyres are mainly driven by the subarctic wind field and are expected to be synchronized with each other. However, the real responses are not so simple. For example, the western subarctic gyre shows large seasonal variability in the western boundary current (Oyashio), while the Alaskan stream does not show large seasonal variability. In addition to these physical characteristics, chemical and biological characteristics are different. For example, iron supply is larger in the western subarctic gyre since the distance from the terrestrial sources is closer than in the Alaskan gyre. This, in turn, affects seasonal cycling and magnitudes of phytoplankton and zooplankton production. Therefore ecosystems are also different in the two gyres. To achieve better understanding of the mechanisms of the subarctic response to atmospheric forcing, comparisons of the responses of the two gyres are essential. This session will focus on the comparison of the physical, chemical and biological characteristics of the two gyres, on all time scales. Presentations on predictability of the two gyres, or which address additional improvements of the subarctic observation network are also welcome.

Friday, October 29 (9:00-12:30)

9:00 *Introduction by Convenors*

9:10 **Osamu Isoguchi and Hiroshi Kawamura (Invited)**
Seasonal to interannual variations of the western boundary current of the subarctic North Pacific using altimeter data (S13-6477)

9:40 **Howard Freeland**
Heat and Salt conservation in the N.E. Pacific (S13-6796)

10:00 **Sachihiko Itoh, Ichiro Yasuda and Hiromichi Ueno**
Warm and cold-core anticyclonic eddies in the western subarctic North Pacific (S13-6545)

10:20 *Coffee/Tea Break*

10:40 **Joaquim I. Goes, Helga do R. Gomes, Kosei Sasaoka and Toshiro Saino (Invited)**
The role of the Aleutian Low Pressure System in regulating phytoplankton biomass, primary production and export production across the subarctic Pacific Ocean basin (S13-6610)

11:10 **Rui Saito, Atsushi Yamaguchi, Ichiro Imai, Sei-Ichi Saitoh and Kenshi Kuma**
East-west comparison of the zooplankton community in the Subarctic Pacific during the summers of 2003-2006 (S13-6433)

11:30 **Sanae Chiba (Invited)**
An overview of ecosystem state variability in the subarctic North Pacific: East-west synchrony and contrast (S13-6587)

12:00 **Hiroaki Saito, Atsushi Tsuda, Hiroaki Tatebe**
West meets East: Inter-gyre transportation of *Neocalanus* copepods (S13-6669)

12:20 *Discussion and Summary by Convenors*

12:30 *Session ends*

S13 Posters

S13-6662 **Shin-ichi Ito, Yugo Shimizu, Shigeho Kakehi, Taku Wagawa, Akira Kusaka and Masatoshi Sato**
Seasonal variation of the Oyashio transport compared with the Alaskan Stream

S13-6712 **Yuichiro Kumamoto, Akihiko Murata, Shinya Kouketsu, Michio Aoyama, Shuichi Watanabe and Masao Fukasawa**
A comparison of dissolved oxygen concentration in intermediate layer between the western and eastern subarctic gyres of the North Pacific from 1985 to 2007

S13-6716 **Yugo Shimizu, Taku Wagawa, Shin-ichi Ito, Shigeho Kakehi, Akira Kusaka and Masatoshi Sato**
Velocity structure and transport of Oyashio measured by vessel-mounted acoustic Doppler current profiler along repeat hydrographic section A-line

S13 Session Oral Presentations

29 October, 9:10 (S13-6477), Invited

Seasonal to interannual variations of the western boundary current of the subarctic North Pacific using altimeter data

Osamu **Isoguchi**[1] and Hiroshi Kawamura[2]

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Seasonal to interannual variations of the East Kamchatka Current (EKC) and the Oyashio are examined using altimeter-derived and tide gauge sea levels at Petropavlovsk-Kamchatsky (PK). We calculate altimeter-based eddy drifting velocities (EDV) as an index of the current variation. The annual cycles of EDV, the PK sea levels and the Sverdrup transport (SV) for 40-50°N show similar seasonal features that have: 1) maxima in early winter and 2) small secondary peaks in early summer. These indicate that the EKC/Oyashio seasonal variation is mainly governed by the Sverdrup dynamics. The early winter intensification recognized as the general EKC/Oyashio seasonal variation involves a large and rapid change from late autumn to early winter, which is roughly explained by the southward shift of the westerlies. Its onset timing is indeed determined by the timing of the southward migration of the westerly jet. The early summer intensification can also be explained by a barotropic response to the intraseasonal evolution of atmospheric circulation in the Baiu (rainy) season peculiar to East Asia and East Siberia. The PK sea levels also agree with the SV and EDV in terms of wintertime year-to-year variability. Based on the relation, wintertime interannual variation is discussed. The 44-year wintertime PK sea levels correlate with the wintertime SV and springtime sea surface temperature off the northeastern coast of Japan with decadal-scale variability. This demonstrates that EKC/Oyashio is primarily explained by a barotropic response to large-scale atmospheric forcing and fluctuates on a decadal timescale almost in phase with atmospheric changes.

29 October, 9:40 (S13-6796)

Heat and Salt conservation in the N.E. Pacific

Howard **Freeland**

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This paper will outline an attempt to understand to what extent Argo observations can be used to constrain the large-scale heat and salt budgets in the N. E. Pacific and to understand the implications for the dynamics of the N.E. Pacific. Results will be shown from an experiment that involves establishing a 1° x 1° grid extending from 33°N to 52°N and 160°W to 135°W. All Argo data available are interpolated objectively onto the nodes of the grid and the resulting grids are used to compute geostrophic velocities. Volume integrals allow the variations in total heat and salt (or freshwater) content to be monitored and integrals around the boundaries allow computation of the net heat and salt flux divergences.

The fluxes across each of the boundaries are very large, but can be summed to total divergence estimates that are much smaller. Heat and salt are not conserved in the volume examined. The net divergence and convergence can be used to monitor large scale climate forcing. For example, the net non-zero salt flux can be used to compute the net excess of precipitation over evaporation over this large area.

29 October, 10:00 (S13-6545)

Warm and cold-core anticyclonic eddies in the western subarctic North Pacific

Sachihiko **Itoh**[1], Ichiro Yasuda[1] and Hiromichi Ueno[2]

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Vertical profiles of temperature and salinity from various sources were analyzed together with satellite altimeter data to investigate the water mass characteristics of warm and cold anticyclonic eddies in the western boundary region of the subarctic North Pacific. Anticyclonic eddies with warm and saline core water occur frequently near the Kuroshio Extension, and their distribution extends northward/northeastward into the western subarctic gyre along the Japan and Kuril–Kamchatka trenches. Eddies with cold and fresh core water are found mainly around the Oyashio southward intrusions and farther north near the Kuril Islands. Based on the heat content anomaly integrated over 50–200 db, 85% of the anticyclonic eddies within the study area (35°–50°N, 140°–155°E) have a warm and saline core; 15% have a cold and fresh core. Warm and saline eddies around the Japan and Kuril–Kamchatka trenches have a double-core structure, with the cold and fresh water mass located below the warm core. The lower core water is colder and fresher on isopycnal surfaces at around 26.70 σ_θ compared with the regional climatology. Northward propagation of these eddies along the trench line results in a large northward transport of heat and salinity in the upper 400 db (250 db) and a negative salinity transport below 350 db. Our presentation will also compare the western subarctic eddies with eddies found in the eastern subarctic gyre.

29 October, 10:40 (S13-6610), Invited

The role of the Aleutian Low Pressure System in regulating phytoplankton biomass, primary production and export production across the subarctic Pacific Ocean basin

Joaquim I. **Goes**[1], Helga do R. Gomes[1], Kosei Sasaoka[2] and Toshiro Saino[2]

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The subarctic Pacific is one of the most productive regions of the world's oceans and an important sink for atmospheric CO_2. Its major distinguishing feature is the development of the Aleutian Low Pressure System (ALPS, ~50°N, 170°W) in winter, under whose influence the entire region experiences strong variations in meteorological and physical oceanographic conditions that have a profound influence on the seasonality, interannual variability and distribution patterns of phytoplankton biomass, primary productivity and export production across the subarctic Pacific. Here we use multi-sensor satellite data to show that these gradients across the western and eastern gyres of the subarctic Pacific can be particularly pronounced following the onset of El Niño conditions when the ALPS strengthens and shifts southeastward causing an anomalous intensification of wintertime monsoonal winds coming off the Asian continent.

29 October, 11:10 (S13-6433)

East-west comparison of the zooplankton community in the Subarctic Pacific during the summers of 2003-2006

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The subarctic Pacific is known to have east-west gradients in the oceanic environment and phytoplankton community. The western subarctic Pacific is characterized by cooler temperature and higher chlorophyll *a* while the eastern region has somewhat higher temperature and lower chlorophyll *a*. Although there is little information on the differences in the zooplankton community between the eastern and western subarctic Pacific, the gradients in the oceanographic environment and phytoplankton community may markedly affect the zooplankton community in this region. The aim of this study is to clarify east-west differences in the subarctic Pacific zooplankton community. Zooplankton were sampled at stations along the 165°E line (western subarctic Pacific from 41°30′N to 49°30′N) and 165°W line (eastern subarctic Pacific from 39°N to 53°30′N) using 0.33 and 0.10 mm mesh size Twin NORPAC net during the summers of 2003-2006. East-west differences in the zooplankton community included: 1) greater total zooplankton abundance in the west, 2) larger within-species body size of calanoid copepods in the west and 3) greater abundance of the hydrozoan *Aglantha digitale* in the east. Differences in east-west zooplankton and hydrozoan abundances are attributed to differences in the magnitude of primary production (higher in the west), the size of primary producers (larger in the west) and ecosystem structure (higher transfer efficiency in the west). Larger body sizes of calanoid copepods in the west are attributed to the lower temperature. Thus, differences in zooplankton abundance and body size are concluded to be due to east-west gradients in the oceanographic environment, phytoplankton community and ecosystem structure.

29 October, 11:30 (S13-6587), Invited

An overview of ecosystem state variability in the subarctic North Pacific: East-west synchrony and contrast

Sanae **Chiba**

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In the subarctic North Pacific, key ecosystem status indicators for lower trophic levels (*e.g.* biomass, community structure, production seasonality and biogeography) vary interannually to decadally in reponse to two major ocean processes: 1) upper layer temperature anomalies driven by wintertime wind stress, and 2) advection associated with dynamics of oceanic currents. Both processes are linked to low-frequency changes in the atmospheric circulation over the subarctic NP. Change in wind stress drives a seesaw-like cool-warm cycle between eastern and western NP. Responding to this cycle, decadal variability of the seasonal timing of the production peak of dominant copepod species is correlated but of opposite phase in the Gulf of Alaska and Oyashio. Stable isotope analyses on salmon scales also show seesaw-like decadal oscillation between east and west, and indicate synchronous change in food web structures in the two remote ecosystems. As for advection, low frequency movements of the subtropical-subarctic boundary due to oceanic current dynamics affects lower trophic level biogeography. In the western NP, intensification of the Kuroshio after the 1980s resulted in an increase of warm water copepod species in the Oyashio. Similarly, in the eastern NP, changing dynamics of the North Pacific Current (which originates from the Kuroshio Extension) in the 2000s has induced shifts in the latitude at which the North Pacific Current bifurcates into the Alaska Current and California Current, and these shifts are associated with latitudinal displacements of zooplankton community boundaries. The goal of this presentation is to first depict synchrony and similarity in the lower trophic level responses to climatic and large scale physical forcing in the eastern and western subarctic NP, and next to clarify the east-west differences in these processes.

S13

29 October, 12:00 (S13-6669)

West meets East: Inter-gyre transportation of *Neocalanus* copepods

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Calanoid copepod in three species of the genus *Neocalanus* are the most dominant zooplankton in both the eastern and western gyres of the subarctic North Pacific (SNP). In spite of their pan-SNP distribution, their biomass, sizes, vertical distributions and life cycles are different between gyres. It has been thought that the productivity and its seasonality of each ecosystem induce these differences. Long-term monitoring studies have revealed that the biomass, species composition, phenology of *Neocalanus* showed decadal-bidecadal variability. Various hypotheses, or scenarios, have been proposed to explain the variations, especially related to climate regime shift and resultant change in the productivity. Tatebe *et al.* (2010) examined horizontal transport of *Neocalanus* using an IBM model including the life cycle and ontogenetic vertical migration of *Neocalanus* and showed that the populations of both gyres can be exchanged within a few generations. The transport distance is quite long (up to 5000 km/generation) along the paths of subarctic circulation. Animals collected off Hokkaido have potentially been transported from the Sea of Okhotsk, Bering Sea, Alaskan Current source region, as well as from the Oyashio region. The biomass obtained in a station/region does not always reflect the local productivity. The circulation pattern and the productivity of source region of *Neocalanus* induce "apparent" change in the biomass. We will present our perspective for future studies to understand the mechanisms of annual-bidecadal variations in the *Neocalanus* biomass.

S13 Session Posters

S13-6662

Seasonal variation of the Oyashio transport compared with the Alaskan Stream

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Recent theoretical studies, based on a time-dependent model of a stratified topographic beta plume, have predicted out weak seasonal variability of subarctic western boundary currents even if the forcing is active only during the winter. This theory is consistent with observations in the Labrador and East Greenland Currents, and in the Alaskan Stream. We evaluated whether this theory can be applied to the Oyashio. The seasonal variation in the Oyashio transport is calculated to be about 25% of its annual average according to the theory. The Oyashio transport was estimated on the Oyashio Intensive observation line off Cape Erimo (OICE) which was set along the altimetry satellite ground track during 1998-2002. The geostrophic transport of Oyashio between 39°30'N and 42°N (referred to 3000 db or the bottom) was compared with sea surface height (SSH) from the satellite altimeter, and an equation to estimate the Oyashio transport from the SSH data was established. These observations showed much larger seasonal variability of transport than is predicted by the theory. (whereas the annual mean transport was estimated as 9.5 Sv, the seasonal variability was estimated as 16.0 Sv, or 168% of the annual mean). To investigate the cause of the discrepancy between the theory and observation, lag correlation between the Oyashio transport and the wind stress curl field was calculated. The result showed the maximum correlation to the local (the northwestern Pacific) wind stress curl with 24-months lag. This fact supports a hypothesis that the steep topography along the Aleutian Archipelago prevents propagation of the topographic beta plume, and that the relative importance of local wind forcing is therefore enhanced.

S13-6712

A comparison of dissolved oxygen concentration in intermediate layer between the western and eastern subarctic gyres of the North Pacific from 1985 to 2007

Yuichiro **Kumamoto**[1], Akihiko Murata[1], Shinya Kouketsu[1], Michio Aoyama[2], Shuichi Watanabe[1] and Masao Fukasawa[1]

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In 2007, a repeat hydrographic observation was conducted along the WOCE Hydrographic Program (WHP) –P01 line (47°N, 145°E – 125°W appox.) across the western and eastern subarctic gyres of the North Pacific. Comparison of hydrographic results from 2007 with those from the WHP cruises in 1985 and 1999 along the identical line revealed basin-wide temporal variability of dissolved oxygen concentration in the intermediate layers (26.0 – 27.0 σ_θ). From 1985 to 1999, apparent oxygen utilization (AOU) increased (oxygen decreased) at most stations between 145°E and 135°W. The largest AOU increase (about 50 µmol kg^{-1}) appeared around 170-160°W on about the 26.6σ_θ surface. On the other hand, from 1999 and 2007 AOU in the intermediate layers decreased (oxygen increased) basin-wide and the largest decrease (about 50 µmol kg^{-1}) appeared around 170-160°W on about the 26.6σ_θ surface where the largest AOU increase was observed from 1985 and 1999. This opposite temporal change between the 1980/90s and 2000s implies basin-wide oscillation in AOU in both the two major gyres in the North Pacific during the last two decades. The decadal oscillation along the WHP-P01 line is similar to those observed in Oyashio region and at Ocean Station P in the western and eastern subarctic gyres, respectively. However, the mechanisms of these oscillations over the North Pacific subarctic region remain uncertain. Temporal change in a semi-conservative tracer, preformed phosphate concentration implies a contribution from circulation changes.

S13-6716

Velocity structure and transport of Oyashio measured by vessel-mounted acoustic Doppler current profiler along repeat hydrographic section A-line

Yugo **Shimizu**[1], Taku Wagawa[1], Shin-ichi Ito[1], Shigeho Kakehi[1], Akira Kusaka[2] and Masatoshi Sato[1]

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The Oyashio and its downstream flows (the northeastward return flow in the subarctic gyre and the southward intrusion across the Oyashio front) were measured by vessel-mounted acoustic Doppler current profiler (ADCP), along a repeat hydrographic section “A-line” extending southeastward from the southeast coast of Hokkaido Island Japan, in order to reveal the absolute velocity structure and transport. We obtained the ADCP and CTD data from twelve A-line cruises conducted in each season during 2006 - 2008. The ADCP used in these surveys was a 38 kHz Ocean Surveyor, RD Instruments USA, which can measure the current down to the depth about 1000 m. The CTD observation was done down to 3000 dbar, or to the bottom if shallower. In the observation in March 2008, the ADCP-referred transport of Oyashio between isopycnal layers 26.7-27.3 σ_θ was estimated to be southwestward 2.4 Sv. This value was considerably less than the estimated geostrophic transport referred to 3000 dbar, which was southwestward 8.0 Sv. The temperature and salinity maps showed a warm eddy near the Oyashio front, and the vertical section of density suggested that the southwestward Oyashio speed was decreased in ADCP velocity due to the northeastward flow along the northern edge of the warm eddy. This was underestimated in the geostrophic calculation because the eddy produced horizontal density gradients that extended below the 3000 dbar reference level. The velocity structure and transport in the other cruises will also be described in the presentation.

S14 POC/MEQ/FUTURE Topic Session
Marine renewable energy development in coastal and estuarine environments around the North Pacific

Co-Convenors: George Boehlert (U.S.A.), Michael Foreman (Canada), Glen Jamieson (Canada) and Kuh Kim (Korea)

Renewable energy projects are increasing worldwide, and many types involve the marine environment. Those under active development are typically designed to directly extract energy from waves, tides, currents, wind, or thermal gradients or indirectly from biomass energy. These novel technologies will require new emplacements, moorings, or other structures in marine and estuarine environments with attendant intrusions upon the environment, including acoustic signals, changes to mixing, and electromagnetic fields. Marine renewable energy sources are able to provide clean energy, but their effects on the physical and biological environment are not well understood. This session will examine the technologies under development in PICES nations and address the current state of our knowledge on how they will interact with estuarine, coastal, and offshore environments.

This session seeks contributions that deal with any topics pertinent to marine renewable energy development, including: (1) status of marine renewable energy in PICES countries; (2) economic costs and benefits of different approaches; (3) marine spatial planning for renewable energy; (4) physical effects of marine renewable energy development (current flow, energy reduction, mixing, sediment transport); and (5) ecological effects (larval transport, entrainment, entanglement, behavior, habitat changes, communities) on all trophic levels.

Wednesday, October 27 (9:00-12:30)

9:00	***Introduction by Convenors***
9:05	**Henry Jeffrey (Invited)** Ocean energy: A European perspective (S14-6676)
9:35	**Tokio Wada and Ken Takagi** Status and perspectives of the utilization of marine renewable energy in Japan (S14-6619)
9:55	**Keyyong Hong, Seung-Ho Shin and Seok-Won Hong** Current status and future perspectives of marine renewable energy development in Korea (S14-6761)
10:15	**George W. Boehlert and Philip C. Malte** Wave and tidal energy research in the Pacific Northwest: The Northwest National Marine Renewable Energy Center (S14-6779)
10:35	***Coffee/Tea Break***
10:55	**Brian Polagye (Invited)** Environmental effects of tidal energy development (S14-6565)
11:25	**Yong Jun Cho, Min Kyun Kim** On the likelihood of Power-Breaker as wave energy extractor and its hydraulic characteristics (S14-6617)
11:45	**Michael Foreman, Dario Stucchi, Kyle Garver and Thomas Grime** A circulation model for the Discovery Islands, Canada: The first step in assessing tidal energy potential and impacts (S14-6540)
12:05	***Discussion and Summary by Convenors***
12:30	***Session ends***

S14 Session Oral Presentations

27 October, 9:05 (S14-6676), Invited

Ocean energy: A European perspective

Henry **Jeffrey**

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2010 has been a busy year for the ocean energy industry both in the UK and Europe. This presentation will describe and discuss the significant progress that has been made in the UK ocean energy sector. It will cover progress in the development of the technologies as well as current and future plans for the large scale deployment of ocean energy devices.

In addition to the technology itself the paper will also cover a range of underpinning, planning and supporting initiatives that have been put in place. Within these a initiatives a number of national roadmaps and action plans that strategically plan for both the technology development and the underpinning infrastructure have been developed. These maps and plans have covered a range of topics, including:

- The regulation, legislation and leasing rounds that have been developed to allow for the strategic spatial planning of the marine resource.
- The increasing involvement of utilities, industry and supply chain as the sector grows
- The variety of technology push, through to market pull funding initiatives that are in place to support the sector.
- The underpinning Research and development programmes that are in place to provide generic and technology specific research.

This paper will also describe and discuss these areas and how they are contributing to the overall progression of the sector.

27 October, 9:35 (S14-6619)

Status and perspectives of the utilization of marine renewable energy in Japan

Tokio **Wada**[1] and Ken Takagi[2]

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The reduction of greenhouse gas emissions by 25% by 2020 is the Japanese policy for alleviating global warming. The utilization of marine renewable energy, such as offshore wind, wave, and ocean current, is expected. It is found that the Japanese exclusive economic zone has a considerable potential for marine renewable energy; in fact, enough to meet the primary energy requirements of Japan. The waters around Japan, however, have severe weather conditions and narrow continental shelves. Therefore, it is not easy to deploy power generation devices for generating marine renewable energy at a lower cost. In this paper, we examine the current status of the technology and economics for utilizing marine renewable energy in Japan and discuss the further possibility for expansion. In addition, we propose a closed system of marine energy generation for the fisheries industry in coastal areas and isolated islands, as a first step of an actual utilization of marine renewable energy.

27 October, 9:55 (S14-6761)

Current status and future perspectives of marine renewable energy development in Korea

Keyyong **Hong**, Seung-Ho Shin and Seok-Won Hong

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The current status of wave and tidal energy development in Korea is reviewed in terms of marine energy resource distribution, R&D projects and prototype devices under development. Future perspectives are introduced in terms of technical and non-technical barriers, the cost of energy expectation and a long-term strategy and roadmap for marine renewable energy R&D in Korea.

The key projects in progress include the Shihwa tidal barrage power plant of 254MW capacity whose construction will be completed in 2011, the Uldolmok tidal current pilot plant which is equipped with a couple of helical turbines of 500kW capacity and which began operation in May of 2009, and the Yongsu pilot plant of OWC wave energy conversion which is equipped with a pair of 250kW impulse turbines and will be installed at Jeju in 2011. Also, a feasibility study on the ocean thermal energy utilization at Korean coastal areas has been carried out. It focused on the thermal energy utilization of deep sea water and discharged water from power plants.

Korea launched its long-term strategy for research, development and demonstration of new and renewable energy in 2008. Its overall target is to supply 11% of national energy demand from new and renewable energy by 2030. Ocean energy is expected to contribute 4.7% of the total new and renewable energy supply, which amounts to 1,540kTOE. Its successful achievement will depend on the progress in the development of the tidal barrage power in the short term as well as both tidal current and wave powers in the long term.

27 October, 10:15 (S14-6779)

Wave and tidal energy research in the Pacific Northwest: The Northwest National Marine Renewable Energy Center

George W. **Boehlert**[1] and Philip C. Malte[2]

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The Pacific Northwest (PNW) is endowed with significant marine renewable energy resources, with wave energy on the open coast and tidal energy mainly in Puget Sound. Interest in renewable energy is high in this region of the US, and recent funding from the US Department of Energy has led to establishment of the Northwest National Marine Renewable Center (NNMREC), a partnership between Oregon State University, focusing on wave energy, and the University of Washington, focusing on tidal energy resources. NNMREC scientists conduct research addressing wave and tidal energy resource forecasting, assessing reliability and survivability of marine energy systems, modeling for device and array optimization, evaluation of potential environmental and ecosystem effects, and outreach/education.

Several applications for pilot or commercial deployment of wave energy devices exist in the PNW, and the NNMREC is involved in many of these. Baseline environmental data collection (benthos, fish, marine mammals, acoustics, and sediment transport) is underway at some sites and proposed at others. A variety of other engineering and oceanographic studies have also been accomplished. NNMREC is also working on a test berth site off Newport, Oregon, for testing and evaluation of full-scale commercial devices. Research on tidal energy development in Puget Sound is focused on the area around Admiralty Inlet, where up to three OpenHydro turbines are being planned for deployment. Environmental and physical data are presently being collected, and modeling of the tidal resource is progressing.

27 October, 10:55 (S14-6565), Invited

Environmental effects of tidal energy development

Brian **Polagye**

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The compatibility of tidal current power generation with the existing marine environment is not yet established. This uncertainty derives from two sources. First, publicly available data which describe the environmental stressors created by tidal energy devices (*e.g.*, pressure fields, noise, electromagnetic fields) are very limited. Second, the response of environmental receptors (*e.g.*, fish, marine mammals) to existing and analogous stressors is not well understood. A workshop in March, 2010 brought together tidal energy practitioners and scientists from the broader oceanographic community to evaluate these uncertainties and identify high priority areas of concern. Participants were drawn from a range of affiliations (academia, research labs, industry, and regulatory agencies) and locations (United States, Canada and Europe). For high priority stressor/receptor interactions, gaps in understanding are identified, recommendations made to monitor the interaction, and mitigation strategies proposed. The uncertainties around many of these interactions can only be reduced by monitoring pilot projects (*e.g.*, risk of blade strike causing injury or mortality). Pilot scale monitoring will also provide useful information to assess some of the environmental costs and benefits of scaling up to commercial deployments. However, cost-effective monitoring of key interactions remains elusive, particularly in the energetic environments suitable for tidal current power generation (*e.g.*, peak currents in excess of 3 m/s, deployments in water deeper than 40m). This challenge can only be overcome by broader engagement between tidal energy practitioners and the oceanographic research community.

27 October, 11:25 (S14-6617)

On the likelihood of Power-Breaker as wave energy extractor and its hydraulic characteristics

Yong Jun **Cho**, Min Kyun Kim

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We numerically analyze the likelihood of Power-Breaker as wave energy extractor and its hydraulic characteristics. Power-Breaker is a vertical type breakwater consisting of immersed water channel and curved water chamber, naive form of which was originally introduced by Nakamura (1999, 2003 and 2005) for the alleviation of reflected waves, and later improved by Cho and Kim (2008). As a wave driver, we use the Navier-Stokes Eq. and mass balance Eq. and the numerical integration of which is carried out using SPH [Smooth Particle hydrodynamics] with a Gaussian Kernel function. It turns out that Power-Breaker has the edge over the conventional extractor in converting efficiency due to its ever anticlockwise flow in the water chamber. Numerical results also show that Power-Breaker can contribute to the improvement of water quality in harbor by forcing fresh water to flow into the harbor through the immersed water channel. As the water level in front of curtain wall, where an anti-node of standing wave due to partial reflection is formed, approaches its lowest level, a unidirectional flow in the water chamber formed by a preceding wave begins to be released toward the offshore. Once it exits the water chamber, this jet flow feeds necessary energy into the vortex formed in front of the water chamber to sustain long enough until next wave is coming. Considering the facts that an intensity of the inflow via the immersed water channel is strongly proportional with an extent and strength of the vortex, we can deduce that aforementioned vortex is responsible for net inflow into the harbor through the immersed water channel. It is also shown that net flux through the immersed water channel increases as the mass inflow into a water chamber is getting larger (T=1.4 sec, L_e=6 cm), which also supports our conclusion.

27 October, 11:45 (S14-6540)

A circulation model for the Discovery Islands, Canada: The first step in assessing tidal energy potential and impacts

Michael **Foreman**[1], Dario Stucchi[1], Kyle Garver[2] and Thomas Grime[3]

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Tidal current speeds in several passages of the Discovery Islands region of British Columbia are greater than 6 m/s, making them among the strongest in the world. As a first step toward assessing the potential for tidal power extraction and the possible near and far-field impacts of that extraction, a high resolution unstructured grid has been created for the region and the finite volume model FVCOM has been applied to simulate the regional ocean circulation. This presentation will briefly describe the creation of initial and forcing fields for this model and then assess its accuracy through comparisons with tide gauge and current meter observations. Plans to model energy extraction and its impact will also be discussed.

S15 MONITOR Topic Session
Development and use of ocean observing and forecasting systems in coastal and marine management

Co-Sponsored by ICES

Co-Convenors: Jonathan Hare (U.S.A.), Vyacheslav B. Lobanov (Russia), David L. Mackas (Canada), Phillip R. Mundy (U.S.A.), Young-Jae Ro (Korea) and Hiroya Sugisaki (Japan)

The session will advance the objectives of the PICES Technical Committee on Monitoring, the PICES FUTURE program (Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems) and the ICES-GOOS Steering Group. These groups have terms of reference related to the coordination of Global Ocean Observing Systems, the development and evaluation of forecasting systems, and their application to ocean management. The session will focus on examples where ocean observations and forecasts have been used in PICES and ICES products.

Methodological advances and issues will also be presented to promote the development of observing and forecasting capabilities. Finally, this session will serve as a forum to bring the ocean observing, ecological forecasting and resource management communities together to better link observing and forecasting efforts with the need to provide scientific advice for marine and coastal resource management.

Thursday, October 28 (9:00-18:00)

9:00 *Introduction by Convenors*

9:05 **Glenn Nolan, Eugene Colbourne and Hedinn Valdimarsson (Invited)**
The ICES Working Group on Oceanic Hydrography (WGOH): Building on over 100 years of North Atlantic observations (S15-6485)

9:30 **Molly McCammon, Carl Schoch and Darcy Dugan**
Alaska Ocean Observing System: Lessons learned in developing an end-to-end observing system (S15-6811)

9:50 **Vyacheslav B. Lobanov**
North-East Asian Regional Global Ocean Observing System: The story of success and current requirements for coastal and marine management (S15-6828)

10:10 **Kwang-Soon Park, Dong-Young Lee, Ki-Cheon Jun, Sang-Ik Kim, Jae-Il Kwon and Jung-Woon Choi**
Introduction of Korea operational oceanographic system (KOOS) (S15-6520)

10:30 *Coffee/Tea Break*

10:50 **Toshio Suga (Invited)**
Profiling floats as tools for biogeochemical and biological monitoring (S15-6696)

11:15 **Gillian B. Lichota and John A. Calder (*presented by Sue Moore*)**
Monitoring Pacific Arctic ecosystem change through development of a Distributed Biological Observatory (DBO) (S15-6776)

11:35 **Yoichi Ishikawa, Toshiyuki Awaji1, Teiji In and Sei-Ichi Saitoh**
Development of coastal data assimilation system for environmental monitoring/forecasting (S15-6535)

11:55 **Jerome Fiechter, Gregoire Broquet, Andrew M. Moore and Hernan G. Arango**
A data assimilative, coupled physical-biological model for the Coastal Gulf of Alaska (S15-6460)

12:15 **Yasumasa Miyazawa, Toru Miyama, Sergey M. Varlamov, Xinyu Guo and Takuji Waseda**
Application of the Ensemble Kalman Filter to the Kuroshio variations around the Kii Peninsula (S15-6750)

12:35 ***Lunch***

14:00 **Sonia Batten (Invited)**
The Continuous Plankton Recorder - A lengthy history and a global future (S15-6638)

14:25 **William Peterson, Edmundo Casillas, Jay Peterson, Cheryl A. Morgan and Jennifer Fisher**
Forecasting returns of coho and Chinook salmon in the northern California Current: A role for long term observations (S15-6834)

14:45 **David G. Foley**
Identification and monitoring of Chinook salmon habitat along the California coast (S15-6823)

15:05 **Réka Domokos**
Acoustic investigation of bigeye tuna at Cross Seamount (S15-6542)

15:25 ***Coffee/Tea Break***

15:45 **Jonathan A. Hare, Jack A. Jossi and Joseph M. Kane**
Fifty years of ship-of-opportunity observations on the northeast U.S. continental shelf: Results and management applications (S15-6586)

16:10 **Carrie A. Holt, Ashleen Benson, Brigitte Dorner, Melissa A. Haltuch, Megan O'Connor and Mary Thiess**
Forecasting Pacific hake distribution at fine spatial scales using satellite-derived oceanographic data (S15-6596)

16:30 **Dong-Jin Kang, Kyung-Ryul Kim, Kyung-Il Chang and Ki Wan Kim**
E-RAP (EAST-1 Real-time Automatic Profiler): Its development and application (S15-6830)

16:50 **Sei-Ichi Saitoh, Toru Hirawake, I Nyoman Radiarta, Tomonori Isada, Robinson Mugo, Fumihiro Takahashi, Ichiro Imai, Yasuhiro Sakurai, Michio J. Kishi, Masaaki Wada, Toshiyuki Awaji and Yoichi Ishikawa**
New challenge of integrated coastal fisheries information system in southern Hokkaido, Japan (S15-6740)

17:10 **Phillip R. Mundy and Dani F. Evenson**
Use of ocean observations to develop forecasts in support of fishery management operations (S15-6598)

17:30 **David W. Welch**
Applications of coastal ocean acoustic telemetry arrays for marine fisheries: Making research cost-effective and policy relevant (S15-6650)

17:50 ***Discussion and Summary by Convenors***

18:00 ***Session ends***

S15 Posters

S15-6423 **Babagana Abubakar**
The impacts of human activities on the Atlantic and Indian Oceans in Africa

S15-6470 **Mohamed Rawidean Mohd Kassim**
A statistical model approach for fish forecasting system using SST and Chlorophyll Satellite Images

S15-6487 **Chunjiang Guan, Minghui Ma, Feng'ao Lin and Xiutang Yuan**
The application of coastal wetland management techniques to absorb greenhouse gases and reduce of nitrogen and phosphorus

S15-6566 **Megan O'Connor, Melissa A. Haltuch, Carrie A. Holt, Brigitte Dorner, Ashleen Benson and Mary Thiess**
Forecasting the north-south distribution of Pacific hake using coastal upwelling indices and oceanographic model outputs

S15-6577 **Zhaohui Zhang, Tao Xia and Pixi Sun**
Risk forecasting of shellfish contamination by ecosystem monitoring in Yellow Sea, PR of China

S15-6616 **Hisashi Yamaguchi, Young Beak Son, Eko Siswanto, Joji Ishizaka, Sinjae Yoo, Yu-Hwan Ahn, Sang-Woo Kim, Junwu Tang, Hiroshi Kawamura and Yoko Kiyomoto**
Variation of satellite chlorophyll *a* in the East China Sea based on local satellite algorithm with reduced influence from suspended sediment

S15-6625 **Tadafumi Ichikawa and Hiroya Sugisaki**
Long term variations of abundance and size composition of copepod communities off southern Japan using bench-top Video Plankton Recorder system (B-VPR)

S15-6675 **Huade Zhao, Xuemei Xu, Minghao Li and Juying Wang**
The partial pressure of carbon dioxide and air-sea fluxes in the northern Yellow Sea of China

S15-6729 **Hiromichi Igarashi, Nozomi Sugiura, Shuhei Masuda, Takahiro Toyoda, Yoshihisa Hiyoshi, Yuji Sasaki, Mitsuo Sakai, Taro Ichii, Takushi Kindaichi, Jun-ya Tanaka, Masaharu Oomizu, Yoichi Ishikawa and Toshiyuki Awaji**
Improved approach for the identification and prediction of neon flying squid abundance and distribution in northwestern North Pacific using an integrated 4D-VAR data assimilation system

S15-6735 **Vadim Burago, Georgiy Moiseenko and Igor Shevchenko**
Modeling spatial distribution of the ocean chlorophyll *a* concentration from remote sensing data

S15-6737 **Xiang Pu, Huiwang Gao, Zhe Liu and Yunjun Yu**
Simulation of non-point source nutrient flux and its impact on water quality of coastal ocean: A case study on Jiaozhou Bay in China

S15-6795 **Howard Freeland**
Argo: A decade of success, what have we learned and what comes next?

S15 Session Oral Presentations

28 October, 9:05 (S15-6485), Invited

The ICES Working Group on Oceanic Hydrography (WGOH): Building on over 100 years of North Atlantic observations

Glenn **Nolan**[1], Eugene Colbourne[2] and Hedinn Valdimarsson[3]

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The Working Group on Oceanic Hydrography (WGOH) is an expert group of the International Council for the Exploration of the Sea (ICES) reporting on matters pertaining to oceanic hydrography, data management and the effects of ocean climate variability on ecosystems and marine resources. The group provides support and advice to other scientific groups within and outside of ICES, industry stakeholders, the general public and other clients. A principal mandate of the group is to review the latest data from over 30 repeat hydrographic sections and stations sampled by ICES member countries throughout the North Atlantic and to summarize the annual state of the North Atlantic Ocean. The work is published annually in the "ICES Report on Ocean Climate (IROC)". The report is a subset of the information collected and presented in the ICES national oceanographic reports from more than a dozen participating countries on ocean hydrography. It focuses on describing the annual and long-term temperature and salinity variability in the ICES area. In this presentation, we focus on the most recent results from the IROC, how the information is communicated to user groups and current and future challenges faced by the group. In particular, we present observed ocean temperature and salinity trends and variability from regional to ocean basin scale as well as meteorological variability and provide examples of oceanographic data products developed by the group and member countries. Finally, we present examples of how this information is related to trends in fish stocks and in marine resource assessments.

28 October, 9:30 (S15-6811)

Alaska Ocean Observing System: Lessons learned in developing an end-to-end observing system

Molly **McCammon**, Carl Schoch and Darcy Dugan

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Encompassing 43,000 miles of coastline, the Alaska Ocean Observing System (AOOS) covers the largest geographic area of the 11 IOOS regions and spans four large marine ecosystems including the Gulf of Alaska, Bering Sea/Aleutian Islands, and Chukchi and Beaufort Seas . AOOS is the designated Alaska regional observing system for the national Integrated Ocean Observing System tasked with integrating and enhancing coastal and ocean observations and data from multiple sources to meet stakeholder needs. AOOS uses a single data portal to provide access to historical and real-time weather and ocean observations as well as model-generated forecasts as they develop and mature. The data system is testing new data access and visualization tools. In 2009, AOOS conducted a field experiment in Prince William Sound (PWS) to test the accuracy of model forecasts and to demonstrate the utility of an ocean observing system for oil spill response, search and rescue, and fishery management. During the experiment, the fixed array of AOOS instruments was supplemented with surface current radar mappers, vessel mounted instruments for measuring temperature and salinity, underwater drones to profile the water column, and drifting buoys to measure current direction and velocity. This real-time data was fed directly to modelers to help refine and calibrate oceanic and atmospheric forecasts. As a stakeholder-driven organization, AOOS strives to produce user-friendly information products for marine operations, boating safety, scientific research, development, fisheries management, and conservation. This presentation will describe the lessons learned in developing the overall AOOS program, conducting the PWS project and field experiment and providing web-based data and information products for Alaska resource managers and stakeholders.

28 October, 9:50 (S15-6828)

North-East Asian Regional Global Ocean Observing System: The story of success and current requirements for coastal and marine management

Vyacheslav B. **Lobanov**

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North-East Asian Regional Global Ocean Observing System (NEAR-GOOS) is one of the oldest global GOOS regional alliances. The project started in 1996 with a focus on marginal seas surrounded by China, Japan, Korea and Russia under the Office for Western Pacific of the Intergovernmental Oceanographic Commission (IOC/WESTPAC). The major achievement of NEAR-GOOS is a network of real-time and delayed mode data bases accessible through the internet free of charge. In spite of some restrictions on oceanographic data exchange in some member states, NEAR-GOOS archives now contain more than 40 different types of data files with total volume of more than 62 GB. The next phase of project development will make a shift from data management toward building a sustained regional integrated ocean observing and operational forecasting system. This requires not only an improvement of the existing data exchange mechanisms through the inclusion of additional parameters, increased coverage in space and time, and generation of data products., but also enhancing its observing capacity by increasing the number of available observing platforms in the region. This, in turn, depends on the effectiveness and usefulness of NEAR-GOOS products and services. Most of the users of oceanographic information now are related to coastal areas which are monitored by national observing systems. One of the challenges for NEAR-GOOS remains to prove its usefulness as an international project.

28 October, 10:10 (S15-6520)

Introduction of Korea operational oceanographic system (KOOS)

Kwang-Soon **Park**[1,2], Dong-Young Lee[1], Ki-Cheon Jun[1], Sang-Ik Kim[1], Jae-Il Kwon[1] and Jung-Woon Choi[1]

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The program for development of Korea Operational Oceanographic System (KOOS) was launched in 2009 and it is expected to finish its first stage in the next four years. The objective of KOOS is to provide the nowcast and forecast information needed to support ocean activities and to inform responders to various coastal disasters such as storm surge, oil spills and search and rescue around the Korean peninsula. During the first year of this program five capabilities were established: 1) numerical weather forecasting system, WRF; 2) operational storm surge prediction system; 3) high-resolution coastal circulation models; 4) wave models, and 5) 3D regional ocean circulation models. The predicted variables are sea level, tides, wind-driven currents, wave properties, temperature, salinity, currents, among others. Model applications for areas around the Korean peninsula based on the observing system include storm surge height at location, oil-spill trajectories, and projected localities through time for search and rescue (SAR). Positive results to date notwithstanding all the model applications need further development before their use in full operational mode. The observations of KOOS are expected to contribute to overall observational network of NEAR-GOOS.

28 October, 10:50 (S15-6696), Invited

Profiling floats as tools for biogeochemical and biological monitoring

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This talk will give a few examples of physical-biological-biogeochemical processes captured by profiling floats equipped with oxygen and fluorescence sensors along with CTD sensors, followed by brief remarks on a way to utilize the floats for biogeochemical/biological monitoring. Tohoku University and JAMSTEC have deployed 20 profiling floats with oxygen and/or fluorescence sensors in the mid-latitude North Pacific since 2005. Three of

them deployed in the northwestern subtropical gyre revealed sustained and sizable subsurface (50-100m) primary production during summer. It is suggested that the primary production was maintained by nutrient supply from the Subtropical Mode Water (STMW) layer immediately below due to enhanced diapycnal diffusivity near the top of the STMW layer. Since subsurface production cannot be monitored by satellite observations, it is likely to be overlooked as a significant biogeochemical/biological process. Another group of floats deployed in the Kuroshio-Oyashio mixed water region frequently captured subsurface (100-300m) layers with high oxygen and chlorophyll concentrations near density fronts. These features along with ship-board observations across one of the density fronts in this region suggested that rapid and intense submesoscale downwelling/upwelling frequently occurs associated with baroclinic instability at the density fronts, which may play a significant role in vertical transport of physical and biogeochemical properties. These examples suggest that profiling floats would play essential roles in global and/or regional monitoring of biogeochemical/biological properties. If a monitoring system using profiling floats is desired, then a systematic feasibility study for designing it is needed.

28 October, 11:15 (S15-6776)

Monitoring Pacific Arctic ecosystem change through development of a Distributed Biological Observatory (DBO)

Gillian B. Lichota and John A. Calder (***presented by Sue Moore***)

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An initiative underway within Pacific Arctic Group (PAG) is to establish a Distributed Biological Observatory (DBO) in the Pacific Arctic sector. Although recent major changes in the physical domain of the Arctic are well documented, such as extreme retreats of summer sea ice since 2007, large uncertainties remain regarding potential responses in the biological domain. Changes have occurred at both lower (prey) and higher (predator) trophic levels, and include shifts in species ranges for zooplankton, benthos, and fish, and loss of sea ice as habitat and platform for marine mammal species. DBO aims to increase our understanding of potential ecosystem changes under further loss of sea ice. The DBO will be focused on known regional "hotspot" locations along a latitudinal gradient from the northern Bering to the western Beaufort Seas. It is envisioned as a change detection array for the identification and consistent monitoring of biophysical responses in pivotal geographic areas that exhibit high productivity, biodiversity and rates of change. Proposed regions are the northern Bering Sea, Bering Strait/ SE Chukchi Sea, Central Chukchi Sea, and Barrow Arc. The DBO depends on international cooperation to sample the DBO sites and conduct joint analysis of shared of data. DBO data will be made available through for the Sustaining Arctic Observing Network (SAON), a process to support and strengthen the development of multinational engagement for sustained and coordinated pan-Arctic observing and data sharing systems that serve societal needs, particularly related to environmental, social, economic and cultural issues. SAON is planned to transition to an operational phase in 2011, and the DBO could become a showcase for SAON.

28 October, 11:35 (S15-6535)

Development of coastal data assimilation system for environmental monitoring/forecasting

Yoichi **Ishikawa**[1], Toshiyuki Awaji[1], Teiji In[2] and Sei-Ichi Saitoh[3]

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For monitoring/forecasting a costal ocean environment, transport processes of nutrients, plankton and other materials are critical issues and realistic current fields are required for good estimation of the transports. Toward this goal, a data assimilation system can provide realistic circulation fields through the optimal synthesis of numerical models and observational data. A data assimilation system using the variational adjoint method (4D-VAR) is particularly well suited for reproducing transport fields since the analysis field obtained using the 4D-VAR is physically consistent. In this study, the 4D-VAR data assimilation system is adapted for optimal use in a physically complicated coastal region south of Hokkaido Island. The original system was designed for data assimilation covering the entire North Pacific (Ishikawa et al., 2009). Subsequent improvements in numerical

modeling and observational data are made in application to the target area. Improvements include embedding the tidal model and utilizing the surface current observation derived from HF radar. Before using our assimilation system for operational forecasting, the observation system simulation experiment (OSSE) was conducted to examine the impact of various observational data in the state estimation of a coastal ocean environment. As a result, the impact region and variables are quite different associated with the variation of the circulation field, and effectiveness of adaptive observations is suggested. The data assimilation system will be coupled with a marine ecosystem model to forecast the bio-geochemical field as well as the physical circulation field.

28 October, 11:55 (S15-6460)

A data assimilative, coupled physical-biological model for the Coastal Gulf of Alaska

Jerome **Fiechter**[1], Gregoire Broquet[2], Andrew M. Moore[1] and Hernan G. Arango[3]

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A data assimilative, coupled physical-biological model for the Coastal Gulf of Alaska (CGOA) is used to investigate how improvements to oceanic circulation yield improvements to ecosystem predictions in relation to mesoscale variability at the shelfbreak on seasonal and interannual timescales. The ocean circulation component is the Regional Oceanic Modeling System (ROMS), the lower trophic level ecosystem component is a Nutrient-Phytoplankton-Zooplankton-Detritus (NPZD) model with iron limitation, and the data assimilation component is the adjoint-based, four-dimensional variational (4DVAR) system available in ROMS. Assimilated observations consist of satellite sea surface height and temperature, and in situ temperature and salinity. Simulation results for 1998 to 2002 indicate that assimilation of physical observations significantly improves the accuracy with which the model reproduces the frequency, duration, and intensity of eddy events along the CGOA shelfbreak. Successful corrections to oceanic mesoscale processes lead to substantial improvements to the biological response predicted by the NPZD model. Ecosystem dynamics at the shelfbreak is tied to eddy activity in the northwestern CGOA, but mesoscale processes and ecosystem response are uncorrelated in the southwestern CGOA, as eddies tend to occur during winter when phytoplankton growth is severely light-limited. Sensitivity calculations suggest that corrections to ocean circulation and ecosystem dynamics are primarily associated with the assimilation of sea surface height, and occur mainly through adjustments to the model initial conditions. The data assimilative, coupled physical-biological model also exhibits skill for forecasting eddy events and their ecosystem response on weekly timescales.

28 October, 12:15 (S15-6750)

Application of the Ensemble Kalman Filter to the Kuroshio variations around the Kii Peninsula

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Combined use of ocean model and observational data is quite useful to predict the oceanic conditions which provide basic information for the coastal fishery management. To provide detailed information of the oceanic conditions for promoting the fishery activities around the Kii Peninsula, we have developed a downscaled ocean forecast system based on three-dimensional variational data assimilation into the ocean general circulation models (OGCMs). Present formulation of the data assimilation scheme implicitly assumes quasi-geostrophic dynamics with typical mesoscale: O (100km) and O (10days), and allows the assimilation of only temperature, salinity, and sea surface height data. Since downscaling of the ocean model enables resolution of smaller scale phenomena including ageostrophic currents, it is effective for the downscaled models to directly assimilate the observed ocean currents obtained from ADCPs and/or HF radars. To do this, we are developing the Ensemble Kalman Filter (EnKF), which allows direct assimilation of the ocean current observations. EnKF is useful for the downscaled models because it represents the flow-dependent dynamic correlations between the model variables, and is therefore able to assimilate highly variable phenomena with smaller spatial and temporal scales than mesoscale.

Focusing on the Kuroshio variations around the Kii Peninsula, we have developed an ocean model with horizontal resolution of 1/36 degree (3km) nested in the Northwestern Pacific OGCM with a coarser horizontal resolution of 1/12 degree. Based on 20 ensemble member models running on the parallel computers, we implemented the Local Ensemble Transformation Kalman Filter (LETKF) algorithm. Identical twin experiments using LETKF demonstrated good representation of the flow dependent correlations and effective assimilation of the ocean current observations. We further discuss results of parameters sensitivity experiments to investigate the potential of LETKF for assimilating various types of observation data.

28 October, 14:00 (S15-6638), Invited

The Continuous Plankton Recorder - A lengthy history and a global future

Sonia **Batten**

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The Continuous Plankton Recorder is a robust mechanical plankton sampler that takes advantage of commercial shipping operations to economically collect samples over large spatial scales. The CPR has been deployed in the ICES areas of the North Atlantic for over 70 years. On the strength of the scientific accomplishments in the Atlantic, CPR became a PICES project with deployments beginning in the North Pacific a decade ago. The Atlantic CPR program formed part of the GOOS Initial Observing System and the Pacific CPR program was endorsed by the Living Marine Resources Panel of GOOS as a pilot project. This presentation will give examples of observations of zooplankton dynamics from CPR data in both regions that underpin the forecasting of ecosystem trends and responses. These include distributional changes and phenological shifts. There are additional CPR surveys in the western North Atlantic, the Southern Ocean and around Australia, with other activities planned. The CPR community is working towards a global survey and enhanced interaction to address the global issues facing marine ecosystems.

28 October, 14:25 (S15-6834)

Forecasting returns of coho and Chinook salmon in the northern California Current: A role for long term observations

William T. **Peterson**[1], Edmundo Casillas[1], Jay Peterson[2], Cheryl A. Morgan[2] and Jennifer Fisher[2]

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Forecasting ecological phenomena requires a basic understanding of the physical and ecological mechanisms that determine the outcomes which one hopes to predict. Successful prediction of fisheries for example will require at least a modicum of knowledge of where in the ocean the given species lives during all parts of its life cycle, and of processes that determine the recruitment bottlenecks. We now provide predictions of salmon returns based on long-term monitoring of hydrography, plankton and juvenile salmonid abundance along 8 transects in coastal waters off Washington and Oregon, in June and September, for the past 13 years, and hydrography, zooplankton and krill along a transect off Newport for 15 years. Forecasts of returns of coho and Chinook salmon to the rivers of the Pacific Northwest are based on the “stoplight” approach; returns are best predicted by biological oceanographic conditions measured during our monitoring programs: date of biological spring transition, biomass anomalies of northern lipid-rich copepods, copepod species richness and community structure, catches of juvenile Chinook during June and catches of juvenile coho in September. Widely used physical indicators such as the PDO, MEI and the Coastal Upwelling Index perform less well as indicators of salmon returns. Our ability to forecast salmon in the future will depend in part on our ability to forecast the impact of global climate change on biological oceanographic conditions in coastal waters. Models along with ecosystem observations may become a requirement to understand how variations in physical climate forcing will affect fisheries and marine ecosystem productivity.

28 October, 14:45 (S15-6823)

Identification and monitoring of Chinook salmon habitat along the California coast

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The stocks of Central California Chinook salmon (*Oncorhynchus tshawytscha*) suffered catastrophic collapses in 2008 and 2009. As a result, both the recreational and commercial fisheries were closed for both of those years. The salmon fishery of the central California coast represents a revenue of about US $70 M per anum, and is also an iconic part of life for the citizens, including the Native American tribes who have fishing rights by treaty. Chinook are anadromous fish, spending the early part of their life in rivers, migrating into the ocean for 2-4 years, then returning to their natal river to spawn. In an effort to understand the conditions experienced during their oceanic phase, over 400 electronic tags recording temperature and depth every minute were deployed on Chinook caught during the fishing season, either by commercial fishers or chartered sport fishers. The 80 tags returned provide a wealth of information regarding dive behavior as well as their temperature preference. By integrating the data from electronic tags with a similar environmental product, either remotely sensed from satellite, or generated with an oceanic model (*e.g.*, ROMS), their oceanic habitat may be monitored, providing a tool that may used towards the responsible and sustainable management of the fishery. The ROMS output from the Jet Propulsion Laboratory has been chosen for the medium-term (strategic) habitat forecast (6-9 months). These monthly mean forecasts are generated out to 9 months every two weeks. The blended microwave/infrared sea surface temperature (SST) product made by Remote Sensing Systems Inc. (Santa Rosa, CA,USA), has been chosen for the near real time (tactical) predictions. These daily, 9km, global products allow the resolution of the meso-scale features and upwelling shadows along the coastline. The recreational and commercial fisheries are highly regulated, with frequent closures in management regions divided into discrete meridional bands. It is anticipated that a combination of these medium-term and short-term predictions will provide a meaningful tool for the management of the fishery.

28 October, 15:05 (S15-6542)

Acoustic investigation of bigeye tuna at Cross Seamount

Réka **Domokos**

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Cross Seamount is an important topographic feature in the Hawaiian archipelago that is known to aggregate juvenile and subadult bigeye tuna, a population heavily targeted by the local fishery. In this study, acoustic descriptors such as aggregation shape, depth, density, and target strength were identified that are consistent with those of bigeye of the expected size range but different from those of other fish found at Cross Seamount. Shipboard acoustic surveys identified fish tracks that are most likely bigeye tuna actively foraging on concentrations of micronekton at the seamount. Bigeye tuna are tightly associated with the 400 m deep plateau or slopes that are not deeper than about 500 m. Acoustic data indicate that bigeye tuna exhibit aggregated deep diving behavior over the plateau. Bigeye tuna appear at dawn at the upcurrent edge of the plateau to feed on specific micronekton layers that are migrating downward from the shallow scattering layer. At this time of day bigeye tuna occupy a very small area of the plateau, are highly mobile, and form very loose aggregations. Later during the morning hours feeding bigeye tuna spread over a larger area of the plateau. Aggregations at this time frequently span the entire depth range of the plateau (~20-400 m). During the afternoon and early evening, bigeye tuna occupy the entire area of the plateau and tend to form thicker aggregations. At around sunset, aggregations of bigeye tuna start dispersing with their acoustic detection being minimal during the night.

28 October, 15:45 (S15-6586)

Fifty years of ship-of-opportunity observations on the northeast U.S. continental shelf: Results and management applications

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Along the northeast United States continental shelf, ships-of-opportunity have been used as platforms for ocean observations since the early 1960's. Primary operations consist of continuous plankton recorder (CPR) tows and expendable bathythermograph (XBT) measurements. The plankton data have been used to document ecosystem changes in zooplankton and phytoplankton abundance, community structure and phenology. Temperature measurements have shown changes in response to natural climate variability and potentially to climate change. Over the past thirty years, other sampling equipment has been incorporated into ship-of-opportunity operations including thermosalinographs, $p\mathrm{CO}_2$ sensors and acoustic current Doppler profilers (ADCP), increasing the value of ship-of-opportunity platforms for ocean observations. The main management contribution of the data is a general increase in the understanding of the northeast U.S. continental shelf ecosystem and the larger Northwest Atlantic Ocean. However, only one specific application has been developed to date – a right whale calving forecast model. Clearly more effort is needed to translate data and information into management tools and several applications are under development. In total, ships-of-opportunity provide a consistent and widely deployed platform for ocean observations, which the ocean science and management communities could use to a much greater extent.

28 October, 16:10 (S15-6596)

Forecasting Pacific hake distribution at fine spatial scales using satellite-derived oceanographic data

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The spatio-temporal distribution of Pacific hake (*Merluccius productus*) is of significant interest when planning surveys of abundance because of the large interannual variability in distribution. The hypothesis that the distribution of Pacific hake off of Washington and Oregon is related to ocean fronts where prey tend to concentrate is tested by fitting a generalized linear model (GLM) and a mixed-effects version of the GLM that accounted unexplained year-to-year variability and spatial autocorrelation, to hake presence/absence and abundance data. Unlike prior work using large-scale oceanographic variables (*e.g.*, ENSO indices) to predict north-south distribution, this study uses satellite-derived at finer spatial scales (5-25 km) and monthly temporal scales in a portion of the summer adult range. The variables included are frontal activity, water depth, and an index of age. Frontal activity is estimated from gradients in sea-surface temperatures derived from historical Advanced Very High Resolution Radiometer imager data. Although depth and age were found to be more important, models that also included SST gradients tended to have lower AIC values and lower prediction errors than those that did not, irrespective of the presence of spatial autocorrelation. Our models were developed using historical data, but could be used to forecast distribution and project impacts of climate change when combined with forecasts of frontal activity from oceanographic models.

28 October, 16:30 (S15-6830)

E-RAP (EAST-1 Real-time Automatic Profiler): Its development and application

Dong-Jin **Kang**[1], Kyung-Ryul Kim[2], Kyung-Il Chang[2] and Ki Wan Kim[3]

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The CREAMS/PICES EAST-1(East Asian Seas Time-series I) program has recently developed E-RAP (EAST-1 Real-time Automatic Profiler). This is a new instrument for observing continuous vertical profiles of hydrographic, chemical, and ecological parameters at a fixed station. Depth is controlled by a modified APEX(Autonomous Profiling Explorer) engine, similar to what is used in Argo satellite drifters. When the buoyancy of E-RAP is adjusted to neutral by buoy blocks, it moves up and down by ballasting and de-ballasting. Its mean vertical speed is about 4 m min^{-1} when the sea condition is not bad. Real-time data are sent to the surface buoy by inductive modem through the deployment wire. The buoy then sends the data to the main shore workstation by wireless telecommunication system (CDMA, Orbcomm Satellite). E-RAP has been deployed at the Super-Station of EAST-1 (37°00'N, 131°00'E) since May, 2010. At present, E-RAP carries temperature, conductivity, dissolved oxygen, and fluorescence sensors. Examples of the data obtained by this system will be shown.

28 October, 16:50 (S15-6740)

New challenge of integrated coastal fisheries information system in southern Hokkaido, Japan

Sei-Ichi **Saitoh**[1,2], Toru Hirawake[1], I Nyoman Radiarta[1,3], Tomonori Isada[1], Robinson Mugo[1,4], Fumihiro Takahashi[2], Ichiro Imai[1], Yasuhiro Sakurai[1], Michio J. Kishi[1], Masaaki Wada[5], Toshiyuki Awaji[6,7] and Yoichi Ishikawa[7]

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Oceanography is moving toward the construction of operational observing systems in coastal regions. This issue is of global interest for sustainable use of fisheries and aquaculture resources. In particular, satellite remote sensing and marine-GIS for fisheries and aquaculture has been developing rapidly, and an operational use is required for sustainable development and management. We started "Hakodate Marine Bio Industrial-Cluster Project" in the Regional Innovation Cluster Program (Global Type) from 2009 supported by the Grant-in-Aid for University and Society Collaboration from the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan. Through this project, we develop an integrated coastal fisheries information system that combines satellite remote sensing, observations from a buoy network, 4-D VAR data assimilation system, ecosystem modeling, and marine-GIS spatial modeling to delineate the potential fishing zone for coastal squid fisheries, and to predict suitable sites for scallop and kelp aquaculture in southern Hokkaido coastal region, Japan. New challenges in the field of fisheries information systems now include developing systems capable of analyzing the marine environment in 3D, prediction and validation of oceanographic parameters, and dissemination of new information products to the user community in real or near-real time. We will present the overview of this on-going project.

28 October, 17:10 (S15-6598)

Use of ocean observations to develop forecasts in support of fishery management operations

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Retrospective analyses of ice cover and sea surface temperature in combination with air temperatures were used to develop forecast models of the time of arrival of salmon in harvest areas near the coast of Alaska in the northern Bering Sea. The models were applied in May of 2010 to successfully forecast the time of arrival of salmon in the harvest areas in June and July for a Chinook salmon fishery near the mouth of the Yukon River. The 2010 forecast and the retrospective analysis are promising steps in establishing the principle that weather and short-term oceanographic conditions at one point in an annual salmon migration can be used to forecast the timing of the salmon migration at a subsequent time and location in the migration. When supported by appropriate ocean observations salmon fishery managers need not rely solely on historical average timing of catches in the design of fishing regulations. Harvest strategies and regulations can be based on forecasts of timing of salmon in the harvest areas from the functional relationships. Examples from salmon fisheries show that development of products from coastal ocean observing systems to serve the needs of fishery management operations is a very promising area of research.

28 October, 17:30 (S15-6650)

Applications of coastal ocean acoustic telemetry arrays for marine fisheries: Making research cost-effective and policy relevant

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In 2009, returns of adult sockeye salmon to Canada's Fraser River collapsed as a result of unprecedented poor marine survival. Data from the POST acoustic telemetry array demonstrated that survival of out-migrating juvenile Fraser sockeye in 2007 (which formed the failed adult return) was as high or higher than in three prior years of study, establishing that the run failure likely did not occur within the first month of life at sea, when the smolts were migrating through the Strait of Georgia. Outmigrating smolts implanted with special acoustic tags in 2007 were also used to measure survival to adult return, with two tagged smolts returning as adults in 2009. The 1% survival rate (2/200) closely matched that of the untagged wild fish, demonstrating that mortality after the first month at sea was 7X greater than during the first month of ocean life. A 2007 DFO salmon survey demonstrated that most juvenile Fraser sockeye failed to reach Hecate Strait, 300 km north of Vancouver Island, so the period of high mortality likely occurred within 3 weeks after smolt migration past Discovery Passage, a region with extensive salmon farms. Our result does not demonstrate causality between aquaculture and wild salmon collapses, but is consistent; the next logical step will be to conduct formal experimental tests using the array to measure the effect of fish farm exposure on wild salmon survival. Our study demonstrates the success of the prototype array as a successful ocean monitoring system and the utility of the data for answering complex policy questions.

S15 Session Posters

S15-6423

The impacts of human activities on the Atlantic and Indian Oceans in Africa

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Africa is the second largest and the most populated continent after Asia. Geographically it is located between the Atlantic and Indian Oceans. Most of the Africa's most populated and industrialized cities are located along the coast of the continent facing the Atlantic and Indian Oceans. Examples of cities facing the Atlantic Ocean include Casablanca, Dakar, Accra, Lagos, Luanda and Cape Town, and cities facing the Indian Ocean include East London, Durban, Maputo, Dar-es-salaam and Mogadishu. As a result of the geographical location of African coastal cities the two oceans are now facing severe and so far inexorable increases in pollution. The primary factors that drive the increased pollution are large increases in human populations, industries, sea port operations, petroleum exploration activities, trafficking of toxic wastes and improper waste management culture. Impacts on the Atlantic Ocean are due to petroleum exploration activities, degreasing activities in ports along quay aprons (i.e. Port Elizabeth, Maputo, Dar-es-Salaam), and sewage wastes primarily from domestic sources. Impacts on the Indian Ocean are different from those on the Atlantic. The Indian Ocean is polluted by toxic and radioactive waste sequestered in shallow sediments that are suspected to have been deposited over long periods of time by activities of the developed nations. The problem of sequestered toxic wastes became apparent on African beaches of the Indian Ocean when the 2004 Tsunami uncovered hazardous waste deposits (*i.e.* North Hobyo in South Mudug and Warsheik, north of Benadir).

S15-6470

A statistical model approach for fish forecasting system using SST and Chlorophyll Satellite Images

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In this paper we propose a new statistical modeling approach to develop a Fish Forecasting System (FFS) using Sea Surface Temperature (SST) and Chlorophyll satellite images. The FFS model uses SST, Chlorophyll and fish catch data to forecast location of pelagic fishes in the South China Sea. The system also incorporates an Intelligent Feedback System (IFS) to improve the model over time. The input for IFS comes from fishermen as a feedback data. The approach is could be adapted for use with other remote sensing data sets or data assimilation products.

S15-6487

The application of coastal wetland management techniques to absorb greenhouse gases and reduce of nitrogen and phosphorus

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Through photosynthesis and biogenic processes wetland plants absorb and fix in their biomass large amounts of carbon (C) and other elements such as nitrogen (N), phosphorus (P). As a consequence wetland plants play important roles in absorbing greenhouse gases and in reducing the rates of eutrophication of ambient waters. Wetlands on the margin of the sea are particularly important ecological functional units for dealing with effects of climate change and for purifying water environment in coastal area. *Phragmites cimmunis* and *Suaeda salsa* in the delta of Bohai Sea are the most representative wetland vegetation types and they are widespread in China. Presently the total area of *Phragmites cimmunis* in the Bohai Sea coastal wetland is 200,800 hectares and that of

Suaeda salsa is 7397 hectares. The amounts removed of carbon, nitrogen and phosphorus were 363,000 t, 4654 t and 174 t, respectively by harvesting *Phragmites cimmunis* from the wetlands around Bohai Sea. Although the wetland area of Shuangtaizi River Estuary in the Bohai Sea reduced by was reduced by 20% from 1953 to 2009, the total harvest of *Phragmites cimmunis* increased from 110000 t to 500000 t through improved wetland management techniques. The amounts removed of carbon, nitrogen, phosphorus increased 3.55 times. The amounts removed of carbon, nitrogen and phosphorus were respectively 231,000 t, 2555 t, and 85 t in 2009. The wetland management technique included irrigating waste water, increasing the amount of water stored in the wetland.

S15-6566

Forecasting the north-south distribution of Pacific hake using coastal upwelling indices and oceanographic model outputs

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Annual variation in the spatial extent of Pacific hake (*Merluccius productus*) migrations between US and Canadian waters has consequences for monitoring, assessment, management and commercial harvest. An acoustics survey (1992-2007) assesses the summertime north-south distribution of hake at fine spatial scales (10-25 km). Weekly hake distribution as a function of bathymetry, population age-structure, and outputs from ocean models were examined in geostatistical and delta generalized linear modeling frameworks. Model variables include coastal upwelling indices, vertical velocity at the coast, temperature at depth, and strength of the pole-ward flow. Disparate spatial scales between hake survey data and covariates are managed by applying universal krieging and re-sampling at contrasting fine (10 km) and coarse scales (≥25 km). Both the population age structure and the coastal upwelling index are related to hake distribution. Spatial indicators of mean spatial location of the hake population characterize the age-structured spatial behavior during the survey. Older aged fish are distributed farther north than younger ages with the northward distribution being amplified during relatively warm years (*e.g.* 1998 and 2005) A short-term weekly forecast of hake distribution could aid survey planning and improve the index of abundance for stock assessment.

S15-6577

Risk forecasting of shellfish contamination by ecosystem monitoring in Yellow Sea, PR of China

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Shellfish aquaculture plays an important role in the seafood production in Yellow Sea areas, so quality control during the farming period provides an essential step in protecting human health. Shellfish accumulate heavy metals that can be transferred to humans via the by food supply, so it is import to monitor and forecast the level of heavy metal accumulation in shellfish. A basic forecast model describes the relationship between environmental factors and levels of heavy metals in shellfish. Data are supplied to the model by a continuous environmental survey and monitoring of levels of heavy metal accumulation level in shellfish (sea-ear, oyster, scallop, mussel and clam) in the mariculture areas. A "shellfish heavy metals forecasting system" incorporates the basic forecast model into ArcGis® Engine 9.2, which is designed to predict accumulation of heavy metals as functions of environmental parameters. The system is used to forecast levels of heavy metals accumulation by locality and to assess ecosystem risk. It not only calculates a point estimate, but it can also provide a spatial distribution image to visualize localities of high concentrations of heavy metals. The study and the GIS-based forecasting system are expected to provide important information for shellfish quality control that is essential to shellfish aquaculture management.

S15-6616

Variation of satellite chlorophyll *a* in the East China Sea based on local satellite algorithm with reduced influence from suspended sediment

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Accuracy of standard ocean color (SeaWiFS) chlorophyll *a* (Chl-*a*) algotithm (OC) is expected to be low in the East China Sea, especially at high suspended sediment areas. Recently, researchers from Japan, China and Korea shared the sea surface in-situ Chl-*a*, and bio-optical data of the East China Sea, supporting development of a local satellite algorithm for Chl-*a*. In this study we combined OC and a new empirical algorithm to minimize the influence of suspended sediment and examine the seasonal and interannual variation of Chl-*a* in the East China Sea. High suspended sediment areas were defined by high normalized water-leaving radiance of 555 nm (nLw555) greater than 2 (mW cm^{-2} um^{-1} sr^{-1}). Empirical local Chl-*a* algorithm based on Tassan's model was derived for high suspended sediment region with SeaWiFS remote sensing reflectance (TS2). Combination of OC and TS2 (OC+TS2) Chl-*a* were lower than OC Chl-*a* from coastal areas to continental shelf with about 50 m isobath in winter, and near coastal areas with about 10 m isobath in summer. This result indicated that OC+TS2 reduced influence of resuspension of sediment typical of coastal areas. It is possible to analyze the seasonal and interannual variation of Chl-*a* more quantitatively by using OC+TS2 Chl-*a*.

S15-6625

Long term variations of abundance and size composition of copepod communities off southern Japan using bench-top Video Plankton Recorder system (B-VPR)

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The Kuroshio warm current area off southern Japan is known as spawning grounds of species important to fisheries. Large scale, long term variations in stock size of these pelagic fish species are well known, but the mechanisms controlling variation are not yet well understood. "Bottom up control" whereby physical processes impact the food and condition of larval pelagic fish, is thought to be an important cause of the long-term stock size variation in the Kuroshio. Fisheries Research Agency (FRA) of Japan has conducted a spawning survey of pelagic fish in the Kuroshio area since 1947 and many zooplankton samples from an extensive area have been stored. Only the total biomass (wet-weight) of most samples was analyzed, due to limitations of time and other resources. Size composition being very important for the analysis of the quality of food for larval fish, we designed the bench-top Video Plankton Recorder (B-VPR) to analyze abundances and size composition of copepods of formalin preserved samples. Using B-VPR, the sample from an entire tow of a plankton net can be imaged and analyzed within 90min. So far about 1500 samples stored since the 1960's have been analyzed. B-VPR analysis clearly shows the long-term variation in size composition of copepods. For example, during 1970s and early 1980s, high abundances of small size copepods were observed during a period when stock size of Japanese sardine was drastically increased. B-VPR analysis can make it feasible to understand the source of long-term variations of pelagic fish species and their ecosystems.

S15-6675

The partial pressure of carbon dioxide and air-sea fluxes in the northern Yellow Sea of China

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In order to elucidate the seasonal and interannual variations of oceanic CO_2 uptake in the China Sea, State Oceanic Administration People's Republic of China initiated a project in 2009 to survey the partial pressure of CO_2 (pCO_2) in surface water and other hydrodynamic, chemical and biological parameters. National Marine Environmental Monitoring Center of China is responsible for research in the northern Yellow Sea of China (NYSC). The pCO_2 in surface water of NYSC was measured in all seasons in 2009 (in March, May, July and October, respectively). Surface water pCO_2 varied within a range of 261–444 µatm in spring, 330–469 µatm in summer, 305–566 µatm in autumn and 338–534 µatm in winter. The average pCO_2 in surface water was 322 µatm, 392 µatm, 405 µatm and 441 µatm in spring, summer, autumn and winter, respectively. The net air-sea CO_2 flux was estimated using the sea-air pCO_2 difference and the air-sea gas transfer rate that was calculated according to the parameterization of Wanninkhof (1992). The average air-sea CO_2 flux was -7.2±1.2 mmol CO_2 m^{-2} day^{-1} in spring, 0.6±0.6 mmol CO_2 m^{-2} day^{-1} in summer, 1.5±1.4 mmol CO_2 m^{-2} day^{-1} in autumn and 6.3±3.6 mmol CO_2 m^{-2} day^{-1} in winter. On an annual basis, NYSC was found to be neutral, which means it is not a major net sink or source of atmospheric CO_2, and surface water approached equilibrium with atmospheric CO_2. Seasonal variation of pCO_2 in NYSC was controlled by a complex combination of sea surface temperature, biological activities and upwelling.

S15-6729

Improved approach for the identification and prediction of neon flying squid abundance and distribution in northwestern North Pacific using an integrated 4D-VAR data assimilation system

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The neon flying squid (*Ommastrephes bartramii*), is one of the major targets in Japanese squid fisheries, and plays an important role in the pelagic ecosystem in the North Pacific. Field observations revealed that its population change is heavily influenced by ocean physical and biological environments. In order to evaluate the suitable habitat area for the winter-spring cohort east of northern Japan (in detail, offshore of the Sanriku coast in northwestern North Pacific), we have recently been developing a leading-edge downscaling from a global (1*1 degree) model down to a very high (1/16*1/16 degree) resolution regional model using a 4-dimensional variational (4D-VAR) ocean-atmosphere coupled data assimilation system. This approach can provide the best possible time-trajectory fit to the observations and thereby offers a better nowcast and forecast of the dynamical oceanic state than can be derived from either models or data alone (Sugiura *et al.*, 2008). We have applied the very high-resolution output to the identification and characterization of possible habitat suitable areas for the winter-spring cohort of neon flying squid offshore of Sanriku by using an improved habitat suitability index (HSI) model. The result is likely to better describe the statistical relationships between the abundance of neon flying squid and the ocean environmental variables associated with meso-scale eddies. We will present examples of preliminary results beneficial to the stock assessment and sustainable management of neon flying squid.

S15-6735

Modeling spatial distribution of the ocean chlorophyll *a* concentration from remote sensing data

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Satellite observations of ocean color permit estimation of many important parameters that characterize the state of the upper layer of seawater. In particular, the recorded intensity of upwelling radiation, processed by special algorithms (*e.g.*, OC3), gives an estimate of the chlorophyll *a* concentration inside the surface layer at each raster point of the received images. Though this approach is easy to implement, it is *not methodologically flawless* because it does not take into account spatial dependencies present in the processed data. The goal of our study is to build a regression model that enables us

- to represent the distribution of the observed data over the whole area or its subregions in a space effective way;
- to compute smoothed interpolations to fill gaps in the data;
- to reveal anomalous zones and describe the distribution in terms of spatial trends;
- to obtain integral characteristics of the distribution within the specified boundaries.

We use the sum of Gaussian functions (model's components) as a model function. The number of components is unknown *a priori* and should be estimated from available input data. This poly-Gaussian approximation occupies an intermediate position between the methods of parametric and nonparametric statistics. It provides smoothing effects and has some predictive ability. In contrast to the methods of geostatistics, it doesn't assume spatial and temporal homogeneity (or stationarity of the increments of the observed variables). As an example of its use, the method is applied to processing MODIS sensor data of the Sea of Okhotsk.

S15-6737

Simulation of non-point source nutrient flux and its impact on water quality of coastal ocean: A case study on Jiaozhou Bay in China

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Non-Point Source (NPS) pollution has received much attention in recent years because of its growing importance in the contribution of nutrient discharge to coastal water bodies and its impact on coastal ecosystem. Jiaozhou Bay, a typical semi-enclosed bay in China, is greatly influenced by human activities. The increasing development of coastal areas and their adjoining watersheds is the main reason for the deterioration of water quality in this area. Because of the discharge of several large rivers, the mode of nutrient limitation in Jiaozhou Bay has changed from phosphorus to silicon, with serious impacts on the ecosystem. However even though it is a major source of pollutant,, the NPS nutrient input from watersheds has not been studied adequately. The distributed hydrological model, SWAT, was used to simulate and estimate the monthly and annual flux of runoff and NPS nutrient of Dagu River, a major river which flows into Jiaozhou Bay. ArcGIS and Erdas tools were also used to analyze spatial information data including land use maps, soil maps and Digital Elevation Model (DEM). The modeled results are consistent with the observations. Monthly runoff Nash-Suttclife (NS) coefficient reaches 0.86 while those of TN, TP are 0.53 and 0.61, respectively. Calculated by SWAT, the annual nutrient loadings of Dagu river varied from 1117-25349t/yr (TN) and 496-1777t/yr (TP) during 1993~2008, and their averages were 16048t/yr and 938t/yr, respectively. Based on spatial analysis tools, the impact of land use/ land cover change on runoff and nutrient yield was also quantitative evaluated.

S15-6795

Argo: A decade of success, what have we learned and what comes next?

Howard **Freeland**

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Argo is presently tracking more than 3300 floats reporting data every 10 days from every ocean basin. The technical objective was to make data freely available in near real-time describing the climate status of the oceans, globally, 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 acquisition.

This poster will review the experience gained as we built a global ocean climate observatory. Ten years after Argo was launched, we do have the global array in place and use of the array is growing rapidly. A delayed-mode quality control system was promised and is working well, but some challenges remain and these will be described. We promised global access, and while this is available in principle, in practice many scientists in developing nations have weak access to high-speed internet and so find the task of downloading many large files to be an overwhelming challenge.

At the OceanObs'09 meeting there were many proposals to "improve" Argo and some have already been adopted, some make sense and likely will be adopted, and some will not be adopted for reasons technical, financial or political. It is clear that as Argo enters its second decade it will change; this poster will outline our opinion of how Argo is likely to evolve over the next 5 years.

BIO Paper Session

Convenor: Michael J. Dagg (U.S.A.)

This session invites oral and poster presentations on all aspects of Biological Oceanography in the North Pacific and its marginal seas that are not covered in specific BIO Topic Sessions (S2, S3, S4, S6, S8 and S13). Papers on marine birds and mammals are especially encouraged this year.

Thursday, October 28 (9:00-17:30)

9:00 ***Introduction by Convenor***

9:10 **Se-J. Ju, H.S. Kim, W.S. Kim, D.H. Kang and A.R. Ko**
Understanding the role of the Yellow Sea Bottom Cold Water Mass (≤10ºC) on the survival strategy of *Euphausia pacifica* throughout the hot summer in the Yellow Sea (BIO-P-6728)

9:30 **C. Tracy Shaw, Leah R. Feinberg, Hongsheng Bi and William T. Peterson**
Cohort data for the euphausiid *Euphausia pacifica* based on biweekly sampling off Newport, OR, USA (BIO-P-6693)

9:50 **Xiuning Du, William T. Peterson and C. Tracy Shaw**
Feeding rates of adult *Euphausia pacifica* on natural particle assemblages in the coastal upwelling zone off Oregon, USA (BIO-P-6764)

10:10 **Harold P. Batchelder and Brie J. Lindsey**
On adding a stage-structured model of krill to NEMURO (BIO-P-6806)

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

10:50 **Kenji Tsuchiya, Yoshiki Tomoko, Hideo Miyaguchi, Kenichi Mori, Tomohiko Kikuchi and Tatsuki Toda**
Typhoon-driven variations in productivity and species composition of phytoplankton in Sagami Bay, Japan (BIO-P-6730)

11:10 **Evgeniya E. Vekhova, Michael I. Kusaykin and Konstantin V. Kiselev**
The phytoplankton contribution to the diet: A comparison of two mussels (Mollusca: Bivalvia) from different biotopes of the Sea of Japan (BIO-P-6581)

11:30 **Bridget E. Ferriss and Timothy E. Essington**
Regional patterns in mercury concentrations of yellowfin and bigeye tuna in the Pacific Ocean (BIO-P-6803)

11:50 **Anastasia S. Dolganova**
The current condition of *Polychaeta* of the northwestern shelf of Bering Sea (BIO-P-6478)

12:10 **Angelica Peña and Diane Masson**
Modelling plankton dynamics in the Straits of Georgia and Juan de Fuca (BIO-P-6786)

12:30 ***Lunch***

14:10 **Meredith L. Elliott, Jaime Jahncke, Moira Galbraith and David L. Mackas**
Copepod assemblages as indicators of ocean conditions in Central California (BIO-P-6769)

14:30 **Hidefumi Fujioka, Atsushi Tsuda and Ryuji J. Machida**
A molecular method for species identification of early life stages of *Neocalanus plumchrus* and *Neocalanus flemingeri* using Real-Time PCR (BIO-P-6534)

14:50 **Tomoko Yoshiki, Tsuneo Ono, Akio Shimizu and Tatsuki Toda**
Egg development time and hatching success of deep sea spawning calanoid copepods, genus *Neocalanus* (BIO-P-6754)

15:10 **Todd W. Miller, Richard D. Brodeur, Koji Omori, Robert L. Emmett and Hideki Hamaoka**
A stable isotope trophic assessment of upper trophic level nekton in the Northern California Current ecosystem (BIO-P-6876)

15:30 ***Coffee/Tea Break***

15:50 **Chiyuki Sassa and Youichi Tsukamoto**
Interannual comparison of diet of larval jack mackerel *Trachurus japonicus* in the southern East China Sea during 2002-2005 (BIO-P-6498)

16:10 **Ah-Ra Ko, Dae-Yeon Moon, Seok-Gwan Choi, Kyung-Hoon Shin and Se-Jong Ju**
Lipid metabolism of minke whale and pacific white-sided dolphin in Korean waters and implications for feeding ecology (BIO-P-6517)

16:30 **Olga Yu. Tyurneva, Yuri M. Yakovlev, Vladimir V. Vertyankin, Glenn Gailey, Olga Sychenko and Judy E. Muir**
Discovering a new feeding area for calf-cow pairs of Western Gray Whales on the south-east shelf of Kamchatka in 2009 and their utilization of different feeding regions within one season (BIO-P-6858)

16:50 **Hector D. Douglas III, Alan M. Springer, Suzanne Budge and Lacey Aucoin**
Fatty acid and stable isotope analyses reveal consumption patterns of planktivorous auklets and variability in ecosystem productivity (BIO-P-6705)

17:10 **George L. Hunt, Jr., Stephani Zador and James Ianelli**
Declines of northern fur seals at the Pribilof Islands: Forage fish depletion, competition with adult pollock and arrowtooth flounder, or fishing activity? (BIO-P-6591)

17:30 ***Session ends***

BIO Paper Session Posters

BIO-P-6436 **Atsushi Yamaguchi, Yurika Hanamiya, Hikaru Watanabe and Hiroto Murase**
Macrozooplankton diel vertical migration and carbon flux in the summer, western North Pacific Ocean

BIO-P-6458 **Alexander V. Zavolokin** (*presented by V. Kulik*)
Forage base of Pacific salmon (*Oncorhynchus* spp.) in the Northwest Pacific Ocean in 2004-2009

BIO-P-6461 **Tatyana A. Belan and Alexander Moshchenko** (*presented by A. Chernova*)
Near-bottom environmental conditions and polychaete taxocenes in the north part of Amursky Bay (The Sea of Japan/East Sea)

BIO-P-6531 **Ludmila S. Belan and Tatyana A. Belan** (*presented by A. Chernova*)
Composition and distribution pattern of macrozoobenthos on the continental shelf of the Okhotsk Sea near NE Sakhalin Island

BIO-P-6557 **Xuehai Liu, Yeli Yuan and Fangli Qiao**
Numerical modeling of physical-biological processes and carrying capacity in an aquaculture sea: A case of the Sanggou Bay in China

BIO-P-6570 **Brett R. Dumbauld and John W. Chapman**
Can an introduced parasitic bopyrid Isopod *Orthione griffenis* cause extinction of mud shrimp *Upogebia pugettensis* populations in U.S. west coast estuaries?

BIO-P-6580 **Sarat C. Tripathy, Joji Ishizaka, Tatsuya Shibata, Eko Siswanto and Yoshihisa Mino**
Evaluation of Vertically Generalized Production Model (VGPM) in Ariake Bay, Southwestern Japan

BIO-P-6583 **Katsumi Takayama, Tatsuro Watanabe, Hideyuki Kawamura and Iori Tanaka**
Reproducibility of chlorophyll *a* and nutrient variability in the Japan Sea by the three-dimensional ecosystem-circulation model

BIO-P-6636 **Hyun Woo Kim, Yong-Rock An, Tae-Geon Park, Zang Geun Kim, Dae-Yeon Moon and Seok-Gwan Choi**
Validity of a photo-identification method for spotted seals in the Baekryongdo, Korea

BIO-P-6647 **Yuji Okazaki, Kazuaki Tadokoro and Yugo Shimizu**
The vertical distribution of krill in the Oyashio and mixed water regions, western North Pacific

BIO-P-6648 **Tae-Geon Park, Yong-Rock An, Zang-Geun Kim, Seok-Gwan Choi and Dae-Yeon Moon**
Distribution of the spotted seal, *Phoca largha*, along the coast of Baekryeongdo in 2006 - 2008

BIO-P-6663 **Shin-ichi Ito, Hiroshi Kuroda, Takahiko Kameda, Takeshi Okunishi, Enrique N. Curchitser, Kate Hedstrom and Jerome Fiechter**
A test of a coupled physical and lower-trophic-ecosystem model NEMUROMS in the North Pacific

BIO-P-6668 **Xiu-ning Du and Guang-xing Liu**
Phytoplankton community structure and its relation to hydrographic conditions in the North Yellow Sea in autumn, 2007

BIO-P-6709 **Soo Jeong Lee, Hyeok Chan Kwon, Sang Cheol Yoon, Yeong Min Choi and Chang Ik Zhang**
Age and growth of *Gomphina veneriformi* in the east coast of Korea

BIO-P-6734 **Youngju Lee, Joong Ki Choi**
Phytoplankton dynamics and primary production of the Yellow Sea in winter and summer

BIO-P-6771 **Brie J. Lindsey and Harold P. Batchelder**
Potential spawning behaviors of *Euphausia pacifica* in the upwelling region of the Oregon coast: A 2-D modeling exploration

BIO-P-6839 **Natalia M. Aminina, Irina A. Kadnikova, Yeon-Kye Kim and Ho-Dong Yoon**
Comparison of UV-absorbing and antioxidant activity of seaweed extracts

BIO Paper Session Oral Presentations

28 October, 9:10 (BIO-P-6728)

Understanding the role of the Yellow Sea Bottom Cold Water Mass (≤10ºC) on the survival strategy of *Euphausia pacifica* throughout the hot summer in the Yellow Sea

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The Yellow Sea Bottom Cold Water Mass (YSBCM: ≤10°C) is a unique physical feature of the Yellow Sea. It forms through winter cooling and mixing and it is persistently observed in the deep central region during summer. Although the important role of YSBCM on physical and biological processes in Yellow Sea has been recognized, few studies have been conducted to understand its role. Particularly, it provides a refuge (*i.e.* over-summering sites) for some organisms (i.e. *Euphausia pacifica*) to survive through the hot summer (>20°C in surface). Therefore, various studies of *E. pacifica*, such as their feeding ecology, live experiments, and their spatial and seasonal distribution using net sampling with acoustics, are being conducted to better understand the role of the YSBCM on *E. pacifica*. According to preliminary results, high egg abundance of *E. pacifica* was found during the spring before the YSBCM was formed but no eggs were found in the summer. However, *E. pacifica* lipid content (about 10% of dry weight), which is closely linked with living strategy, was not significantly changed between seasons. Therefore, in order to fully understand *E. pacifica*'s over-summering strategies (*e.g.*, migration, hibernate, shrinkage, minimizing metabolism) and the YSBCM role on *E. pacifica*, further analyses (acoustics, net sampling, stomach analysis, so on) are currently being done.

28 October, 9:30 (BIO-P-6693)

Cohort data for the euphausiid *Euphausia pacifica* based on biweekly sampling off Newport, OR, USA

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Euphausia pacifica is widely distributed throughout the Pacific Ocean and is the most abundant species of euphausiid found off the Oregon Coast. We have sampled euphausiids every two weeks off Newport, OR since 2001. *E. pacifica* spawn from February–October with an intense period of spawning during July-August. This intense spawning during a short time period initiates a cohort. Using our biweekly samples, we were able to identify cohorts, based on lengths of juveniles and adults, and track them over time. Cohorts were identified using the maximum likelihood fitting procedure in Matlab. This procedure is particularly useful for cohort data since it identifies overlapping distributions. In the laboratory, *E. pacifica* develop from egg to juvenile in an average of 60 days (Feinberg et al. 2006), therefore the appearance of a cohort can be attributed to a spawning event that occurred approximately two months prior. The study period encompasses a wide variety of environmental conditions but there was little interannual variability in cohorts other than in 2005 when the onset of upwelling was delayed by approximately one month. Growth rates calculated from cohort data and growth rates of individual animals measured in live animal instantaneous growth rate (IGR) experiments were generally between ±0.1mm d^{-1}. Survivorship curves suggest that the juvenile stage lasts about six months and that adults live an average of two years. We will explore the potential for using this data set to calculate population parameters such as stage-specific production and mortality.

28 October, 9:50 (BIO-P-6764)

Feeding rates of adult *Euphausia pacifica* on natural particle assemblages in the coastal upwelling zone off Oregon, USA

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Feeding experiments on adult *Euphausia pacifica* were initiated in February 2010 with the plan to determine how feeding rate and selectivity changes during the upwelling season. Incubation experiments were conducted using krill caught at the shelf break 25 miles offshore of Newport, Oregon. We measured the clearance rates and daily rations by feeding the krill on natural plankton assemblages. Feeding rates were calculated from microscopic counts of the phytoplankton and ciliates species. Preliminary rates based on experiments conducted in February and April showed that *E. pacifica* had higher grazing rates on diatoms (the dominants were *Thalassiasira* and *Chaetoceros*) during the spring bloom in February compared to post-bloom conditions in April when plankton biomass was low and *E. pacifica* had negative clearance rates on total enumerated biomass and extremely low or negative feeding rates based on Chl a data; very low biomass of larger phytoplankton taxa (diatoms and dinoflagellates) in April made it difficult to determine *E. pacifica* grazing preference. In addition, we found in both months that *E. pacifica* had a high preference for ciliates and that they did not like eating the smaller flagellates. Our results support the hypothesis that *E. pacifica* feeds omnivorously on the natural assemblages with ciliates as an important food source and with larger food taxa preferred over the smaller taxa. The above conclusions will be tested further throughout the upwelling season and results of all experiments will be presented at PICES 2010.

28 October, 10:10 (BIO-P-6806)

On adding a stage-structured model of krill to NEMURO

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The North Pacific Ecosystem Model for Understanding Regional Oceanography—NEMURO—was developed by PICES CCCC investigators to serve as a consensus structure for a general lower trophic level model of the North Pacific. It has eleven state variables: dissolved silica, ammonia and nitrate; small and large phytoplankton; small, large and predatory zooplankton; and dissolved and particulate organic nitrogen. The large zooplankton was considered to equate to *Neocalanus* spp. that seasonally occupy the upper layer through an ontogenetic vertical migration. While the consensus structure has proven useful to investigate a variety of processes in North Pacific waters, it has also been enhanced in several ways. Including iron as a control on phytoplankton production, and adding a carbon cycle to examine biogeographic cycles are examples.

Concentration-based models are unable to include size-dependent processes of the individuals that compose the aggregate state variables of the model. For instance, a single variable representing the aggregate biomass of large zooplankton assumes that all of the biomass ingests and respires, experiences mortality and is capable of reproduction in a size-independent fashion. Because of these constraints, individual-based models (IBMs), which can more easily deal with size-dependent relationships and behaviors have become popular. However, it is difficult to simulate realistic densities (or biomasses) within IBMs. Consequently, most IBMs provide qualitative indications of how size-based behavior or functions influence potential population dynamics and demography. Quantitative responses are preferable for examining responses to future climate scenarios. We describe an approach for adding size dependent processes of krill to NEMURO.

28 October, 10:50 (BIO-P-6730)

Typhoon-driven variations in productivity and species composition of phytoplankton in Sagami Bay, Japan

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Climate change has the potential for increasing the intensity of typhoons, which leads to an increase in wind speed and precipitation. It is likely that effects of typhoons on marine and coastal ecosystems will be stronger in the future. In the present study, the effect of typhoon MAWAR, passing our study site in Sagami Bay on 25 August 2005, on productivity and species composition of phytoplankton was investigated from August to September 2005. Immediately after the typhoon passage, salinity decreased dramatically and nutrient concentrations (nitrogen, phosphate and silicate) increased to more than twice the average summer values. Primary production (PP) reached a maximum of 350 mg C m^{-3} day^{-1} three days after the typhoon passage and high PP lasted for nine days. The integrated PP value during the nine days after the typhoon passage when PP was enhanced was 1.8×10^3 mg C m^{-3} typhoon $period^{-1}$ and accounted for 4.8-8.0% of the annual PP in the upper waters of Sagami Bay. The contribution of PP enhanced by typhoon passage to annual productivity is not negligible. Phytoplankton species composition during the 5 days after typhoon passage was similar to the composition before typhoon passage. Further study is needed to quantify the carbon flow from enhanced PP to high trophic levels.

28 October, 11:10 (BIO-P-6581)

The phytoplankton contribution to the diet: A comparison of two mussels (Mollusca: Bivalvia) from different biotopes of the Sea of Japan

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The Bivalve mollusks of the Mytilidae Grayan's mussels' family, *Crenomytilus grayanus* and the *northern horse mussel, Modiolus modiolus,* are considered the main components of coastal marine benthic communities. Study of the Mytilid's role as consumers of seston is required for understanding the trophic structure of marine coastal communities, especially in areas where Mytilidae are abundant. However, little is known about the seston composition in the mussel's diet. We explored the diets of *C. grayanus* and *M. modiolus* collected within mussel beds in different parts of Peter the Great Bay (northwestern part of the Sea of Japan). The specific activity of the digestive enzymes endo 1,3-β-D-glucanases, and the molecular activity of the gene in mussels of different age, were analyzed. The analysis of both glucanase gene expression and enzyme activity showed that the contribution of phytoplankton to the mussels' diet is different for each species collected from different parts of the Peter the Great Bay. The levels of gene expression and specific activities in mussels collected from Amursky Bay were significantly higher (*ANOVA,* $p < 0.05$) than in mussels collected from Vostok Bay and Ussuriisky Bay. At different stages of development, the *C. grayanus* and *M. modiolus* consume different amounts of phytoplankton. These and prior results suggest that analysis of endo 1,3-β-D-glucanase gene expression and molecular activity can be successfully used as a new method to determine the contribution of phytoplankton to the diet of marine invertebrates.

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28 October, 11:30 (BIO-P-6803)

Regional patterns in mercury concentrations of yellowfin and bigeye tuna in the Pacific Ocean

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Mercury (Hg) levels vary in high trophic level fish, including the commercially important bigeye and yellowfin tuna (*Thunnus obesus* and *Thunnus albacares*) and can often exceed consumption advisories. Regional variation in tuna Hg concentration may result from local environmental conditions that promote conversion of inorganic to organic mercury and subsequent uptake and transfer in marine food webs, including a combination of low dissolved oxygen concentrations and high rates of primary production. Here we tested whether this would translate into different Hg levels in 444 bigeye and yellowfin tuna captured in five regions across the central and eastern equatorial Pacific that provided contrasts in these oceanographic features. Size-corrected Hg levels for both species were highest in the eastern equatorial region (5ºS-5ºN; 110ºW-120ºW), but were relatively similar among the remaining regions, with the greatest regional differences of 0.22 µg/g and 0.17 µg/g for yellowfin and bigeye, respectively. Applying these results to the central north Pacific food web, using an Ecopath model coupled with a Hg mass balance model, we can explore the fate and flow of Hg in the system and how it dictates regional differences in tuna Hg levels. We will explore the roles of trophic structure and Hg absorption at the base of the food web in producing regional differences in tuna Hg levels. While the mechanisms are still unclear, the extent of variation among regions points to the need to consider species, size, and location of capture in setting consumption advisories for these species.

28 October, 11:50 (BIO-P-6478)

The current condition of *Polychaeta* of the northwestern shelf of Bering Sea

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The northwestern part of the Bering Sea is one of the fishing areas for crabs, flounders, herrings, pollock and others. Polychaetes are one of the most important groups of marine macrobenthos in any region of the Far Eastern Seas. They are a favorite food of most demersal and benthic fish and invertebrates, including commercial ones. The purpose of this article is to determine the current condition of the polychaete fauna of the northwestern shelf of Bering Sea. Quantitative samples of polychaetes were collected by the staff of TINRO-Center in the summer of 2001 in Karaginskiy (90 samples) and Mechigmenskiy (20 samples) Bays, in the summer of 2005 at the Navarinsko Olyutorskiy-shelf (102 samples) and in the Gulf of Anadyr (94 samples) using an "Okean-50" (0.25 m^2) bottom-grab in the depth range of 18-200 m. In Karaginskiy Bay, 85 species of polychaetes were found. Their share in the macrobenthos was 8% and their average biomass was 27 g/m^2. In Mechigmenskiy Bay 63 species of polychaetes with an average biomass of 46 g/m^2 were found. Their share was 12% of the total benthos of the Bay. At the Navarinsko-Olyutorskiy shelf, 80 species of polychaetes were found. Their average biomass was 28 g/m^2 and their share was 7%. In the Gulf of Anadyr, 78 species of polychaetes were found. Their average biomass was 40 g/m^2 and their proportion in the macrobenthos was 11%. Across the northwestern shelf of the Bering Sea *Axiothella catenata* and representatives of the genus *Nephtys* were among the dominant species of polychaetes.

28 October, 12:10 (BIO-P-6786)

Modelling plankton dynamics in the Straits of Georgia and Juan de Fuca

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The Strait of Georgia is a highly productive, semi-enclosed sea with strong estuarine circulation connected to the North Pacific by the Juan de Fuca Strait. In order to better understand the key links between physical and biological processes determining lower trophic levels and to predict plausible ecosystem changes, a coupled plankton/circulation model (ROMS-Regional Ocean Modeling System) has been developed. The biological model includes two size classes of phytoplankton and zooplankton, nitrate, ammonia and silicate. Model results from simulations of the mean annual cycle will be presented. In the Strait of Georgia, modeled phytoplankton biomass is higher and more variable than in the Juan de Fuca Strait and shows pronounced seasonal variability consistent with observations. In the model, physical variability plays an important role in maintaining the high spatio- temporal variability of plankton abundance. In particular, the influence of tidal mixing on phytoplankton production and biogeochemical cycles is discussed.

28 October, 14:10 (BIO-P-6769)

Copepod assemblages as indicators of ocean conditions in Central California

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At-sea surveys conducted in the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries in central California have shown drastic changes in the abundance and species compositions of copepods from 2004 to 2008. We characterized copepod species as "transition zone" (*i.e.*, common to the region), boreal (*i.e.*, larger, high-lipid species common to northern latitudes), and equatorial (*i.e.*, smaller, less fatty species with a more equatorial distribution). In 2004, a relatively "normal" year for upwelling, "transition zone" copepods (*e.g.*, *Calanus pacificus* and *Metridia pseudopacifica)* were most numerous. In the poor upwelling years of 2005 and 2006, "transition zone" species dominated samples again. In the strong upwelling conditions of 2007, boreal copepods became copious, particularly coastal and shelf species (*e.g.*, *Pseudocalanus mimus* and *Acartia longiremis*); boreal species continued to be abundant into 2008 (another relatively "good" ocean productivity year). Correlation analysis between monthly average abundances of copepod species and three different climate variables (SOI, PDO and NPGO) produced the most significant results for boreal species than for the other categories of copepods. Boreal species such as *Acartia hudsonica*, *Aetideus divergens*, *Pseudocalanus mimus*, and *Tortanus discaudatus* showed positive significant correlations with SOI and NPGO. Although *Neocalanus cristatus* and *N. plumchrus* did not produce significant results with climate variables, the abundances of these species were low in 2004-2006 and increased dramatically in 2007-2008. These results suggest that boreal copepod species in northern and central California are abundant during years with strong northerly winds, and thus indicators of healthy ocean conditions.

28 October, 14:30 (BIO-P-6534)

A molecular method for species identification of early life stages of *Neocalanus plumchrus* and *Neocalanus flemingeri* using Real-Time PCR

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Neocalanus plumchrus and *N. flemingeri* are abundantly and widely distributed copepods in the subarctic Pacific and are key species in the ecosystem. Although their life histories have been reported, early life histories during egg and nauplius stages have not been studied yet. During the egg and nauplius stages, it is difficult to identify them because of their undeveloped morphological characteristics. To overcome this problem we developed a Taq Man probe, real-time PCR method to identify them genetically. Mitochondrial CO1 genes were used to design two sets of specific primer pairs and probes for both species. A total of 96 specimens of 8 species of adult copepods including these two *Neocalanus* species were collected in the Oyashio region to test the real-time PCR reaction with two sets of specific primer pairs and probes, and to verify whether we could identify the two target species or not. The result showed that amplification was observed not only in target species but also in other copepod species. However, for other copepod species, the increase in fluorescence intensity (indication of amplification) was slower than increases in the two target species. We then tested this method with laboratory-hatched nauplii of *N. plumchrus* and *N. flemingeri* and obtained the same results as adults. These results suggest that real-time PCR can be an effective tool for detecting *N. plumchrus* and *N. flemingeri* at the nauplius stage. Preliminary results on seasonal samplings in the Oyashio region will be presented at the meeting.

28 October, 14:50 (BIO-P-6754)

Egg development time and hatching success of deep sea spawning calanoid copepods, genus *Neocalanus*

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Neocalanus cristatus, N. flemingeri and *N. plumchrus* are key food-web components throughout the subarctic Pacific Ocean as they feed on photoautotrophs and microheterotrophs, as well as being a food source for higher trophic levels. These species can also be sensitive bio-indicators, closely tracking the effects of climate change on aquatic biological productivity. The recruitment rates of these species provide a sensitive indicator of several environmental changes. Examination of egg survival rate is necessary for accurate evaluation of recruitment rate. *Neocalanus* copepods produce eggs in deep water, and these eggs are exposed to high pressure. However, the effects of hydrostatic pressure on egg development have not been considered yet. The purpose of the present study is to examine the effects of pressures observed at spawning depth, on *Neocalanus* eggs. Egg development times (EDT) and egg hatching successes (EHS) of each species were examined. EHS varied between 0 and 100% among clutches for the three species. However, a high correlation was observed between the high-pressure condition and 1 atm. Neither the EDT nor EHS were affected by pressure change, which implies that eggs of *Neocalanus* copepods are adapted to a wide pressure range even though reproduction is conducted in a high-pressure environment. On the other hand, variable environmental conditions may affect the physiological states of eggs causing high variability of EHS..The effects of physiological factors such as enzyme and lipid content of eggs on the survival rate need to be determined in the future.

28 October, 15:10 (BIO-P-6876)

A stable isotope trophic assessment of upper trophic level nekton in the Northern California Current ecosystem

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Upper trophic level nekton of the Northern California Current (NCC) are strongly affected by changes in prey community structure and production. It is therefore important to understand the relative trophic levels of these predators in relation to potential prey, which can then be used to evaluate trophic response to ecosystem or climate change. In this study we applied stable isotope analysis of carbon and nitrogen to examine the relative trophic position (using nitrogen) and source production (carbon) of major nekton predators and prey within the northern California Current. A full spectrum trophic analysis from top predators such as great white, blue, soupfin and salmon sharks to lower trophic level fishes (sardine and anchovy) and squid (*Loligo* and Humboldt), ichthyoplankton (sardines) and zooplankton (euphausiids and copepods) showed very clear trophic-level differences between zooplankton and known zooplanktivores, and between fishes and piscivores such as soupfin and great white sharks. Results from several isotope mixing models suggest most fish including adult blue sharks were within a trophic range indicative of mixed feeding on juvenile fishes and euphausiids. Using several fish species for a trophic-isotope comparison NCC and Southern California Current ecosystems, we present potential reasons for the prevalence of mixed-feeding in the NCC.

28 October, 15:50 (BIO-P-6498)

Interannual comparison of diet of larval jack mackerel *Trachurus japonicus* in the southern East China Sea during 2002-2005

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We describe and compare the feeding habits of jack mackerel larvae (<5 and 5–8 mm body length (BL)) sampled during February to March of four consecutive years (2002–2005) in the shelf-break region of the southern East China Sea where the primary spawning ground is found. Dietary overlap based on Schoener's index revealed high affinities (47–94%) among the four years. In larvae 5–8 mm BL, the diet was strongly dominated by calanoid copepodites (mainly *Paracalanus* spp.) and poecilostomatoid copepodites (*Oncaea* spp., *Corycaeus* spp. and *Farranula* spp.). Larvae <5 mm BL fed occasionally on copepod nauplii and gastropod larvae, as well as the above two main prey items. Feeding was mainly restricted to daylight hours (0700–2100 h). Feeding incidence during 0700–2100 h was 78–90% and 100% in larvae <5 and 5–8 mm BL, respectively, without interannual variation. The mean number of prey consumed was positively correlated with larval size and in each size class the number of prey did not significantly differ among the four years. The gut evacuation time was estimated at 2–3 h. Based on information on the feeding period, the mean number of prey and gut evacuation time, we estimated that jack mackerel larvae <5 and 5–8 mm BL would consume ca. 11–21 and 27–48 prey items per day, respectively. We estimate that <0.5% of the available prey items were consumed by larvae per day. The high interannual similarities in feeding habits are evidence that food availability for jack mackerel larvae did not significantly differ during 2002-2005.

28 October, 16:10 (BIO-P-6517)

Lipid metabolism of minke whale and pacific white-sided dolphin in Korean waters and implications for feeding ecology

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In order to understand the lipid metabolism of minke whale (*Balaenoptera acutorostrata*) and pacific white-sided dolphin (*Lagenorhynchus obiquidens*), lipid content, composition, and compound-specific stable isotope content were examined in their blubber. Mean lipid content of the two species ranged from 54 to 92% of wet weight, with dominance of triacylglycerols (94 to 99% of total lipids). Although lipid content and composition in the blubber were similar between two species, the relative abundance of some fatty acids (*e.g.* 14:1, 16:0, 18:1n-7, 18:0, 20:1n-11 and 20:2) were significantly different. These differences might be related to their diets because bulk stable isotope ratios ($\delta^{13}C$, $\delta^{15}N$) in the skin indicated the minke whale mainly feeds on krill and anchovy but pacific white-sided dolphin mainly fed on fishes. However, we found a significant shift of FA composition within blubber layers for both species. While monounsaturated FAs (MUFAs) gradually increased from the inner (near muscle) to the outer layer (near skin), polyunsaturated FAs (PUFAs) decreased from the inner to outer layer. These compositional shifts in the blubber could be related to their physiological needs (i.e. thermoregulation, streaming, buoyancy and energy storage). With the addition of compound-specific stable isotope analysis, detailed information on lipid metabolism and the diet history of these marine mammals would be disclosed.

28 October, 16:30 (BIO-P-6858)

Discovering a new feeding area for calf-cow pairs of Western Gray Whales on the south-east shelf of Kamchatka in 2009 and their utilization of different feeding regions within one season

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In 2009, photo-ID studies were conducted principally at the two Sakchalin feeding areas and at the two Kamchatka areas (Olga and Vestnik Bays). Photo-ID studies of gray whales have been performed annually in the Piltun and Offshore feeding areas off northeast Sakhalin during the period 2002-2009. Photo-ID studies conducted offshore southeast Kamchatka since 2006 revealed that some of Kamchatka whales belong to the Western gray whale (WGW) population. Until 2008, cow-calf pairs had only been recorded in Piltun, and often near the mouth of Piltun Bay, where prey abundance is high and water is shallow. In 2008 a mother-calf pair was registered in Olga Bay for the first time. The earlier start of the survey season in Olga Bay in 2009 compared to previous years allowed more comprehensive data to be collected about mother-calf pairs; seven pairs were identified in 2009. Four of these mothers identified in Olga Bay had been observed on the Sakhalin shelf in previous years. Two of the seven calves were also observed later in the Piltun area during the 2009 season, one of them with its mother. Five mother-calf pairs and one calf without mother were identified only in the Piltun area on the Sakhalin shelf. Thus, a total of ten calves that have mothers in the Sakhalin catalogue were recorded in 2009. These results indicate that the Piltun area offshore Sakhalin is not the only feeding area for mother-calf pairs of the WGW, but that a second "nursery ground" exists in Olga Bay, Kamchatka.

28 October, 16:50 (BIO-P-6705)

Fatty acid and stable isotope analyses reveal consumption patterns of planktivorous auklets and variability in ecosystem productivity

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Planktivorous auklets occupy ecological niches near the base of marine food webs, although important details of their diets and trophic ecology remain unknown. We combined the applications of stable isotope and fatty acid (FA) analyses with this guild to help explain consumption patterns and provide insights about variability in ecosystem productivity. We tested for differences in diets among crested and least auklets (*Aethia cristatella*, *A. pusilla*) at several scales (geographic, seasonal, interannual, interdecadal). Principal Component Analysis of FA discriminated auklet samples according to geographic locations of colonies. In the northern Bering Sea seasonal and geographic patterns emerged in auklet FA profiles that contrasted dependence upon local versus advected production. FA analysis provided powerful discrimination of interspecific and intraspecific differences in diet. Contrary to predictions and assumptions in the literature, adult auklet diets differed significantly from diets of chicks. Interdecadal differences (2002 *vs.* 1987) in carbon isotope composition of auklet feathers at Little Diomede I. in the northern Bering Sea exhibited a pattern similar to a trend previously observed in bowhead whale baleen. Interdecadal differences in fatty acid composition were most apparent in one principal component for least auklets, based upon fatty acid biomarkers characteristic of diatoms (C16:1n-5 and C16:2n-4), suggesting changes in the floral community over time. Our study demonstrates the power of these techniques to discriminate patterns from the fine scale to the ecosystem level, and we suggest this application has utility for studying climate-induced change in the Bering Sea.

28 October, 17:10 (BIO-P-6591)

Declines of northern fur seals at the Pribilof Islands: Forage fish depletion, competition with adult pollock and arrowtooth flounder, or fishing activity?

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Populations of northern fur seals on the Pribilof Islands have declined since the mid-1970s. We examined data on population trajectories and reproductive performance of the fur seals, and indices of the distributions and abundances of forage fish (age-1 pollock and capelin), adult pollock, arrowtooth flounder, and fishing activity (number of hauls, biomass of pollock removed) in concentric rings of 50, 100 and 200 km around the Islands. We found a strong negative relationship between pups born on both St. Paul and St. George Islands and the biomass of arrowtooth flounder around the islands the year before, and a weak negative relationship with adult pollock biomass the year before. There was an apparent negative relationship between the number of pups born and the commercial catch of pollock the year before, as well as negative correlation between the number of pups born on the islands and the number of observed tows by the pollock fleet the year before. Since we could find no evidence of a decline in forage fish abundance, we hypothesize that large predators on forage fish and possibly fishing activity exert their negative impacts on the numbers of pups by changing the availability of forage fish to the seals. We hypothesize that the impact is through nutritional stress on female fur seals during and after pup rearing that leads to failure to produce pup in the following year.

BIO Paper Session Posters

BIO-P-6436

Macrozooplankton diel vertical migration and carbon flux in the summer, western North Pacific Ocean

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The Western North Pacific is thought to be an ocean where the "Biological Pump" acts efficiently. While information is available on active flux by mesozooplankton, mainly mesozooplanktonic copepods, in this region, little information is available for macrozooplankton. In the present study, we observed the diel vertical distribution of macrozooplankton (*e.g.* amphipods and euphausiids) at three stations (39ºN, 41ºN, 44ºN) along 158ºE in the western North Pacific during 16-25 June 2003, and estimated their active carbon flux by physiological methods (Ikeda and Motoda 1978). Sampling was conducted by 8-layer stratified oblique tows of MOCNESS (mouth area: 1 m^2, mesh size: 0.315 mm) down to 250 m both day and night. There were 25 species of amphipods belonging to 17 genera, dominated by *Phronima* spp. (39ºN) or *Themisto pacifica* (41ºN and 44ºN). *Cyphocaris challengeri* and *Vibilia gibbosa* increased at night. Euphausiids, 19 species in 7 genera, were dominated by *Euphausia* spp. and *Thysanoessa* spp. Throughout the stations, both taxa showed clear diel vertical migration. Ingestion in the surface and respiration in the deep layers by both taxa were estimated to be 9-31 mg C m^{-2} day^{-1} and 4-19 mg C m^{-2} day^{-1}, respectively. These ingestion and respiration values corresponded to 4-13% of primary production and 3-14% of the gravity induced passive flux, respectively. Thus the active flux by macrozooplankton is a negligible component of the marine ecosystem flux in the western North Pacific Ocean.

BIO-P-6458

Forage base of Pacific salmon (*Oncorhynchus* spp.) in the Northwest Pacific Ocean in 2004-2009

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The forage base of Pacific salmon in the Northwest Pacific Ocean (near the Kuril Islands) was estimated for the summers of 2004 and 2006-2009 based on data from plankton hauls and on mathematic modeling of micronekton biomass. Copepods and chaetognaths dominated the forage base of Pacific salmon (65-72 %). Euphausiids contributed 2-11%, amphipods – 1-2%, and pteropods – less than 1%. A significant part of the forage base (13-15%) consisted of micronekton (small fishes and squids). Average biomass of Pacific salmon forage base was estimated to be 2011 mg/m^3. It was lowest in 2004 (968 mg/m^3) and highest in 2008 (2865 mg/m^3). Forage base biomass tends to increase from 2004 to 2009. Forage base biomass was lower in the Pacific waters of the South Kuril Islands compared to Pacific waters of the North Kuril Islands because of lower concentrations of both zooplankton and micronekton.

BIO-P-6461

Near-bottom environmental conditions and polychaete taxocenes in the north part of Amursky Bay (The Sea of Japan/East Sea)

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Data are presented on the composition, structure and distribution of polychaete taxocenes in the north part of Amursky Bay in 2005. Long-term changes in polychaete communities since the 1930s are analyzed also. Water eutrophication and changes in sediment grain size are considered to be the main factors controlling characteristics and distribution of taxocenes in the inner, northern part of Amursky Bay. The level of chemical contamination in the region is rather low and does not affect the associations of animals. The most numerous polychaetes in the silty sands in the 1930s were *Maldane sarsi, Scoloplos armiger, Lumbrineris minuta, Sigambra bassi, Anobothrus gracilis, Staurocephalus (Schistomeringos) annulatus,* and *Heteromastus giganteus.*

The peak anthropogenic impact on the marine coastal zone in the Primorye Region occurred during 1960-1980. Cardinal reorganization of benthic communities in Amursky Bay decreased between 1970-1980. At this time species tolerant to pollution and eutrophication such as *Tharyx pacifica,* appeared and became numerous. At the beginning of the 20th century, the numerical abundance and area of habitat of the most common polychaetes *Maldane sarsi* and *Scoloplos armiger* became sharply reduced. Only a few species of polychaete retained their positions at the beginning of 21st century, including *Sigambra bassi* as well as representatives of the *Lumbrineris* and *Schistomeringos* genera.

BIO-P-6531

Composition and distribution pattern of macrozoobenthos on the continental shelf of the Okhotsk Sea near NE Sakhalin Island

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Data are presented on composition and distribution of macrozoobenthos in an area of the continental shelf of the Okhotsk Sea near NE Sakhalin Island (54°N and 143°E). 282 species of benthic invertebrates belonging to 27 faunal groups, have been identified within the depth range between 80-180 m. Benthic macrofauna of the study area is characterized by very high diversity and abundance. The total benthic biomass at depths between 90-150 m is more than 900 g/m^2 on average. Strong near-bottom currents and coarse-grained sands make conditions favorable for the development of epifauna. Sponges (*Mycale lobata, Phakellia cribrosa, Myxilla incrustans,*

Suberites montiniger, Cornulum tubiformis, Tedania cf. microrhaphidiophora, *Farrea* sp), bryozoans (*Leieschara* sp.), hydroids (*Abietinaria derbeki, Thuiaria coronifera, Lafoea grandis, Obelia longissima, Sertularia similes, Thuiaria thuja, Allopora stejnegeri*), alcyonarian (*Gersemia rubiformis*), sea anemones (*Epiactis arctica, Halcampoides purpurea, Actinistola callosa, Halcampa duodecimcimcirrata*), and ascidians (*Rhodosomatidae* gen. sp., *Boltenia cf. echinata*) play the main role among sedentary fauna. The biomass of sedentary fauna may reach 2500 g/m^2 and more. Errant benthos characterized by the highest frequency of occurrence are amphipods and polychaetes (100%), and bivalves (93%). Sea-urchins *Strongylocentrotus pallidus, S. pulchellus*, and polychaetes *Nephtys caeca, Nothria iridescens* dominate in biomass among free-ranging forms of macrofauna. Also, the brachiopod *Terebratalia* sp. and the sipunculoid *Golfingia margaritacea* make up a considerable part of the biomass.

BIO-P-6557

Numerical modeling of physical-biological processes and carrying capacity in an aquaculture sea: A case of the Sanggou Bay in China

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In Sanggou Bay, a typical aquaculture sea in China, we developed a suite of models to reproduce physical and biological processes and evaluate carrying capacity (CC). By disposing frictional coefficients in culturing layers where water-current is evidently reduced, a hydrodynamic model is developed for aquaculture areas. The model results are in general agreement with *in situ* observation. Simulations indicate that water exchanges were weakened by aquaculture activities. The half-life of water in the bay is 7-d without aquaculture, 12-d with shellfish culture only, and 16-d with both shellfish and kelp cultured.

A 3D ecosystem model is developed from a NPZD module and by parameterizing other biological processes related to dissolved-organic-matter and depletion/expiration of bait/nutrient by shellfish/kelp. The model shows, relatively low Chl-*a* in winter (except weak peak in February) and high in summer (maximum in September), which is a commonly observed feature for kelp, oyster and scallop culturing areas.

With the ecosystem model, the estimates of CC of shellfish and kelp are developed based on balance relationships between substance supply and demand. The scallop's CC is high in winter and autumn, low in spring and summer, and minimum in April. Its annual average is 53 ind m^{-2} and the present density might be maintained; oyster's CC is lowest in late August and highest in mid-February, and the recommended density is 59 ind m^{-2}; the total CC of kelp is 21250 t, and a recommended seedling density is 4 ind/m^2.

BIO-P-6570

Can an introduced parasitic bopyrid Isopod *Orthione griffenis* cause extinction of mud shrimp *Upogebia pugettensis* populations in U.S. west coast estuaries?

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The burrowing mud shrimp, *Upogebia pugettensis,* is parasitized by an introduced bopyrid isopod, *Orthione griffenis*, that prevents female egg production. Prevalence of this isopod increased dramatically in Willapa Bay, Washington, between 1998-2001, and the *Upogebia* population collapsed to below detection limits. We continued to monitor prevalence of *Orthione* in *Upogebia* populations in Washington and Oregon estuaries to further document the effects of this invader and determine whether this new parasite was controlling its host populations. *Orthione* prevalence fluctuated from year to year, but was highest in large female shrimp, greater than 20% in all populations, and prevalence trends were similar among estuaries. Results of a transplant experiment of un-infested shrimp to Willapa Bay, where the shrimp were no longer abundant, suggest that *Orthione* is extremely effective at finding its host and that these shrimp do not find refuge even at very low population density. *Orthione* prevalence increased with shrimp size and was highest among reproductive sized females. *Upogebia* egg production losses

to *Orthione* averaged 68% between 2005 and 2009. Both shrimp and isopods have pelagic larval stages that are greatly affected by coastal nearshore oceanography and estuarine recruitment processes. Despite significant *Upogebia* recruitment to shrimp populations in Oregon estuaries in some years and recent declines in isopod prevalence, our data suggest that shrimp populations are still declining and this is cause for concern that this introduction and non-coevolved relationship could result in loss of this important ecosystem engineer from US West coast estuaries.

BIO-P-6580

Evaluation of Vertically Generalized Production Model (VGPM) in Ariake Bay, Southwestern Japan

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The VGPM (Behrenfeld and Falkowski, 1997; BF), that was basically designed for open ocean waters, was evaluated with the existing *in situ* measurements of primary production (PP) in the characteristically turbid coastal waters of Ariake Bay. The euphotic depth (Z_{eu})-integrated PP (IPP, mgC m^{-2} d^{-1}) was significantly overestimated (x1-3) by the VGPM using BF suggested formulation for chlorophyll *a* (Chl-*a*)-specific maximum PP (P^B_{opt}) and Z_{eu}. The weak correlation between observed and modeled IPPs could be due in part to the fact that BF suggested P^B_{opt} showed weak correlation (r^2=0.23) with the *in situ* data. When we replace the BF suggested P^B_{opt} and Z_{eu} with observed *in situ* P^B_{opt} and Z_{eu}, the model estimates significantly improved (r^2=0.84, $p<0.0001$, RMSE = 676 mgC m^{-2} d^{-1}). Thus, one or both of P^B_{opt} and Z_{eu} seems to be strongly influencing the correlation between model-estimated and *in situ* IPP. Hence, individual contributions of P^B_{opt} and Z_{eu} towards the correlation between estimated and *in situ* IPP were calculated. The estimated and *in situ* P^B_{opt} have insignificant differences, and do not account for the reduced correlation. Conversely, the Z_{eu} suggested by BF were 2-3 times greater than the observed Z_{eu}, and appears to be the cause of the poor IPP correlations between observations and theVGPM. The BF suggested Z_{eu} model, based on surface Chl-*a*, did not hold well in Ariake Bay as it was basically developed for Case-1 waters, where the underwater light attenuation is mostly determined by Chl-*a* concentration. Results revealed that the contribution from non-phytoplankton particles is the dominant factor for underwater light attenuation in Ariake Bay. Recent studies show that inherent optical properties (IOP) such as absorption (a) and backscattering (b_b) can be directly linked to the water constituents. An IOP-based approach for better estimation of Z_{eu} in Ariake Bay is under process.

BIO-P-6583

Reproducibility of chlorophyll *a* and nutrient variability in the Japan Sea by the three-dimensional ecosystem-circulation model

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A three-dimensional lower trophic ecosystem model called NEMURO (Kishi et al., 2007) was applied to gain understanding of spatial and temporal variation of chlorophyll *a* and nutrients in the Japan Sea. The ecosystem model was forced using monthly solar radiation data from NCEP and daily calculations of temperature, current velocity and vertical diffusion coefficient from an eddy-resolving ocean circulation model (1/12 degree horizontally and 36 levels vertically) that assimilated satellite-derived SST and SSH data as well as ship-observed CTD profiles. Additionally, monthly chlorophyll *a* and nutrient profiles derived from WOD09 were used as the lateral incoming condition at Tsushima Straits. The model analysis period was five years from 2003 to 2007. To validate the ecosystem model results, satellite chlorophyll *a* concentration on the sea surface and the long-term bimonthly observations in the northern Japan Sea, which were carried out by the Hokkaido Central Fisheries Experiment Station, were used. The ecosystem model qualitatively reproduced the general characteristics of

seasonal chlorophyll *a* and nutrient variations in the Japan Sea, including, for example, the spring and autumn blooms of phytoplankton at the sea surface, the subsurface (30-60 m) chlorophyll *a* maximum from late spring to autumn and the high chlorophyll *a* and nutrient concentrations around the east coast of Korea in summer. Spatial averages of correlation coefficients and RMS differences between the model and the satellite-observed chlorophyll *a* were 0.455 and 1.468 mg m^{-3}, respectively. There was a good relationship between the nutrients supplied to the sea surface due to winter convection and the chlorophyll *a* concentrations in spring.

BIO-P-6636

Validity of a photo-identification method for spotted seals in the Baekryongdo, Korea

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Identification of individuals has become one of the standard tools for the study of animal behavior and ecology. Numerous photographic identification studies have been successfully conducted on various species of marine mammals. In this study, we attempted to validate the photo-identification method for spotted seals. We tested the method using 4,939 photographs gathered in 30 field surveys from 2006 to 2008 in Baekryongdo, Korea. 20 individuals were identified and cataloged in 2006 using unique spot patterns on their left cheek pelages as natural marker. 3 and 9 individuals were recaptured in 2007 and 2008 respectively. 6 individuals were frequently recaptured within survey years. We confirmed that the spot patterns of spotted seal pelages were constant in shape and location throughout time. These characteristics provide an opportunity for identifying individuals within a population for a long survey period. The use of photo-identification has great potential for mark-recapture studies.

BIO-P-6647

The vertical distribution of krill in the Oyashio and mixed water regions, western North Pacific

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The vertical distribution of krill was investigated in the Oyashio and mixed water regions. We obtained day and night samples at five fixed stations along the A-line using a 1m^2 MOCNESS (0.33mm mesh size at 8 discrete depths: 0-50, 50-100, 100-150, 150-200, 200-300, 300-500, 500-750, 750-1000m) in May 2006. Twenty-three species of adult krill were indentified in this study. However, five species accounted for 98% of the total numerical concentration: *Euphausia pacifica* (84.5%), *Thysanoessa inspinata* (6.8%), *Nematoscelis difficilis* (5.2%), *Euphausia gibboides* (0.8%) and *Tessarabrachion oculatum* (0.7%). In these 5 species, 4 species (the exception was *N. difficilis*) were mainly distributed in surface layers (0-50m or 50-100m) during nighttime. During daytime, they stayed in deeper layers (50-100m for *T. inspinata*, 100-150m for *E. gibboides*, 150-200m for *E. pacifica*, 200-300m for *T. oculatum*). On the other hand, *N. difficilis* did not perform diel vertical migration, and the peak abundance tended to be in the 50-100m layer both night and day. For *E. pacifica*, diel vertical migration starts after the furcilia stage. Results will be discussed in relation to variability of environmental factors.

BIO-P-6648

Distribution of the spotted seal, *Phoca largha*, along the coast of Baekryeongdo in 2006 - 2008

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This study is aimed at investigating the spotted seal inhabiting the coast of Baekryongdo between 2006 and 2008, in response to the need for understanding the distribution, change in numbers, migration, and behavior habits of this species. The research was conducted using a 5-ton small vessel to conduct surveys one hour before low water. The monthly maximum numbers were observed to be 274 seals in September 2006, 139 seals in September 2007,

and 213 seals in August 2008, respectively. Surveys indicated that the average observed monthly numbers were largest in August and September. Observed numbers varied according to the tide cycle showing an increase as the sea level was lowered and rock appeared. When there were few clouds and plenty of sunshine, relatively more spotted seals were observed. Other observations from bycatch, stranding, and finding of spotted seals since 2000 in Korea have shown that spotted seals were observed 4 times in the western coastal region, 3 times in the southern east region, and 12 times in the east coast region. This may imply that spotted seals inhabiting Baekryongdo migrate to the East Sea via the west and south seas as individuals or as a group.

BIO-P-6663

A test of a coupled physical and lower-trophic-ecosystem model NEMUROMS in the North Pacific

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A community ocean circulation model ROMS (Regional Ocean Modeling System) has incorporated NEMURO (North Pacific Ecosystem Model for Understanding Regional Oceanography) as one of its ecosystem model components. We implemented a North Pacific physical-biological coupled model with half degree resolution both in latitude and longitude based on ROMS. To test the performance of the coupled model, climatological forcing was applied and seasonal variability of the biological variables was evaluated. Although seasonal vertical migration of the large zooplankton was originally incorporated in NEMURO, it was excluded in the ROMS's NEMURO part. As a consequence the model results showed a higher bias of phytoplankton density in the subarctic region during the spring bloom season and a lower bias in the subtropical region in autumn. Additionally, the spring bloom showed an earlier peak and redundant silicate throughout the year. We conducted two types of case studies with biological parameters, which were derived with the aid of the automated calibration software PEST (Model-Independent Parameter Estimation) with an out-of-the-box version of NEMURO. The first is estimated with climatological concentration of nutrients, densities of phytoplankton and meso and macro zooplanktons. The other is estimated by adding the predatory zooplankton density. Both of parameters showed higher energy flow from nutrients to plankton production compared with the original NEMURO parameters. The former parameters improved the timing of the spring bloom but the excess silicate was not totally dissolved. However, the latter parameters improved the resulting silicate concentration. Further improvements may be possible by using a finer resolution model which improves physical processes.

BIO-P-6668

Phytoplankton community structure and its relation to hydrographic conditions in the North Yellow Sea in autumn, 2007

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The investigation was carried out in the North Yellow Sea (NYS), in autumn (from 14 to 25 October 2007). Phytoplankton species composition, abundance, distribution, and the relationships between phytoplankton and hydrographic conditions were analyzed. Temperate neritic species and cosmopolitan species dominated phytoplankton community in autumn. Compared with historic records, total phytoplankton abundance was lower than that of 1960s but higher than that of 1990s; species composition varied greatly during the past half century; more warm water species and oceanic species appeared in October 2007 with growing species richness and abundance compared with Chinese General Oceanographic Survey (CGOS) in 1958-1960; the species richeness and abundance of dinoflagellates showed an increasing trend. Three biogeographic assemblages were identified: the

coastal oligohaline assemblage of south Liaoning (ASL), the coastal oligohaline assemblage of north Shandong (ANS) and the central low temperature and high salinity assemblage of North Yellow Sea (ACY). When compared phytoplankton community in autumn 2007 with the results in winter 2006/2007 in the same investigation waters, we found obvious seasonal variations in each of the above three assemblages. The coastal oligohaline assemblage of south Liaoning changed most significantly. Stepwise linear regression analysis between phytoplankton abundance and hydrographic factors identified that bottom temperature in autumn and salinity in winter predominantly influenced on phytoplankton community, and we figured out 18°C isotherm and 31.8psu isohaline as the potential dividing line of high and low density areas, respectively. This study highlights variations in species composition, community structure as well as interactions with water types.

BIO-P-6709

Age and growth of *Gomphina veneriformi* in the east coast of Korea

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Using samples of *Gomphina veneriformi*, which were collected monthly from Uljin in the east coast of Korea from March 2009 to February 2010, ages were determined from annuli on shells by a naked-eye's observation. We determined ages using these annuli data, which were then used to estimate growth parameters of the shellfish. Monthly variations in the marginal index (MI) of the shell indicated that the annulus of this species was formed once a year during the period of June-September. The relationship between shell length (SL; mm) and shell height (SH; mm) was SH = 0.746*SL + 0.068 (r^2=0.991). The relationship between shell height (SH) and total weight (TW; g) was TW = 0.0005 SH*2.9878 (r^2=0.985). For describing growth of this species, a von Bertalanffy growth model was adopted. The von Betralanffy growth parameters estimated by a non-linear method were SH_∞=55.32mm, K=0.193/year, and t_0=-1.317 year.

BIO-P-6734

Phytoplankton dynamics and primary production of the Yellow Sea in winter and summer

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The Yellow Sea is a shelf sea surrounded by the Korean peninsula and the eastern coast of China. Phytoplankton abundance, photosynthetic pigments, and primary productivity of the Yellow Sea were studied in January and August 2008. The vertical distribution of phytoplankton abundance and chl *a* concentration showed homogeneity in winter, but heterogeneity in summer. Chl-*a* concentrations of phytoplankton and primary production in the Yellow Sea during wintertime (mean; 0.22 ug l^{-1}, 79.5 mgC m^{-2} d^{-1}, respectively) were significantly lower than those in summer (1.24 ug l^{-1}, 721.6 mgC m^{-2} d^{-1}). The spatial distribution of phytoplankton abundance and Chl-*a* concentration showed high values in the waters near China during winter and summer. In the Chinese coastal waters, *Paralia sulcata, Skeletonema costatum, Cylindrotheca closterium* predominated in the phytoplankton biomass during wintertime. In summer, *Chaetoceros* spp., cryptomonads, *Paralia sulcata*, *Karenia mikimotoi*, and *Navicula* spp. occurred as dominant species in the waters near China. High concentrations of diatom and the dinoflagellate pigments were found in the western part of the Yellow Sea during both seasons. In winter, higher concentrations of alloxanthin, 19'-hexanoyloxyfucoxanthin and zeaxanthin were observed in the middle of the Yellow Sea than at other stations. On the other hand, highest concentrations of zeaxanthin were found in summer. The results suggested that the distribution of phytoplankton in the Yellow Sea was strongly affected by the Changjiang River in summer and Yellow Sea Warm Current in winter.

BIO-P-6771

Potential spawning behaviors of *Euphausia pacifica* in the upwelling region of the Oregon coast: A 2-D modeling exploration

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Despite *Euphausia pacifica* being the most studied euphausiid species in the northern California Current System, there remain unanswered questions about its spawning behavior that are difficult to address with field observations. *E. pacifica* eggs are most often found mid-shelf off Oregon, well inshore of the highest concentrations of adults, which reside at and beyond the shelf break. This cross-shelf gradient in population stage-structure exists despite frequent upwelling events that result in the offshore transport of surface waters, where eggs are generally presumed to be released. A temperature-based model of *E. pacifica* development is run backward in time with 2-D temperature and velocity fields from a ROMS model. Initial locations of particles are based on known locations of early larval stages in the region. Since early larvae (naupliar and calyptopid) stages are relatively nonmotile, tracking them in reverse physiological time will identify the locations and times of adult spawning. In forward time in the real ocean there is substantial mortality which is difficult to invert in backward time, so these simulations yield information on potential locations and times of female egg laying for individuals that survive to the early larval stages. A goal of the modeling is to link observations of early larval stages nearshore with gravid females offshore. We describe potential physical mechanisms, and postulate behavioral mechanisms, that could lead to the oft-observed difference in cross-shelf distributions of *E. pacifica*.

BIO-P-6839

Comparison of UV-absorbing and antioxidant activity of seaweed extracts

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Seaweed extracts are known to have various UV-absorbing and antioxidant activities. It is established that different components of the extracts cause different degrees of biological activity. Maximum antioxidant activity is found in water-alcohol extracts of all investigated seaweeds in comparison with water and alcohol (ethanol, buthanol, methanol) extracts. There is high antioxidant activity for extracts from *Alaria angusta*, *Sargassum pallidum*, *Cystosiera crassipes*, *Polysiphonia morrowii*, and *Neorhodomella larix*. Spectrophotometric research has shown the presence of UV-absorbing components in water-alcohol extracts of *Laminaria bongardiana*, *Chondrus armatus*, *Mazzaella* sp., *Tichocarpus crinitus*, and *Polysiphonia morrowii*. The peak of absorption is between 310-325 nanometers. The UV-absorbing components are found only in alcohol extracts of red seaweeds: *Chondrus armatus* and *Mazzaella* sp.

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 those covered by Topic Sessions S5, S6, S7, S8, S10 and S11.

Tuesday, October 26 (9:00-12:30), Day 1

9:00	***Introduction by Convenors***
9:05	**Jennifer L. Nielsen** Adaptive and behavioral responses to a changing climate: A genomic perspective (FIS-P-6567)
9:25	**Stewart Johnson, Marije Booman, Sophie Hubert, Brent Higgins, Tudor Borza, Jennifer Kimball, Cynthia Stone, Gary Simpson, Marlies Rise, Charles Feng, Tiago Hori, Jennifer Hall, Edward A. Trippel, Sharen Bowman and Matthew L. Rise** Atlantic Cod Genomics: Development of tools, resources and applications (FIS-P-6847)
9:45	**Anna V. Dakus** The use of molecular techniques for population genetic analysis of the Pacific herring (*Clupea pallasii*) in the northwestern Pacific (FIS-P-6861)
10:05	**Angela M. Johnson, Lorenzo Ciannelli and W. Waldo Wakefield** Effects of hypoxia on the juvenile demersal fish community structure in nearshore Central Oregon waters (FIS-P-6793)
10:25	***Coffee/Tea Break***
10:50	**Motomitsu Takahashi, David M. Checkley, Jr., Marisa N.C. Litz, Richard D. Brodeur and William T. Peterson** Responses in growth rate of larval northern anchovy to anomalous upwelling in 2005 in the northern California Current (FIS-P-6815)
11:10	**Vladlena V. Gertseva, Jason M. Cope and Sean E. Matson** Growth variability of the splitnose rockfish (*Sebastes diploproa*) in the Northeast Pacific Ocean: Pattern revisited (FIS-P-6438)
11:30	**Hye-Min Park, Jung Nyun Kim, Hae Won Lee, Byeong Gyu Hong, Jin Ho Bae, Hyeong Gi Kim and Chul-Woong Oh** Vertical distribution and reproductive aspects of caridean shrimps in the deep-water of the East Sea, Korea (FIS-P-6698)
11:50	**Tetsuichiro Funamoto, Satoshi Honda, Yuho T. Yamashita, Masayuki Chimura and Kazushi Miyashita** Distribution of walleye pollock (*Theragra chalcogramma*) larvae around Funka Bay, Japan: Relationships with environmental factors (FIS-P-6440)
12:10	**Kerim Aydin and Troy Buckley** An analysis of 30 years of seasonal and geographic variability in marine food webs through fish food habits and stable isotope analyses (FIS-P-6800)
12:30	***Session ends***

Friday, October 29 (9:00-12:40), Day 2

9:00	**Jennifer L. Boldt, Thomas W. Therriault, Marc Trudel, Tyler Zubkowski and Jake Schweigert** Recruitment strength indices for northern British Columbia stocks of Pacific herring (FIS-P-6543)
9:20	**Akihiko Yatsu** A two-stanza outbreak hypothesis for the Pacific stock of Japanese sardine during the 1970s (FIS-P-6486)
9:40	**Jung Jin Kim, William T Stockhausen, Yang-Ki Cho, Chang Sin Kim and Suam Kim** Inter-annual variability in larval dispersion of common squid *Todarodes pacificus* during the 2000s (FIS-P-6671)
10:00	**Akira Okuno, Tatsuro Watanabe, Katsumi Takayama, Naoto Honda, Koji Kakinoki and Osamu Katoh** Numerical simulation of the larval transport of snow crab *Chionoecetes opilio* in the Japan Sea (FIS-P-6585)
10:20	**Elizabeth A. Daly and Richard D. Brodeur** Shifting trophic utilization by juvenile Chinook salmon in coastal marine waters: An interdecadal perspective with implications for climate change (FIS-P-6443)
10:40	***Coffee/Tea Break***
11:00	**Beverly Agler and Greg Ruggerone** Growth of the Bristol Bay and Yukon River, Alaska, chum salmon in relation to climatic factors and inter-specific competition (FIS-P-6569)
11:20	**Bernard A. Megrey, Jason S. Link, Thomas J. Miller, Tim Essington, R. Ian Perry, Alida Bundy, Ken F. Drinkwater and Erlend Moksness** Can production models be used as a tool to examine factors that influence productivity of marine systems? (FIS-P-6718)
11:40	**Louis W. Botsford, Matthew D. Holland, J. Wilson White and Alan Hastings** Population dynamic effects of fishing and climate change on upper trophic levels in the northeast Pacific (FIS-P-6752)
12:00	**Shang Chen, Dachuan Ren, Dong Wang, Jingmei Li, Tao Xia and Guoying Du** Marine ecological capital assessment: Concepts and frameworks (FIS-P-6554)
12:20	**James R. Irvine, Kim D. Hyatt, Janelle Curtis and Ray Lauzier** Science-based ecosystem approaches under Canada's Wild Salmon Policy (FIS-P-6763)
12:40	***Session ends***

FIS Paper Session Posters

FIS-P-6435 **Elena V. Gritsay**
Effectiveness of walleye pollock fishing in the northwestern Bering Sea in 2007-2009

FIS-P-6452 **Michio J. Kishi, Kenta Awa and Takeshi Terui**
Ecosystem approach for management of chum salmon coupled with NEMURO

FIS-P-6459 **Oleg G. Zolotov**
Greenlings of the genus Hexagrammos in waters off the Kamchatka Peninsula: Distribution and some biological features

FIS-P-6469 **Sang-Rae Lee, Tae Keun Rho, Jung Hyun Oak, Tongsup Lee, Jin Ae Lee and Ik Kyo Chung**
Metagenomic approach to plankton species diversity of the East Sea of Korea

FIS-P-6495 **Eugene Samko, Nafanail Bulatov, Larisa Muktepavel, Alexander Nikitin and Alexander Kapshiter**
Use of remote sensing data to support a fishery in the Far-Eastern Seas

FIS-P-6511 **Thomas C. Kline, Jr.**
Estimating over-winter mortality of age-0 Pacific herring based on loss of energy content and implications for recruitment

FIS-P-6515 **Yu-Chun Huang and Wen-Bin Huang**
Maturation of female Pacific saury *Cololabis saira* (Brevoort) in the northwestern Pacific from the Taiwanese fishery catch

FIS-P-6582 **Takaomi Kaneko, Takashi Yamakawa and Ichiro Aoki**
Formularization and internalization of the future external diseconomies produced by present fishing activities

FIS-P-6589 **Thomas C. Wainwright and Laurie A. Weitkamp**
Climate effects and Oregon coast coho salmon: A multi-ecosystem approach

FIS-P-6599 **Hideaki Kudo, Akihiro Etoh and Masahide Kaeriyama**
Attempt to estimate spawning escapement of chum salmon, *Oncorhynchus keta*, using aerial census by radio-controlled helicopter

FIS-P-6614 **You Jung Kwon, Doo-Hae An, Keith Bigelow and Dae-Yeon Moon**
Effects of fishery factors on catch rate of bigeye tuna, *Thunnus obsesus* and yellowfin tuna, *Thunnus albacare* in the Korean tuna longline fishery

FIS-P-6615 **Hyeok Chan Kwon, Chang Ik Zhang and You Jung Kwon**
Estimation of population paramters for filefish (*Stephanolepis cirrhifer*) in the Japan/East Sea of Korea

FIS-P-6623 **Hiroshige Tanaka, Seiji Ohshimo and Chiyuki Sassa**
Trophic relationships of small pelagic fish in the East China Sea and Sea of Japan: A stable isotope approach

FIS-P-6626 **Yuichiro Kogura, James E. Seeb, Noriko Azuma, Hideaki Kudo, Syuiti Abe and Masahide Kaeriyama**
Genetic population structure of lacustrine sockeye salmon, *Oncorhynchus nerka*, in Japan

FIS-P-6629 **Alexei M. Orlov, Vadim F. Savinikh and Eugeny F. Kulish**
Pacific sleeper shark in the North Pacific: New data on distribution and size composition

FIS-P-6639 **Kevin Thompson**
Factors affecting the diets of groundfish in the Gulf of Alaska

FIS-P-6654 **Elizabeth Logerwell, Kimberly Rand and Tom Weingartner**
Arctic cod (*Boreogadus saida*) and snow crab (*Chionoecetes opilio*) distributions relative to oceanography in the Alaskan Beaufort Sea, August, 2008

FIS-P-6672 **Ryuji Yukami, Mari Yoda, Seiji Ohshimo and Hiroshige Tanaka**
Stock size fluctuations in chub and spotted mackerel in the East China Sea and Sea of Japan from 1973 to 2008

FIS-P-6687 **Nancy D. Davis, Robert V. Walker and Katherine W. Myers**
Factors affecting winter survival of Chinook salmon in the Bering Sea: Start of a new investigation

FIS-P-6700 **Tao Xia, Shang Chen, Li Wang, Dachuan Ren and Min Wang**
A software for marine ecosystem services assessment: Main functions and application

FIS-P-6706 **Hector D. Douglas III, Alan M. Springer, Suzanne Budge, Igor Ermakov and Werner Gellermann**
Discriminating variation in consumption patterns and carotenoid content of juvenile Pacific Salmon with fatty acid analysis and Raman spectroscopy

FIS-P-6710 **Ji-Hyeon Kim, Jung Nyun Kim, Tack-Yoon Oh, Jin Ho Bae, Hyeong Gi Kim and Chul-Woong Oh**
Age, growth and reproductive biology of Filefish *Tamnaconus modestus* in the Southern Sea of Korea

FIS-P-6714 **Sukgeun Jung and Il Su Choi**
Estimating abundance of Pacific cod (*Gadus macrocephalus*) by applying a mark-recapture method during the spawning season in Jinhae Bay, Korea

FIS-P-6732 **Heui Chun An, Bong Seong Bae, Kyoung Hoon Lee, Chang Doo Park and Chae Sung Lee**
Evaluation of LED fishing lamps for jigging and angling boats

FIS-P-6738 **Jae Bong Lee, Soo Jeong Lee, Jong Hee Lee, Young Jae Shin, Yeong Min Choi, Dong Woo Lee and Chang Ik Zhang**
Seasonal variations in the composition of fisheries resources in the coastal ecosystem of Youngil Bay, Korea

FIS-P-6742 **Jong Hee Lee, Jae Bong Lee and Chang Ik Zhang**
Forecasting variations of fishery and ecosystem risk indices for large purse seine and two-paired trawl fisheries in Korean waters using IFRAME

FIS-P-6783 **Graham E. Gillespie, Antan C. Phillips and Lindsay C. Orr**
Population dynamics and biological characteristics of the invasive European green crab, *Carcinus maenas*, in British Columbia, Canada

FIS-P-6784 **Tatiana Tunon and Gottfried Pestal**
Authorship patterns in 30 years of DFO research documents: Is applied fisheries research like other science?

FIS-P-6785 **Gottfried Pestal and Tatiana Tunon**
Visualizing a complex spawner-recruit model for sockeye salmon

FIS-P-6804 **Jung Hyun Lim and Chang Ik Zhang**
Estimation of population ecological characteristics of Thomas's rapa whelk, *Rapana venosa*, along the west coast of Korea

FIS-P-6809 **Hee Won Park and Chang Ik Zhang**
Study on the ecological characteristics of *Mugil cephalus* in waters south of Korea

FIS-P-6810 **Soo Jeong Lee, Hyeok Chan Kwon, Sang Cheol Yoon, Yeong Min Choi and Chang Ik Zhang**
Age and growth of *Gomphina veneriformi* along the east coast of Korea

FIS-P-6825 **Jae Bong Lee, Young Jae Shin, Jong Hee Lee, Yeong Min Choi, Jae Seong Lee, Dong Woo Lee and Inja Yeon**
Spatial biomass distribution of *Corbicula japonica* in the Seomjin River of southern Korea

FIS-P-6854 **Hyun Jeong Lim, Kwang Jae Park, Sang Ho Baik, Tae Seek Lee, In Kwon Jang, Hyun Sob Han and Phillip R. Mundy**
Recovery of the productivity of shellfish aquaculture in the Western Sea of Korea after the *Hebei Spirit* oil spill

FIS-P-6870 **Theresa A'mar**
Incorporating ecosystem forcing through predation into a management strategy evaluation for the Gulf of Alaska walleye pollock (*Theragra chalcogramma*) fishery

FIS Paper Session Oral Presentations, Day 1

26 October, 9:05 (FIS-P-6567)

Adaptive and behavioral responses to a changing climate: A genomic perspective

Jennifer L. **Nielsen**

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Our new and ever increasing knowledge of fish genomes is opening a different perspective on local adaptation that will prove invaluable in fish conservation and management. Functional genomics and gene expression have been linked to physiological traits associated with important characteristics in many organisms, including commercially important fishes. Genomic analyses can document critical adaptive responses at the organism and population levels. Behavioral genomics can open new perspectives on life history diversity and phenology in fishes facing a warming climate. The conservation of fish stocks is rapidly incorporating new genomic research on the affects of human disturbance and harvest. This presentation will review current genomic research in fisheries focusing on differences in functional genes and gene expression among phenotypes and within or across populations. New and evolving genomic information is critically important to the conservation of fish and their relationship to humans.

26 October, 9:25 (FIS-P-6847)

Atlantic Cod Genomics: Development of tools, resources and applications

Stewart **Johnson**[1], Marije Booman[2], Sophie Hubert[3], Brent Higgins[3], Tudor Borza[3], Jennifer Kimball[4], Cynthia Stone[3], Gary Simpson[3], Marlies Rise[2], Charles Feng[2], Tiago Hori[2], Jennifer Hall[2], Edward A. Trippel[5], Sharen Bowman[3,6] and Matthew L. Rise[2]

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The Genome Canada-funded "Atlantic Cod Genomics and Broodstock Development Project" (CGP) has developed an extensive set of genomics tools for this species (www.codgene.ca). These include a large set of expressed sequence tags (ESTs), markers such as microsatellite sequences and single nucleotide polymorphisms (SNPs) and a 20K element oligonucleotide microarray. ESTs were generated from normalized and subtracted libraries developed using various tissues isolated from fish of a variety of ages from two geographical regions. These included fish that were stimulated with antigens (bacterial and viral-like) or exposed to stressors such as elevated temperature. Unique sequences were screened to identify microsatellites, with contigs analyzed to identify single nucleotide polymorphisms (SNPs). Sequences used in microarray design included those with informative annotation (both contigs and singletons), followed by sequences with similarity to database entries of unknown function. Other sequences were selected based on criteria such as known sequence directionality and degree of representation within our sequence database. Recently, we applied the microarray to examine the transcriptome responses of cod spleen to stimulation with formalin-killed atypical *Aeromonas salmonicida.* The results obtained from this study compare favorably with our SSH study that utilized the same cod spleen samples and demonstrates the value of this microarray as a tool for Atlantic cod functional genomics research. This presentation will provide an overview of our activities and illustrate how such resources can be applied in an integrated manner to investigate traits of importance such as disease resistance, tolerance to temperature and other stressors, and harvest traits.

26 October, 9:45 (FIS-P-6861)

The use of molecular techniques for population genetic analysis of the Pacific herring (*Clupea pallasii*) in the northwestern Pacific

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Molecular techniques are widely used in genetic identification of various marine species and populations. We applied restriction fragment length polymorphism of the 16S rRNA gene of mitochondrial DNA (mtDNA) with the purpose to reveal intraspecific genetic variation and differences among spawning aggregations of the Pacific herring (*Clupea pallasii*) from the Sea of Okhotsk, western Bering Sea and northern Japan Sea. Variation was revealed at the 16S rRNA gene of mtDNA after digesting amplified fragment with three restriction enzymes (RsaI, BsuI, HhaI). Mean haplotype diversity was high (0.747), and mean nucleotide divergence between samples was rather small (0.000513). Haplotype frequencies varied greatly, and heterogeneity among herring samples has been observed. Genetic variability was the highest in herring spawning areas along the northwestern Sakhalin, somewhat lower in fish from the northern Okhotsk Sea, and the lowest in samples from the western Bering Sea. Unique haplotypes, found in some samples, could be used as markers for identifying herring caught on the high seas, *e.g.*, from wintering or foraging aggregations.

26 October, 10:05 (FIS-P-6793)

Effects of hypoxia on the juvenile demersal fish community structure in nearshore Central Oregon waters

Angela M. **Johnson**[1], Lorenzo Ciannelli[1] and W. Waldo Wakefield[2]

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Nearshore Central Oregon waters provide necessary juvenile habitat for a variety of fishes including several species of flatfish, rockfish, sculpin, and poacher. Over the past decade these waters have seen an increase in nearshore hypoxia induced by coastal upwelling. Studies have shown that exposure to low dissolved oxygen (DO) can have negative impacts on fishes including but not limited to decreased metabolic rates, increased predation risk, decreased prey capture, and changes in community structure. In this study, we explored the effects of DO on catch per unit effort (CPUE), diversity, and body condition of several juvenile demersal species of fish off the Central Oregon Coast. Samples were collected during three years (2008-2010) at four stations along the Newport Hydrographic Line over four different depths (from 30 to 80 m) using a 2 m-wide beam trawl with a 3 mm mesh codend. Using multivariate and univariate statistical approaches data were inspected for evidence of changes in community composition, species abundance patterns, individual body size and conditions in relation to varying levels of DO. Additional variables included in the analysis are depth and distance from shore and water temperature. Our results will help to understand the impacts that low DO may have on juvenile demersal species and their subsequent adult populations.

26 October, 10:50 (FIS-P-6815)

Responses in growth rate of larval northern anchovy to anomalous upwelling in 2005 in the northern California Current

Motomitsu **Takahashi**[1], David M. Checkley, Jr.[2], Marisa N.C. Litz[3], Richard D. Brodeur[4] and William T. Peterson[4]

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The onset of upwelling was anomalously delayed 2-3 months in 2005, resulting in warm SSTs, low productivity, and recruitment failure across many trophic levels in the northern California Current. We examined variability in growth rate during early life stages of northern anchovy in response to physical and biological environments in 2005. Late larval and early juvenile anchovy were collected using a midwater trawl net in August, September and October off Oregon and Washington. Hatch dates of the larval northern anchovy ranged from late May to early September with a peak in mid July based on the number of otolith daily increments. Widths of otolith daily increments during the larval stage were standardized at their formation dates to zero mean and unit deviation as a proxy for seasonal variability in somatic growth rates. The standardized increment width was negatively correlated with SST at NOAA buoy 46050, but positively correlated with biomass of neritic cold-water copepod species caught at the Newport Line Station NH-5. To distinguish effects of temperature and prey concentrations on growth rate, absolute increment widths of larval northern anchovy hatched in July 2006 were compared to those hatched during the same period in 2005, because the larvae in 2006 were considered to experience higher food availability than those in 2005 under similar temperature conditions. The absolute increment width in 2005 was significantly smaller than those in 2006. Our results suggest that delayed upwelling in 2005 resulted in low food availability and consequently a reduced larval growth rate of northern anchovy in the coastal waters off Oregon and Washington.

26 October, 11:10 (FIS-P-6438)

Growth variability of the splitnose rockfish (*Sebastes diploproa*) in the Northeast Pacific Ocean: Pattern revisited

Vladlena V. **Gertseva**[1], Jason M. Cope[2] and Sean E. Matson[3]

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Understanding patterns of somatic growth within populations greatly contributes to fisheries stock assessment and helps determine the proper model structure. Splitnose rockfish was reported as having a striking pattern of latitudinal growth variability from studies conducted in the 1980s. We investigated variation in growth parameters of splitnose rockfish by latitude using recent data from the NOAA Fisheries Groundfish Survey (2003-2008), current ageing techniques and advanced modeling and statistical methods to provide an updated understanding of growth along this species' latitudinal range. Age data generated from sectioned otoliths was fit to a von Bertalanffy growth function incorporating ageing error. Growth parameters were estimated for each of five International North Pacific Fisheries Commission areas along the U.S. west coast. Generalized linear models and Akaike's Information Criteria were used to evaluate hypotheses for growth parameter relationship with latitude. We found that splitnose rockfish exhibited a cline in asymptotic length (L_∞) with L_∞ increasing with rising latitude. We also found that although the growth coefficient (k) was smallest in the Conception INPFC area, there was no apparent cline along the coast; a northward cline in k has previously been reported in the literature. We propose that differences in fishing intensity could be responsible for cline in L_∞, as higher fishing pressure in the south could skew the size distribution of the population in that region, and reduce southern L_∞ estimates. We also attribute slower growth in the Conception area to the oceanographic characteristics and low productivity of the area south of Point Conception.

26 October, 11:30 (FIS-P-6698)

Vertical distribution and reproductive aspects of caridean shrimps in the deep-water of the East Sea, Korea

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We investigated distributional patterns of deep-water shrimps in the East Sea. The distribution of the deep-water shrimps showed significant differences by depth. Shallow-dwelling species, *Neocrangon communis* and *Pandalus eous*, occurred at similar depths, but the distributional range of the former was wider. Of deep-dwelling species, *Argis toyamaensis* and *Eualus biunguis*, the latter exhibited a narrow depth range at the deepest depths of all species in the East Sea. Significant differences in sex ratio by depth were found; more females than males were found at all depths except in the case of *P. eous.* A size-related bathymetric distribution was observed for all shrimps. For example, large ovigerous females of crangonid species, *N. communis* and *A. toyamaensis* were mainly distributed in shallow waters (300-400 m), but for pandalid (*e.g.*, *P. eous*) and hippolytid species (*e.g.*, *E. biunguis)*, large ovigerous females were distributed in deep water (700 and 800 m, respectively). The percentage of ovigerous females of both *N. communis* and *P. eous* females increased at shallow depths during winter. The proportion of females of both species in advanced stages of ovarian development (mainly spent stage) peaked at 300 to 400 m and decreased dramatically with increasing depth. These results suggest that females had already laid eggs at shallow depths (300-400 m) and that ovigerous females migrate to shallow water for hatching. On the other hand, ovigerous females of deep-dwelling species, *A. toyamaensis,* and *E. biunguis,* were more widely distributed over all depth ranges. In the case of *A. toyamaensis* the gonadosomatic index did not vary significantly with depth. We suggest that shrimp life-history strategy is determined by many environmental factors associated with depth and that the four species studied were primarily distributed at optimal depths for their reproductive strategies.

26 October, 11:50 (FIS-P-6440)

Distribution of walleye pollock (*Theragra chalcogramma*) larvae around Funka Bay, Japan: Relationships with environmental factors

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The Japanese Pacific stock (JPS) of walleye pollock is one of the most valuable commercial fish stocks in Japan, and the majority of spawning occurs in the waters adjacent to the mouth of Funka Bay from December to March. Eggs and larvae are transported into the bay, and juveniles remain in the bay until approximately June. To understand a detailed distribution of JPS larvae and its determinants, we conducted acoustic trawl surveys around Funka Bay in April 2007 to 2009. Oceanographic conditions were concurrently monitored by XCTD casts. Most fish were composed of larval pollock (10-30 mm) for all trawls, so acoustic backscatter at 38 kHz was attributed to these larval pollock. In 2007 and 2009, warm, high-salinity water characterized the inner bay over which larval pollock were widely distributed. In contrast, the southern part of the bay was dominated by cool, low-salinity water in 2008, and larval pollock aggregated in the northern part of the bay. Few pollock were found in waters <3.5°C across all years. It is likely that the distribution of JPS larvae around Funka Bay is under the control of small-scale environmental variability. We also estimated the approximate number of pollock larvae in the survey area.

26 October, 12:10 (FIS-P-6800)

An analysis of 30 years of seasonal and geographic variability in marine food webs through fish food habits and stable isotope analyses

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The ecology of marine food webs has been an area of active research in Alaska, particularly with respect to the management of marine fisheries. Food web analyses have played a role in managing fisheries for species, such as walleye pollock, which are also an important prey for many predators, and in monitoring ecosystem function (*e.g.* the trophic level of the catch) and in modeling and predicting ecosystem responses to climate change. Over the last 30 years, the Alaska Fisheries Science Center has collected data from over 500,000 groundfish stomachs, which has contributed to these efforts. Here, we present a synthesis of much of these data. In particular, we compare a new study of stable isotope ($d^{13}C$ and $d^{15}N$) samples of 26 marine fish and invertebrate species (1,425 samples) with 30 years of seasonal diet data collected from fish stomachs. Stable isotope samples from groundfish livers show fine-scale biogeographic patterns and seasonal food web variation between the Bering Sea and Gulf of Alaska, while the analysis of muscle tissue provides a more integrated picture across a feeding season. The analysis points to differences in food chain length by region and by habitat, which is not easily detected by gut contents analysis. Model simulations show that these differences may have critical effects on assumptions about the overall stability of marine food webs and may impact assumptions on turnover rates, seasonal cycles (*i.e.*, the timing of the seasonal switch of fish from planktivory to piscivory) and ultimately the production of important commercial species.

FIS Paper Session Oral Presentations, Day 2

29 October, 9:00 (FIS-P-6543)

Recruitment strength indices for northern British Columbia stocks of Pacific herring

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Pacific herring comprise economically important fisheries in British Columbia (BC), Canada. There are five major migratory stocks of herring in BC, three in the north and two in the south. Offshore summer surveys have been conducted off the west coast of Vancouver Island, a summer feeding area used by both southern stocks, since the early 1990s. Results from this survey have been utilized successfully to predict the recruitment of age 3 fish to these two stocks and information is incorporated into stock assessment and management advice. No such survey, however, exists for northern BC stocks and recruitment strength is based on model estimates of the pre-fishery biomass in the previous year. Surveys for groundfish and salmon stock assessments are conducted on a semi-annual or seasonal basis in northern BC and herring comprise a portion of bycatch in these surveys. These data sources were explored for the potential to provide indices of herring recruitment strength for the three northern stocks. Estimates of recruitment strength are based on the relationship between pre-recruit herring in summer feeding aggregations (age 2+ fish) and recruit fish (age 3 herring) present on the spawning grounds (as sampled in herring test fisheries). Initial results indicate that some of the survey data can be utilized to successfully predict recruitment strength to the three northern BC herring stocks. Improvements in our ability to predict recruitment strength has the potential to enhance stock assessment and management advice.

29 October, 9:20 (FIS-P-6486)

A two-stanza outbreak hypothesis for the Pacific stock of Japanese sardine during the 1970s

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The 1976 climate regime shift is often attributed as a cause of the outbreak of Japanese sardine, as well as the collapse of Peruvian anchovy. The population dynamics of the Pacific stock of Japanese sardine are associated with dynamics of the Aleutian Low, condition of Oyashio and winter SST of the Kuroshio Extension South Area (KESA). The LNRR (LN Residuals of annual Recruitment from a Ricker stock-recruitment curve), an indicator of reproductive success of this stock, drastically increased in the early 1970s associated with the strong 1972 year class. The LNRR remained positive until 1988, coincided with periods of cool SST in KESA and a deeper mixed layer depth (MLD) of Kuroshio Extension, despite a shift in the Aleutian low, PDO and Oyashio expansion in association with the 1976 regime shift. On the basis of recent findings on the dynamics in the Kuroshio and Kuroshio Extension (KE) since 1960s and "old" knowledge on the geographic transition of spawning and fishing grounds of sardine along the Pacific coast of Japan, the following two-stanza outbreak hypothesis is proposed. Stage 1 (between the 1970 and 1976 regime shifts): spin-down of Kuroshio and wakening of winter monsoon causing the nearshore straight path of the Kuroshio and cooling of Kuroshio and KE, which formed favorable prey conditions for larval and juvenile sardines, thus increasing LNRR although biomass was below 0.5 million tons. Stage 2 (between the 1976 and 1988 regime shifts): spin-up of Oyashio caused the southward expansion of subarctic waters and provided wider feeding habitats for juvenile and adult sardines, which, together with cool and deeper MLD conditions of KE, resulted in positive LNRR, high carrying capacity, and finally a peak of biomass (20 million ton) in 1988.

29 October, 9:40 (FIS-P-6671)

Inter-annual variability in larval dispersion of common squid *Todarodes pacificus* during the 2000s

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To examine the horizontal distribution pattern and transport process of common squid larvae, surveys were conducted in the northern East China Sea and Korea/Tsushima Strait during July 2006-2008. Most larvae occurred southeast of Jeju Island and north of Kyushu Island. Larval abundance was highest along the inshore edge of the frontal zone (18-20°C), where the Tsushima Warm Current and inshore waters meet. A Regional Ocean Modeling System (ROMs) based on reanalyzed data, was applied to investigate transport processes and distributional patterns of eggs and larvae of common squid from spawning to nursery areas. We modified the particle-tracking module of the three-dimensional circulation model for the northwest Pacific to incorporate simple larval behaviors such as diel vertical migration. We used the model to simulate dispersal of common squid larvae during the summer spawning season. To estimate the origin of common squid larvae southeast of Jeju Island and north of Kyushu Island, particles were released at the each sampling position and were transported backward for 7 to 30 day, taking into account larval growth rate. Based on this backward experiment, particles were released at the inferred spawning area and tracked for 90 days. We also addressed intra- and interannual variability in dispersal by repeating the simulations with larval releases occurring during different seasons and years for in the 2000s.

29 October, 10:00 (FIS-P-6585)

Numerical simulation of the larval transport of snow crab *Chionoecetes opilio* in the Japan Sea

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Snow crab *Chionoecetes opilio*, which inhabits the Japan Sea, is one of important fishery resources in Japan. Abundance of the Japanese snow crab shows significant spatio-temporal variation. Although the mechanism underlying such variation has not been clarified yet, we hypothesized that yearly larval transport of the crab may trigger spatio-temporal variation in crab abundance. Thus, we developed a system for Lagrangean (particle tracking) simulation of the larval transport of the crab in the Japan Sea, utilizing data produced by an operational ocean prediction system called JADE (Japan sea Data assimilation Experiment). First, we tried simulating the larval transport in 2009 with a single particle-source domain, which includes the recent main hatching ground (Oki Spur), and compared results with the surveyed megalopal distribution in June, 2009. Qualitatively, the simulation reproduced the observed characteristics of the megalopal distribution. That is, megalopae were concentrated along the Tsushima Warm Current and its meandering eddies, and the swimming depth of megalopae was deeper in the eastern half of the surveyed area. Then, we carried out the same simulation for other years (from 1999 to 2008). It was revealed that the larval transport of the crab is strongly affected by the path variation of the Tsushima Warm Current and eddy activity, and shows significant yearly variation. Furthermore, it was suggested that the subsurface counter current beneath the Tsushima Warm Current could be important for the success of local reproduction of the Japanese snow crab.

29 October, 10:20 (FIS-P-6443)

Shifting trophic utilization by juvenile Chinook salmon in coastal marine waters: An interdecadal perspective with implications for climate change

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The diets and feeding intensity of yearling Chinook salmon (*Oncorhynchus tshawytscha*) caught early in their marine residence were examined during two oceanographically contrasting time periods (1980-1985 and 1998-2006). Interdecadal shifts in their prey composition were detected, as well as changes in the total amount of food eaten. Yearling Chinook salmon ate more fish prey in the 1980s compared with more recent samples, and these results were similar to an interdecadal diet comparison made on juvenile coho salmon. When we examined diet composition relative to sea surface temperature (SST), our results show a significant shift in prey composition and stomach fullness. During colder years, stomachs had less food and prey composition exhibited more lipid-rich prey such as Pacific sandlance and sculpins. Chinook salmon ate significantly more food during warmer years and prey of lesser quality such as juvenile rockfishes. Eating more food during warmer oceanographic conditions may reflect higher bioenergetic and metabolic demands due to the warmer ocean temperatures. Comparing diet changes between years and decades under variable ocean conditions may help to understand the effects of warming ocean conditions on trophic habits of juvenile Chinook salmon and their survival in the ocean environment.

29 October, 11:00 (FIS-P-6569)

Growth of the Bristol Bay and Yukon River, Alaska, chum salmon in relation to climatic factors and inter-specific competition

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Questions remain about how ocean climate shifts influence salmon survival and abundance. In addition, questions exist regarding the ocean's capacity to support the large number of hatchery salmon released each year in addition to wild salmon, and recent studies have documented trends toward smaller adult salmon. These questions are difficult to examine because sampling salmon at sea is difficult, and few long-term time series exist. We present results of recent studies designed to test hypotheses related to how climatic factors affect growth of chum salmon in western Alaska and whether interactions with Asian pink salmon have affected the growth of these salmon. We created indices of growth for age 0.3 and 0.4 Bristol Bay and Yukon River chum salmon by year (mid 1960s–2006) by measuring annual and seasonal growth. We examined the relationship between growth and the Pacific Decadal Oscillation (PDO), as well as the effect of Asian pink salmon abundance on growth. Generalized linear modeling indicated a significant positive correlation between the PDO and pink salmon abundance and the first year of growth and a negative correlation between the PDO and pink salmon abundance on the third year of growth. During the first and third growth years, there was a significant interaction between the PDO and the abundance of pink salmon. Use of a general additive model yielded similar results. These studies provide examples of how scale measurements can be used to reconstruct salmon growth trends in the ocean as a means to test otherwise problematic hypotheses.

29 October, 11:20 (FIS-P-6718)

Can production models be used as a tool to examine factors that influence productivity of marine systems?

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Given the inherent complexity and large scale of marine ecosystems, progress toward understanding how marine ecosystems influence and regulate patterns of fisheries production requires a comparative approach. We present the results of an international workshop focused on applying various surplus production model configurations as a tool for ecosystem comparison with the goal to answer the question — how does ecosystem structure and function interact to support fisheries production, and what processes amplify, dampen or obstruct the production that ecosystems provide? Our workshop goal was to understand how multiple drivers of productivity in fishery ecosystems simultaneously interact to determine overall production levels. These drivers reflect the triad of factors influencing fisheries production including fisheries, the environment, and trophodynamics. In this presentation, we describe a common methodological framework (*i.e.*, surplus production models) that span several levels of taxonomic aggregation for several species and communities from several marine ecosystems and examine model outputs from multiple production modeling packages. The methodology was applied to 10 northern hemisphere ecosystems. We estimate management-relevant metrics and ecosystem attributes and compare them across populations and ecosystems. We also describe the utility of applying surplus production models in single-species, multi-species, and aggregate species group frameworks. We conclude by elucidating challenges of fitting such modeling approaches to similar species or functional guilds in contrasting arrangements (different species within ecosystems and similar species between ecosystems) to better delineate what controls ecosystem fisheries production. Implications of our results for future work relevant to operational oceanography, population and community modeling, and ecosystem-based fisheries management are discussed.

29 October, 11:40 (FIS-P-6752)

Population dynamic effects of fishing and climate change on upper trophic levels in the northeast Pacific

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Projection of the effects of climate change on harvested upper trophic levels in the Northeast Pacific will require accurate predictions of the combined effects of fishing and a changing climate on these age structured populations. In research on population dynamics, there is increasing appreciation for the selective sensitivity of age-structured populations to variability on specific time scales. The cohort resonance effect in age structured populations with density-dependent recruitment involves greater sensitivity to variability on time scales near the dominant age of spawning and very slow time scales (*i.e.*, trends). Moreover, it has recently been shown to produce greater variability with increased fishing, an effect that needs to be considered in future projections of climate effects. Here we describe the implications of the cohort resonance effect on fish species in the northeast Pacific in the context of biological data from several salmon and ground fish species and physical data from the Pacific Decadal Oscillation and the North Pacific Gyre Oscillation.

29 October, 12:00 (FIS-P-6554)

Marine ecological capital assessment: Concepts and frameworks

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Concepts and assessment frameworks of marine ecological capital (MEC) are developed based on natural capital and ecosystem service theories. The MEC consists of marine living organisms and their habitat and the whole marine ecosystem, which provide benefits for mankind. The value of MEC includes includes both the value of standing stock of marine ecological resources as well as the value of marine ecosystem services. The former is defined as the monetary value of the standing stock of marine ecological resources with a market price set at a specific point in time. Three resources with market-price are recommended for valuation: marine living resources (fish, shellfish, shrimp, crab, seaweed *etc.*), seawater (*e.g.* for cooling) and chemical elements (K, Mg, Cl, Br, salt *etc.*), and surficial sea floor resources (*e.g.* sand). The value of marine ecosystem services includes the value of provisioning, regulating, cultural and supporting services during a specific period of time. Provisioning services are material products provided by the marine ecosystem, including production of food, raw material, and oxygen and provisioning of genetic resources. Regulating services are the benefits obtained from the regulation of ecosystem processes, including climate regulation, waste treatment, disturbance regulation and biological control. Cultural services are the nonphysical benefits obtained from ecosystems, including recreational activities, scientific services, and cultural activities. Supporting services are those that are necessary for the production of all other ecosystem services, including primary production, nutrient cycling and species diversity maintenance. They are different from provisioning, regulating and cultural services in that their impacts on people are often indirect or occur over a very long time. The assessment frameworks are developed to calculate the value of each element of MEC and total value.

29 October, 12:20 (FIS-P-6763)

Science-based ecosystem approaches under Canada's Wild Salmon Policy

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Canada's 2005 policy for the conservation of wild Pacific salmon includes three science-based strategies that assess risks to salmon, their habitats, and ecosystems in a socially neutral way. Monitoring and assessment information are integrated into a structured-decision-making process to manage human activities at appropriate temporal and spatial scales. The ecosystem strategy commits to developing an approach to monitor and assess the structure (*e.g.*, species compositions, trophic structure) and function (*e.g.*, productive capacity, multiple trophic-level processes) of salmon-associated ecosystems. Here, we propose a framework to set operational objectives for the various sectors that Fisheries and Oceans Canada has at least partial jurisdiction over (fishing, fish cultivation, habitat perturbations) within each of the major ecosystems frequented by anadromous salmon (open ocean, coastal, estuarine, fresh water). Ecosystem indicators link to operational objectives and refer back to the sectors that reflect top-down effects (*e.g.*, fishing), bottom-up effects (*e.g.*, enrichment), and lateral interactions (*e.g.*, competition). Once benchmarks have been identified for the indicators, many of which are already being monitored, they will allow managers to assess whether operational objectives are being met. Indicators can often be linked to multiple objectives, improving their affordability and information content. Reference states can vary among ecosystems. For instance, for some ecosystems society may choose a relatively undisturbed and pristine state, while in other instances, an ecosystem much more impacted by humans may be deemed as desirable. This science-based ecosystem approach is being evaluated in Barclay Sound on the West Coast of Vancouver Island, prior to more wide-spread implementation.

FIS Paper Session Posters

FIS-P-6435

Effectiveness of walleye pollock fishing in the northwestern Bering Sea in 2007-2009

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In the northwestern Bering Sea (area from 170°E to 175°W) two pollock stocks are exploited – the western Bering Sea population is harvested west of 174-176°E and the eastern Bering Sea population is harvested east of 174-176°E (Navarin area). Historically, the biomass of two populations differed significantly, which reflected on fishing efficiency in these areas. In recent years the western stock gradually began to recover, and the eastern stock has fallen to its lowest level in the last 30 years. In 2007 in area west of 174°E catch per unit effort (CPUE) of Russian factory trawlers was 16.2% higher than in the Navarin area. In 2008 the CPUE in both areas declined by 31 and 19%, respectively. In 2009, the CPUE in the western area was increased slightly (4.7%), whereas CPUE in the Navarin area continued to decline. The 2006 year class (3-years-old in 2009) was most abundant among commercially permitted size pollock in Navarin area, resulting in the smallest average fish length in the catch over the last fifteen years. The total scale of pollock migration into Russian waters reduced last years.

FIS-P-6452

Ecosystem approach for management of chum salmon coupled with NEMURO

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The suitable release number of Hokkaido chum salmon was calculated based on an "Ecosystem approach". The constraining condition is the carrying capacity of North Pacific Ocean, which is calculated by a two-way version of NEMURO (*i.e.*, the prey density = ZP and ZL in NEMURO, decreases by grazing by fish) and the cost function is total income of fishermen. The unit price of chum salmon, which is used to calculate a cost function, is determined by empirical data as a function of return ratio. We modeled the competition of chum and pink salmon for prey. NEMURO, which is lower trophic model of North Pacific, coupled with physical model, was used to calculate prey density and to predict wet weight of salmon. Observations indicate a decline in the number of salmon. Results indicated that present release numbers are under current conditions.

FIS-P-6459

Greenlings of the genus Hexagrammos in waters off the Kamchatka Peninsula: Distribution and some biological features

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Five species of the Hexagrammidae family occur in waters off Kamchatka: one of the genus *Pleurogrammus* (Atka mackerel *P. monopterygius*) and four of the genus *Hexagrammos* – rock greenling *H. lagocephalus,* fringed greenling *H. superciliosus,* masked greenling *H. octogrammus,* whitespotted greenling *H. stelleri*. Very little information is available about *Hexagrammos* spp. Their biology in Kamchatkan waters was poorly studied till present. In our work we distinguished two species as is common practice in Russia system – fringed greenling *H. superciliosus* and rock greenling *H. lagocephalus*; an alternative interpretation elsewhere considers them as a single species. In Russian Far East waters *H. superciliosus* is usual around the Commander Islands, but there are only two catch records of this species near the mainland coast. The distribution and some biological features of greenlings were analyzed. Masked greenling is a typical bottom fish spending its entire life in nearshore waters no deeper than 20 m. Whitespotted greenling is more eurybenthic, inhabiting not only rocky substrates, but also sand-pebble grounds from the shoreline up to 70-90 meters. The rock greenling is the largest and most abundant representative of the genus. The species prefers rocky substrates and is extremely eurybenthic; its depth range varies from 1-2 m during the spawning period in summer up to 665 m in winter. Bottom trawl surveys were used to calculate an approximate estimate of rock greenling biomass.

FIS-P-6469

Metagenomic approach to plankton species diversity of the East Sea of Korea

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Waters of the euphotic zone of the East Sea of Korea are a mixture of various origins, namely coastal waters, Tsushima warm current and upwelled cold waters, which seem to be sensitive to imminent climate change. Classical physicochemical approaches were not enough to delineate the effect of different water masses on plankton geography. In this study, plankton species diversity was evaluated as biological indicators of environmental factors. Total genomic DNAs were extracted directly from seawater samples and 18S rDNA clone libraries were constructed using environmental PCR, cloning and sequencing. Results show the high species diversity with new

taxonomic lineages, as well as species diversity specific to distinct water masses. We would like to suggest that the metagenomic analysis is a novel, quantitative method to monitor plankton species diversity, and can provide refutable information about environmental variability in aquatic ecosystem associated with climate change.

FIS-P-6495

Use of remote sensing data to support a fishery in the Far-Eastern Seas

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The application of remote sensing data to sustain fisheries in the Far-Eastern Seas is presented. We used infrared images to describe in detail sea surface temperature fields, along with patterns, such as fronts, currents, and eddies. The use of altimetry data makes it possible to trace some dynamic patterns more carefully. Although pelagic fish and squids concentrate at oceanic fronts extending over hundred and thousand miles, fishing grounds are formed only in rather limited areas. The question is, how to find these limited areas of commercial abundance? In well-studied regions, such as the South Kuril region, it is reasonable to assume that the fishery concentrates in areas of fish (or squid) concentrations. Satellite data in the Japan Sea were used to define the patterns favorable for a successful fishery for squid and to reveal the mechanisms of squid spatial distributions. A joint analysis of distribution of daily catches on the Japanese flying squid fishery and satellite altimetry data in Russian Exclusive Economic Zone in 2003 revealed received a strong relationship between sea level surface topography and squid grounds formation. As another example, satellite-based sea surface temperature data were used to monitor oceanographic conditions for kelp *Laminaria japonica* reproduction, revealing its dependence on activity of the Primorye current. Finally, satellite data on sea ice in the Okhotsk Sea allowed us to understand relationships between ice conditions and atmospheric circulation and to classify seasonal ice features in the main herring spawning grounds along the northwestern coast of the Okhotsk Sea for spawning forecasts.

FIS-P-6511

Estimating over-winter mortality of age-0 Pacific herring based on loss of energy content and implications for recruitment

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For the past two decades, recruitment of the Prince William Sound Pacific herring stock has been two to three orders of magnitude lower than what it was during the 1980s. Mortality during their first winter was posited to drive weak recruitment. Recent observations suggest that age-0 herring lose an appreciable amount of energy during the long high-latitude (~ 60° north) winter period. Energy loss between November and March was modeled using the results of forced starvation experiments (FSE) and compared to observations made in March and April. November observations were used as model initial conditions. The lowest observed FSE mortality energy value, 2.8 KJ/g wet mass, was used as the criterion for certain death (CD) whereas the highest, 3.6 KJ/g wet mass, was used as the criterion for possible death (PD). The range in modeled March energy levels >CD generally overlapped observed values. Based on the FSE loss rate of 23 J/day, the fraction of the modeled population in March between CD and PD suggested a possible mortality range between 70 and 94%. The CD and PD criteria and the FSE-based model applied to March observations suggested a further mortally of 41 to 84% before April. Therefore, age-0 mortality between November and April is >88% and potentially as high as 99%. A scenario of no mortality between November and April could thus explain a recruitment increase of one to two orders of magnitude. A strong recruitment following such a scenario needs to be observed to further this hypothesis.

FIS-P-6515

Maturation of female Pacific saury *Cololabis saira* (Brevoort) in the northwestern Pacific from the Taiwanese fishery catch

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Pacific saury *Cololabis saira* migrates widely in the northwestern Pacific and is an important commercial fish in the Far East and Taiwan. Maturity variations of female saury were examined from the Taiwanese catch among three fishing periods: May, June-July, and August-November 2009. Five maturity stages of oocytes were found, including peri-nucleolus, early cortical alveoli (CA1), late cortical alveoli (CA2), primary yolk (YF1), and secondary yolk stages (YF2). Oocyte maturity sampled at the middle of the ovary was higher than samples from the tip and end portions. The ovary diameter was not larger than 2 mm until the oocyte in the ovary had developed past the CA2 stage. At body lengths of 27-28 cm, most females were developed to the CA2 or higher stages. The highest maturity stage (YF2) was found only in the May specimens. Individuals with oocytes mainly comprised of the CA1 and YF1 stages were found in the catch of May, while the catch mainly consisted of the CA2 stage individuals in June-July and August-November. The maturity of the age-1 females were generally developed at least to the CA2 stage, while only few age-0 females had developed past the CA1 stage and were found in August-November. The oocyte diameter and gonadosomatic index of age-1 females were larger than those of age-0 females. These results indicate that maturity of age-1 female saury was higher than that of the age-0 females and no females developed to the condition of instantaneous spawning in the Taiwanese catch.

FIS-P-6582

Formularization and internalization of the future external diseconomies produced by present fishing activities

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The losses of future fishing value, which comes from recruitment overfishing and growth overfishing under present fishing activities, could be regarded as a kind of external diseconomy. We can prevent these losses to internalize them into a market mechanism by imposing corresponding Pigovian taxes as social costs. In this research, we defined and formulated these external diseconomies for theoretical quantification to impose Pigovian taxes, by applying a similar method used in previous research on optimum harvesting theory. Then, we analyzed the consequences of the Pigovian taxation and its performance as a fishery management tool by computer simulation. From optimum harvesting theory we could classify and formulate two types of future external diseconomies: the inter-generational stock external diseconomies and intra-generational stock external diseconomies. These external diseconomies vary in growth processes, so we have to impose age-based or size-based Pigovian taxes to each fish. When we assumed a deterministic stock-recruitment relationship with complete knowledge on the size of escapement required for maximizing long-term catch value, we attained the intended social optimum by Pigovian taxation. When we assumed that recruitment fluctuated by a stochastic stock-recruitment relationship, appropriate Pigovian taxation would lead to the same consequences of optimum CES (constant escapement strategy) and CHR (constant harvest rate strategy). The significance of this research is to serve a theoretical basis for catch taxes depending on fish size for effective stock management.

FIS-P-6589

Climate effects and Oregon coast coho salmon: A multi-ecosystem approach

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Coho salmon (*Oncorhynchus kisutch*) that spawn in the coastal rivers of Oregon, U.S.A., are listed as 'threatened' under the U.S. Endangered Species Act. We present an assessment of the effects of climate change on sustainability of this population group. Four distinct ecosystems are important to different life-history stages of coho salmon: terrestrial forests, freshwater rivers and lakes, estuaries, and the North Pacific Ocean. Each of these systems is affected by multiple aspects of climate change, resulting in a complex web of pathways influencing sustainability. While climate models provide quantitative estimates of likely trends for some of the physical changes, we lack sufficient understanding of the biological response to reliably quantify the effects on salmon populations and extinction risk. For this reason, our analysis is qualitative: we summarize likely trends in climate, identify the pathways by which those trends are likely to affect salmon, and assess the likely direction and magnitude of response by life history stage. While we find some positive effects, negative effects predominate at every stage. We then consider the cumulative impacts across the coho salmon life-cycle and across multiple generations. Because effects are multiplicative, small effects at individual life stages can result in large changes in the overall dynamics of populations, so we expect a strong overall negative effect. Similarly, cumulative uncertainties for life-stage-specific effects will lead to large uncertainties in future sustainability, and these uncertainties contribute to risk. Increasing risks from climate change interact with other human-caused risks, requiring strong conservation measures to sustain these populations.

FIS-P-6599

Attempt to estimate spawning escapement of chum salmon, *Oncorhynchus keta*, using aerial census by radio-controlled helicopter

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Wild salmon are important to conserve and protect species and genetic diversity of Pacific salmon (*Oncorhynchus* spp.) in Japan, although fisheries resources of chum salmon (*O. keta*) depend on hatchery programs. Needless to say, it is difficult to estimate spawning escapement of wild salmon in the river, except for equipment (*e.g.*, weir) at salmon capture sites for hatchery programs. We attempted to establish an aerial census of chum salmon escapement by radio-controlled helicopter (RC heli) in the Moheji River, located in southern Hokkaido, in 2008. In this river, all salmon were captured for hatchery programs every morning. Aerial photographs of the river were taken by the RC heli equipped with a digital single-lens reflex camera and polarized filter. To quantify the salmon density in the census area, the numbers of salmon per each aerial photograph were counted using the image analysis software (NIH ImageJ 1.36b). Salmon in the river could be recognized clearly by the photographs taken with the RC heli at an altitude of approximately 30 m. The number of salmon counted by this aerial census system (A) was significantly correlated with the number of salmon caught at the weir (W) in the river ($W=0.59A-11.9$; $r^2=0.933$, $F=83.5$, $p<0.0001$). Our results indicate that this aerial census system is an useful monitoring method for the estimation of salmon spawning escapement in Japanese rivers.

FIS-P-6614

Effects of fishery factors on catch rate of bigeye tuna, *Thunnus obsesus* and yellowfin tuna, *Thunnus albacare* in the Korean tuna longline fishery

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Korean tuna longline research cruise was conducted in the eastern and central Pacific Ocean from July 2005 to August 2007 to compare catch rates associated with different factors, including latitude, year, hook type, bait type, depth and other factors. We analyzed differences of fork length, survival and hooking location between the circle hook and tuna hook for both bigeye and yellowfin tuna. There was no difference in the mean size of yellowfin tuna caught on the two types of hook, but the difference for bigeye tuna was significant. Regarding survival, there was no difference between the two hook types, but the difference of hooking location was significant for both species. We also analyzed determinants of bigeye and yellowfin tuna catch rates using generalized linear models (GLMs). Spatial factors (latitude and longitude) and temporal factors (year and month) affected catch rates of bigeye tuna and yellowfin tuna. Depth is an additional factor that influenced catch rates.

FIS-P-6615

Estimation of population paramters for filefish (*Stephanolepis cirrhifer*) in the Japan/East Sea of Korea

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This purpose of this study was estimate biomass and population parameters useful to providing management guidance for the filefish. Estimated population parameters included growth parameters, survival rate, instantaneous natural (*M*) and fishing (*F*) mortalities, and age at first capture (t_c). We estimated monthly changes in maturity stages and gonadosomatic index (GSI). The total length (TL) at 50% group maturity ($TL_{50\%}$) was estimated. The spawning period ranged from May to August. A von Bertalanffy growth model was used to describe growth of this species. The von Betralanffy growth parameters (TL_∞, K and t_0) were estimated using non-linear methods.

FIS-P-6623

Trophic relationships of small pelagic fish in the East China Sea and Sea of Japan: A stable isotope approach

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We analyzed carbon and nitrogen stable isotope ratios ($d^{13}C$ and $d^{15}N$) of small pelagic fish and other pelagic organisms in the western Japanese waters (East China Sea and Sea of Japan) to clarify their trophic relationships. We especially focused on anchovy (*Engraulis japonicus*) as a key species in this pelagic ecosystem. Among small pelagic fish species, $d^{13}C$ and $d^{15}N$ of anchovy overlapped with those of sardine (*Sardinops melanostictus*) ($d^{13}C$: from –19 to –17 ‰, $d^{15}N$: from 8 to 11 ‰), suggesting that they have similar trophic niches. Other small pelagic fish, such as jack mackerel (*Trachurus japonicus*), chub mackerel (*Scomber japonicus*) and round herring (*Etrumeus teres*), showed positive correlations between $d^{15}N$ and body length. Moreover, $d^{15}N$ of these species were more enriched than that of anchovy and sardine even in the similar size range after the juvenile stage, implying differences in trophic level. These findings provide insights about biological processes in the stock fluctuation and species replacement of small pelagic fish. On the other hand, anchovy showed variations in $d^{13}C$

and $d^{15}N$, which are considered to be related to the "inshore-offshore" geographical variations in habitat and population structure of anchovy. With some case studies we suggest that stable isotope ratios can also be a useful tool to investigate the geographical origin and migration of anchovy in inshore waters.

FIS-P-6626

Genetic population structure of lacustrine sockeye salmon, *Oncorhynchus nerka*, in Japan

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Lacustrine sockeye salmon (*Oncorhynchus nerka*) are listed as an endangered species in Japan despite a little genetic information on their population structure. We analyzed the mitochondrial DNA (mtDNA) *ND5* region and 45 single nucleotide polymorphisms (SNPs) in 640 lacustrine salmon in Japan and 80 anadromous sockeye salmon from Iliamna Lake, Alaska, USA. The genetic diversities of the Japanese populations in both mtDNA and SNPs were significantly lower than those of the Iliamna Lake populations. In spite of low allelic variability and observed heterozygosity, the SNPs analyses showed that the Japanese populations were significantly divided into three groups. In addition, significant heterozygosity excess was observed in Tachibana Lake and the Abira River populations but not in the Shikotsu Lake within Japanese sockeye salmon. These findings suggest that: (1) all Japanese lacustrine sockeye salmon have extremely lower genetic diversity than anadromous sockeye in the North America and Russia; (2) the Shikotsu Lake population may have a slightly reduced allelic diversity associated with the reduction in population size caused by overpopulation in the 1920s, but a significant bottleneck effect did not occur; and (3) transplants of anadromous sockeye salmon eyed-eggs from the Ulmobetsu Lake population did not affected the population structure of native Japanese lacustrine sockeye salmon.

FIS-P-6629

Pacific sleeper shark in the North Pacific: New data on distribution and size composition

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Results of long-term research on spatial and vertical distribution of Pacific sleeper shark, *Somniosus pacificus*, in the North Pacific and its size composition are provided. This study is based on the analysis of datasets from the TINRO-Center (Russia) and Alaska Fisheries Science Center (U.S.A.) over 1960 to 2008. In total, 7984 captures of Pacific sleeper shark were analyzed (1031 with indication of capture depth). Size composition is based on measurements of 226 specimens caught by pelagic trawls and 684 by bottom trawls. Pacific sleeper shark attends to be associated with the bottom, because most aggregations occur over the continental shelf and slope within the area surveyed. Seasonal and long-term changes of its spatial distribution were observed. This species is most widely distributed in the North Pacific from April to September. A broad distribution of this species in the North Pacific occurred after 1990, likely associated with a recent sharp increasing of its abundance probably related to climatic changes. Within the water column, a maximum number of sleeper shark captures occurred between 100 and 300 m. Maximum number of captures near the bottom occurred between 200-700 m depths; catch rates increased with depth. During the daytime sleeper shark catches were considerably larger as compared to nighttime, perhaps indicating existence of vertical diurnal migrations. Catches of this species were taken at water temperatures between 0.5 to 7.6ºC; maximum catches were observed at temperatures around 7ºC. Mean size of sharks differed somewhat among bottom (136.0 cm) and pelagic (150.2 cm) trawl catches.

FIS-P-6639

Factors affecting the diets of groundfish in the Gulf of Alaska

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Modeling ecosystem dynamics and implementation of ecosystem management has become a research priority in marine fisheries. A wide variety of approaches have been taken to model fisheries in a multispecies framework. However, most previous efforts in modeling inter-species interactions have been somewhat restricted in the functional form of predators' foraging responses. Most commonly, a predator's functional response is assumed to depend on prey density alone (*e.g.*, the Holling functional responses). However, ecological evidence suggests that predators may also respond to other factors, such as habitat and temperature. These abiotic factors have been shown to alter behavior and activity of predators and prey. Furthermore, non-additive predation effects, in which one predator facilitates another by altering prey behavior has been illustrated in a variety of aquatic systems. The Gulf of Alaska (GOA) ecosystem is highly diverse and sustains multiple large marine fisheries. Using a time series of data on the diets of groundfish predators in this system as a case study, I investigate the importance of several abitoic and biotic environmental factors that could affect diet and predatory dynamics. Diet metrics are related to temperature, habitat type, location, and the density of competitors and other predators by using multivariate and linear regression statistical approaches. This work can then be applied to multi-species modeling frameworks by expanding the functional response forms so as to incorporate those relationships determined to be significant.

FIS-P-6654

Arctic cod (*Boreogadus saida*) and snow crab (*Chionoecetes opilio*) distributions relative to oceanography in the Alaskan Beaufort Sea, August, 2008

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In August 2008, NOAA-NMFS Alaska Fisheries Science Center, University of Alaska Fairbanks and University of Washington conducted the first offshore marine fish survey since 1976 in the Beaufort Sea, Alaska. The survey used standardized trawl gear which provided quantitative estimates of benthic fish and invertebrate abundance (catch-per-unit-effort, CPUE) and synchronously, we measured oceanographic variables such as temperature and salinity. Arctic cod was the most abundant fish species captured by weight and numbers. Arctic cod were found throughout the study area with the highest abundances occurring in the western portion of the study area at depths greater than 100 m where temperatures were less than -1°C and salinities greater than 32 psu. Snow crab was one of the dominant invertebrate species caught. Similar to Arctic cod, snow crab abundance was highest in the western portion of the study area between the depths of 100 and 500 m in cold, high salinity water. General Additive Models support the association of cod and crab with greater depth, cold temperature and high salinity. Arctic cod and snow crab apparently prefer the very cold winter water that emanates from the Chukchi Sea through Barrow Canyon and into the Beaufort Sea. We hypothesize that this water mass is rich in organic matter and would thus provide good foraging for fish and crabs.

FIS-P-6672

Stock size fluctuations in chub and spotted mackerel in the East China Sea and Sea of Japan from 1973 to 2008

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We analyzed fluctuations in stock size of chub mackerel *Scomber japonicus* and spotted mackerel *S. australasicus* in the East China Sea and Sea of Japan using cohort analyses from 1973 to 2008. The stock size of chub mackerel showed a continuous decrease, with fluctuations from 1975 to 1990. After a remarkable increase in 1992-1996, the stock size fell to its lowest level in 2000. After 2000, stock size has been increasing slightly. In contrast to chub mackerel, stock size fluctuations of spotted mackerel were relatively stable from 1973 to 2008. There are significant correlations between recruitment success (number of recruits/spawning biomass) and stock size for both species. The residuals from the linear regression between spawning success and stock size of chub mackerel were inversely correlated with sea surface temperature in the southern part of East China Sea in February. On the contrary, residuals for spotted mackerel were positively correlated with sea surface temperature in the southern part of East China Sea in January. These results suggest that stock fluctuations of both species are influenced by environmental factors, possibly through ambient water temperature during the spawning season.

FIS-P-6687

Factors affecting winter survival of Chinook salmon in the Bering Sea: Start of a new investigation

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Winter conditions in the Bering Sea are severe and most salmon species leave the Bering Sea in winter, migrating southward to the North Pacific Ocean. Western Alaska Chinook salmon (*Oncorhynchus tshawytscha*) are a well-known exception, and some northern populations spend their entire ocean life in the Bering Sea. Northern populations of Chinook salmon (*e.g.*, Yukon River) are also renowned for their high fat (lipid) content, making them a potentially valuable food resource for marine mammals, birds, fish, and humans in the Bering Sea ecosystem. High lipid storage may enhance the ability of Chinook salmon to survive prolonged periods of poor ocean conditions. We have begun a new research endeavor (first field season September, 2010) to evaluate the seasonal trophic, nutritional, and energetic status of Chinook salmon in the Bering Sea. Our goal is to identify physiological factors that affect winter survival of Chinook salmon in the Bering Sea. We outline our research plan on how we will relate interannual variation in salmon survival to the synoptic type of winter (cold or warm) and discuss the potential effects of seasonal and interannual environmental change on Chinook salmon energetics.

FIS-P-6700

A software for marine ecosystem services assessment: Main functions and application

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As a research result of the National Program of Marine Ecosystem Services Assessment in China Waters, a software for Marine Ecosystem Services Assessment was developed based on an ArcGIS Engine. The software's main functions include: (1) management of multi-source (*e.g.*, biological, chemical, physical, geological, social and economic data) and conversion into a unified data format for model calculation; (2) calculation of the value of each ecosystem service; (3) mapping of the spatial distribution of each ecosystem service and visual inspection of the spatial variation of ecosystem service; (4) overlays of spatial distribution maps of multiple services to identify

the complicated spatial characteristic of ecosystem services; and (5) display of a thematic map of ecosystem services for management and demonstration purposes. The software was used to calculate the services of the Yellow Sea ecosystem and make the spatial distribution maps and thematic maps of ecosystem services of the Yellow Sea.

FIS-P-6706

Discriminating variation in consumption patterns and carotenoid content of juvenile Pacific Salmon with fatty acid analysis and Raman spectroscopy

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The early juvenile stage is a critical phase in the life histories of Pacific Salmon. We studied variability in fatty acid (FA) composition of 51 and 65 juvenile salmon captured by BASIS cruises in 2004 and 2005, respectively. Seventy five FAs were detected in salmon. Principal Components Analysis (PCA) of these FAs discriminated salmon in interspecific and interannual comparisons, as well as intraspecific differences related to the ecoregions where the fish were caught. This complemented analysis of prey in stomach contents by providing integration of salmon diets over 2-4 weeks. We measured total carotenoids (astaxanthin + canthaxanthin) in back muscle of salmon caught in 2005 using Raman spectroscopy. Carotenoids are powerful antioxidants and important immune stimulators, and their transfer through food webs is important for the immunocompetence of higher trophic levels. We hypothesized that carotenoid abundances increase as diatoms become more important in food web productivity. Five FAs that serve as diatom biomarkers entered into a linear regression (stepwise) and together explained 68% of the variance in carotenoid among salmon. We predicted that carotenoid abundances should decrease as flagellates become more important in food web productivity. Docosahexaenoic acid (22:6n-3), a biomarker for flagellates (*e.g.*, coccolithophorids, dinoflagellates), was negatively correlated with carotenoid abundances ($r = -0.7$, $p < 0.001$, $n = 65$). Climate change with attendant warmer surface waters could result in lower quality prey resources, lower abundances of carotenoids, and greater survival challenges for juvenile salmon.

FIS-P-6710

Age, growth and reproductive biology of Filefish *Tamnaconus modestus* in the Southern Sea of Korea

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Abundance of filefish *Thamnaconus modestus*, dried as “Gi-po”, a popular snack, has decreased dramatically since 1990. The mean annual catch peaked at 250,000 t in the 1980s, declined in the 1990s, and has been approximately 2,000 t in recent years. In the most recent 5 years, most catches have been taken in winter (October to January). Major fishing gears are gillnet, trap and blanket net in coastal fisheries and fyke net and Danish seine in offshore fisheries. The recent 5-year mean percentage of juveniles in the catch were 34.7% in inshore and 0.3% in offshore fisheries (14.6% for both combined), indicating severe growth overfishing in filefish fisheries. In part to address this situation, artificial enhancement started since 2007. Biological characteristics of filefish in Korea are poorly understood. Therefore, we collected specimens near Geoje and Jeju Islands from May 2009 to April 2010. Mean size was smaller for individuals collected inshore than offshore. The length-weight relationship was $W=0.011L^{3.073}$ (n=645, $r^2=0.968$, $p<0.01$). Sex composition was 56% female and 44% male, and there was no significant difference in sex ratio inshore and offshore ($p>0.05$). The gonadosomatic index of females was high in May and June and tended to decrease starting in July. Mean fecundity was 200,000 at 22.2 cm total length (TL) and more than 1,000,000 at 25.5 cm TL. Sexual maturity occurred between age 1 and 2 yr at mean TL of 21.10 cm; the proportion mature was estimated by $P_l=1/(1+\exp(-0.34(L-21.10)))$ ($r^2=0.89$, $p<0.01$). The mean longevity is 8 yr. The estimated von Bertalanffy growth equation is $L_t=39.34*(1-\exp(-0.38(t+0.92)))$, with growth parameters

L_∞=39.34cm, k=0.38, and t_0=-0.92. Based on our results, we recommend a minimum size limit (21.10 ±2.08 cm) and a seasonal fishery closure during June to early August. Additional biological studies, especially relationships to recent climate changes, are recommended.

FIS-P-6714

Estimating abundance of Pacific cod (*Gadus macrocephalus*) by applying a mark-recapture method during the spawning season in Jinhae Bay, Korea

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We estimated the population size of Pacific cod (*Gadus macrocephalus*) during the spawning season in waters off Woipo, Geoje Island, Korea, by applying a mark-recapture method. We marked and released a total of 61 cod >50 cm in total length, among which 6 were recaptured by local fishermen during the period from December 15-31, 2009. The estimated population size and fishing mortality of the exploitable cod was approximately 180,000 and 26%, respectively. As the sample size was very small, we evaluated the uncertainty in estimates by applying a bootstrap resampling technique. The estimated 95% confidence interval was 94,000~568,000 for the population size, and 8~49% for fishing mortality. Our study demonstrated that application of mark-recapture methods and bootstrap resampling can be useful in stock assessment for fisheries management in Korea, but it requires a larger sample size, spatially extensive coverage, and more sophisticated mark-recapture models based refined sampling design for reliable stock assessment and biological reference points for sustainable cod management.

FIS-P-6732

Evaluation of LED fishing lamps for jigging and angling boats

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This research aimed to develop a highly efficient LED fishing lamp for the squid jigging and hairtail angling fishery to reduce fuel consumption and greenhouse gas emissions. Korean commercial fishing boats use a conventional metal halide lamp, which consumes fuel accounting for 65% of the total fuel consumption by the fishing boats. In this study, two kinds of LED lamps were used to investigate catch efficiency and fuel consumption. Type A was a 150W LED lamp unit with an air-cooled system installed on a 9.77-ton squid jigging boat. Type B was 120W LED lamp unit with air-cooled system installed on a 9.77-ton hairtail angling boat. Catch efficiency and fuel consumption of vessels equipped with LED lamps were compared with those with metal halide lamps during July to October 2009. Catch efficiency of vessels with the LED lamps was equal to or marginally higher than those with metal halide lamps. In addition, fuel consumption of vessels using the LED lamp was 69-70% less than that of vessels using conventional lamps.

FIS-P-6738

Seasonal variations in the composition of fisheries resources in the coastal ecosystem of Youngil Bay, Korea

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Coastal marine ecosystems provide spawning and nursery grounds for fisheries resources. Youngil Bay, located in the southwestern East Sea, is an important component of the coastal marine ecosystem of Korea. Species composition and abundance of marine organism in the Youngil Bay were investigated by season from March to November 2009. Trammel nets and traps were used to survey pelagic and demersal species composition. A total of 106 species, 69 families, and 7 classes were sampled from this coastal ecosystem. Specimens included two species of Ascidiacea, two Bivalvia, six Cephalopoda, 21 Crustacea, five Echinodermata, 13 Gastropoda, and 57 Pisces. Diversity indices (Shannon index, H′) showed seasonal variation with a low value (2.11) in winter and high value (2.63) in spring. Dominant species were *Asterias amurensis*, *Pleuronectes yokohamae*, *Siphonalia spadicea fuscolineata*, *Trachurus japonicas*, *Sillago japonica*, *Conger myriaster*, *Volutharpa ampullaceal*, *Engraulis jsponicu*, *Asterina pectinifera*, and *Portunus* (*Portunus*) *sanguinolentus*, which in aggregate comprised over 71.5% of total individuals and 52.9% of wet weight. Seasonal variations of fishery resource composition was correlated with environmental factors of Youngil Bay. Results from this study will provide scientific data and information to develop an ecosystem-based, coastal fisheries assessment and management system in Korea.

FIS-P-6742

Forecasting variations of fishery and ecosystem risk indices for large purse seine and two-paired trawl fisheries in Korean waters using IFRAME

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The purpose of this study is to discuss how an ecosystem-based fishery assessment approach (EBFA) can contribute to better understanding of climate change impacts on fisheries. Sea surface temperatures increased at an accelerating rate in recent decades in Korean waters. This recent warming trend was associated with species replacements; cold-water species declined in abundance, warm-water species increased in abundance, and there were changes in the spatial distribution of fish stocks in the Korean marine ecosystem. A pragmatic ecosystem-based approach, the Integrated Fisheries Risk Analysis Method for Ecosystems (IFRAME), was developed with an aim to assess and forecast impacts of climate changes and fishing activities on fish and fisheries of an ecosystem. Using IFRAME, the impacts of climate change were evaluated by the projected status of fish species and the fishery for 50 years into the future for Korean waters. This approach was applied to the Korean large purse seine and two-paired trawl fisheries, which combined account for over 22% of total commercial fish catch in Korea. We assessed risk indices for species, fishery and ecosystem and evaluated fishery management under the changing climate. Finally, implications for fisheries management were discussed under the changing climate in Korean waters.

FIS-P-6783

Population dynamics and biological characteristics of the invasive European green crab, *Carcinus maenas*, in British Columbia, Canada

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The invasive European green crab, *Carcinus maenas,* arrived on the Pacific coast of North America in the late 1980s. From an initial introduction in San Francisco Bay, the crab spread both north and south and arrived in British Columbia (BC) in the winter of 1998/1999. Extensive exploratory surveys to document distribution and dispersal of green crab in BC began in 2006. In addition, a time series of survey and tagging information was undertaken for an abundant population in Pipestem Inlet, Barkley Sound. In 2010 an intensive tagging program in May was followed by an eradication attempt in September; standard tagging and depletion estimates are compared. To date, green crab populations have been confined to the west coast of Vancouver Island; Quatsino Sound harbours the northernmost population known on the Pacific coast of North America. Surveys in other areas of BC did not capture green crab but provide information on species currently inhabiting potential, but un-invaded, green crab habitat. On the west coast of Vancouver Island, green crabs are generally distributed in all sounds with relatively few sites supporting high abundance populations. Age distributions derived from size frequency and shell condition indicate that recruitment is sporadic. Tagging studies provided information on moult frequency/increment and seasonal surveys provided life history information for the species in BC.

FIS-P-6784

Authorship patterns in 30 years of DFO research documents: Is applied fisheries research like other science?

Tatiana **Tunon** and Gottfried Pestal

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Patterns in scientific activity have been studied extensively, culminating in scientometrics as a distinct discipline. We introduce some empirical laws of scientometrics and check them against the body of work captured in Research Documents published by the Canadian Science Advisory Secretariat (CSAS) of Fisheries and Oceans Canada (DFO). The size of science (people, journals, papers) has doubled every 10-20 years for the last 300 years, at roughly twice the rate of population growth, so that over 85% of all scientists that ever worked are still active and the body of literature increases tenfold over the course of a professional career. About 25% of the researchers contribute 75% of the published materials, and more recent papers tend to have more authors spanning more specialties. We explore which of these observations hold up for the grey literature produced by a fisheries agency and discuss implications for the role of individual scientists in decision-making processes that need to digest the accumulated information.

FIS-P-6785

Visualizing a complex spawner-recruit model for sockeye salmon

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Observed 4-year cycles in the abundance of many sockeye salmon (*Oncorhynchus nerka*) stocks pose a challenge for spawner-recruit (SR) analyses, and alternative SR models can have more influence on expected performance than alternative harvest control rules. For example, Larkin's extension to the classic Ricker model adds delayed-density effects to account for cross-cycle interactions. In addition to biological questions regarding potential mechanisms and statistical intricacies associated with moving from a 2-parameter model to a 5-parameter model, the complex properties of the Larkin model also present a communication challenge for collaborative planning

processes. We present a sequence of figures that visualize the differences between the Larkin and Ricker models, and illustrate the implications of capturing uncertainty through Bayesian parameter estimates. Figures emphasize: (1) changing recruitment curves, (2) alternate trajectory patterns, and (3) parameter uncertainty.

FIS-P-6804

Estimation of population ecological characteristics of Thomas's rapa whelk, *Rapana venosa*, along the west coast of Korea

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This study was performed to estimate population ecological characteristics of Thomas's rapa whelk, *Rapana venosa*, along the west coast of Korea. Samples of *Rapana venosa* were randomly collected from Taean on the west coast of Korea from August 2009 to July 2010. Using annuli on opercula of this species, ages were determined visually. The relationship between shell height (SH; mm) and shell width (SW; mm) was SW = 0.778SH – 2.310 (R^2=0.916). The relationship between shell height (SH) and total weight (TW; g) was TW = $0.0001SH^{3.0188}$ (R^2=0.953). Growth of this species was described by a von Bertalanffy growth equation.

FIS-P-6809

Study on the ecological characteristics of *Mugil cephalus* in waters south of Korea

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This study was performed to estimate population characteristics including growth parameters, survival rate, and instantaneous coefficient of natural and fishing mortalities of *Mugil cephalus* in south of Korean waters. We collected 618 samples from September 2009 to August 2010. Otoliths were used for aging. We used a new technique for aging otoliths developed by Robillard et al. (2009). Length ranged over 27.3-54.6 cm and weight ranged over 236.1-1900.0 g. Using the von Bertalanffy growth model, we estimated the theoretical maximum length (L_∞), growth coefficient (K), the theoretical age at zero length (t_0). The instantaneous coefficient of natural mortality (M) was estimated using the Zhang and Megrey method (2006).

FIS-P-6810

Age and growth of *Gomphina veneriformi* along the east coast of Korea

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Using samples of *Gomphina veneriformi*, which were collected monthly from Uljin along the east coast of Korea from March 2009 to February 2010, ages were determined from annuli on shells by visual inspection. We determined ages using these annuli, which were then used to estimate growth parameters of the shellfish. Monthly variations in the marginal index (MI) of the shell indicated that the annulus of this species was formed once a year during the period of June-September. The relationship between shell length (SL; mm) and shell height (SH; mm) was SH = 0.746*SL + 0.068 (r^2=0.991). The relationship between shell height (SH) and total weight (TW; g) was TW = 0.0005 SH*2.9878 (r^2=0.985). The von Bertalanffy growth model was fitted using non-linear methods to describe growth of this species; the following parameters were estimated: SH_∞=55.32mm, K=0.193/year, and t_0=-1.317 year.

FIS-P-6825

Spatial biomass distribution of *Corbicula japonica* in the Seomjin River of southern Korea

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Corbicula japonica is small bivalve species inhabiting freshwater and brackish water zones of most rivers in Korea. The catch of bivalve *Corbicula japonica* in the Seomjin River, located in the southern Korea and connected to East China Sea, occupied at over 90% of southern Korea and at about 30% of Korean total catch of the species. Due to the economic value of this species in the inland fisheries, the fishery production has been down since the late 1990s. In this study the recent biomass of this bivalve species were estimated by dredge net fishery survey. The effects of freshwater discharge and nutrient distribution on this species' spatial distribution in the river were investigated. The habitat of *Corbicula japonica* included brackish waters of salinity up to 28 psu in the Seomjin River, where the current biomass of this bivalve was estimated to be 736.24 metric tons. Results from this study will provide scientific data and information to develop an ecosystem-based coastal fisheries assessment and management system in Korea.

FIS-P-6854

Recovery of the productivity of shellfish aquaculture in the Western Sea of Korea after the *Hebei Spirit* oil spill

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Recently there have been various kinds of oil spill incidents worldwide. Oil spill incidents threaten to cause loss of productivity in oceanic ecosystems. Furthermore, oil spills lead to collapse of marine resource dependent industries in oil spilled area. The research accomplished by the Korea-USA joint research program contributes to restoring the shellfish aquaculture industry in western sea of Korea that was ruined due to the *Hebei Spirit* oil spill in 2007. We monitored physical and biological restoration status of the Pacific oyster, *Crassostrea gigas*, and Manila clam, *Ruditapes philippinarum*, aquaculture farms after clean up procedures. In addition, we analyzed the presence and levels of PAHs and benzopyrene of cultured shellfish as food safety indices. The levels of oil effects are decreasing rapidly in shellfish aquaculture farms, although it still remains in sediments. Therefore, we recommend different approaches to aquaculture methods for the oyster, and turning the ground over regularly for the clam. These results can be used as criteria for the resumption of aquaculture activity in oil spill affected regions.

FIS-P-6870

Incorporating ecosystem forcing through predation into a management strategy evaluation for the Gulf of Alaska walleye pollock (*Theragra chalcogramma*) fishery

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National and international fisheries management organizations are defining and developing ecosystem-based approaches to fisheries management. The mechanisms determining changes in an ecosystem and their impacts on marine populations are not well established for most species, but the expectations of managers are that these impacts should be accounted for when selecting management strategies. Predation is an important component of ecosystem dynamics, and predator–prey functional responses can be used to represent predation in multispecies population dynamics models. The primary predators of walleye pollock (Theragra chalcogramma) in the Gulf of Alaska include arrowtooth flounder (Atheresthes stomias), Pacific cod (Gadus macrocephalus), and Pacific halibut (Hippoglossus stenolepis). Management strategy evaluation is used to examine the impact of changes over time in natural mortality-at-age related to trends in predator abundance on the performance of the current management strategy for the fishery for walleye pollock in the Gulf of Alaska. The current management strategy is evaluated under nine scenarios which capture uncertainty regarding the predator–prey functional relationship and the level of future fishing mortality on the predators. The current management strategy, which ignores the possibility of changes over time in natural mortality, kept the spawning biomass high relative to the target level and had a low risk of fishing mortality exceeding the overfishing limit, due to low catches relative to the total biomass.

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 those covered by Topic Sessions S8, S13 and S14.

Thursday, October 28 (9:00-18:00)

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

9:05 **Young Jae Ro**
Linking tropical oceanic conditions to water characteristics in the subtropical western Pacific marginal seas (POC-P-6467)

9:25 **Antonietta Capotondi, Michael Alexander, James Scott, Enrique Curchitser and Nicholas Bond**
Climate change in upper-ocean stratification as inferred from the IPCC AR4 models (POC-P-6682)

9:45 **Fangli Qiao, Zhenya Song, Changshui Xia and Dejun Dai**
The improvement of ocean circulation models and climate models through surface waves: From mean state to long-term variations (POC-P-6607)

10:05 **Liqi Chen, Zhongyong Gao and Weijun Cai**
Precision evaluation of air–sea fluxes of CO_2 in the western Arctic Ocean under rapid sea ice shrinking and its implication to global climate change (POC-P-6506)

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

10:45 **William R. Crawford**
Features of the northeast Pacific Ocean (POC-P-6780)

11:05 **Maxim A. Ishchenko and Vladimir B. Darnitskiy**
New effects of synoptic dynamics of sea currents and fluctuations in the North Pacific (POC-P-6642)

11:25 **Hanna Na, Kwang-Yul Kim, Kyung-Il Chang, Kuh Kim and Shoshiro Minobe**
Warming signal in the upper layers of the East/Japan Sea (POC-P-6736)

11:45 **Olga Trusenkova and Dmitry D. Kaplunenko**
Low frequency variability of sea level in the Japan/East Sea estimated from AVISO satellite altimetry (POC-P-6481)

12:05 **Hiroshi Kuroda, Takashi Setou, Yuichi Hirota, Manabu Shimizu and Kazuhiro Aoki**
A numerical study on the winter mixed layer on the shelf-slope region south of Japan (POC-P-6646)

12:25 ***Lunch***

14:00 **Phyllis J. Stabeno, Nicholas A. Bond and Jeffrey M. Napp**
Eastern Bering Sea shelf: Comparison between a cold period (2007–2010) and a warm period (2001–2005) (POC-P-6694)

14:20 **Nicholas A. Bond, Phyllis J. Stabeno, Albert J. Hermann and Muyin Wang**
What controls the extent of ice in the Bering Sea in spring? (POC-P-6620)

14:40	**Elena I. Ustinova and Yury D. Sorokin** Winter extreme events in the thermal state of the Okhotsk and Bering Seas (POC-P-6748)
15:00	**Olga Trusenkova** Multivariate analysis of wind stress and curl over the Japan/East Sea based on satellite scatterometry data (POC-P-6482)
15:20	**Zhongyong Gao, Liqi Chen and Heng Sun** Developments of the Arctic carbon sink from 1999 to 2008 (POC-P-6548)
15:40	***Coffee/Tea Break***
16:00	**Jae-Hyung Park and Kyung-Il Chang** Characteristics of anomalous coastal upwelling detected off the east coast of Korea in summer 2007 (POC-P-6824)
16:20	**Carol Ladd, Phyllis J. Stabeno and Julia O'Hern** The Pribilof Eddy in the eastern Bering Sea (POC-P-6605)
16:40	**Svetlana Y. Ladychenko, Vyacheslav B. Lobanov and Dmitry D. Kaplunenko** Evolution and hydrographic structure of mesoscale eddies formed in the northwestern Japan Sea (POC-P-6726)
17:00	**Karen Nieto, Sam McClatchie and Edward D. Weber** How does mesoscale oceanic structure in the California Current System affect the distribution and ultimately the survival of larval fish? (POC-P-6801)
17:20	**Hiromichi Ueno, Hiroji Onishi, Sachihiko Itoh, Ichiro Yasuda, Yutaka Hiroe, Toshio Suga and Eitarou Oka** Observations of a Kenai eddy along the Alaskan Stream south of the Aleutian Islands (POC-P-6448)
17:40	**Guangliang Liu, Zhe Liu, Huiwang Gao and Shizuo Feng** Simulation of the Lagrangian tide-induced residual current in Jiaozhou Bay, North China (POC-P-6747)
18:00	***Session ends***

POC Paper Session Posters

POC-P-6480 **Fedor F. Khrapchenkov and Nadezda M. Dulova**
Current variability features in the northeastern part of Posyet Bay, the Sea of Japan (East Sea)

POC-P-6489 **Zhongyong Gao, Liqi Chen and Heng Sun**
CO_2 system in the Bering Sea

POC-P-6518 **Ze Liu and Yijun Hou**
The Stratified Influence of the Kuroshio Intrusion over the Continental Shelf Break off Northern Taiwan

POC-P-6519 **Talgat R. Kilmatov, Elena V. Dmitrieva and Olga I. Trinko**
The indirect estimation of the climatic trend of kinetic energy production in the North Pacific

POC-P-6549 **Zhongyong Gao, Liqi Chen and Heng Sun**
Summertime CO_2 system distribution and air–sea CO_2 fluxes in the Bering Sea

POC-P-6562 **Yugo Shimizu, Lynne D. Talley, Shin-ichi Ito, Shigeho Kakehi and Taku Wagawa**
Spreading pattern and transport of the Okhotsk Sea Intermediate Water to the northwest Pacific revealed by profiling floats with optode and hydrographic observations

POC-P-6673 **V.V. Moroz**
Peculiarities in intermediate water characteristics in the Komandor–Kamchatka area

POC-P-6715 **Tae-Hoon Kim and Guebuem Kim**
Basin-scale low N:P ratios and DOC export in the East/Japan Sea

POC Paper Session Oral Presentations

28 October, 9:05 (POC-P-6467)

Linking tropical oceanic conditions to water characteristics in the subtropical western Pacific marginal seas

Young Jae **Ro**

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The East (Japan) Sea in particular is one of the important marginal seas in the western boundary of the Pacific, well known as a miniature ocean which is subject to impacts from the tropics as well as the subarctic. Diverse influences have been considered such as summertime buoyancy input by the Kuroshio via the Korea Straits, and wintertime deep convection with cold water mass formation in the northern part of the East Sea.

On the other hand, in the Yellow Sea, which is shallow with an average depth of 55 m, two processes are regarded as important: cold water formation in the northern part of the Yellow Sea during the winter monsoon, and the impact of the Changjiang diluted water on the southern part of the Yellow Sea during the summer monsoon, and its passage toward the East Sea.

Statistical analyses including correlation, EOF, long-term trend, spectral and wavelet will be carried out to the datasets such as KODC and JODC hydrographic data for the East Sea, and Reynolds SST, SODA 3-D ocean temperature, SSH, wind velocity and SLP for the western Pacific.

28 October, 9:25 (POC-P-6682)

Climate change in upper-ocean stratification as inferred from the IPCC AR4 models

Antonietta **Capotondi**[1], Michael Alexander[1], James Scott[1], Enrique N. Curchitser[2] and Nicholas A. Bond[3]

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The stratification in the upper ocean influences both entrainment of nutrient-rich deep waters in the surface layer, as well as deep-water ventilation. Both processes (entrainment and ventilation) have a large influence upon biological activity in the euphotic zone by regulating the nutrient supply and oxygen levels. The projected sea surface temperature (SST) increase is expected to reduce the surface density, leading to increased stratification. Global warming is also expected to change the hydrological cycle, with increased precipitation vs. evaporation in the Tropics and high-latitudes, and reduced precipitation in the Subtropics. Thus, surface salinity will also change. In this study we will use a subset of the Intergovernmental Panel on Climate Change 4th Assessment Report (IPCC-AR4) models to examine the changes in the surface density over the World Ocean, and the relative contribution of temperature and salinity to the density changes. The changes are computed as differences between the average conditions in 2050–2099 from the SRES-A2 emission scenario for the 21st century, and 1950–1999 from the 20th century simulations. An estimate of upper-ocean stratification is obtained by considering the difference between density at 200m and surface density. Our results show large increases in stratification in many areas of the World Ocean, and in particular in the Northeast Pacific. According to some models, stratification changes can be as large as 100% in the Gulf of Alaska and in the California Current System, with salinity being the major contributor.

28 October, 9:45 (POC-P-6607)

The improvement of ocean circulation models and climate models through surface waves: From mean state to long-term variations

Fangli **Qiao**, Zhenya Song, Changshui Xia and Dejun Dai

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Incorrect parameterizations of the ocean mixing processes essentially render the atmospheric and oceanic dynamics to be either decoupled or coupled incorrectly. Because the ocean covers three quarters of the global surface, it is essential that we correctly model the ocean mixed layer (ML) so that we can better simulate and predict the climate. However, the simulated mixed layer depth is always too shallow for nearly all ocean circulation models, especially for the summer season. In most ocean dynamics studies, wave motions have always been treated separately from the ocean circulation. To overcome this shortcoming, we have established a new scheme of non-breaking wave-induced vertical mixing (Bv) that will correct the systematic error of insufficient mixing. We have already observed this kind of non-breaking surface wave-induced vertical mixing in laboratory experiments. The new scheme of Bv has enabled the mixing layer to deepen, resulting in a much better agreement with observed climatologic data. Different OGCMs, such as POM, ROMS, MOM4, POP and HIM, show similar improvements in the global ocean. Then we examine the effects of Bv on climate models, CCSM3 and FGCM0. Both climate models show dramatic improvements from mean state to long-term variations. For example, the tropical biases which, in fact, are a common problem for all climate models without flux correction, are much improved.

28 October, 10:05 (POC-P-6506)

Precision evaluation of air–sea fluxes of CO_2 in the western Arctic Ocean under rapid sea ice shrinking and its implication to global climate change

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The Arctic Ocean is rapidly changing with thinning and retreating of sea ice due to its sensitivity to global warming. The Chinese National Arctic Research Expedition (CHINARE) has experienced this sea ice retreating. The MV *Xuelong*, an icebreaker for Chinese polar expeditions, reached 75°N in marginal sea ice during the first CHINARE in 1999, 80°N during the second CHIANRE in 2003, and farthest north at 85°N during the third CHINARE in 2008. Larger-scale open waters have appeared yearly in the summer in the western Arctic Ocean and present a significant carbon pool to newly absorb atmospheric CO_2. However, different pCO_2 distributions would depend on physical, biological and carbon chemical driving forces. On the continental shelf, such as the Chukchi shelf with a high productivity area, a biological pump will act as the main driving force, continually pumping atmospheric CO_2 through the surface into deep water and even to the sea bottom, thus presenting a strong uptake of CO_2 in surface water. However, in oligotrophic or low productivity areas, such as the Canada Basin which shows a weakened biological pump, the physical and chemical pumps will then become the major driving forces. We hypothesize "low-low-high" distributions of pCO_2 in surface water under an ice melting scenario in the Canada Basin: low "L" pCO_2 of surface water under the ice cover in winter, low "L" in the melt-ice mixed water in early summer, but high "H" in the open water melted ice for a period of 1–2 months. High pCO_2 of surface water in the prolonged open water can be explained as due to increased surface temperature from solar radiation and enhanced rate of air–sea CO_2 gas exchange, demonstrating the process of the carbon chemical pump, with temperature control to be the main factor. The increase in surface water pCO_2 due to this CO_2 uptake would accelerate the negative impact of ocean acidification on pelagic and benthic ecosystems. Based on the "L-L-H" hypothesis, surface water pCO_2 will reach atmospheric levels and tend to saturation. In this case, the previous assessment of surface CO_2 uptake of 4–14% of global atmospheric carbon in the Arctic Ocean should be revaluated. However, based on surveys in the western Arctic Ocean from CHINARE cruises, we estimate an extra CO_2 flux of only 4.6×10^{12} gC yr^{-1} in ice-free basins in the Arctic Ocean, which is only one seventh of the 33×10^{12} gC yr^{-1} of the previous evaluation under constant pCO_2. Therefore, it is important to improve measurement technology of pCO_2 and relative parameters, and enhance serious field observation, as well as numerical modeling, under a rapidly melting Arctic Ocean.

POC PAPER

28 October, 10:45 (POC-P-6780)

Features of the northeast Pacific Ocean

William R. **Crawford**

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By combining data from satellite altimeters and a high-resolution geoid, we are now able to track ocean currents with great precision. Images of sea level changes reveal the North Pacific Current has strengthened since continuous high-resolution observations began in 1992. Much of this increase is attributed to strengthening westerly winds. Each of the past five El Niño events has triggered a brief surge in strength of the Alaska Current and Alaskan Stream, accompanied by a decline in the California Current. These changes are attributed to deepening of the Aleutian Low Pressure system in Northern Hemisphere winters during El Niño events. When ocean color images are superimposed on sea level heights, one can see that the mesoscale features of phytoplankton are dominated by mesoscale ocean currents, in both deep-sea regions and along the continental slope. In addition, interannual changes in the approach of deep-sea "blue" water toward the North American west coast can be compared to the ocean current patterns revealed by sea level contours.

28 October, 11:05 (POC-P-6642)

New effects of synoptic dynamics of sea currents and fluctuations in the North Pacific

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Analyses of currents calculated from altimetry data obtained from the Naval Laboratory in the U.S. confirm many of the previously established facts on the horizontal structure of the Kuroshio meander and eddy activity in the western sector of the Subtropical Gyre. Observations on a much larger scale than those carried out by oceanographic surveys have found many features of synoptic-scale water dynamics that otherwise could not be detected by classical oceanographic surveys carried out between the interannual and seasonal periodicities.These features include the changing location of bifurcation points of the Kuroshio, their temporal variability, and the direction of the bifurcation flows in the area of the NW Pacific from Japan to 180° between 25–45°N.L. Altimeter surveys clearly show the effects of a new dynamics of the upper ocean, such as: the Pacific subarctic front, the Kuroshio current and its eddies, and a meandering and bifurcation zone (Darnytskiy, Bulatov, 2002, 2005). Regular monitoring of the ocean surface reveal a spontaneously arising jet in the meridional direction usually oriented along the normal, or at different angles to the zonal flows. The length of these jets reaches a maximum of 300–600 miles (~483–965 km). The average length of the jet is about 100–200 miles (~160–320 km). The jets moving over the underwater terrain features of the North Pacific undergo bifurcation which, in their successive repetitions, form bifurcations of branching streams. A tree of bifurcations characterized by a system of branches diverges from the central fan of a highly concentrated jet. After a fairly short life (1–8 days), the branches dissipate into chaotic small-scale eddies and jets of smaller scale (Darnytskiy, Kanevskiy, 2006). In vast oceanic areas (from Japan to 180°), we found chaotic regimes of small-scale movements of water repeated periodically over the space in contrast to the continuum of zonal flows on a planetary scale. At intervals of synoptic scale (days-weeks), local areas of chaotic motions of surface water reappear (self-organize) as ordered structures in the form of localized high-speed jets, large-scale eddies or zonal flows are interspersed with low-velocity flows of different directions. Some elements of such structures in the subarctic front have been observed earlier by satellite (Darnitskiy, Bulatov, 2002, 2005). Such complex unpredictable behavior of flows is manifested not only on the surface but at depths of tens or hundreds of meters (Darnitskiy, Ishchenko, 2008, 2009, and 2010).

28 October, 11:25 (POC-P-6736)

Warming signal in the upper layers of the East/Japan Sea

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A 40-year long temperature and salinity dataset is analyzed to investigate the long-term heat content variability in the upper layers of the East/Japan Sea from 1968 to 2007. The second cyclostationary EOF (CSEOF) mode of the heat content integrated in the upper 300 m represents an overall warming signal. The spatial patterns show generally positive signs throughout the year with large positive anomalies to the west of the northern Honshu, western end of the Tsugaru Strait, and west of southern Hokkaido. The corresponding principal component (PC) time series exhibits an increasing trend with fluctuations with a period of ~10 years, although the autoregressive power spectral density function of the PC time series shows a statistically significant spectral peak only at 12 months. One interesting feature is that the characteristics of the decadal fluctuations changed in the late 1980s. The overall amplitude of the decadal fluctuations has increased, while its range has decreased since the late 1980s. This indicates that the upper water heat content in the East/Japan Sea has generally increased and the range of decadal variations has decreased. Multiple regression analysis shows that the overall warming in the East/Japan Sea is closely linked with the positive temperature anomalies, particularly in the 50–100 m layer. Relationships with the oceanic and atmospheric variability in the northwestern Pacific will be discussed.

28 October, 11:45 (POC-P-6481)

Low frequency variability of sea level in the Japan/East Sea estimated from AVISO satellite altimetry

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Satellite altimetry data on sea level anomalies (SLAs) have already covered the period of almost two decades, motivating the revisit of interannual variability. Seasonal variability was previously analyzed in the Japan/East Sea (JES), using Empirical Orthogonal Functions (EOFs) of the AVISO gridded SLAs (Trusenkova et al., 2010). It was shown that two leading modes accounting for the synchronous sea level oscillations and the circulation strength in the entire JES, respectively, were interrelated, sharing the temporal and spatial patterns. However, the dominant seasonal signal hampered the analysis of interannual variability. Here, we analyze low-pass filtered SLA computed by wavelet transform, with the 6th order Morlet mother wavelet, of the 1/4°-gridded weekly AVISO reference and update products. Weak, but statistically significant, quasi-biennial synchronous SLAs are derived as the leading interannual mode, while trend-like temporal patterns are not revealed. The seasonal and interannual synchronous modes have similar spatial patterns. There are no counterparts of the circulation mode in the low-frequency SLAs. Thus, coupling with the synchronous mode breaks up, implying the stability of the meridional density gradient on interannual timescales, despite the strong transport variations in the Korea Strait (Ostrovskii et al., 2009). In contrast, the seasonal east–west redistribution of subtropical water entering the JES in the Korea Strait is subject to strong interannual variability, in line with previous findings (Hirose and Ostrovskii, 2000; Choi et al., 2004). The EOF decompositions of the reference and updated AVISO products yielded the same seasonal and interannual EOF patterns.

28 October, 12:05 (POC-P-6646)

A numerical study on the winter mixed layer on the shelf-slope region south of Japan

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The shelf-slope region between the Kuroshio and the southern coast of Japan has been considered as a significant spawning ground of some pelagic fish. For instance, Japanese sardine spawns over the shelf-slope region primarily in February, when the winter mixed layer (hereafter, "WML") is expected to develop due to energetic sea surface cooling. Our previous study based on long-term *in situ* temperature records has inferred that there are predominant intra-monthly variations of the WML, and that three-dimensional structures of the WML are quite difficult to capture only from *in situ* observations. To further investigate behavior and dynamics of the WML, this study develops a triply nested numerical model with the highest resolution of 1/50 degree (~2 km), forced by monthly climatological mean fluxes at the sea surface. The realistic Kuroshio and tide are also given on lateral boundaries of this model. It is found that the 1/50-degree model can successfully simulate properties of seasonal and intra-monthly variations of the WML that are similar to observed features, whereas the second highest-resolution model of 1/10 degree can reproduce less well, particularly the intra-monthly variation. This is because the intra-monthly variations are attributed to dominant submesoscale variability with a spatial scale of 10–20km and a timescale of a few days to a week. In addition, a streak-like distribution of shallow WMLs is frequently simulated and associated with horizontal advection of the shallow WMLs. In our presentation contributions of the horizontal advection to temporal change of the WML will be explained in detail.

28 October, 14:00 (POC-P-6694)

Eastern Bering Sea shelf: Comparison between a cold period (2007–2010) and a warm period (2001–2005)

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The five-year period 2001–2005 was particularly warm on the southeastern Bering Sea shelf, with greatly reduced sea-ice extent, warm surface temperatures during the summer (>12°C), and a cold pool (region where bottom temperatures < 2°C) largely limited to the northern half of the eastern shelf. This warm period was followed by a transition year in 2006, and then a cold period (2007–2010) with sea ice covering most of the eastern shelf during early April, cold surface temperatures during the summer (<10°C), and an extensive cold pool covering much of the eastern middle shelf. These differences between cold and warm are most evident on the southern portion of the shelf (south of ~60°N) and far less pronounced on the northern portion. Atmospheric forcing largely determines sea-ice extent and duration and, in turn, sea-ice extent and duration strongly influence summer ocean temperatures, the extent of the cold pool and the timing of the spring phytoplankton bloom. These swings in ice extent and ocean temperatures have profound impacts on the Bering Sea ecosystem. Warming in 2001–2005 was associated with a sharp decrease in summer copepod concentrations. At the same time, the 2001–2005 year classes of walleye pollock in the Bering Sea were poor, resulting in a marked decrease in pollock biomass. With the return of cold conditions in 2007, the summer concentration of copepods increased to concentrations similar to those observed in the 1990s. From surveys conducted in 2006–2009, there are indications that the 2006 year-class of walleye pollock may be above average.

28 October, 14:20 (POC-P-6620)

What controls the extent of ice in the Bering Sea in spring?

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The southeast shelf of the Bering Sea experiences very large interannual variability in sea ice extent in spring. This parameter essentially determines the boundary between the sub-arctic and arctic portions of the Bering Sea and therefore has important implications for the marine ecosystem ranging from zooplankton community structure to timing of salmon returns to the suitability of the habitat for marine mammals. The sensitivity of sea ice to the seasonal mean atmospheric forcing is already well-appreciated. What has not been as well documented is the relative importance of other factors including: 1) the pre-existing heat content in fall at the start of the seasonal cooling; 2) the pre-existing salinity profile and ultimately the development of ice in early winter; 3) episodic weather events of 1–3 week duration in early spring in terms of their impacts on the advection of ice. These and potentially other factors are being investigated based on the historical record and a hindcast simulation by the Regional Ocean Modeling System (ROMS) for the period from 1970 to the present. The procedure involves first regressing observed ice extents against the mean seasonal forcing and then determining how the residual in the sea ice signal relates to the other factors listed above. The year-to-year variability in the skill of the sea ice hindcasts from ROMS is examined to indicate how well the model accounts for these factors. The results from this work will show which processes must be modeled properly to reliably forecast Bering Sea ice extent into the future.

28 October, 14:40 (POC-P-6748)

Winter extreme events in the thermal state of the Okhotsk and Bering Seas

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In this study winter extreme events in the thermal state of the Okhotsk and Bering Seas were analyzed using regional data sets based on historical observations. Multi-year data on ice cover, and air and water temperatures from meteorological stations located on the coast of the Far-Eastern Seas are the longest time series of relatively regular and homogeneous information for the Seas. Additionally, we used air temperature from NCEP Reanalysis and SST from the Real Time Data Base, NEAR-GOOS. In the Okhotsk Sea, the frequency of extreme situations has increased in the last 15 years. So, after the severe winter of 2000–2001, with extreme ice conditions, mean winter ice cover was close to an absolute minimum (38.3 % from total area of the Sea) in 2006 and 2009. Previous extreme minima of ice cover in the Okhotsk Sea were observed in 1996–1997. In the Bering Sea, a similar tendency was absent. The extreme warm and cold winters were characterized by strong atmospheric anomalies, with changes in the paths of the storms. From the middle of 1980s, the well-known contrast in oscillation phases of ice cover in the Okhotsk and Bering Seas stopped. During recent “extreme” years (2001, 2006 and 2009) for the Okhotsk Sea, anomalies of ice cover for the Bering Sea were in opposite phase with those in the Okhotsk Sea. The opposition in ice phase was accompanied by the epicentres of cold and heat in the atmosphere during these years. The formation of strong winter atmospheric anomalies over the Far-Eastern region causes a fast response in large ice cover anomalies.

28 October, 15:00 (POC-P-6482)

Multivariate analysis of wind stress and curl over the Japan/East Sea based on satellite scatterometry data

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Satellite scatterometry has provided high-resolution data on surface ocean winds since 1999. However, frequent gaps occur due to satellite track divergence and rain contamination. Therefore, our analysis of wind variability relies on the 0.5°-gridded QSCAT/NCEP Blended Ocean Winds product of merged satellite and reanalysis data, providing fields over ocean and land. The Complex Empirical Orthogonal Functions (EOFs) of wind stress vectors over the Japan/East Sea (JES) yield the same patterns as those previously derived from the 1°-gridded NCEP reanalysis. The leading mode accounting for the general wind direction covers about 30% of the total variance for the original fields and above 50% if synoptic variability is removed by wavelet filtering. Monthly histograms of prevailing wind directions reveal the dominant northwestern mode in winter and several modes in other months. The southern wind prevailing in monthly mean fields in summer does not necessarily represent a mode. Time series of prevailing wind directions reveal that from winter to spring the wind generally shifts from the northwest to southwest, while in fall it can shift from the southwest to northwest or from the northeast to north and northwest. The 0.5°-gridded winds resolve fine features such as several northwestern gap jets in winter. The EOF analysis of 40-day low-pass filtered wind stress curl yields the winter pattern as the leading mode. The second mode features a curl of the same sign over most of the JES, which is anticyclonic in fall and late winter, with several sign changes and strong interannual variability in summer.

28 October, 15:20 (POC-P-6548)

Developments of the Arctic carbon sink from 1999 to 2008

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Polar oceans play an important role in the global carbon cycle. Measurements of atmospheric and surface sea water pCO_2 were conducted during the 1st, 2nd and 3rd Chinese National Arctic Research Expedition cruises in July to September of 1999, 2003 and 2008, respectively. The Arctic carbon sink has increased during the past 10 years, from 1999 to 2008, accompanying the receding of sea ice cover. In particular, our summer 2008 CO_2 data suggest that increased initial ice-melting will greatly enhance air–sea CO_2 flux greatly in the western Arctic Ocean. Greater summertime ice melting is projected to occur in the following years with increasing speed. The increased CO_2 uptake by the Arctic Ocean slopes and basins thus, may provide a negative feedback mechanism to reduce atmospheric CO_2 and thus, the rate of warming. However, such a CO_2 sink will be weakened gradually, as our data also suggest that a completely ice-free condition in the slope and basin areas for a prolonged period during the summer may result in an increase in surface pCO_2 and reduced CO_2 flux (though still higher than today). Furthermore, warming and ice melt will promote permafrost thawing in the Arctic continent and thus, increased river inputs of dissolved inorganic carbon (DIC) and organic carbon that are expected to be recycled as CO_2 will further reduce the capacity of the Arctic Ocean to absorb atmospheric CO_2.

28 October, 16:00 (POC-P-6824)

Characteristics of anomalous coastal upwelling detected off the east coast of Korea in summer 2007

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An ocean buoy station ESROB (East Sea Real-time Ocean Buoy) deployed off the east coast of Korea at a depth of 130 m has been in operation since 1999. An anomalous surface cooling was detected by ESROB from 8 to 20 August 2007. During that period, temperature at 7 m depth decreased by 14°C within 3 days. The appearance of coastal cold water was thought to be due to an unprecedented coastal upwelling linked to large-scale atmospheric circulation [Park *et al.*, 2010]. CTD data taken in a wider area and surface geostrophic current distribution calculated from satellite-derived sea surface height suggest the important role of a cyclonic mesoscale eddy resulting in a doming of the thermocline. The cold lower layer would then become more vulnerable to surfacing when southerly winds blow. The buoy station equipped with meteorological sensors, an acoustic current profiler, and temperature/conductivity sensors at five depth levels enables us to investigate the ocean's internal structure during the evolution of this anomalous coastal upwelling event. We will show the temporal evolution of the vertical structure of temperature and currents during the event.

28 October, 16:20 (POC-P-6605)

The Pribilof Eddy in the eastern Bering Sea

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Eddies in the Bering Slope Current form along the shelf break of the eastern Bering Sea near Pribilof and Zhemchug Canyons. These eddies have been shown to influence nutrient and phytoplankton distributions. The eddies that form near Pribilof Canyon may be particularly important to upper trophic levels due to their proximity to the Pribilof Islands, an important breeding ground for fur seals and numerous species of seabirds. A Pribilof Eddy formed in April 1997, strengthened during spring/summer, moved off-shelf toward the southwest, and persisted until December. Water properties (temperature, salinity, chlorophyll, nutrients) within the eddy were sampled on multiple occasions in the summer of 1997. When first sampled in June, the eddy had a diameter of ~100 km and extended to ~2,000 m depth. Significant changes in the eddy properties were observed when it was sampled approximately a week later. In addition, eight satellite-tracked drifters, some of which included ocean color sensors, were deployed within the eddy, resulting in months of Lagrangian data. Results from this 1997 Pribilof Eddy will be described in the context of interannual variability of eddy activity along the eastern Bering Sea shelf break from satellite altimetry data.

28 October, 16:40 (POC-P-6726)

Evolution and hydrographic structure of mesoscale eddies formed in the northwestern Japan Sea

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Mesoscale eddies are often observed around and north of the Japan Sea subarctic front in the satellite SST images. Since oceanic variability of the northern Japan Sea is related to eddy behavior, it is important to study and understand their generation and evolution. In the present study, we investigate the formation and evolution of several mesoscale anticyclonic eddies formed in northwestern part of the sea near the coast of northern PDR Korea and western part of Primorye (Russia) for different years of the period 1999–2010. We used NOAA AVHRR satellite infrared images received by the Inter-Institute Center for Satellite Monitoring, Vladivostok, satellite

altimetry data and in situ observations obtained from Pacific Oceanological Institute (POI) FEB RAS cruises. We determined the scheme of movement and evolution for each long-lived anticyclonic eddy with a lifetime from one to two years. Eddy diameters vary from 60 to 110 km. Hydrographic structure of mesoscale anticyclonic eddies show that they trap low salinity and warm water during their formation in the coastal area and transfer it into the open sea. After formation, the eddies drift southeast and eastward along the subarctic front with a velocity of about 0.9–2 cm/s, influencing mass and heat transport in the area to the north of the subarctic front.

28 October, 17:00 (POC-P-6801)

How does mesoscale oceanic structure in the California Current System affect the distribution and ultimately the survival of larval fish?

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Physical mesoscale characteristics play an important role in the life cycles and distribution of pelagic fishes. In this study, we used a new method for automatic detection of frontal structures based on an improved version of the Cayula-Cornillon algorithm for upwelling regions to map fronts. A specific algorithm to identify filaments based on object-oriented programming was implemented. The work focused on the California Current System: 19°N–43°N and 109°W–133°W. We used daily satellite images at 1 km resolution of sea surface temperature, computed from MODIS raw data (2002–2009) to create indices of frontal and filament activity. The spatial and temporal patterns of the mesoscale frontal activity were described. Our goal is to relate the distribution and abundance of commercially important species of ichthyoplankton to the fronts and filaments likely to produce flows aggregating or dispersing plankton. In this way we hope to better understand how mesoscale physical variability can impact larval survival and ultimately, recruitment.

28 October, 17:20 (POC-P-6448)

Observations of a Kenai eddy along the Alaskan Stream south of the Aleutian Islands

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A Kenai eddy formed in winter 2007 in the area south of the Kenai Peninsula and east of Kodiak Island was observed from T/S *Oshoro-maru* and R/V *Hakuho-maru* around 170ºW in summer 2009. This eddy was the same eddy as the one observed from the University of Washington vessel *Thomas J. Thompson* around 155ºW in September 2007 (Rovegno *et al.*, 2009). In summer 2009, a warm (~5.4ºC) core was observed at the center of the eddy in the density range of 26.5–26.7σ_θ, forming distinct temperature maxima in the vertical and horizontal directions. The temperature maxima were denser and colder than those observed in 2007, suggesting erosion of the eddy core from the above due to surface cooling and mixing in winters 2008 and 2009. The dissolved oxygen of the eddy core in summer 2009 was lower than the surrounding water. Such low oxygen might be a remnant of shelf water, which was characterized by low-oxygen and was suggested to be a source of the Kenai eddy core.

28 October, 17:40 (POC-P-6747)

Simulation of the Lagrangian tide-induced residual current in Jiaozhou Bay, North China

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Recent research reveals that the general Lagrangian residual current was more reasonable to represent coastal water circulation in realistic general nonlinear systems, such as shallow bays and estuaries, where the tidal flow fields are often complex. Jiaozhou Bay (JZB), located on the western side of the Yellow Sea, is a potential general nonlinear system. In this paper, we simulated the general M2 Lagrangian Tide-Induced Residual Current (TIRC) of JZB by water parcel tracking method. In particular, the hydrodynamic mechanism governing the nonlinearity of the M2 tidal system was further investigated. The simulated time mean Lagrangian TIRC coincides well with the observed long-term sediment transport trend, indicating the simulated results are reliable. The general Lagrangian TIRC in JZB appears quite different from both Eulerian TIRC and weak nonlinear Lagrangian TIRC. For instance, several Eulerian eddies near the bay mouth disappear in the Lagrangian TIRC. Additionally, except in the small northwestern region in the inner bay, the weak nonlinear Lagrangian TIRC shows substantial differences from the general Lagrangian TIRC. In JZB, the Lagrangian TIRC varies significantly with the initial tidal phase, which shows strong nonlinearity of the seawater movement. The multiple linear regression analysis suggests that horizontal advection dominates the nonlinearity of the M2 tidal system in JZB and vertical diffusivity is significant only near the tidal flat. The modeling results are sensitive to the tidal flat, which occupies about 1/3 of the bay area. Without taking the tidal flat into account, horizontal advection, vertical advection and vertical diffusivity jointly determine the Lagrangian TIRC.

POC Paper Session Posters

POC-P-6480

Current variability features in the northeastern part of Posyet Bay, the Sea of Japan (East Sea)

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Posyet Bay is located in the southwestern part (the Sea of Japan) of Peter the Great Bay. In recent years, interest in studying the main factors determining the environmental safety of the bay waters has increased due to the threat of anthropogenic pollution. Dynamics of pollution in the bay are determined by the regime of currents, which have not been sufficiently studied. This paper analyzes the observational data of currents, sea level and hydrological processes in Posyet Bay. Observations were performed in two polygons in August–September 2009. Measurements were taken on the shallow shelf in Vityaz Bay and southeast of the Schultz Cape. Current velocity at different depths reached 0.5 m/s in Vityaz Bay and 0.4 m/s southeast of the Schultz Cape. Spectral analysis allowed the identification of peaks corresponding from synoptic (2–5 days), the tidal (24 and 12 hours) and inertial (17 and 9 hours) periods to high-frequency periods from 1 hour to 7–9 minutes. As a result of complex research of the shelf zone, new information on the nature of currents and of the sea level variability in the coastal zone, on water exchange of Vityaz Bay with the open areas of the Sea of Japan, and on the mechanisms of thermohaline water structure formation in the shelf zone were obtained. New data on internal wave transformation and on the thin water structure on Vityaz Bay shelf were obtained in addition to the dependence of changes in tide and wind field parameters.

POC-P-6489

CO_2 system in the Bering Sea

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The 3rd Chinese National Arctic Research Expedition (CHINARE 2008) was carried out from July to September of 2008. The partial pressure of CO_2 (pCO_2) in the air and in the surface sea water were observed along the cruise track and a number of sea water samples were taken for CO_2 system parameter measurements (*viz.*, pH, total alkalinity (TA), total dissolved inorganic carbon (DIC)). The distributions of CO_2 system parameters in the Bering Sea and the western Arctic Ocean were clarified and the according controlling factors were discussed. The flux of CO_2 from air to sea and its trend of changing in the future were estimated in the Arctic Ocean under rapid changes, which could give us better understanding of the response and its feedback of the Arctic to global changes. Results can be summarized in the following: Spatial-temporal distributions of pCO_2 in the surface sea water in the Bering Sea in summertime were described as: central Bering shelf < Bering Basin < northeast Bering shelf < Bering Strait upwelling, where pCO_2 in the central Bering shelf was 213±34 µatm (148~301 µatm), in the Bering basin was 297±51 µatm (178~374 µatm), in the northeast Bering shelf influenced by river plumes was 332±30 µatm (277~387 µatm), and Bering Strait upwelling had values of 476±68 µatm (302~562 µatm) because of high pCO_2 in the bottom water. The Bering Sea generally acts as a net sink for atmospheric CO_2 in summer. Analyzing pCO_2 controlling factors for different areas of the Bering Sea indicated that a pCO_2 northward decrease in the Bering basin was attributed to temperature cooling and was mainly driven by a solubility pump, while low pCO_2 in the Bering shelf was driven by a biological pump as a result of high primary production. However, the northeastern Bering shelf received much river discharge which was commonly supersaturated in pCO_2, so pCO_2 in this region was mainly influenced by a mixing of water masses and net balance of photosynthetic CO_2 fixation and respiration of organic material. In the upwelling of the Bering Strait, *p*CO2 was controlled by hydrological processes and acted as a strong CO_2 source though its primary production and chlorophyll were both high. In other regions of the Bering Strait, pCO_2 was driven by different water masses and their mixing.

The ranges of summertime DIC and TA in the Bering Sea surface water were 1827~2145 µmol kg^{-1}, 2097~2244 µmol kg^{-1}, respectively. TA in this area was mainly influenced by freshwater input, but DIC showed a complicated distribution, driven by many factors. Our results suggested TA in the upper water column of the Bering Sea was mainly driven by conservative mixing with fresher water, and no obvious $CaCO_3$ dissolution/precipitation was detected. When the effect of dilution by normalized DIC and TA to salinity of 35 was removed, the nDIC showed a good relationship to the nTA, with a value of ΔnTA/ΔnDIC approximate to the Radfield ratio, which implied that DIC in the upper water column of the Bering Sea was mainly controlled by biological factors. Using the average wind speed and average pCO_2, the air–sea CO_2 fluxes in the Bering shelf–slope and Bering basin were estimated, –12.3 mmol $m^{-2}d^{-1}$ and –7.6 mmol $m^{-2}d^{-1}$, respectively, resulting in an annual uptake of ~30 Tg C in the Bering Sea.

POC-P-6518

The Stratified Influence of the Kuroshio Intrusion over the Continental Shelf Break off Northern Taiwan

Ze **Liu** and Yijun Hou

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The Brunt-Väisälä frequency is weak in winter and strong in summer, especially along the continental shelf northeast of Taiwan. The sea surface height (SSH) anomalies for the period 1992~2009 combined with the sea surface temperatures (SST) from 1958~2007, are used to reveal the variability of the Kuroshio intrusions and their effects around the region. The EOF analysis results indicate a seasonal cycle dominated by the annual signal.

Based on the actual situation around the shelf break northeast of Taiwan, the magnitude orders of all the variables are estimated and used in the simplification of equations. The non-dimensional parameter S denotes the ratio between the different horizontal scales (L_R/L) and reflects the intensity of the stratification in the study region directly. Besides the inducing effect of the topography and the influence of the monsoons, the stratified effect plays an important role in the mechanism of the Kuroshio intrusion onto the continental shelf. In the subsurface layer, the streamlines have a significant uplift tendency along the shelf break with strong stratified condition. And according to the principle of conversation of potential vorticity (PV), the upwelling of the subsurface water intrudes into the ECS continental shelf more easily in summer than other seasons.

POC-P-6519

The indirect estimation of the climatic trend of kinetic energy production in the North Pacific

Talgat R. **Kilmatov**[1,2], Elena V. Dmitrieva[2] and Olga I. Trinko[2]

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Using the second law of thermodynamics, an indirect estimation of the trends of the climatic component of kinetic energy production in the North Pacific for the last half-century is made. The assumption is made that the production of mechanical energy is proportional to the temperature difference as a "heater" and "cooler" in the heat engine. In the simple application to ocean, the kinetic energy production is proportional to the spatial gradient of the SST. The SST gradient in the poleward–equatorward direction corresponds to the climatic component of energy. The annual variations of internal energy, winds on the ocean surface, and tidal energy are ignored. The data used for the calculation is the HadSST data set (1948–2008) for two months –February and August. The results of calculations of the SST gradient climatic trends in the poleward–equatorward direction for various water areas are given. The average climatic change of the SST gradient zone is 10^{-2} °K/10° degrees latitude for 50 years. There is an asymmetry in the change in the northern and the southern hemispheres for all oceans. In the northern hemisphere there is a reduction of the SST gradient; in the southern hemisphere there is an increase. There is an asymmetry for the western (+) and the eastern (–) parts of the North Pacific during the winter period as well. The results of calculations are discussed from the aspect of the second law of thermodynamics and transformation of the types of energy. The opportunity of asymmetric climatic changes for the western and the eastern gyres in the subarctic North Pacific is also discussed.

POC-P-6549

Summertime CO_2 system distribution and air–sea CO_2 fluxes in the Bering Sea

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The 3rd Chinese National Arctic Research Expedition (CHINARE-III) was carried out from July to September in 2008. The partial pressure of CO_2 (pCO_2) in the air and in the surface sea water were observed along the cruise track in the Bering Sea during July 11–27, 2008, and a number of sea water samples were taken for CO_2 system parameters measurements (*viz.*, pH, total alkalinity (TA), total dissolved inorganic carbon (DIC)). The distributions of CO_2 system parameters in the Bering Sea were clarified, and the controlling factors were discussed. Summertime spatial-temporal distributions of pCO_2 in the Bering Sea surface water were described as the following: central Bering shelf < Bering Basin < northeast Bering shelf < western Bering Strait. The Bering Sea generally acts as a net sink for atmospheric CO_2 in summer. Using the average wind speed and average pCO_2, the estimated air–sea CO_2 fluxes in the Bering shelf, slope and basin were –9.4 mmol, –16.3 $m^{-2}d^{-1}$ and –5.1 mmol $m^{-2}d^{-1}$, respectively, resulting in an annual CO_2 uptake of ~34 Tg C in the Bering Sea.

POC PAPER

POC-P-6562

Spreading pattern and transport of the Okhotsk Sea Intermediate Water to the northwest Pacific revealed by profiling floats with optode and hydrographic observations

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The spatial distribution and transport of the Okhotsk Sea Intermediate Water (OSIW) component off the east coast of Japan to 156°E were examined with the aim of quantifying the outflow and downstream spread of OSIW to the northwest Pacific. Four profiling floats, which were set to drift at a 26.8 σ_θ isopycnal surface and were attached with an optode to measure dissolved oxygen (DO), were deployed in the southwestward Oyashio flow in 2008. After deployment, all floats drifted southward to reach the Oyashio-Kuroshio mixed water region where three of them drifted farther northeastward along the subarctic front (SAF). Hydrographic observations with a CTD and ADCP were also done to cover the float trajectories along SAF west of 156°E. The OSIW component is calculated at densities from 26.7 to 27.3 σ_θ by a multiple tracer analysis that hypothesizes an isopycnal mixture between the three waters from the outflow of Okhotsk Sea, East Kamchatka (EK) current and the subtropical Kuroshio, and numerically solves the equations of mixture with respect to temperature, salinity and DO. A high OSIW component exceeding 50% is seen horizontally along the Oyashio, Oyashio intrusion and SAF, and vertically in the relatively upper intermediate layer 26.7-27.0 σ_θ. The OSIW component along SAF in 1500 dbar referred geostrophic transports is estimated to be 0.7 Sv in 26.7-27.0 σ_θ, which accounts for about 50% of the OSIW transport component in the Oyashio, suggesting that a large volume of OSIW outflow is advected northeastward along SAF.

POC-P-6673

Peculiarities in intermediate water characteristics in the Komandor–Kamchatka area

V.V. **Moroz**

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Using the resources of the Pacific Oceanological Institute (POI) FEB RAS data bank, including the archive materials of national research cruises in the Komandor–Aleutian Islands area, the data of modern field observations carried out by POI, as well as the global array of the average long-term hydrological data of the more than semi-centennial period covering the whole area of the NW Pacific, the thermohaline structure, hydrology–acoustic characteristics, and dynamic water variability were studied. New information about the variability of hydrological water characteristics was obtained. We confine our attention to the intermediate water characteristics. It was shown that the waters of Komandor-Kamchatka area are formed by the cold transformed Bering Sea waters, very cold and more freshened waters of the Kamchatka Peninsula East Coast, and Pacific waters of the warm and saltier Aleutian Current. This mixture of the differently modified water enters the Kuril-Kamchatka Current zone and the North Pacific Ocean as the forerunner of North Pacific Intermediate Water. Characteristic differences of various water modifications in the Komandor-Kamchatka area were found. The cold intermediate layer in the Kamchatka Peninsula East Coast zone is identified by winter temperature conditions in the region. The Kamchatka Strait is the supplier of the cold transformed Bering Sea waters. The intermediate water is replenished both by the warm and the saltiest waters of the Aleutian Current. As a result of the variability of the water discharge to the ocean through the Kamchatka Strait and of Aleutian Current zone distribution, a variable picture of the water circulation in the Komandor-Kamchatka area emerges, and correspondently, its thermohaline characteristics. Such variability is of both seasonal and interannual character. Along with it, a change in location of intermediate layer boundaries and extremes occurs in the thermohaline field structure in the Komandor-Kamchatka area. The location of homogeneous cores of minimal temperature in the cold intermediate layer is observed in the eddies and in the Kuril-Kamchatka Current stream that carry and preserve their own characteristics.

POC-P-6715

Basin-scale low N:P ratios and DOC export in the East/Japan Sea

Tae-Hoon **Kim** and Guebuem Kim

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Vertical and horizontal distributions of nutrients and dissolved organic carbon (DOC) in the East/Japan Sea (EJS) were determined for 2001–2007. The EJS is a typical mid-latitude marginal sea with basins that are over 2000 m deep. A number of upper-ocean characteristics such as the presence of cold and warm waters, a sub-polar front, and eddies are observed in the EJS. The vertical distribution patterns of nutrients in the EJS were typical of those in the major oceans, but the N:P ratios (13) were considerably lower over the entire range of depths. A simple physical-biological box model shows that the physical ventilation of the surface water with a low N:P ratio (about 12) could result in low N:P ratios over the entire water column. The concentrations of DOC in the surface layer (0–200 m) and deep layer (> 200 m) were 66–81 µM and 50–66 µM, respectively, with higher values in the northern part relative to the southern part. The DOC export fluxes calculated by using a simple box model were 0.08 and 1.64 mol C m^2 yr^{-1}, respectively, for the southern and northern area of the EJS. Much of the DOC in the deep ocean is formed in the northern part due to relatively rapid ventilation. Since the low N:P ratios and high DOC export fluxes in the EJS are closely associated with the water ventilation system, the EJS serves as a good natural laboratory for studying biogeochemical responses to climate change.

E-Poster TCODE Topic Session Monitoring and Ocean Observing Systems

Convenor: Bernard A. Megrey (U.S.A.)

Integrated Ocean Observing Systems have recently received significant attention for monitoring and reporting the status of coastal, continental shelf and even deep ocean ecosystems. Ocean Observing Systems enhance our ability to collect, deliver, and use ocean information, and they deliver the data and information needed to increase understanding of our oceans and coasts, so decision makers can take actions to improve safety, enhance the economy, and protect the environment. Ocean Observing System information is also used to initialize numerical ecosystem models. Contributors to this session will demonstrate the application of ocean observing systems that support the FUTURE goals of improved understanding, status reports, outlooks and forecasts through the use of electronic display systems, including interactive web sites and animations.

Thursday, October 28 (18:00-20:30)

TCODE E-Poster Session Posters

E-poster-6450 **Igor Burago, Bernard A. Megrey, Georgiy Moiseenko, Olga Vasik, Tatiana Semenova and Igor Shevchenko**
Using the PICES rented server

E-poster-6685 **Karen Baker, Edward D. Weber and J. Anthony Koslow**
CalCOFI information management and data delivery

E-poster-6717 **Richard Dewey and Verena Tunnicliffe**
VENUS: Real time ecosystem monitoring from a coastal observing system

E-poster-6450

Using the PICES rented server

Igor Burago[1], Bernard A. Megrey[2], Georgiy Moiseenko[3], Olga Vasik[1], Tatiana Semenova[4] and Igor **Shevchenko**[1]

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2 National Marine Fisheries Service, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA 98115
3 Russian Federal Research Institute of Fisheries and Oceanography (VNIRO), 17 V. Krasnoselskaya St., Moscow, 107140, Russia
4 PICES Secretariat, c/o Institute of Ocean Sciences, 9860 West Saanich Rd., Sidney, BC, V8L 4B2, Canada

GeoNetwork opensource provides tools for managing and publishing metadata on spatial data and related services. It includes a web-based interactive map viewer that permits users to composite maps picking layers from distributed servers on the internet. GeoNetwork is based on International and Open Standards for services and protocols. GeoNetwork opensource software is installed and running on the PICES rented server as the PICES TCODE geospatial portal. Along with services for authentication and access control, advanced metadata editing, map visualization and composition, it provides catalog services that actually implement a metadata, data, information and services clearinghouse for the PICES community. Several interface languages (English, Chinese, Russian, French, Spanish) are available. Metadata collected under various TCODE projects in the Federal Geographic Data Committee (FGDC) metadata standard were uploaded to the clearinghouse under the datasets category. The portal is configured to harvest metadata from the TINRO GeoNetwork portal. Some portal services are used by the PICES Secretariat for hosting and cataloging the PICES digital document library. All *PICESians* and expert groups are invited to register and start their own metadata collections, or contribute to such existing categories as datasets, maps and graphics, applications, case studies, best practices, interactive resources, *etc.* At present, the rented server is also a home for the project on the metadata federation of PICES member countries, and hosts a web version of the North Pacific Ecosystem Status Report.

E-poster-6685

CalCOFI information management and data delivery

Karen Baker[1], Edward D. Weber[2] and J. Anthony **Koslow**[1]

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The California Cooperative Oceanic Fisheries Investigations (CalCOFI) program has been developing a web-based information-management system known as DataZoo since 2007. DataZoo expands upon existing CalCOFI data management practices to allow the worldwide community of scientists and the general public to use CalCOFI data effectively. DataZoo is a substantial advance over publishing raw databases because it includes additional elements that, in combination, make it the central feature of an "information environment". The DataZoo information environment aggregates heterogeneous data (*e.g.* two and three-dimensional physical and biological data sampled on a variety of scales), enhancing data access and contributing to the coherence and quality of the long-term CalCOFI data. Currently, data and associated metadata can be browsed, queried and visualized before download by individual users. DataZoo includes datasets ranging from species level counts and hydrographic profiles to biogeochemical measurements and ancillary datasets such as marine birds. It includes the core CalCOFI data sets as well as data from partner programs such as the California Current Ecosystem Long-Term Ecological Research Program. A recent redesign enables delivery of larger files including profile data not previously included in DataZoo. Data delivery and exchange services are under development to meet the future goals of improved and automated access to CalCOFI datasets in coordination with other ocean observing programs.

E-poster-6717

VENUS: Real time ecosystem monitoring from a coastal observing system

Richard **Dewey** and Verena Tunnicliffe

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VENUS has been operational since 2006, and has already amassed a significant archive of high resolution oceanographic time series and supported a variety of interactive experiments. With cabled arrays in both Saanich Inlet and the Strait of Georgia, VENUS is a coastal observing system with real time data displays and user controlled interactive experimental systems, all accessible over the Internet. In addition to standard CTD measurements from each observatory Node, time series of dissolved oxygen, turbidity, ADCP currents, and inverted echo-sounder images of both fish and zooplankton will be presented. A live hydrophone array allows us to listen to the ocean in real time. VENUS is a new tool for monitoring coastal ecosystem health, and will provide core time series in order to assess ocean change over the next few decades. This E-poster presentation will highlight some of the key features of the observing system, review several interactive experiments, demonstrate access to the on-line data archive, and show real time signals from both Saanich Inlet and the Strait of Georgia. There will also be a brief review of our 2011-2013 expansion plans that include mobile assets (Gliders, AUVs, water column profilers) and geospatial mapping of marine conditions (CODAR).

W1 BIO Workshop
Marine ecosystem model inter-comparisons (III)

Co-Convenors: Bernard A. Megrey (U.S.A.), Harold P. Batchelder (U.S.A.), Shin-ichi Ito (Japan), Guimei Liu (China) and Yvette Spitz (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 coastal zooplankton functional groups. Models with high performance will be used to examine the future state of the marine ecosystem to global climate change. This workshop builds upon the discussions and planning accomplished at the successful workshop held at PICES-2009. The workshop will be technical, hands-on, and focus on parameterizing, executing and calibrating three test bed versions of a biogeochemical lower trophic level (LTL) marine ecosystem models. At each test bed 3 to 6 ecosystem models will be run. Specific ecosystem models (i.e., NPZD, NEMURO and CoSINE) will be executed. Some models will be tuned to run in a specific region and others will be applied to areas different from where they were calibrated. Model skill assessment will be evaluated. The models will be used to identify important mechanisms that control secondary production, zooplankton biomass and variability, as well as bounding the levels of uncertainty in model predictions by calculating ensemble statistics. Comparisons at multiple locations will provide information on the spatial-temporal robustness of particular model structures and parameterizations. The products of the comparison will contribute to FUTURE by estimating the uncertainty and the limits of forecasting.

Saturday, October 23 (9:00-18:00), Day 1

9:00	**Workshop Convenors** Welcome, Introductions and General MEMIP Goals
9:30	**Guimei Liu, Hui Wang and Fei Chai (Invited)** Developing Nowcast/Forecast Ecosystem Model in the South China Sea (W1-6493)
10:00	**Harold Batchelder** Data types and availability for the CCS (Newport) and GOA (Seward) test bed locations
10:30	***Coffee/Tea Break***
10:50	**Shin-ichi Ito** Data types and availability for Western Subarctic (A-Line) test bed location
11:05	**Harold Batchelder (with input from all)** Test beds, Ecosystem Models Available, Computer Platforms for MEMIP
11:25	**Yvette Spitz** Demonstration: How to merge/modify an ecological model into ROMS/Compiling Example
11:55	**Small group activity** Whet your modeling appetite before lunch; identify biological models to implement
12:30	***Lunch***
14:00	Implement new ecosystem models into ROMS and run existing codes
15:30	***Coffee/Tea Break***
15:50	Meet in plenary to discuss problems/troubleshoot
16:10	Continue implementation of models
18:00	***Workshop ends***

Sunday, October 24 (9:00-18:00), Day 2

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

9:05 **Yvette Spitz**
Demonstration: Running a model; an example from the Oregon Shelf; BC's, IC's, surface forcing

9:25 Continue implementation of models/run models if ready/debugging

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

10:50 More debugging

12:30 ***Lunch***

14:00 More debugging, and hopefully some successful model runs

15:30 ***Coffee/Tea Break***

15:50 Debugging, debugging, debugging…

17:30 **Workshop Convenors**
Progress Review, Timetable, Next steps incl. post-simulation analyses, Action Item Identification

18:00 ***Workshop ends***

W1 Workshop Oral Presentation

23 October, 9:30 (W1-6493), Invited

Developing Nowcast/Forecast Ecosystem Model in the South China Sea

Guimei **Liu**[1], Hui Wang[1] and Fei Chai[1,2]

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Recent advances in observing systems, computational power and understanding of physical-biological interactions allow us to develop and advance ecosystem model forecasting capability and skill. Simulating and forecasting physical, biological and chemical conditions for the marginal seas are important steps to identify the factors that lead to some extreme environmental events, such as red/green algal blooms, increase of jellyfish population, and anoxia events. At the NMEFC (National Marine Environmental Forecasting Center, China), we have been developing circulation and ecosystem models for the marginal seas of China with a goal to support marine ecosystem management. In this contribution, we present the development of physical and ecosystem models, and investigate physical variations and ecosystem responses in the South China Sea (SCS). The circulation model is based on the Regional Ocean Model System (ROMS). The ecosystem model consists of multiple nutrients and plankton functional groups and detailed carbon cycle dynamics. The physical-biological model is forced with daily air-sea fluxes derived from the National Centers for Environmental Prediction (NCEP) reanalysis data from 1991 to 2009; and then driven by NCEP-GFS (Global Forecast System) datasets from 2010 to the present. The NCEP-GFS provides 72-hour forecasted atmospheric forcing with a resolution of 0.25 degree, so that the physical-biological model can generate daily nowcasts and 3-day forecasts, which include physical conditions, nutrients, phytoplankton biomass, primary productivity, and carbon cycle in the SCS. The coupled model is capable of reproducing many observed features and their variability in the SCS. However, the development of an ecosystem forecasting system is still in the early stage. We outline and discuss some of the technical issues and future directions.

W2 FIS Workshop
Beyond Lagrangian: Modeling migratory fish behavior in Global Circulation Models

Co-Convenors: Enrique Curchitser (U.S.A.), Shin-Ichi Ito (Japan), Michio Kishi (Japan), Skip McKinnell (PICES)

The advent of high resolution coupled atmosphere–ocean circulation models and the creation of repositories of high resolution 4-D ocean hindcasts and future scenarios has made it possible to contemplate adding virtual fish to an increasingly virtual ocean. The ability to study virtual fish in a virtual ocean has a potential to understand past phenomena and potentially, to predict future behavior. Recent developments in satellite data availability, in data assimilating physical models, and in tagging technologies for fishes, all increase the chance to improve our understanding of fish migration mechanism. However, fish behavior is complex. It is a consequence of genes, the physical, chemical and biological environment and their interaction, and perhaps even from learned behavior. This makes the modeling of fish behaviors potentially very complex, and this complexity suggests that a team approach to model building might be desirable. The purpose of this workshop is to understand the current state of development in modeling fish behaviour. Presentations are anticipated that discuss successes (and failures) in modeling migratory fish behavior. Presentations related to data availability to evaluate fish behavior models and laboratory experimental approaches to investigate fish behavior are also welcomed. Based on the results and opinions expressed at the workshop, the convenors would like to discuss the desirability of establishing a group that will focus its attention on developing and advancing the state of fish behavioral modeling.

Saturday, October 23 (14:00-18:00)

14:00	***Introduction by Convenors***
14:05	**Geir Huse (Invited)** Individual based modeling of fish behavior in coupled biophysical models (W2-6588)
14:35	**James Anderson** Seeking principles for modeling fish migratory behavior - A cross discipline approach (W2-6766)
14:55	**Dongwha Sohn, Lorenzo Ciannelli, Janet T. Duffy-Anderson and William T. Stockhausen** Modeling the drift pathways of Greenland halibut (*Reinhardtius hippoglossoides*) from spawning to settling locations in the eastern Bering Sea using the Dispersal Model for Early Life Stages (W2-6792)
15:15	**Chloe Bracis** Successes and limitations modeling fish behavior with limited data (W2-6546)
15:35	***Coffee/Tea Break***
15:55	**Brian J. Burke, James J. Anderson and Edmundo Casillas** Evaluating behavioral rules potentially used by migrating salmon (W2-6432)
16:15	**Steven L.H. Teo, Suzy Kohin, Heidi Dewar, David Wells and Candan Soykan** Movement patterns of pelagic sharks and tunas in the Northeast Pacific (W2-6537)
16:35	***Discussion and Summary by Workshop Convenors***
18:00	***Workshop ends***

W2 Workshop Oral Presentations

23 October, 14:05 (W2-6588), Invited

Individual based modeling of fish behavior in coupled biophysical models

Geir **Huse**

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The presentation will initially focus on describing a general framework for simulating the spatial dynamics of fish populations by using individual based modeling with strategy- and attribute vectors, and super individuals. Then this concept is applied to several cases focusing on climate change, predator-prey interactions and coupled end-to-end biophysical models. Two different approaches for modeling fish behavior are addressed including rule based and adaptation modeling approaches. Rule base approaches are particularly useful for comparing effects of different assumptions about behaviors on spatial or population dynamics, or for models that are validated directly against field observations. Adaptation modeling using a genetic algorithm on the other hand is particularly useful when studying behaviors in relation to the fitness consequences for the fish. The first case focuses on the Barents Sea capelin. This small planktivorous fish has been referred to as a "sea canary for climatic change" due to its sensitivity to climatic variability. Behavioral adaptations of virtual capelin equipped with an artificial neural network "brain" to different climate scenarios will be shown. Next consequences of different assumptions about predator and prey behavior on interactions between cod and capelin are tested in a rule based model. Finally a fully coupled individual based model system for the Norwegian Sea ecosystem will be presented, focusing on migrations of competing planktivorous herring, mackerel, and blue whiting populations. Other topics addressed during the presentation will be learning and collective dynamics of fish.

23 October, 14:35 (W2-6766)

Seeking principles for modeling fish migratory behavior - A cross discipline approach

James **Anderson**

School of Aquatic and Fishery Sciences, University of Washington, P.O. Box 358218, Seattle, WA, 98195-8218, USA. E-mail: jjand@uw.edu

I briefly review studies for how hydrodynamic, magnetic, visual and chemical cues affect behavior of fish and in particular the migratory behavior of salmon. Taking a mechanistic perspective, I consider the physical properties of the cues, an animal's ability to sense and process weak and variable information in the cues and some models relating the cues to fish response. The overall goal is to illustrate how neurological, psychological and ecological principles might be incorporated into models of fish migratory behavior.

23 October, 14:55 (W2-6792)

Modeling the drift pathways of Greenland halibut (*Reinhardtius hippoglossoides*) from spawning to settling locations in the eastern Bering Sea using the Dispersal Model for Early Life Stages

Dongwha **Sohn**[1], Lorenzo Ciannelli[1], Janet T. Duffy-Anderson[2] and William T. Stockhausen[2]

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Analyses of historical ichthyoplankton data revealed that Greenland halibut (*Reinharditius hippoglossoides*) in the eastern Bering Sea have a very long pelagic larval duration, are subject to extended drift pathways before settlement, and have rather strict habitat requirements during the settling phase in the eastern Bering Sea. The distance of probable drift from spawning (near Bering Canyon) to settling locations (near St. Matthew Island) is approximately 1,000 km, taking place over a six-month period and a vertical excursion of over 400 m. We hypothesize that settlement success, associated with recruitment of Greenland halibut, is influenced by inter-annual variability in currents of the Bering Sea slope and shelf during their dispersal. To test our hypothesis, we

W2

simulated annual patterns of drift pathways of Greenland halibut from spawning to settling locations using the Dispersal Model for Early Life Stages (DisMELS). DisMELS is a coupled biophysical individual based model that incorporates behavioral ontogenetic and diel changes (*i.e.* vertical distribution and development stages) in early life stages parameters under 3-dimensional oceanographic currents, temperature and salinity fields from a Regional Ocean Modeling System oceanographic model for the Northeast Pacific Ocean. The results indicate that variation of dispersal pathways are associated with hydrographic variability and can play an important role in early life history of Greenland halibut and their settlement success.

23 October, 15:15 (W2-6546)

Successes and limitations modeling fish behavior with limited data

Chloe **Bracis**

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I created a model of the oceanic phase of adult Pacific salmon homing migration by combining a ocean surface current model with behavior rules in which fish direct their homeward migration by comparing the magnetic field properties of their location against those imprinted at ocean entrance. Critical model parameters are homeward migration initiation date, location and the swimming angle as a function of the magnetic field. Fish swimming speed was set with published information and known fish age at return. Exploring the parameter space that reproduced the arrival windows of Columbia River spring Chinook salmon stocks, I determined that: 1) fish could readily reach the river on time from a wide range Northeast Pacific starting locations, 2) age-dependent differences in return date could be explained by age-dependent differences in swimming speed, and 3) across-year arrival timing variability provides some information on the probable ocean distributions among stocks. Additional information on the stock-specific homeward migration initiation date or location would significantly resolve the uncertainties in migratory paths and would provide a stronger test of the behavior hypothesis.

23 October, 15:55 (W2-6432)

Evaluating behavioral rules potentially used by migrating salmon

Brian J. **Burke**[1,2], James J. Anderson[2] and Edmundo Casillas[1]

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Juvenile Chinook salmon emigrating from the Columbia River, USA, tend to migrate north towards British Columbia and Alaska. However, coastal currents during spring and summer generally flow southward. Do salmon initiate an energetically-expensive positive rheotactic migration with the genetic 'knowledge' that feeding conditions are better in the north? Or do they solely respond to local conditions to maximize growth or survival, inadvertently selecting small-scale currents and depth-specific flows to passively migrate north? We combined output from a 3-D oceanographic model with an individual-based model of Chinook salmon migration and growth. By comparing the spatial distribution of simulated salmon with empirical data, we evaluated a suite of potential behavioral mechanisms used by salmon. We show that overly-simplistic behavioral rules, such as passive migration or a single compass bearing, are inadequate. Although invalidation of behavioral rules is easier than validation, with this tool we can gain insight into the types of behavioral mechanisms likely required for salmon to migrate at realistic rates and with appropriate spatial distributions.

23 October, 16:15 (W2-6537)

Movement patterns of pelagic sharks and tunas in the Northeast Pacific

Steven L.H. **Teo**, Suzy Kohin, Heidi Dewar, David Wells and Candan Soykan

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Many species of pelagic sharks and tunas are well-known for their ability to move large distances in a relatively small period of time. In recent years, the advent of electronic tags has allowed us to track these animals for prolonged periods, up to several years. For over 10 years, the Fisheries Resources Division of the Southwest Fisheries Science Center has tracked the movements of several pelagic shark and tuna species in the Northeast Pacific, using a variety of electronic tags. Research goals center on understanding movement patterns and stock structure, and on improving stock assessments of these species. In this presentation, we will describe the horizontal and vertical movement patterns of albacore tuna, mako, common thresher, and blue sharks. We are in the initial stages of modeling the movement patterns of these species with the aim of including these data into stock assessments. There are also parallel efforts to integrate complimentary information from traditional fisheries sources, such as conventional tags, catch/effort, genetics and otolith microchemistry, in order to obtain a more complete understanding of their movement patterns and stock structure. The aim of this presentation is to share information on our movement database so as to initiate dialogue and collaborations with other labs. Of particular interest is the development of models that predict the habitat use and movement patterns of these animals in response to environmental and climatic variability.

W3

MEQ Workshop and a Laboratory Demonstration New technologies and methods in HAB detection: I. HAB species detection and HAB-S Meeting

Co-Convenors: Ichiro Imai (Japan) and Vera Trainer (U.S.A.)

Here we begin a series of workshops focusing on new technologies in harmful algal bloom (HAB) research and monitoring. The first workshop in this series will include lectures and integrated demonstrations of new methods in organism detection with concentrated information on HAB species. This workshop will describe equipment and methods from the following list: environmental sampling platform (ESP), FloCam, sandwich hybridization assay (SHA), qPCR, FISH, and in situ sensors including gliders. This series will continue in the future with demonstrations on automated nutrient samplers, modeling, remote sensing, and other techniques.

Saturday, October 23 (9:00-18:00), Workshop 3 Presentations

9:00	***Introduction by Convenors***
9:05	**Satoshi Nagai (Invited)** **Recent developments in molecular diagnostic technology for HAB detection** (W3-6472)
9:40	**Katie Flynn Bush, Juli Dyble Bressie, Chris Navas and Clare E. Rogers** A novel, portable flow cytometer facilitates algal population quantification in cultures and environmental samples (W3-6826)
10:05	**Ichiro Imai, Tomotaka Shiraishi, Ken-Ichiro Ishii, Keigo Yamamoto, Masaki Nakajima and Satoshi Nagai** Detection of *Alexandrium tamarense* (Dinophyceae) cysts in bottom sediments with real-time PCR assay: Cyst dynamics and occurrence of bloom in Osaka Bay, the Seto Inland Sea (W3-6744)
10:30	***Coffee/Tea Break***
10:50	**Katherine Hubbard, Claire H. Ellis and E. Virginia Armbrust** Molecular detection and insights into differentiation of Eastern Pacific *Pseudo-nitzschia* communities from the open ocean to the Puget Sound estuary (W3-6855)
11:15	**Vera L. Trainer, Mark S. Strom, Qiuming Yu and Mark L. Wells** A proposal for raman-based barcoding for the identification of toxic marine pathogens and phytoplankton (W3-6775)
11:40	**Nicolaus G. Adams, Piper Schwenke and Vera L. Trainer** Population structure of *Pseudo-nitzschia australis* and its association to domoic acid production in the waters of Washington State (W3-6688)
12:05	**James Birch, Scott Jensen, Brent Roman, Doug Pargett, Christina Preston, Roman Marin, Cheri Everlove and Christopher Scholin** Remote detection of marine microbes, their genes and gene products using the Environmental Sample Processor (ESP) (W3-6857)
12:30	***Lunch***
14:00	**Harry Nelson and Benjamin Spaulding** Demo: Identification and enumeration of *Alexandrium* using an imaging flow cytometer (FlowCAM®) (W3-6831)

14:45 **Wet Labs, Inc.**
Demo

15:30 ***Coffee/Tea Break***

15:50 **Satoshi Nagai and Shigeru Itakura**
Demo: Simple, rapid, specific and cost-effective method for identifying *Alexandrium tamarense* and *A. catenella* using "LAMP" method (W3-6468)

16:50 **Katie Flynn Bush**
Demo: Flow Cytometry

17:35 ***Discussion and Summary by Workshop Convenors***

18:00 ***Workshop ends***

W3 Posters

W3-6760 **Bich-Thuy L. Eberhart, Brian D. Bill, Nicolaus G. Adams, Soram Hong and Vera L. Trainer**
Pseudo-nitzschia and cellular domoic acid levels along the coastline of the Pacific Northwest, USA: Summer 2009

W3-6773 **Brian D. Bill, William P. Cochlan and Vera L. Trainer**
Kinetics of nitrogen uptake and transient ammonium uptake response by the toxigenic diatom *Pseudo-nitzschia turgidula*

Sunday, October 24 (9:00-18:00), HAB-S Meeting Presentations

9:00 **Vera Trainer and Changkyu Lee**
Welcome, goals of HAB Section meeting, introduction of Dr. Lee as new HAB Section co-chair

Country Reports (2009-10) and HAE-DAT (year 2005) reports

9:30 **Changkyu Lee**
R Korea

9:45 **Shigeru Itakura**
Japan

10:00 **Jinhui Wang**
PR China

10:15 **Charles G. Trick**
Canada

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

11:00 **Vera L. Trainer**
U.S.A.

11:15 **Tatiana Orlova**
Russia

11:30 **Mingyuan Zhu**
Harmful algal blooms (HABs) in the Coastal Waters of China in 2009 (HAB-6555)

11:50 **Donald Anderson**
Report on ICES HAB working group and potential areas of collaboration

12:10 ***Discussion***

12:30 ***Lunch***

14:00 **Yoshida Takafumi**
NOWPAP/CEARAC

14:20 **Charles Trick**
PICES Seafood Safety Project

14:40 **Charles Trick and William Cochlan**
Report on GEOHAB Open Science Meeting on Benthic HABs (HAB-6875)

15:00 **Vera Trainer**
The joint Harmful Algal Bloom Programme and International Oceanographic Data and Information Exchange Harmful Algae Information System: An update and proposal for the future

15:30 ***Coffee/Tea Break***

16:00 ***Final Discussion of Proposals for the Future***

18:00 ***Meeting ends***

W3 Workshop Oral Presentations

23 October, 9:05 (W3-6472), Invited

Recent developments in molecular diagnostic technology for HAB detection

Satoshi **Nagai**

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E-mail: snagai@affrc.go.jp

Molecular diagnostic techniques such as PCR-RFLP, real-time Q-PCR, Fluorescence In-Situ Hybridization (FISH) using RNA target probes, and DNA microarray technology have been developed to accurately identify some HAB species. Until recently, my group has developed several molecular techniques in HAB detection. (1) LAMP method: LAMP primers, which can specifically detect five *Alexandrium* species, are currently available. All species can be detectable from single cells within 1 hour from isolation to diagnosis. (2) Multiplex-PCR: a multiplex PCR assay that enables simultaneous detection of 6 *Alexandrium* species on the basis of differences in the lengths of the PCR products has successfully developed. Species-specific identification by the multiplex PCR assay was certainly possible from single cells of the target species. (3) DNA microarray: we designed DNA probes to detect target HAB species and succeeded in developing 42 DNA probes to specifically detect 18 HAB species including *Alexandrium*, *Chattonella*, *Cochlodinium* and *Karenia*. We need to further test the microarray system to apply natural samples for practical use. (4) Metagenome analysis of plankton species using next generation sequencer: to investigate plankton diversity, seawater samples were taken from two locations and DNAs were extracted. The target region (ca. 500 bp) was PCR-amplified using universal primers and ca. 50,000 sequences (500 bp in average) were determined from ten DNA templates. Each sequence was blast-searched, resulting in >960 different sequences from each location (in total >1500 sequences) containing almost all plant phylum (21 algal classes) except for cyanobacteria and prochlorophytes and many phylum in protozoa, fungi and Animalia.

23 October, 9:40 (W3-6826)

A novel, portable flow cytometer facilitates algal population quantification in cultures and environmental samples

Katie Flynn **Bush**[1], Juli Dyble Bressie[2], Chris Navas[3] and Clare E. Rogers[3]

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2 NOAA, University of Washington, Seattle, WA, USA
3 Accuri Cytometers, Inc., Ann Arbor, MI, USA

Flow cytometers are useful tools for monitoring phytoplankton populations both in cultures and environmental samples, as multiparametric measurements of particle size and autofluorescence can be collected quickly (10,000 events/sec) on large samples (up to several mLs). We have utilized the Accuri C6 flow cytometer in both a lab setting and onboard a small boat to assess the feasibility of real-time monitoring of cyanobacterial blooms in Michigan lakes. The C6 system has several advantages for this application: 1) The system has pre-optimized voltage settings and > 6 logs of dynamic range on all detectors, which simplifies data collection for the novice user and reduces the chance of data loss due to improper instrument set up, 2) unlike other small, easily portable cytometers, the C6 has a microprocessor controlled, peristaltic pump-driven fluidics system which allows large volumes of sample (several mLs) to be collected continuously, and a count per mL of any identified population to be determined without the addition of counting beads, and 3) the system is light (30 lbs), can be operated from a laptop, and is easily connected via DC power converter to an onboard-electric system. The system was validated for particle size discrimination of 0.5 um and larger using Megamix sizing beads (BioCytex). Fluorescence excitations and emissions (Ex/Em) were analyzed at the following wavelengths: 488Ex/585BP, 488Ex/670LP, 640Ex/675BP, corresponding, respectively, to the following endogenous fluorescent species: phycoerythrin, chlorophyll accessory pigments, phycocyanins. The fluorescence "signatures" (median channel fluorescence value ratios determined from the emissions at each of the wavelengths listed) of 5 different *Microcystis* cultures, and 6 other phytoplankton species (diatoms, cyanobacteria and green algae) were determined. Data collected from 8 different lake samples were compared to these signatures, and counts per mL of each putative species were determined.

23 October, 10:05 (W3-6744)

Detection of *Alexandrium tamarense* (Dinophyceae) cysts in bottom sediments with real-time PCR assay: Cyst dynamics and occurrence of bloom in Osaka Bay, the Seto Inland Sea

Ichiro **Imai**[1], Tomotaka Shiraishi[2], Ken-Ichiro Ishii[3], Keigo Yamamoto[4], Masaki Nakajima[4] and Satoshi Nagai[5]

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[5] National Research Institute of Fisheries and Environment of Inland Sea, Fisheries Research Agency, Hatsukaichi, Hiroshima, 739-0452, Japan

In Osaka Bay from spring of 2002, the toxic dinoflagellate *Alexandrium tamarense* caused PSP toxin contamination of bivalves such as manila clams and blue mussels, apparently for the first time in recorded history. A “red tide (maximum of 7.27×10^4 cells ml^{-1})” was formed and the highest toxicity of 140MU g^{-1} was recorded for manila clam in spring of 2007. We conducted monthly monitoring of *A. tamarense* from August 2007 to February 2009 in Osaka Bay for enumeration of cysts in sediments and vegetative cells in the water column.. Water samples (depths of 0, 5, 10m) and sediments (0-3cm) were collected from 4 stations. Vegetative cells were identified and counted after the staining with calcofluor white M2R, and cysts were enumerated with epifluorescence microscopy after the primulin staining. Quantification of cysts was simultaneously performed using real-time PCR assay for *A. tamarense* and *A. catenella*. Nutrient,and chlorophyll *a* concentrations were measured, and other phytoplankton were quantified. The results of cyst enumeration by both primulin staining method and real-time PCR method revealed corresponding values. The real-time PCR method turned to be a feasible method for specific and quantitative monitorings of cysts in sediments. No cysts of *A. catenella* were detected at all. Vegetative cells of *A. tamarense* appeared in January of 2008, increased thereafter, showed a peak (3.6 – 15 cells ml^{-1}) in April, then disappeared through cyst formation in April to May. Cyst densities of *A. tamarense* in sediments abruptly increased in April (from < 40 in March to 119 – 258 g^{-1} wet sediment). Nutrient concentrations showed the depletion of silicate (around 1mM) and phosphate (0.5mM or lower) during February and April, when diatoms markedly decreased and *A. tamarense* dominated in the water column.

23 October, 10:50 (W3-6855)

Molecular detection and insights into differentiation of Eastern Pacific *Pseudo-nitzschia* communities from the open ocean to the Puget Sound estuary

Katherine **Hubbard**, Claire H. Ellis and E. Virginia Armbrust

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More than thirty species have been described for the diatom genus *Pseudo-nitzschia*, many of which are capable of producing the neurotoxin domoic acid. Similar morphologies have been described for highly toxigenic and less toxigenic species in the Eastern Pacific. We designed *Pseudo-nitzschia* specific PCR primers targeted to the variable internal transcribed spacer 1 (ITS1) region to permit molecular identification of species with Automated Ribosomal Intergenic Spacer Analysis (ARISA). The primers have the ability to amplify novel *Pseudo-nitzschia* diversity, and are predicted to amplify species from geographically distant regions. Species are identified by differences in sequence length, and clone library sequences are used to confirm species identifications. We found a positive relationship between concentrations of *Pseudo-nitzschia* culture DNA added to PCRs and relative ARISA fluorescence (R^2=0.66-0.83), and results indicated that ARISA could detect cellular abundances ranging over 5 orders of magnitude. Here, we used ARISA to characterize the relative abundance of *Pseudo-nitzschia* species in samples obtained on cruises of opportunity from open ocean, coastal, and estuarine waters. Fourteen different *Pseudo-nizschia* species were identified. Temporal and spatial patterns of community similarity were linked to seasonal ocean circulation patterns. A few species were good indicators of open ocean, coastal, or estuarine water masses, suggesting that *Pseudo-nitzschia* species might be suitable tracers of physical and environmental processes.

23 October, 11:15 (W3-6775)

A proposal for raman-based barcoding for the identification of toxic marine pathogens and phytoplankton

Vera L. Trainer[1], Mark S. Strom[1], Qiuming Yu[2] and Mark L. **Wells**[3]

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Maintaining shellfish food safety currently requires extensive and expensive monitoring for phytoplankton toxins and marine pathogens. Most biological sensors under current development employ specific gene markers to provide specificity and sensitivity; i.e., well-founded methods in molecular biotechnology. While these approaches have a high likelihood for success, they require complex wet chemistry and often depend on environmentally susceptible antibody methods, greatly complicating their engineering transition to sensor network arrays. Recent work has shown preliminary success with the use of nanotechnology-enabled Surface-Enhanced Raman Scattering (SERS) to measure unique, species-specific signals that allow detection and quantification of pathogens. We show that using SERS spectra combined with principal component analyses it is possible to clearly differentiate among four bacteria; *Acinetobacter calcoaceticus*, *Staphylococcus epidermidis*, *Pseudomonas aeruginosa*, and *Escherichia coli*, and there is good reason to expect that similar species selectivity would be possible for eukaryotic, toxic producing phytoplankton responsible for HABs. Moreover, it is conceivable that SERS may be able to distinguish between toxic and non-toxic forms of *Pseudo-nitzschia* species. The goals of our project are to develop SERS vibrational spectra libraries of marine pathogens and HAB species found in Puget Sound, and to test the ability of SERS-based detection schemes to provide early warning of marine events that threaten human health. This work will provide the basis for future development of nano-enabled biosensor networks for HAB and pathogen monitoring in coastal waters.

23 October, 11:40 (W3-6688)

Population structure of *Pseudo-nitzschia australis* and its association to domoic acid production in the waters of Washington State

Nicolaus G. **Adams**, Piper Schwenke and Vera L. Trainer

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Since 1991, contamination of razor clams with the neurotoxin domoic acid has resulted in frequent closures of this important recreational and commercial fishery on the outer coast of Washington State. However, prior to September 2003 there had not been a closure of shellfish harvesting in the inland waterways of Washington State due to domoic acid contamination. In September 2003 at Kilisut Harbor, WA domoic acid concentrations reached 29 ppm in blue mussels (*Mytilus edulis*) and prompted the first closure of shellfish harvesting due to domoic acid in Puget Sound waters. Although this was the first closure due to domoic acid in the inland waters of Washington State, diatoms of the genus *Pseudo-nitzschia*, which can produce domoic acid, have been observed in Puget Sound waters since at least 1990. One of the species responsible for the 2003 closure, as well as a subsequent closure in Puget Sound at Penn Cove in 2005, was *Pseudo-nitzschia australis*. This species is frequently observed on the outer coast of Washington State as well as in Puget Sound, and was thought to be the causative organism in the first documented domoic acid event on the outer coast of Washington in 1991. Microsatellite markers are being developed to determine the population structure of *P. australis* in Washington State waters. Additionally, relationships between distinct populations and population specific production of domoic acid will be assessed in laboratory culture experiments using ELISA to assess low-level toxin production. Further work will ascertain whether genetically distinct populations of *P. australis* are predisposed to producing higher concentrations of domoic acid than other populations as well as the environmental conditions conducive to elevated production of domoic acid. If certain populations prove to be more toxic than others, specific molecular markers will be developed to target these populations.

23 October, 12:05 (W3-6857)

Remote detection of marine microbes, their genes and gene products using the Environmental Sample Processor (ESP)

James **Birch**, Scott Jensen, Brent Roman, Doug Pargett, Christina Preston, Roman Marin, Cheri Everlove and Christopher Scholin

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The application of molecular techniques for identifying marine microbes, specific genes, and gene products currently demands collecting discrete samples, sometimes in liter quantities, and transporting samples to a laboratory for processing. This requirement typically results in delays ranging from many hours to days between collection of material and its analysis. We have approached this problem by the development of an *in situ* sensor, the Environmental Sample Processor (ESP). The ESP is a field-deployable system that combines autonomous sample collection capability with molecular analytical detection functionality.

The ESP can assess the presence and abundance of specific organisms, their genes and/or metabolites in near real-time using low-density DNA probe and protein arrays. Filter-based sandwich hybridization methodology enables direct detection of ribosomal RNA sequences diagnostic for groups of bacterioplankton, as well as a variety of invertebrates and harmful algal species. An antibody-based technique is used for detecting domoic acid, an algal biotoxin. The ESP also allows for application of a 2-channel real-time PCR module. Users can configure this system to support a variety of master mixes, primer/probe combinations and control templates. This presentation will highlight development of methods for use onboard the ESP, results of recent field trials and an outline of plans for its use in coastal and oligotrophic oceanic regimes.

23 October, 14:00 (W3-6831)

Identification and enumeration of *Alexandrium* using an imaging flow cytometer (FlowCAM®)

Harry **Nelson** and Benjamin Spaulding

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The ability to detect, identify and enumerate harmful algal species is a requirement in coastal ecosystems for monitoring programs and early detection of harmful bloom events. To date the majority of research monitoring programs utilize microscopes and chemically altered samples for fluorescence or other agents for whole cell species-specific identification of bloom species that can be both laborious and time consuming. The FlowCAM® is an imaging-flow-cytometer that combines the capabilities of a flow cytometer with a digital-imaging microscope providing for semi-automated phytoplankton detection and enumeration. Having the capability to detect two fluorescence signals, the FlowCAM can capture images from fluorescing cells containing specific stains for the purpose of both identifying a target species and for enumerating their abundance. Here we describe how the FlowCAM can detect, identify and enumerate *Alexandrium fundyense* when stained with an off-the-shelf oligonucleotide probe. Data from cultured samples as well as from wild samples will be presented.

23 October, 15:50 (W3-6468)

Simple, rapid, specific and cost-effective method for identifying *Alexandrium tamarense* and *A. catenella* using "LAMP" method

Satoshi **Nagai** and Shigeru Itakura

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"LAMP" which stands for **L**oop-mediated Isothermal **Amp**lification is a simple, rapid, specific and cost-effective nucleic acid amplification method solely developed by Eiken Chemical Co., Ltd in Japan. Advantages of LAMP are: 1) there is no need for a step to denature double stranded into a single stranded form; 2) the whole amplification reaction takes place continuously under isothermal conditions (ca. 65°C); 3) the amplification efficiency is extremely high, with DNA being amplified 10^{9}-10^{10} times in 15-60 minutes; 4) by designing 6 primers

to recognize 8 distinct regions, the LAMP method is able to specifically amplify the target gene; 5) the total cost can be reduced, as LAMP dose not require special reagents or sophisticated equipments such as thermal cycler and other basic apparatus for molecular biological experiments; 6) the amplification can be checked with eyes through the presence of amplified product (the turbidity of magnesium pyrophosphate, a by-product of the amplification reaction).

We have developed LAMP primers for detecting *A. tamarense* and *A. catenella*, and it is possible to identify each species from a single cell within 1 hour (starting from isolation of cells by capillary pipet to detection of DNA amplification). This method can be used in underequipped laboratories and local monitoring offices with no thermal cycler and other basic apparatus for molecular biological experiments.

W3 Workshop Posters

W3-6760

Pseudo-nitzschia and cellular domoic acid levels along the coastline of the Pacific Northwest, USA: Summer 2009

Bich-Thuy L. **Eberhart**[1], Brian D. Bill[1], Nicolaus G. Adams[1], Soram Hong[2] and Vera L. Trainer[1]

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2 Center for Environmental Health Sciences, University of Montana, Missoula, MT, USA

In recent years, phycotoxin and phytoplankton data collected during research cruises have indicated the efficacy of monitoring domoic acid (DA) toxin and phytoplankton concentrations simultaneously as a useful strategy for early warning of harmful algal bloom events. Seawater samples collected along the Pacific coast from south of Monterey Bay, CA northward to Cape Flattery, WA in the summer of 2009 allowed the near real-time tracking of *Pseudo-nitzschia* and particulate domoic acid (pDA) concentrations. A highly sensitive indirect competition Enzyme-Linked Immunosorbent Assay (icELISA) was used to quantify low levels of cellular DA at concentrations ranging from 2 to 950 ng/L. *Pseudo-nitzschia* were enumerated and speciated using light and scanning electron microscopy, respectively. The mismatch of toxin concentrations and *Pseudo-nitzschia* abundance demonstrated the variability of cellular DA by several *Pseudo-nitzschia* species along the Pacific coast of the U.S. Such cruise data allow for the tracking of toxic *Pseudo-nitzschia* cells in the open ocean before they are transported to shorelines where they can negatively impact the harvest of shellfish.

W3-6773

Kinetics of nitrogen uptake and transient ammonium uptake response by the toxigenic diatom *Pseudo-nitzschia turgidula*

Brian D. **Bill**[1,2], William P. Cochlan[2] and Vera L. Trainer[1]

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2 Romberg Tiburon Center for Environmental Studies, San Francisco State University, 3152 Paradise Dr., Tiburon, CA, 94920, USA

Nitrogen uptake kinetic parameters and transient ammonium uptake capabilities of *Pseudo-nitzschia turgidula* were investigated using the N-15 isotopic tracer technique using unialgal batch cultures grown under saturating light conditions. Maximum specific uptake rates and affinity values for three nitrogen substrates: nitrate, ammonium and urea were estimated for this primarily oceanic species for the first time. Transient, or 'surge', ammonium uptake capabilities were also investigated on nitrogen-starved batch cultures. *P. turgidula* demonstrated a nitrogen uptake preference of the order: ammonium > nitrate > urea, and mean maximum uptake rates (V_{max}) of 96.3, 48.5, and 12.6 x 10^{-3} h^{-1}, respectively. Substrate affinity at low nitrogen concentrations was determined by the initial slope (a) of the Michaelis-Menten curve (or equivalent), and nitrogen preference followed the same order as determined with maximum uptake rates and elevated nitrogen concentrations. Values for the initial slope were

36.7, 29.4 & 0.9 x 10^{-3} h^{-1}/(μg-at N L^{-1}), respectively for the ammonium, nitrate and urea substrates. *P. turgidula* demonstrated a capacity for transient 'surge' uptake of ammonium during the first 3-5 minutes and this capacity declined within 0.5 h to a relatively constant rate. These are the first results to demonstrate that an oceanic isolate of *Pseudo-nitzschia* can utilize both inorganic and organic nitrogen for assimilation and has the capacity for surge uptake of ammonium. These results will be useful for managing anthropogenic inputs into marine systems and understanding the potential contributions of *P. turgidula* to phytoplankton bloom development and its toxigenic capacity in both coastal and oceanic waters.

HAB Section Meeting Oral Presentations

23 October, 10:15 (HAB-6875)

Report on the 2009 GEOHAB Meeting on Benthic Harmful Algal Bloom species

Charles G. **Trick**[1] and William P. Cochlan[2]

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A GEOHAB-sponsored open science meeting on HAB in benthic systems was held in Honolulu, HI in June 2010 that brought together researchers specializing in benthic HAB outbreaks. The primary HAB-related health issue discussed at this symposium was CFP (ciguateria fish poisoning) and its causative organism(s) - benthic dinoflagellates. CFP, while strongly associated with tropical regions, affect PICES countries (primarily Japan and U.S.A.), but also represents a HAB outbreak that is somewhat unique and distinct from the traditional planktonic HABs that dominate most PICES discussions for northern Pacific Ocean coastal regions. We will summarize the conclusions of this meeting, placing our emphasis on the extent of the problem, the level of knowledge on the causative species, the degree of monitoring presently being conducted, complications associated with linking species presence and health concerns, and research opportunities for PICES HAB scientists. We will also outline the proposed CFP monitoring efforts to be initiated in the South Pacific region as part of a PICES-administrated, "Sea Food Safety and HABs" program, funded through the Government of Japan.

23 October, 11:30 (HAB-6555)

Harmful algal blooms (HABs) in the Coastal Waters of China in 2009

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There were 68 HAB events in coastal water of China in 2009. Among them, 4 were in Bohai Sea, 13 in the Yellow Sea, 43 in the East China Sea and 8 in the South China Sea. The season with frequent HAB was from April to August. More HABs occurred in East China Sea accounting for 63% of the total events. The large scale HABs were occurred in Bohai Sea and East China Sea. The main causative species include *Noctiluca scintillans Skelotonema costatum, Heterosigma sp., Karenia mikemotoi*. The toxic HAB reached 11 times the concentration of nontoxic species and the total direct economic loss of these events was 65 million Chinese yuan. There was a large scale green tide in the Yellow Sea during June and July. In early July, the effected area reached 58,000 km^2 and covered area 2,100 km^2. The economic loss caused by green tide was 641 million Chinese Yuan.

W4 POC Workshop PICES Working Group on Evaluations of Climate Change Projections (WG 20): Progress and FUTURE

Co-Convenors: Michael G. Foreman (Canada) and Yasuhiro Yamanaka (Japan)

Presentations and discussions will be carried out on: (1) progress related to the WG20 Terms of Reference, (2) status of, and future work on, the final report, and (3) follow-up activities that conform to FUTURE objectives and needs.

Sunday, October 24 (14:00-18:00)

Objectives and Agenda for Workshop W4

Objectives: Present and discuss drafts of chapters for the final WG20 Report and finalize recommendations to PICES/FUTURE. The following list of possible chapters was put forward at the April WG20 meeting in Sendai, Japan:

- ***Introduction***: Background and Terms of Reference
- **Wang, Overland, Bond**: GCM downscaling procedures & examples
- **Di Lorenzo, Miller**: Regional climate modeling and covariability in North Pacific
- **Foreman and colleagues**: RCM development for BC shelf waters
- **Christian**: GCM carbon cycle development
- **Curchitser, Hermann**: RCM development for the NE Pacific and Bering Sea and two-way coupling of this RCM into the NCAR GCM
- **Ustinova, Zuenko**: Evaluation of climatic variability in Far Eastern Seas
- **Navrotsky**: interactions between climate and ecosystems
- **Yamanaka, Hasumi, and colleagues**: Ecosystem projections for the Kuorshio/Oyashio system
- **Jang, Pang, Park, Yeh, and colleagues**: GCM projections of changes to mixed layer depth
- **Qiao, Wang, Wu and colleagues**: Chinese contributions
- ***Summary and recommendations***

Informal Agenda:

1. Review of WG20 Terms of Reference and what was accomplished
2. Discussion of proposed chapter topics and presentations of recent research that might be included
3. Updates on chapter assignments and setting of deadlines
4. Recommendations for follow-up work and/or groups within FUTURE
   Summary of Seoul Advisory Panel meeting, August 16-18
5. Adjournment to local pub/restaurant

W5 POC/BIO Workshop Carbon data synthesis (III)

Co-Convenors: Masao Ishii (Japan) and Robert M. Key (U.S.A.)

This workshop will continue the implementation of the North Pacific carbon data synthesis. Investigators who submit data to the workshop 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 process, and will lead directly to value-added data products and collective publications.

Friday, October 22 (9:00-18:00), Day 1

9:00 **Masao Ishii, Masahide Wakita, Akihiko Murata, Toru Suzuki, Alex Kozyr and Robert Key**
Second-level quality control of PACIFICA synthesized database (W5-6602)

9:30 **Robert M. Key (Invited)**
Expanding the ocean interior carbon data collection

10:00 **Toru Suzuki**
Review for the method of cross-over analyses and inversions for secondary QC of PACIFICA

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

10:50 Subgroup-1: Secondary QC of CO_2 parameters - 1
Subgroup-2: Secondary QC of oxygen and nutrients - 1

12:30 ***Lunch***

14:00 Subgroup-1: Secondary QC of CO_2 parameters - 2
Subgroup-2: Secondary QC of oxygen and nutrients - 2

15:30 ***Coffee/Tea Break***

15:50 Subgroup-1: Secondary QC of CO_2 parameters - 3
Subgroup-2: Secondary QC of oxygen and nutrients - 3

18:00 ***Workshop ends***

Saturday, October 23 (9:00-18:00), Day 2

9:00 Subgroup-1: Secondary QC of CO_2 parameters - 4
Subgroup-2: Secondary QC of oxygen and nutrients - 4

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

10:50 Subgroup-1: Secondary QC of CO_2 parameters - 5
Subgroup-2: Secondary QC of oxygen and nutrients - 5

12:30 ***Lunch***

14:00 **Michio Ishii**
Report from sub-group - 1

14:20	**T. Ono** Report from sub-group - 2
14:40	**A. Murata** Secondary QC of data from Bering Sea
15:00	**K. Sasaki** Secondary QC of CFCs
15:30	***Coffee/Tea Break***
15:50	Discussion on the future plan : Opening of PACIFICA to the public
17:00	Discussion on the future plan : Scientific products
18:00	***Workshop ends***

W5 Workshop Oral Presentation

22 October, 9:00 (W5-6602)

Second-level quality control of PACIFICA synthesized database

Masao **Ishii**[1], Masahide Wakita[2], Akihiko Murata[3], Toru Suzuki[4], Alex Kozyr[5] and Robert Key[6]

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PACIFICA is a synthesized Pacific Ocean database. Important uses include estimating anthropogenic CO_2, ocean acidification, and investigating natural variability of the biogeochemical processes. PACIFICA has data from 265 cruises including 14 CLIVAR cruises and other often repeated lines and stations such as 137ºE, Line-P, KNOT and A-line. Following the agreements in the workshop held in Jeju, Korea, we have begun to quantify systematic differences in reported values, i.e., 2nd level QC, based on cross-over analyses using deep ocean data. At the next workshop in Tokyo, Japan, in June 2010, selection of core cruises, variable settings for cross-over analysis, inversion weightings, minimum adjustments, *etc.*, that are potentially unique to the Pacific, were discussed on the basis of preliminary cross-over runs as well as oceanographic and methodological knowledge. At the 3rd workshop to be held during PICES 2010, each suggested adjustment value, either additive or multiplicative, for parameters including salinity, total dissolved inorganic carbon (DIC), total alkalinity (TA), oxygen, nutrients, and CFCs for each cruise will be decided to finish the 2nd level QC. Once the 2nd QC is completed, both the original cruise files and a fully calibrated data product will be published and distributed via CDIAC. Details of the QC work, the data adjustments and the production of the data products will finally be described in a series of papers.

WG-21 Working Group 21 Meeting Non-indigenous Aquatic Species

Co-Chairmen: Vasily Radashevsky (Russia) and Darlene Smith (Canada)

Saturday-Sunday, October 23-24 (9:00-18:00)

WG-21-6866

Per capita invasion probabilities: A linear model to predict rates of invasion via ballast water

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Ballast water discharges are a major source of species introductions into marine, estuarine, and freshwater ecosystems. For example, in the San Francisco Estuary, dubbed the "most invaded estuary in the world", it is estimated to account for 38-76% of the aquatic invaders. To predict the potential rate of invasion from ballast water, we developed a linear invasion model based on historic invasion rates for the San Francisco Estuary and Great Lakes. The per capita invasion probability was calculated by dividing the number of ballast water invaders by the total number of organisms discharged via ballast water, which was estimated from total volume of ballast discharged times the mean ballast water concentration of organisms. The resulting per capita invasion probability represents the likelihood that a single discharged organism becomes established. In these calculations, we used a mean ballast water concentration of 4640/m3 for organisms >50 microns. Based on data from the National Ballast Information Clearinghouse, an average of 819,364 metric tons per year of ballast water from foreign ports was discharged into the San Francisco Estuary from 2004-2008. Between 1991- 1995 it is estimated that the invasion rate from ballast water in the San Francisco Estuary was 1.6-3.2 species per year. Assuming an underestimate of 100% due to unknown, unidentified and unclassified species, invasion rates were adjusted to 6.4 species per year. Assuming a linear dose-response relationship, the per capita invasion probability for San Francisco Estuary is 1.68 x 10-9. For the Great Lakes, the National Biological Invasion Shipping Study recorded that the total annual foreign ballast water discharged in 1991 was 1,395,461 metric tons. The invasion rate was estimated at 2 species per year, yielding a per capita invasion probability for the Great Lakes of 3.09 x 10-10. These two well studied systems provide a first approximation of per capita invasion probabilities that can be used to estimate the probability of invasion from either a single ship's discharge, or the total volume of ballast discharged into a system. While these numbers will vary linearly along a continuum of ballast discharge values, organism concentrations, and invasions rates for individual places, we suggest that these per capita invasion probabilities for the San Francisco Estuary and the Great Lakes are viable surrogate values for other less studied estuarine and freshwater areas.

WG-21-6867

Density matters: Comparison of approaches to developing ballast water discharge targets

Henry **Lee II**[1], Deborah A. Reusser[2] and Melanie R. Frazier[3]

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A consensus has evolved that invasion risk increases with propagule pressure. However, translating this general principal into ecologically "acceptable" concentrations of organisms in ballast water has proven challenging. The treaty being promulgated by the International Maritime Organization (IMO) contains performance standards for different size guilds, with a standard of <10 organisms per m3 for organisms >50 microns. To put the IMO standards into context, we are evaluating other approaches to generating ballast water targets. The most protective is the zero discharge standard of organisms >50 microns being considered by California, though there is a question regarding its technological feasibility in the near term. An alternative California proposal is to set the invasion rate via ballast water discharges equivalent to the "natural invasion rate". This approach, developed by Dr. Andrew Cohen, is purportedly ecologically protective but an initial analysis by experts generated a one-hundred fold range in natural invasion rates. Another low target is the 0.1 organisms per m3 that had been proposed in U.S. Senate bills, and which appears to be based on expert opinion. Modeling approaches include reaction-diffusion models that predict establishment of an invader as a "race" between the dilution of the population and population growth. Such models are most appropriate to passively distributed organisms that spend their entire life cycle within the water column. Application of this approach by Drake et al. generated acceptable ballast discharge volumes but these were not readily converted to organism concentrations. A more general approach uses population viability analysis (PVA) models that predict the likelihood of extinction (= non-establishment) as a function of the population's growth rate and population variation. A practical limitation of the PVA models is the paucity of population data, in particular long-term population data to estimate population variability. A final approach is the per capita invasion probability that we are developing based on historic invasion rates. Assuming a linear propagule dose-response, the per capita invasion probability represents the likelihood that an individual will become established. These various approaches generate "acceptable" ballast water concentrations that vary by orders of magnitude, a consequence of differences in both assumptions and levels of acceptable risk.

WG-21-6872

Is it or isn't it? Taxonomic proficiency of North Pacific NIS Polychaete assessments in the Northeast Pacific

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All non-indignous species (NIS) programs rest on the bedrock of species identifications for the assessments of their native, cryptogenic, or non-indigenous origins. Millions of dollars are spent on detection, prevention, control, and eradication programs. The economic damage of wide spread invasive species is likely to reach into the billions of dollars. While large, charismatic marine invertebrates, such as green crabs, European fan worms, lionfish, and tunicates are readily identified, the smaller and more diverse species such as polychaetes that can also exert great ecosystem effects are often poorly identified if at all. Examples include well-established NIS that are at first mis-identified as natives or cryptogenic species before closer examination. The reverse is also true - poorly identified natives or cryptogenic species are mistaken for NIS. These problems stem from poor access to taxonomic training, inadequate literature, lack of support, and poor communication between taxonomists. What's needed is enhanced exchange of information between regional and international taxonomists, both morphological and molecular methods of identification for cryptic species, and a greater reliance on previously verified specimens. Voucher collections are essential as is their being made accessible by museum deposition with their locations included as part of the ecological literature.

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