PICES Sixteenth Annual Meeting

The changing North Pacific: Previous patterns, future projections, and ecosystem impacts

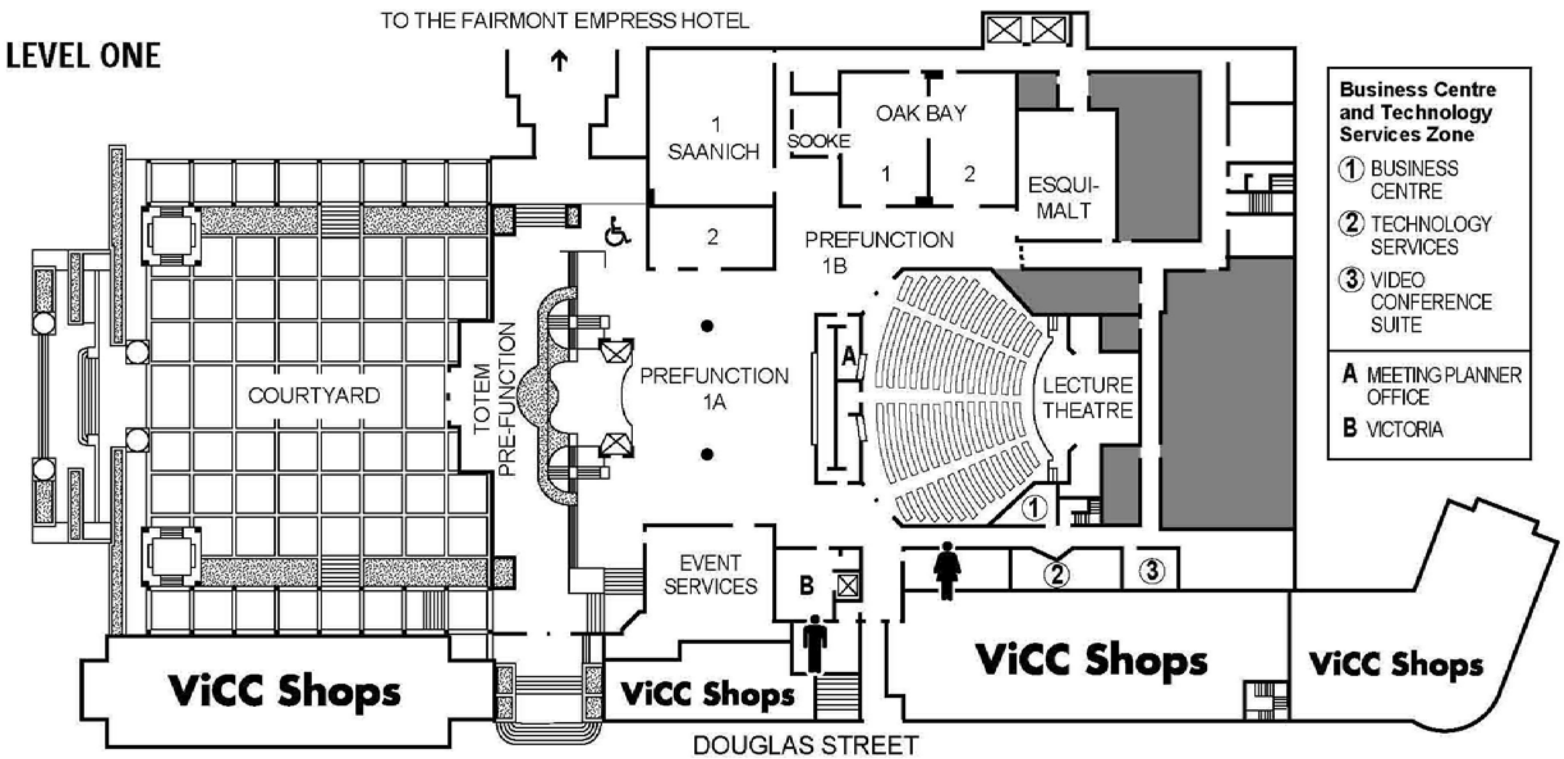
PICES

October 26 – November 5, 2007
Victoria, British Columbia, Canada

Table of Contents

Abstracts for oral presentations are sorted first by session and then by presentation time. Abstracts for posters are sorted by paper ID number. Presenter name is in bold-face type and underlined. The Author Index lists all authors and co-authors in alphabetical order and includes their paper ID numbers and page numbers. Some abstracts in this collection are not edited and printed in the condition they were received.

The Victoria Conference Centre



Notes for guidance

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. (On average, time slots for contributed oral presentations are **20 minutes**. All authors should allocate at least **5 minutes** for questions.)

Authors should provide their presentations on **CDs** or **USB** memory sticks, preferably a day before their presentations to PICES staff for uploading, in the registration area. **PowerPoint** is the preferred media for oral presentations.

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 29 (a.m.) until the end of the Wine & Cheese Poster Session on the evening of November 1, when poster presenters are expected to be available to answer questions. Posters must be removed in the morning of November 2. The location for poster displays is at the Courtyard Pavilion, Victoria Conference Centre (VCC).

Internet access

Internet access via wireless LAN will be available in the VCC, lobby area ONLY. A few desktop computers will also be available for participants to use.

Social activities

29 October (18:00-20:30)	Welcome Reception hosted by Fisheries and Oceans Canada (Royal BC Museum)
31 October (20:00-23:00)	Canada Games: Curling (Juan de Fuca Curling Club; a bus will be provided at 19:30)
1 November (18:30-20:30)	Wine & Cheese Poster Session (Courtyard Pavilion, VCC)

Keynote Lecture

The North Pacific, human activity, and climate change

Kenneth Denman[1,2]

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Humans are profoundly altering the oceans – by changing the climate through the burning of fossil fuels, by overfishing, and by physical and chemical alteration of the coastal zone. Human-induced warming of the oceans can be detected to depths of thousands of meters. The rate of sea level rise, due to the warming expansion of seawater and freshwater input from glacial and snow melt, has accelerated over the last two decades. Nearly half the CO_2 that has been emitted into the atmosphere through human activities, primarily fossil fuel and biomass burning, now resides in the oceans. This 'anthropogenic' CO_2 can be detected to the bottom of the ocean, and has already made it more acidic, further reducing the ocean's ability to accept more CO_2 from the atmosphere. In Canada, in 2006 we marked 50 years of sampling along Line P and at Ocean Station Papa, and this year marks 100 years of sampling fisheries ecosystems by the Pacific Biological Station. From these and sustained sampling programmes by other PICES member nations, we have determined that the subarctic North Pacific represents the state of future global oceans. It is more stratified. Subsurface dissolved oxygen is decreasing. And the depth below which calcareous organisms are subjected to dissolution is already only a few hundred metres in some areas. By 2100 this increasing acidity in the North Pacific risks the dissolution and disappearance of calcareous organisms such as coccolithophorids, pteropods and the cold water corals found in some British Columbia fjords. More frequent harmful algal blooms seem to occur in some coastal regions, and 'dead zones' with anoxic conditions that kill large numbers of benthic invertebrates may be more frequent in others. To what extent are these findings caused by human activities and climate change? From coupled carbon-climate models we can forecast future CO_2-related changes in the North Pacific seawater for different scenarios of human development, but we cannot yet predict how the community structure of marine planktonic foodwebs will change, and what the possible feedbacks will be, both to ocean biogeochemical cycles and to higher trophic levels including living marine resources. We need to develop such 'end-to-end' foodweb and biogeochemistry models and embed them in comprehensive climate models. This modelling requires sustained sampling and focused scientific studies in both the coastal and open ocean. PICES collaboration is essential to address this challenge.

Schedules and Abstracts

S1 Science Board Symposium The changing North Pacific: Previous patterns, future projections, and ecosystem impacts

Co-convenors: *Kuh Kim (SB), John E. Stein (SB), Michael J. Dagg (BIO), Gordon H. Kruse (FIS), Glen Jamieson (MEQ), Jeffrey J. Napp (MONITOR), Michael G. Foreman (POC), Igor I. Shevchenko (TCODE), Harold P. Batchelder (CCCC), Michio J. Kishi (CCCC), Fangli Qiao (China) and Sinjae Yoo (Korea)*

The PICES Special Publication, "*Marine Ecosystems of the North Pacific*", concluded that "during the past five years profound changes have occurred in the North Pacific climate system, in the composition, abundance and distribution of its living marine resources, and in the human societies that depend on the North Pacific Ocean and its resources". This symposium will build on studies of climate variability and other anthropogenic impacts in the North Pacific and its marginal seas, the latest North Pacific climate projections (whose results have been summarized in the Fourth Assessment Report of the Inter-governmental Panel for Climate Change), future scenarios for direct human forcing by population growth and fishing, and the combined impacts that these changes have already had, and can be expected to have, on North Pacific ecosystems. The symposium will address issues such as: 1) trends *versus* variability; 2) synergisms between climate and direct human forcing; 3) ecosystem indicators and their applicability in the future; 4) impacts arising from regional changes (*e.g.*, less ice-cover in the Bering Sea and Sea of Okhotsk, aquatic bioinvasions); 5) the effects of terrestrial climate change (*e.g.*, river discharge); 6) how projected global change and anthropogenic impacts may alter sustainability of the North Pacific; and 7) what the key messages should be for policy makers regarding sustainability of the North Pacific. Talks describing links with climate change in the Arctic and the International Polar Year Projects are also welcome.

Monday, October 29, 2007 10:50 – 18:00

10:50 **Kenneth Denman (Keynote)**
The North Pacific, human activity, and climate change (S1-4160)

11:30 **Richard. A. Feely, Christopher L. Sabine, Victoria Fabry, Robert Byrne, J. Martin Hernandez-Ayon, Debby Ianson and Burke Hales (Invited)**
Ocean acidification: Present status and future implications for marine ecosystems in the North Pacific (S1-4187)

11:55 **Gregory M. Flato (Invited)**
A brief summary of results from the IPCC Fourth Assessment Report (S1-4376)

12:20 **William J. Merryfield and Suelji Kwon**
Changes in North Pacific mixed layer depth in the 20^{th} and 21^{st} centuries as simulated by coupled climate models (S1-4470)

12:40 ***Lunch***

14:00 **Muyin Wang and James E. Overland**
Future climate of North Pacific projected by IPCC models (S1-4070)

14:20 **Yasunori Sakurai and Michio J. Kishi (Invited)**
Prediction of life strategy and stock fluctuation of the Japanese common squid, *Todarodes pacificus*, related to climate change during the 21st century (S1-4153)

14:45 **Steven A. Murawski (Invited)**
Integrated ecosystem assessments: The first step in ecosystem-based management of living marine resources (S1-4504)

15:10 **Francisco E. Werner, Bernard A. Megrey, Michio J. Kishi, Kenneth A. Rose, Shin-ichi Ito, Yasuhiro Yamanaka, Maki Noguchi-Aita and Taketo Hashioka**
Extensions of the NEMURO models for use in studies of future climate scenarios (S1-4374)

15:30 **Dave Preikshot and Nathan Mantua**
Comparisons of modeled climate and lower trophic level time series for the North Pacific from 1950 to 2002 (S1-4404)

15:50 ***Coffee / tea break***

16:10 **Emanuele Di Lorenzo and Niklas Schneider**
A North Pacific gyre-scale oscillation: Mechanisms of ocean's physical-biological response to climate forcing (S1-4516)

16:30 **Yaqu Chen, Zhijie Hu, Weifeng Gu, Yonghua Jiang, Weimin Quan and Liyan Shi**
Long-term change and ecological restoration of the Yangtze River estuarine ecosystem in past decades (S1-4067)

16:50 **Chang-Ik Zhang, Suam Kim and Jae Bong Lee (Invited)**
Marine ecosystems, fisheries and the ecosystem-based resource management in Korea (S1-4292)

17:15 **Gregory M. Ruiz (Invited)**
Biogeography of marine invasions: Current status and future predictions (S1-4472)

17:40 **Thomas A. Okey**
The changing Pacific: A strategic collaboration for assessing climate impacts and developing effective policy for adaptation (S1-4464)

S1 Posters

S1-4117 **Ludmila S. Dolmatova**
IL-1-like cytokine production by the phagocytes of the holothurian *Eupentacta fraudatrix* in response to bacterial toxin

S1-4147 **Olga N. Lukyanova, Margarita D. Boyarova and Andrey P. Chernyaev**
Seabirds as bioindicators of POPs in the marginal seas of northwestern Pacific

S1-4253 **Alexander V. Moshchenko, Anastasia S. Chernova and Tatyana S. Lishavskaya**
Long-term changes in the marine environment in apex parts of Amur Bay (Peter the Great Bay in the Japan/East Sea)

S1-4286 **Jingqing Fang and Xueen Chen**
A 44-year hindcast simulation of the North East Asian Regional Seas

S1-4317 **Valentina V. Kasyan**
Bioaccumulation of heavy metal in zooplankton (Copepoda) from the Amursky Bay, Japan/East Sea

S1-4369 **Vladimir I. Ponomarev and Elena V. Dmitrieva**
Changing global-regional linkages in the Northwest Pacific and Northeast Asia

S1-4438 **Inga A. <u>Nemchinova</u>**
Impact of towed airgun arrays, used in seismic exploration, on marine zooplankton from the northeastern Sakhalin shelf coastal waters

S1-4445 **K. David <u>Hyrenbach</u>, Ken H. Morgan, Mike F. Henry, Chris Rintoul, Gary Drew, John Piatt and William Sydeman**
Documenting changes in the distribution and abundance of warm-water gadfly petrels (*Pterodroma* spp.) in the subarctic North Pacific using vessels of opportunity (2002 - 2006)

S1-4476 **Andrey P. <u>Chernyaev</u>**
Pollution of Russian Far East seas by petroleum hydrocarbons discharged in bilge water from fishing ships

S1 Oral Presentations

29 October, 11:30 (S1-4187) Invited

Ocean acidification: Present status and future implications for marine ecosystems in the North Pacific

Richard. A. **Feely**, Christopher L. Sabine, Victoria Fabry, Robert Byrne, J. Martin Hernandez-Ayon, Debby Ianson and Burke Hales

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The addition of fossil fuel carbon dioxide to the atmosphere is rapidly changing seawater chemistry and the calcium carbonate saturation state of the world's oceans as a result of the acidifying effects of CO_2 on seawater. This acidification makes it more difficult for marine organisms (*e.g.*, corals, plankton, calcareous algae, and mollusks) to build skeletons, tests, and shells of calcium carbonate. Impacts on these calcifying organisms will lead to cascading effects throughout marine ecosystems. Repeat hydrographic and coastal cruises in the North Pacific show direct evidence for ocean acidification. The dissolved inorganic carbon increases, of about 10–15 µmol kg^{-1} in surface and intermediate waters over the past 15 years, are consistent with corresponding pH decreases of approximately 0.025 units over large sections of the northeastern Pacific. These dramatic changes can be attributed, in most part, to anthropogenic CO_2 uptake by the ocean over the past decade. These data verify earlier model projections that the oceans are undergoing acidification as a result of the uptake of carbon dioxide released by the burning of fossil fuels. From these results we have estimated an average upward migration of the aragonite saturation horizon of approximately 1 m yr^{-1} in the North Pacific. Such shoaling is due to the effects of anthropogenic CO_2, ventilation and biological respiration processes in the surface and intermediate waters. However, in the northeastern Pacific the upward migration has been significantly greater, with values exceeding 5 m yr^{-1} in some places. This may be the result of enhanced invasion of colder CO_2-rich Subarctic Water at depths between 50 and 150 m into the California Current over the last few years. These dramatic changes in circulation may be to due natural climate variability, climate change or some combination of both processes.

29 October, 11:55 (S1-4376) Invited

A brief summary of results from the IPCC Fourth Assessment Report

Gregory M. **Flato**

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The IPCC Fourth Assessment Report provides an updated synthesis of the science of climate change that is widely used by decision- and policy-makers. In this talk, I will briefly summarize the process that went into writing this report, and present an overview of the results contained therein. To the extent possible the overview will focus on the North Pacific. The talk will include a summary of what observations tell us about recent climate change, of the ability of models to simulate this change and to provide insight into the causes, and of the model's projections of future climate change.

29 October, 12:20 (S1-4470)

Changes in North Pacific mixed layer depth in the 20th and 21st centuries as simulated by coupled climate models

William J. **Merryfield** and Suelji Kwon

Canadian Centre for Climate Modelling and Analysis, Meteorological Service of Canada, University of Victoria, Victoria, BC, V8W 2Y2, Canada E-mail: bill.merryfield@ec.gc.ca

The depth of the surface ocean mixed layer is influenced by surface winds, buoyancy fluxes, and near-surface stratification, all of which are likely to be affected by anthropogenic warming. The seasonal climatology of mixed-layer depth can therefore also be expected to change, potentially leading to significant changes in rates of air–sea exchange, ocean ventilation, and ocean ecosystems. This study examines the evolution of North Pacific mixed-layer depth over the 20th and 21st centuries as simulated by an ensemble of coupled climate models contributing to the IPCC Fourth Assessment. The projected trend at most locations in the North Pacific (and also the global ocean) is toward a shallower winter mixed layer as a result of increases in near-surface stratification. This modeled tendency is especially strong in the subtropical and NE Pacific. Comparisons are made with observations over the past half century at Ocean Station P in the Gulf of Alaska, which have shown a pronounced and sustained trend toward a shallower mixed layer.

29 October, 14:00 (S1-4070)

Future climate of North Pacific projected by IPCC models

Muyin **Wang** and James E. Overland

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Major shifts in species distribution and abundance in North Pacific marine ecosystems are expected in the 21st century due to climate change, from corals in the south to walrus in the north. The results of the Intergovernmental Panel on Climate Change Fourth Assessment Report (IPCC-AR4), and availability of the individual IPCC model simulations, provide a major opportunity to assess the magnitude and patterns of climate change for the North Pacific. In this study we evaluate simulations from 23 models of climate patterns such as the Pacific Decadal Oscillation (PDO), sea surface temperature (SST), sea level pressure (SLP), and sea ice coverage, by comparing with 20th century observations. We then provide their projections for the next 50 years. Compared to the means from all available models presented in the IPCC-AR4, we find increased confidence in composite projections if "outlier" models are removed based on certain selection rules. Results from a sub-group of 10 models which simulate the spectra of the twentieth-century SST (PDO) pattern well, show that projected SST increases will exceed the range of natural variability in 30–50 years over most of the North Pacific. Projections of sea-ice area over the Sea of Okhotsk and Bering Sea by a sub-group of seven models show a reduction of winter sea ice of 40% by 2050. We find a deepening of the Aleutian low in winter and an increase in North Pacific SLP in summer. Greenhouse gas emission scenarios diverge after 2050, and the possibility of more complex feedbacks increase, thus we have less confidence in longer range projections.

29 October, 14:20 (S1-4153) Invited

Prediction of life strategy and stock fluctuation of the Japanese common squid, *Todarodes pacificus,* related to climate change during the 21st century

Yasunori **Sakurai**[1] and Michio J. Kishi[2]

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[2] Faculty of Fisheries Sciences, Hokkaido University, N13 W8, Sapporo, Hokkaido, 060-0813, Japan. E-mail: mjkishi@nifty.com

Life cycle of squid can be summed up in the phrase "live fast and die young". Annual catches of Japanese common squid, *Todarodes pacificus* decreased during the cool regime period from the late-1970s to late-1980s. Squid catch has recently increased after the late-1980s warm regime period. *T. pacificus* produces gelatinous, nearly neutrally buoyant egg masses that contain many small eggs. These egg masses are thought to occur within or above the pycnocline at temperatures suitable for egg development. Recently, we estimated from laboratory studies that

hatchlings (<1mm ML) will ascend to the surface at temperatures between 18–24ºC, especially between 19.5–23ºC. After hatching, the paralarvae presumably ascend from the mid layer near the pycnocline to the surface layer above the continental shelf and slope and are transferred into convergent frontal zones. We used this new reproductive hypothesis to explain the last bi-decadal stock fluctuation related to climatic regime shifts. We conclude that short and long-term change of *T. pacificus* stock can be explained and predicted by physical parameters such as wind stress, air temperature, SST, and MLD during the spawning period based on this new reproductive hypothesis. We can map the inferred spawning grounds using the SST areas between 18–24ºC, especially between 19.5–23ºC and within a specific range of bottom topography (100–500m depth). Based on this method, we try to predict whether the squid will be extinct or will occupy a marine ecosystem during the 21^{st} Century based on the Global Warning Scenario (IPCC) using the Earth Simulation System (FRCGC, Frontier Research Center of Global change, Japan).

29 October, 14:45 (S1-4504) Invited

Integrated ecosystem assessments: The first step in ecosystem-based management of living marine resources

Steven A. **Murawski**

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The NOAA Ecosystem Goal Team (EGT) has identified Integrated Ecosystem Assessments (IEAs) as a critical tool to enable NOAA's ecosystem approach to management. An IEA is a synthesis and quantitative analysis of information on relevant physical, chemical, ecological and human processes in relation to specified ecosystem management objectives. IEAs focus not on collecting new observations or conducting new research, but on integrating existing datasets to produce more useful assessments, build ecological forecast models, and develop other ecological decision support tools. An IEA contains the information necessary to understand the inter-relationship between resource management decisions and the changing state of ecosystems. Steps in an IEA include: (1) Identification of major human and natural factors affecting the ecosystem and the scale at which the ecosystem or its parts will be assessed; (2) Organization of the relevant existing ecosystem information (from various sources) and development of appropriate indicators of ecosystem status; (3) Linkage of ecosystem status indicators to human and natural pressures on the ecosystem that drive change; (4) Evaluation of ecological and economic impacts of management options, consistent with NOAA and other statutory responsibilities; and (5) Use of the IEA as the science tool supporting an adaptive approach to management to achieve target levels for appropriate ecosystem goals, while avoiding thresholds for undesirable ecosystem conditions. These five implementation steps will be applied in the three pilot regions (California Current, Alaska, and the Northeast US), and the lessons learned applied to the expansion of the IEA concept to create a comprehensive, hierarchical series of IEAs at appropriate local and regional scales, consistent with NOAA's stewardship responsibilities for marine ecosystems. IEAs will provide NOAA three critical outcomes. First, by synthesizing all of the existing information on the state of ecosystems that the agency already collects, NOAA resource managers will have a more complete picture of the threats posed by various human activities as they undertake their marine stewardship responsibilities. Understanding the complexity of marine ecosystems allows managers to anticipate a wider range of factors that will influence the outcomes for their specific missions. Having a global view of a marine ecosystem and the threats it faces will also help ensure that NOAA allocates resources to the highest priority regional needs. Second, the IEA will provide a higher level performance metric for NOAA and other federal and state agencies (*e.g.*, the state of the ecosystems under management), that will integrate the series of disparate ecosystem parts that are not the primary focus for management. Third, by providing a forum for the development of IEAs, NOAA will better engage other federal agencies, the states, tribes and other non-governmental agencies as these entities undertake their missions in ocean, coastal, and Great Lakes management. For example, activities conducted by the Environmental Protection Agency, the Department of the Interior and others provide information critical for successful outcomes for NOAA's missions. Similarly, these other agencies potentially would benefit from a structured access to the diversity of ecosystem information held by NOAA. The eventual production of routine integrated ecosystem assessments (IEAs) represents a significant and forward-looking leadership opportunity for NOAA to more effectively address ocean and coastal resource management issues in the United States and internationally.

29 October, 15:10 (S1-4374)

Extensions of the NEMURO models for use in studies of future climate scenarios

Francisco E. **Werner**[1], Bernard A. Megrey[2], Michio J. Kishi[3,4], Kenneth A. Rose[5], Shin-ichi Ito[6], Yasuhiro Yamanaka[4,7], Maki Noguchi-Aita[4] and Taketo Hashioka[4]

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The NEMURO, NEMURO.FISH and NEMURO.SAN models have been applied in the study of North Pacific pelagic fish, including saury, herring, sardine and anchovy, among others (*Ecological Modeling*, vol. 202, 2007). Case studies have considered hindcast scenarios of the past 50-years, *e.g.*, including the North Pacific regime shifts of the 1970s and 1980s, as well as possible future conditions based on IPCC projected scenarios over the next 100 years. Results have yielded valuable insight to the links between the physical environment and the lower and higher trophic levels and to possible shifts in future marine ecosystem states (such as phenology and changes in relative species' abundances). However, the applications have been limited by necessary simplifications of the models' formulations, computing capabilities, and difficulties in coupling across trophic levels, *i.e.*, from biogeochemistry to higher trophic levels. The next generation models, as related to required extensions to the NEMURO suite and of relevance to the new PICES FUTURE program, need to consider the possibility of "seamless" links between physical, biogeochemical and ecological scales. We discuss requirements, modifications and extensions to the NEMURO suite that will enable us to frame results in light of increased climate variability, expected long-term trends, and direct human forcing. Approaches include embedding NEMURO models into high resolution regional studies (*e.g.*, downscaling from global to regional climate models), and into an earth system framework via explicit links to terrestrial components (*e.g.*, river discharge and changes in land practices), ice dynamics and atmospheric coupling.

29 October, 15:30 (S1-4404)

Comparisons of modeled climate and lower trophic level time series for the North Pacific from 1950 to 2002

Dave **Preikshot**[1] and Nathan Mantua[2]

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2 University of Washington, School of Aquatic and Fishery Sciences, Box 355020, Seattle, WA, 98195-5020, USA

In the MALBEC project various time series of climate change or carrying capacity can be used to examine the effect of different bottom up mechanisms upon salmon production in the North Pacific. Time series of phytoplankton production change (from Ecopath with Ecosim models) and zooplankton biomass change (from NEMURO models) show that very different modeling approaches provide rather similar pictures of how carrying capacity changed, where areas modeled overlap. These model derived time series are compared with empirical data to show relations to past trends in climate time series, *e.g.*, sea surface temperature, mixed layer depth, Ekman transport, and PDO. Relations derived from such comparisons are used to extend climate model generated future ocean conditions into future carrying capacity scenarios for MALBEC model runs examining the effects of changing climate on Pacific salmon populations over the next 100 years.

29 October, 16:10 (S1-4516)

A North Pacific gyre-scale oscillation: Mechanisms of ocean's physical-biological response to climate forcing

Emanuele **Di Lorenzo** and Niklas Schneider

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[2] International Pacific Research Center, University of Hawaii at Manoa, 1680 East West Road, Honolulu, HI, 96822, USA

Understanding past climate fluctuations in the North Pacific is critical to predicting the ocean's physical-biological response to 21st century climate change. We find that previously unexplained decadal variations of salinity and nutrients in the Southern California Current reflect an oscillation in the North Pacific gyre-scale circulation (NPGO), which is independent of the Pacific Decadal Oscillation (PDO). Along the California coast, changes in alongshore wind stresses associated with the NPGO, rather than PDO, cause low-frequency variations in nutrient upwelling and surface chlorophyll-*a*. The NPGO and PDO both exhibit sharp transitions associated with major North Pacific ecosystem shifts, suggesting that both modes contribute to decadal variations in zooplankton and fish populations. Therefore observed amplifications of the NPGO decadal variance during global warming may be critical to accurate ecosystem forecasts.

29 October, 16:30 (S1-4067)

Long-term change and ecological restoration of the Yangtze River estuarine ecosystem in past decades

Yaqu **Chen**, Zhijie Hu, Weifeng Gu, Yonghua Jiang, Weimin Quan and Liyan Shi

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The Yangtze River estuary is recognized as one of the most important EcoRegions in China. This ecosystem has been extensivly disturbed by human activities, such as land-reclamation, over-exploitation of biological resources, discharge of pollutants (nutrients and metals) and bio-invasions (*e.g.* cordgrass *Spartina alerniflora* and jellyfish). In the past 40 years, the nitrate and SRP concentrations have increased about seven and two times, respectively. Eutrophication has become increasingly serious and red tides have become more frequent in the Yangtze River Estuary. More than 1000km^2 of tidal wetlands have been reclaimed in the estuary. The exotic plant *S. alterniflora* is rapidly displacing native vascular marsh plants, which reduces the biodiversity, alters the biogeochemical processes and affects the function of the salt marsh ecosystem in the estuary. The important economical fishery species *Tenualosa reevesii*, *Hemitsalanx prognathus*, *Coilia mystus*, *Coilia ectenes*, *Anguilla japonica*, white shrimp *Exopalaemon annandalei* and Chinese mitten-handed crab *Eriocheir sinensis* have significantly decreased in past decades. In particular, the economically valuable fishes *Tenualosa reevesii* and *Hemisalanx prognathus* are near extinction due to overfishing. This overfishing of high trophic level consumers has decreased food chain length, and low trophic level fishes now dominate the food web, leading to instability of food web structure. In order to ameliorate these degradations to the ecosystem, a series of large ecological restoration projects have been carried out in the estuary during the past ten years, including breeding of the Chinese sturgeon, *Acipenser sinensis*, and Chinese mitten-handed crab, *Eriocheir sinensis*. In another ecological restoration project, large amounts of benthos and bivalves (mainly oysters) were released near navigational dams. About 74km^2 of artificial oyster reefs have been built and the present standing stock has reached 1.07×10^6t. Recent investigation has demonstrated that the artificial reefs play an important role in purifying the water, conserving biodiversity, restoring the ecosystem and supporting estuarine fishery production.

29 October, 16:50 (S1-4292) Invited

Marine ecosystems, fisheries and the ecosystem-based resource management in Korea

Chang-Ik **Zhang**[1], Suam Kim[1] and Jae Bong Lee[2]

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Many fisheries resources in Korean waters have been depleted due to over-harvesting, marine environmental degradation and some unknown factors. Population biomasses, annual catch and catch per unit of effort for major fisheries resources have shown declining patterns. Moreover, some ecological indices such as FIB, FRP, EHI have exhibited continuous declines, indicating changes in quality as well as quantity of fisheries resources. Climate regime shifts of 1976/77 and 1988/89 were detected and they caused changes in the structure and productivity of Korean marine ecosystems. Trends in the indicators mentioned above suggest that a comprehensive ecosystem-based approach might be required to manage depleted Korean ecosystems. An ecosystem-based approach is being developed for the assessment and management of fisheries resources in Korean waters. A variety of projects are going on to recover depleted fish resources in Korea, but conventional tools to assess and manage these resources might not be effective. Assessment and management of fishery resources at the ecosystem level could aid efforts to recover depleted fish stocks in Korean marine ecosystems.

29 October, 17:15 (S1-4472) Invited

Biogeography of marine invasions: Current status and future predictions

Gregory M. **Ruiz**[1,2]

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Biological invasions are a significant force of change in coastal ecosystems. Invasions have occurred throughout Earth's history, but the scale and tempo has increased strongly in recent time due to global trade. Available data suggest there is a strong latitudinal pattern in recent invasions, with more non-native species documented in temperate marine communities than polar or tropical systems. While this geographic pattern of invasion may reflect some historical biases in search effort and taxonomic knowledge, contemporary surveys also suggest these patterns are robust when controlling for search effort. For example, a standardized survey of sessile invertebrate assemblages in estuaries of western North America found a significant decrease in non-native species richness with increasing latitude (32 to 61°N). Several mechanisms may explain the observed invasion pattern across latitudes, operating alone or in combination, such as differences in (a) propagule supply, (b) biotic resistance to invasion, (c) environmental resistance to invasion, and (d) disturbance regime. To date, the relative importance of these mechanisms across geographic regions has not been evaluated, but each may be expected to change over time. Of particular interest and concern are the interactive effects of climate change and human activities on marine invasions, especially at high latitudes. Current climate change models predict not only an increase in sea surface temperatures but also a rapid reduction in sea ice in the Artic. Combined with human responses, climate change is predicted to cause directional shifts in invasion biogeography, including increased invasion opportunity at high northern latitudes.

29 October, 17:40 (S1-4464)

The changing Pacific: A strategic collaboration for assessing climate impacts and developing effective policy for adaptation

Thomas A. **Okey**

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Profound changes are occurring not only in the North Pacific, but also in other regions of the Pacific Ocean and in adjacent seas. In some settings, these changes are being examined with the ultimate goal of developing adaptation strategies designed to bolster ecosystem resilience to projected climate changes. In other cases, future changes might ultimately be too large to hope to meet conservation challenges, but North Pacific science can benefit from experiences in other regions. A strategic approach to assessing climate impacts and developing effectives policies

for adaptation might include three interacting phases: (1) assessment of the current knowledge of the ecological impacts of climate change on Pacific Ocean ecosystems and the identification of useful marine ecological indicators of climate change for Pacific settings, (2) development and integration of innovative analytical approaches, such as the integration of global climate models and trophodynamic models, for the assessment of climate change impacts and the exploration of policies, and (3) identification of imaginative and viable policies and management strategies. This integrated three-pronged process can be accomplished through an international collaboration that builds on the work and experiences of the regional science programs already in place in various regions of the Pacific. Examples for a PICES audience include some approaches being developed in Australia, but there are other examples as well.

S1 Posters

Poster S1-4117

IL-1-like cytokine production by the phagocytes of the holothurian *Eupentacta fraudatrix* in response to bacterial toxin

Ludmila S. **Dolmatova**

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Increasing biological pollution of seawater necessitates studying interactions between pathogenic bacteria and marine hydrobionts. Bacteria *Yersinia pseudotuberculosis* are able to live in holothurians, and their thermostable toxin (TsTYp) is lethal to those animals. The aim of the study was to investigate the mechanisms of immune response of holothurian *Eupentacta fraudatrix* (Holothuroidea, Dendrochirota) to TsTYp. A pure fraction (98%) of phagocytes (P) of the holothurian was obtained using a ficoll-verographine density gradient. *In vitro*, phagocytes were treated with TsTYp (0.2 and 0.5 mkg/ml) for 18 h. After incubation, apoptosis was registered in the cells by Hoeschst 33342 staining. *In vivo*, TsTYp (0.25 and 1.2 mkg/g) was injected to holothurians, and P was obtained in 5 h. Cytokine production was investigated with an assay kit ("Cytokine", Russia) for human IL-1α. *In vitro*, TsTYp increased apoptosis of P compared to the control at a concentration of 0.2 mkg/ml but decreased it at 0.5 mkg/ml. *In vivo*, a relatively high concentration of IL-1α-like cytokine (1.75±0.38 ng/mg protein) was determined in control nuclear-free supernatants of P. TsTYp (0.25 mkg/g) almost completely inhibited cytokine production. However, a concentration of 1.2 mkg/g TsTYp decreased cytokine concentration only by 49%. The data obtained indicate that P of holothurians produces human IL-1α-similar cytokine, and its synthesis is inhibited by TsTYp in a concentration-dependent manner. Obviously, cytokine production inhibition is connected to cell apoptosis.

Poster S1-4147

Seabirds as bioindicators of POPs in the marginal seas of northwestern Pacific

Olga N. **Lukyanova**[1], Margarita D. Boyarova[2] and Andrey P. Chernyaev[1]

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Global climatic changes can influence the distribution and migration of certain hazard compounds, such as chlorinated persistent organic pollutants (POPs). Background contaminant levels are now found in all the World Ocean, including sub-arctic regions and current fisheries areas. Seabirds are usually at the top of marine food webs and therefore are particularly susceptible to pollutant bioaccumulation. Since they accumulate organochlorines over time, seabirds have often been used as indicators of ecosystem health. Hexachlorocyclohexane (HCH) and its isomers, DDT, DDD and DDE concentrations from the livers of seabirds inhabiting the Japan/East Sea, Okhotsk Sea and Bering Sea were investigated during 2000–2006. Pollutants amounted to 3000–4000 ng/g wet weight in livers of gulls from the Japan/East Sea near Vladivostok. In the Okhotsk Sea, five gulls from offshore waters were analyzed, and the level of contaminants ranged from 25 to 50 ng/g. Ten individuals from five species were studied in the

Bering Sea and there, the total POPs concentration was about 1800 ng/g in the only specimen of *Larus glaucecsens*, while in the other species, POP levels did not exceed 250 ng/g. Beta-HCH and DDE content were maximal among other POPs in all samples, confirming the long-term presence of POPs in the northwestern Pacific.

Poster S1-4253

Long-term changes in the marine environment in apex parts of Amur Bay (Peter the Great Bay in the Japan/East Sea)

Alexander V. Moshchenko[1], Anastasia S. **Chernova**[2] and Tatyana S. Lishavskaya[2]

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Changes in the marine environment are estimated for the last 10 years in the upper parts of Amur Bay (Peter the Great Bay in the Sea of Japan) for water quality and for 20 years for bottom sediments by means of a water quality (WQI) and total pollutant factor (TPF) indices, respectively. During the period 1995 to 2005, WQI values in an internal part of the Amur Bay were always less than the maximum-permissible concentration. WQI values changed seasonally, with values increasing in the spring during floods. Similar dynamics were not found in TPF values, though its variation also had a distinct seasonal pattern. In long-term studies of TPF values, a decrease was observed during a period of economic decline from 1990 to 1995 (from values exceeding ERM_q (Effects range-medium)) when irreversible changes occurred in benthos communities. Values observed during this time were ERL_q (Effects range-low) less than when anthropogenic impacts to biota were absent or not externally revealed. Later, TPF values noticeably increased and changed, mainly within the limits of ERL_q range (no irreversible effects).

Poster S1-4286

A 44-year hindcast simulation of the North East Asian Regional Seas

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The North East Asian Regional Seas (NEAR-seas) have the broadest shelf waters and the most complicated topography in the world. They also have the through-flow of the Kuroshio which is one of the two largest western boundary currents. In the present study, a regional numerical model with a high resolution both vertically and horizontally and based on the parallelised HAMburg Shelf Ocean Model (P-HAMSOM) is developed and a 44-year hindcast study is run with the surface flux dataset derived from ERA40 re-analysis for the period of 1958 to 2001. A systematic verification using historical observations and satellite remote sensing observations proves that the model's performance is successful. It is shown that the long-term variability of the simulated temperature fields is well reproduced in most of the model domain, especially on the East China Shelf where the Kuroshio dominates. This indicates that sea surface temperature is mainly determined by the local physical processes of ocean atmosphere interaction in this region. In addition, the high correlation between the observed and simulated sea level fields indicates that because of the through-flow of the Kuroshio, the boundary conditions for the regional model of NEAR-seas are particularly important.

Poster S1-4317

Bioaccumulation of heavy metal in zooplankton (Copepoda) from the Amursky Bay, Japan/East Sea

Valentina V. **Kasyan**

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Heavy metals (Cu, Zn, Cd, Mn and Fe) were evaluated in zooplankton samples collected in areas of controllable releases of sewage in the Amursky Bay, Japan/East Sea (Summer, 2006). The estuary of the Razdolnaya River has runoff from the Ussuryisk (agricultural center), while the in-shore part of the Bay receives sewage water from

Vladivostok. Major classes of the zooplankton community were Copepoda (80%), Chaetognatha (4%), Cladocera (2%), Polychaeta (7%), and Bivalvia (3%) larvae. Dominant and subdominant coastal copepod species were represented in June by *Pseudocalanus newmani* (53%), *Acartia longiremis* (28.7%) and *Oithona similis* (11%). Heavy metals levels of zooplankton measured in Razdolnaya River estuary samples were higher than those in samples from the in-shore part of the Bay, while abundance of major groups, species richness and diversity of zooplankton were lower. Concentrations of heavy metals were highest in the estuary of the Razdolnaya in comparison with the in-shore part of the Bay (*e.g.* Cd – 0.213 vs. 0.0045 $\mu g/g^{-1}$, Cu – 0.488 vs. 0.035 $\mu g/g^{-1}$, Zn – 1.244 vs. 0.324 $\mu g/g^{-1}$, Fe – 23.777 vs. 5.029 $\mu g/g^{-1}$, w. wt, respectively). The mean increase in concentrations of metals in zooplankton organisms followed the sequence Fe (11.3) > Zn (0.75) > Mn (0.14) > Cd (0.11) > Cu (0.08). Heavy metal contamination is thus a matter of concern.

Poster S1-4369

Changing global-regional linkages in the Northwest Pacific and Northeast Asia

Vladimir I. **Ponomarev** and Elena V. Dmitrieva

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Statistical relationships between North Hemisphere climatic indexes and anomalies of meteorological and/or oceanographic characteristics in Northeast Asia and the Northwest Pacific and its marginal seas are estimated for different observational periods including the first half of the 20th century and the last 56 years. The major regional parameters analyzed are surface air temperature, precipitation, SST, and Ice Extent. It is shown that the NW Pacific SSTA has significant unlagged or lagged correlations with most of the Northern Hemisphere monthly/seasonal/annual mean teleconnection indexes (SOI, AO, WP, SH (Siberian High), NPI, SV NAM). The unlagged correlations between seasonal mean SOI and SSTA / WP and SSTA in winter–spring show significant inverse relationships, being negative / positive in the subtropic and positive / negative in the subarctic NW Pacific. Correlations between winter AO and SSTA in spring–summer show patterns which are similar to the SOI-SSTA relationship in winter–spring with a shift of the subarctic core westward and the subtropic core eastward. The NPI-SSTA and SV NAM-SSTA linkages look like counterclockwise propagated signals in the subarctic Pacific. The SOI-SSTA correlation patterns are similar for the first and second half of the observational records. The winter AO-spring/summer SSTA correlation patterns are turned counterclockwise in the second half of the observational records in comparison with the first half. In the several last decades the positive AO-SSTA lagged correlation pattern occupies the Okhotsk and Japan (East) Sea area. Inverse trends in the SST and global-regional linkages in the subarctic and subtropic NW Pacific are discussed.

Poster S1-4438

Impact of towed airgun arrays, used in seismic exploration, on marine zooplankton from the northeastern Sakhalin shelf coastal waters

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In this paper we present the results of investigations of the impact of towed airguns on zooplankton. The study was conducted in September 2004 in the coastal water of eastern Sakhalin Island. For the first time, losses of planktonic animals under natural conditions during a commercial seismic survey have been assessed in the Far East. The study was performed in two phases aboard the scientific-research vessel-catamaran “Iskatel-4”. In the first phase, plankton was sampled before the operation of airguns. These samples were used as a control. The second phase involved plankton sampling during operation of the airguns. The impact on pelagic invertebrates during operation of the bunched airguns was found to occur in the limited space around the airguns, and over the larger space from the depth of the submerged airguns to the water surface. In this paper, we deal with a total complex of factors arising from the acoustic wave originating with the airguns, which cause pressure differences and form gas bubbles which rise to the surface. Among the examined zooplankton groups, the jelly-body and soft-body plankton appeared to be the most affected by the airguns. Among crustaceans, the maximum losses were recorded for the Copepoda. In the

study area, the groups of zooplankton with a high coefficient of impact made up about 74% of the total biomass. The weighted mean loss from the operating airguns was 22.1%.

Poster S1-4445

Documenting changes in the distribution and abundance of warm-water gadfly petrels (*Pterodroma* spp.) in the subarctic North Pacific using vessels of opportunity (2002–2006)

K. David **Hyrenbach**[1], Ken H. Morgan[2], Mike F. Henry[3], Chris Rintoul[3], Gary Drew[4], John Piatt[4] and William Sydeman[3]

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Gadfly Petrels (*Pterodroma* spp.) are medium-sized (<1m wingspan) surface-feeding tubenose seabirds (*Procellariiformes*), which disperse widely across the Pacific Ocean. While the marine ranges of many North Pacific petrels are poorly understood, these species often inhabit specific oceanographic domains. Thus, shifts in their distributions are indicative of changing water mass distributions. For instance, increases in warm-water petrel sightings off North America's west coast have been ascribed to warmer ocean conditions. In 2002, we initiated a monitoring program to survey marine birds and mammals from British Columbia (Canada) to Hokkaido (Japan) using the bulk-cargo carrier '*Skaubryn*' as a platform of opportunity. This project, supported by the North Pacific Research Board, documents spatial patterns and temporal fluctuations in upper-trophic predator community structure across the subarctic North Pacific Ocean and the southern Bering Sea. Herein, we summarize seasonal (spring, summer, fall) and interannual (2002–2006) petrel sightings across our study area. In particular, we focus on the occurrence of several subtropical species in the Gulf of Alaska. We compare their contemporary distribution and abundance with historical (1980s) surveys in the North Pacific Pelagic Seabird Database (NPPSD), archived by USGS and USFWS. Recent surveys have documented sightings of eight gadfly petrel species: Bonin, Cook's, Hawaiian, Herald, Juan Fernandez, Mottled, Murphy's, and Solander's. Perhaps the most striking result is the presence of Murphy's Petrels (*Pterodroma ultima)* during all three survey seasons. This baseline information, coupled with historical datasets and future surveys, will allow researchers to assess changes in the biogeography of the subarctic North Pacific.

Poster S1-4476

Pollution of Russian Far East seas by petroleum hydrocarbons discharged in bilge water from fishing ships

Andrey P. **Chernyaev**

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Nowadays fishing and transport ships are the main sources of pollution in traveled areas of Russia's Far East Seas. 'The Water code' legislation in Russia regulates harmful discharges of land-sourced waste products from combustive and lubricating materials, but does not apply to vessels when they are at sea. Bilge water pollutant levels on trawler-refrigerator vessels in port were investigated to allow estimation of potential ecological effects from these vessels when they were at sea. Bilge waters were sampled after filtrational separators were installed on the vessels. Extraction of petrohydrocarbons (PH) was done by the standard technique using freon-12. Measurements of the PH maintenance was done with an IR-spectrometer. The normal maximum range of petrohydrocarbons in investigated waters is 1.5 to 1.6 mg/l. According to the Kamchatka regional center of radio communication monitoring, pollution levels in the Sea of Okhotsk can reach 1000 units during the pollock winter fishing season. Dumping of bilge waters into the water by many vessels is resulting in an increase in PH concentration in areas of active fishing. Therefore, prevention of uncontrolled dumping of polluted bilge waters from vessels at sea remains an important issue.

S2 BIO/POC Topic Session Decadal changes in carbon biogeochemistry in the North Pacific

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

This session will be the first effort by the PICES Section on *Carbon and Climate* to synthesize the current understanding on inter-relationship between the carbon cycle and climate in the Pacific. Emphasis will be placed on decadal change in carbon cycling, *e.g.*, anthropogenic carbon, air-sea exchange of CO_2, the biological pump, impacts of increasing levels of carbon dioxide on carbonate chemistry and marine biota, and possible feedbacks to atmospheric greenhouse gases. We expect that the session will enable us to update our understanding of the relationships between the carbon cycle, marine biota, and climate in the Pacific, and to identify gaps in our knowledge for future research in areas of importance for the PICES Section on *Carbon and Climate*.

Tuesday, October 30, 2007 09:00 – 18:10

09:00 ***Introduction by convenors***

09:10 **Taro Takahashi, Stewart C. Sutherland, Rik Wanninkhof, Colm Sweeney, Richard A. Feely, Burke Hales, Gernot Friederich, Francisco Chavez, Andrew Watson, Dorothee C.E. Bakker, Ute Schuster, Nicolas Metzl, Hisayuki Yoshikawa-Inoue, Masao Ishii, Takashi Midorikawa, Christopher Sabine, Mario Hopemma, Jon Olafsson, Thorarinn S. Arnarson, Bronte Tilbrook, Truls Johannessen, Are Olsen, Richard Bellerby, Hein J.W. de Baar, Yukihiro Nojiri, C.S. Wong, Bruno Delille and N.R. Bates (Invited)**
Climatological mean and decadal change in surface ocean $p\mathrm{CO_2}$, and net sea–air CO_2 flux over the global oceans (S2-4468)

09:50 **C.S. Wong, Shau-King Emmy Wong, Sophia Johannessen, Liusen Xie and John Page**
Time-series of $p\mathrm{CO_2}$ (partial pressure of CO_2) at Station P / Line P in the sub-arctic Northeast Pacific Ocean (S2-4166)

10:10 **Hiromichi Tsumori and Yukihiro Nojiri**
Trend analysis of ocean $p\mathrm{CO_2}$ and the air–sea CO_2 flux in the North Pacific (S2-4354)

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

10:50 **Christopher L. Sabine, Richard A. Feely, Frank Millero, Andrew Dickson, Chris Langdon, Sabine Mecking, Jim Swift and Dana Greeley**
Decadal changes in Pacific Ocean inorganic carbon (S2-4224)

11:10 **Masao Ishii, Takayuki Tokieda, Shu Saito, Daisuke Sasano, Toshiya Nakano, Takashi Midorikawa, Akira Nakadate and Hitomi Kamiya**
Trend of DIC increase in the post-WOCE era in the western North Pacific subtropical gyre (S2-4262)

11:30 **Nobuo Tsurushima, Koh Harada and Yutaka W. Watanabe**
Spatial distribution and temporal change of dissolved inorganic carbon in the western North Pacific (S2-4356)

11:50 **Masahide Wakita, Shuichi Watanabe, Akihiko Murata, Nobuo Tsurushima, Makio Honda, Yuichiro Kumamoto, Hajime Kawakami and Kazuhiko Matsumoto**
Temporal variability of dissolved inorganic carbon at the K2 and KNOT time-series stations in the western North Pacific (S2-4431)

12:10 **Hernan E. Garcia, Tim P. Boyer, Sydney Levitus, John I. Antonov and Ricardo A. Locarnini**
Seasonal to decadal variability in phosphate in the upper ocean (S2-4361)

12:30 ***Lunch***

14:00 **Tsuneo Ono and Akihiro Shiomoto**
Decadal trend of summer nutrient content in the North Pacific HNLC region (S2-4170)

14:20 **Yutaka W. Watanabe**
Decadal change in N/P/Si ratio over the North Pacific subpolar region (S2-4102)

14:40 **Akira Nakadate, Hitomi Kamiya, Takashi Midorikawa, Masao Ishii and Toshiya Nakano**
Interannual variability of winter oceanic CO_2 along 137°E in the western North Pacific (S2-4352)

15:00 **Anand Gnanadesikan and Keith B. Rodgers**
Ventilation variability in the North Pacific as simulated by a coupled climate model (S2-4226)

15:20 **Kimio Hanawa and Shusaku Sugimoto**
Reemergence of winter SST anomalies and spring chlorophyll-*a* concentration in the central North Pacific (S2-4137)

15:40 ***Coffee / tea break***

16:00 **James R. Christian, Kenneth L. Denman and Konstantin Zahariev**
The North Pacific Ocean in the enhanced greenhouse (S2-4124)

16:20 **Makio C. Honda**
Interannual variability of the biological pump in the northwestern North Pacific (S2-4068)

16:40 **Debby Ianson, Richard A. Feely, Chris L. Sabine and J. Martin Hernandez-Ayon**
Annual carbon fluxes in the coastal Northwest Pacific (S2-4466)

17:00 **Kitack Lee and Guen-Ha Park**
No recent uptake of anthropogenic CO_2 by the East/Japan Sea (S2-4511)

17:20 **Fei Chai, Guimei Liu, Huijie Xue, Lei Shi and Yi Chao**
Variability of the carbon cycle and productivity in the China Seas during 1960-2006: A three-dimensional physical-biogeochemical modeling study (S2-4272)

17:40 **Xiuren Ning, Chenggang Liu, Qiang Hao, Fei Chai, Huijie Xue, Yuming Cai, Jun Sun, Fengfeng Le, Wuchang Zhang and Junxian Shi**
Physico-biological oceanography coupling of planktonic production and the influence on carbon cycle in the South China Sea (S2-4114)

18:00 ***Summary and wrap up***

S2 Posters

S2-4087 **Takeshi Yoshimura, Jun Nishioka, Koji Suzuki, Hiroshi Hattori, Hiroshi Kiyosawa, Daisuke Tsumune, Kazuhiro Misumi and Takeshi Nakatsuka**
Responses of phytoplankton assemblage and organic carbon dynamics to CO_2 increase

S2-4158 **Hongbo Li, Tian Xiao, Wuchang Zhang, Sanjun Zhao and Ruihua Lv**
Spatial and temporal variation of bacterioplankton population in the southern Yellow Sea, China

S2-4235 **Galina Yu. Pavlova and Pavel Ya. Tishchenko**
Calcium and alkalinity in the Okhotsk Sea and adjacent basins

S2-4255 **Masahiko Fujii, Yasuhiro Yamanaka, Yukihiro Nojiri, Michio J. Kishi and Fei Chai**
Comparison of seasonal characteristics in carbon biogeochemistry among the subarctic North Pacific stations described with a NEMURO-based marine ecosystem model

S2-4305 **Takayuki Tokieda, Masao Ishii, Shu Saito, Daisuke Sasano, Takashi Midorikawa and Akira Nakadate**
Evaluation of changes in ocean circulation and anthropogenic CO_2 storage based on CFCs age in the western North Pacific

S2-4306 **Chun-Ok Jo and Kyung-Ryul Kim**
Decadal changes of phytoplankton activity during spring in the southern East/Japan Sea

S2-4316 **Shinichi S. Tanaka and Yutaka W. Watanabe**
The effect of bubble injection on concentrations of N_2 and Ar in the western North Pacific

S2-4318 **Ruixiang Li, Yan Li and Mingyuan Zhu**
Long term variation of phytoplankton in the Yellow Sea in spring

S2-4358 **Yukihiro Nojiri, Hitoshi Mukai, Hiromichi Tsumori, Takeshi Egashira, Katsumoto Kinoshita and Hideshi Kimoto**
Development of $p\mathrm{CO}_2$ measuring buoy in the surface ocean

S2-4364 **Akihiko Murata, Yuichiro Kumamoto, Ken'ichi Sasaki, Shuichi Watanabe and Masao Fukasawa**
Decadal increases of anthropogenic CO_2 in the subtropical and tropical oceans along the WOCE P10 line

S2-4517 **Pete Davison, David M. Checkley, Jr. and Tony Koslow**
Is diel vertical migration important to oceanic carbon export flux?

S2 Oral Presentations

30 October, 09:10 (S2-4468) Invited

Climatological mean and decadal change in surface ocean pCO_2, and net sea–air CO_2 flux over the global oceans

Taro **Takahashi**[1], Stewart C. Sutherland[1], Rik Wanninkhof[2], Colm Sweeney[3], Richard A. Feely[4], Burke Hales[5], Gernot Friederich[6], Francisco Chavez[6], Andrew Watson[7], Dorothee C.E. Bakker[7], Ute Schuster[7], Nicolas Metzl[8], Hisayuki Yoshikawa-Inoue[9], Masao Ishii[10], Takashi Midorikawa[10], Christopher Sabine[4], Mario Hopemma[11], Jon Olafsson[12], Thorarinn S. Arnarson[12], Bronte Tilbrook[13], Truls Johannessen[14], Are Olsen[14], Richard Bellerby[14], Hein J.W. de Baar[15], Yukihiro Nojiri[16], C.S. Wong[17], Bruno Delille[18] and N.R. Bates[19]

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4 Pacific Marine Environmental Laboratory, National Oceanographic and Atmospheric Administration, Seattle, WA, USA
5 College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR, USA
6 Monterey Bay Aquarium Research Institute, Moss Landing, CA, USA
7 School of Environmental Sciences, University of East Anglia, Norwich, UK
8 Laboratoire d'Oceanographie et du Climat, Universite Pierre et Marie Curie, Paris, France
9 Graduate School of Environmental Earth Science, Hokkaido University, Sapporo, Japan
10 Meteorological Research Institute, Tsukuba, Japan
11 Alfred Wegener Institute, Bremerhaven, Germany
12 Marine Research Institute and University of Iceland, Reykjavik, Iceland
13 Antarctic CRC and CSIRO Marine Research, Hobart, Tasmania, Australia
14 Bjerknes Centre for Climate Research, University of Bergen, Norway
15 Royal Netherlands Institute of Sea Research, Den Burg, The Netherlands
16 National Institute for Environmental Studies, Tsukuba, Japan
17 Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC, Canada
18 Universite de Liege, Liege, Belgium
19 Bermuda Institute of Ocean Science, Bermuda

A climatological mean distribution for the surface water pCO_2 over the global oceans in non-El Niño conditions has been constructed with a 5° × 4° resolution for a reference year 2000 based on about 3 million measurements of surface water pCO_2 obtained from 1970 to 2006. A time-trend analysis using deseasonalized surface water pCO_2 data shows that surface water pCO_2 over the global oceans has increased at a mean rate of 1.5 μatm yr^{-1}, a rate similar to the atmospheric CO_2 increase. Distinctly different rates of -1.1±0.6 μatm yr^{-1} are observed in the Bering Sea and the vicinity of the Okhotsk Sea. These rates are used for correcting pCO_2 values observed in different years to a single reference year 2000. The high latitude northern oceans are a source (or a weaker sink) for atmospheric CO_2 in January–March and a sink in July–September. The rate constant for the air–sea gas transfer flux is parameterized as a function of wind speed squared. The scaling factor of 0.24 for long-term mean gas transfer piston velocity is estimated by inverting the bomb ^{14}C data using Ocean General Circulation models and the 1979–2005 NCEP-DOE AMIP-II Reanalysis wind speed data. Using the sea–air CO_2 transfer rates and the sea–air pCO_2 differences, the annual mean for the net sea–air CO_2 flux over the global oceans is estimated to be 1.4 ± 0.7 PgC yr^{-1}. This includes an additional systematic bias of 0.26 PgC yr^{-1}, caused by undersampling and the interpolation method used.

30 October, 09:50 (S2-4166)

Time-series of pCO_2 (partial pressure of CO_2) at Station P / Line P in the sub-arctic Northeast Pacific Ocean

C.S. Wong[1], Shau-King Emmy Wong[1,2], Sophia **Johannessen**[2], Liusen Xie[1,2] and John Page[1,2]

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A time-series of pCO_2 (partial pressure of CO_2) in surface water has been collected at Ocean Station P (50ºN, 145ºW) along line P (between Station P and Juan de Fuca Strait) in the northeast subarctic Pacific Ocean since 1978. Factors affecting pCO_2 are discussed, including upwelling, advection, ENSO events, change in ocean productivity and the increase in pCO_2 due to decrease in sub-surface oxygen, especially in recent years. The long-term trend in seawater pCO_2 and its implication for increasing atmospheric CO_2 are also discussed.

30 October, 10:10 (S2-4354)

Trend analysis of ocean pCO_2 and the air–sea CO_2 flux in the North Pacific

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Since 1995, National Institute for Environmental Studies (NIES) has made surface ocean CO_2 measurements in the mid and high latitude North Pacific using volunteer observing ships. Partial pressure of CO_2 (pCO_2) in the atmosphere and ocean, and sea surface temperature and salinity were obtained for about 160 observation legs through March 2006. Decadal trends of CO_2 in both atmosphere and ocean and a climatology of ΔpCO_2 (= ocean pCO_2 – atmospheric pCO_2) were determined in each ±5° latitude by ±1.25° longitude box area over the North Pacific from 1995 to 2006. Also, we analyzed the annual variation of the air–sea CO_2 flux which was estimated from the ΔpCO_2 climatology and the decadal trend of ocean pCO_2. The deseasonalized ocean surface pCO_2 increased at approximately the same rate as atmospheric pCO_2 (≈ 1.7 µatm/year), however, differences in the rate of increase were observed. In particular, at 40°N, the western North Pacific showed a smaller rate of ocean pCO_2 increase than the atmosphere. On the other hand, eastern North Pacific at 40°N showed a larger rate of increase. This suggests that the ocean sink for CO_2 increased in the eastern North Pacific and decreased in the western North Pacific during this decade.

30 October, 10:50 (S2-4224)

Decadal changes in Pacific Ocean inorganic carbon

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The Pacific Ocean plays a unique role in the ocean carbon cycle because it is the final destination of deep waters containing high levels of preformed nutrients and dissolved inorganic carbon (DIC), and because of the way that Pacific circulation affects the transport and storage of anthropogenic CO_2. High-quality DIC and total alkalinity data were acquired as part of the WOCE/JGOFS global CO_2 survey cruises in the early 1990s. Hydrographic survey cruises conducted as part of the CLIVAR/CO_2 Repeat Hydrography Program recently reoccupied the zonal P02 line along 30°N in 2004 and the meridional P16 line along 152°W in 2005 and 2006. Maximum changes in DIC along P02 are 15–20µmol kg^{-1} over 10 years, somewhat higher than the expected ~1 µmol kg^{-1} yr^{-1} increase. The changes along P16 over the 14–15 year time frame fit with the maximum expected magnitude of the anthropogenic signal, but the relative distribution and penetration of the signal in the North Pacific compared to the South Pacific is unusual. The effect of varying circulation on the total DIC change based on decadal changes in the apparent oxygen

utilization rate is estimated to be greater than 10 µmol kg^{-1} in the North Pacific, accounting for up to 80% of the total DIC change. An upward migration of the aragonite and calcite saturation horizons, ranging from 1 to 5m yr^{-1}, results from the uptake of anthropogenic CO_2 but is also strongly impacted by regional circulation changes.

30 October, 11:10 (S2-4262)

Trend of DIC increase in the post-WOCE era in the western North Pacific subtropical gyre

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We demonstrate the importance of subduction processes in the northwestern subtropical gyre and in the transition zone between the subtropical and subarctic gyres including the formation of Subtropical Mode Water ($\sigma_\theta \approx 25.2$) and Central Mode Water ($\sigma_\theta \approx 26.2$) in transporting anthropogenic CO_2 into the interior of the North Pacific. On the basis of high-quality data collected in the WOCE Hydrographic Program in the 1990s and a number of post-WOCE cruises conducted by JMA and the WEST-COSMIC project, we have analyzed the decadal trend of total inorganic carbon (TCO_2) and apparent oxygen utilization (AOU) on the isopycnal surfaces $25.0 \leq \sigma_\theta \leq 27.3$ in the northern limb of the subtropical gyre along 165ºE (P13) and 137ºE (P09). On both sections, significant increasing trends of TCO_2 and AOU were detected. The preformed $NTCO_2$ [= (TCO_2 – 117/170·AOU) · 35/S] at layers $\sigma_\theta \leq 26.7$ on 165ºE and $\sigma_\theta \leq 26.1$ on 137ºE are also increasing at a rate of +0.7 to +1.2 µmol kg^{-1} yr^{-1}, near equilibrium with the atmospheric CO_2 increase. The rate of increase of preformed $NTCO_2$ reduced moderately to +0.4 to +0.6 µmol kg^{-1} yr^{-1} at $26.2 \leq \sigma_\theta \leq 26.8$ on 137ºE, and abruptly decreased in deeper layers with no significant increase detected at $\sigma_\theta \geq 27.0$ on both sections. The difference in the increase rate between 165ºE and 137ºE and among isopycnal surfaces are qualitatively consistent with the differences in *p*CFC-12 age.

30 October, 11:30 (S2-4356)

Spatial distribution and temporal change of dissolved inorganic carbon in the western North Pacific

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As part of GEOSS activities in Japan, we have been compiling a dataset of concentrations of dissolved inorganic carbon (DIC) and related species in the western North Pacific since the 1990s. At this stage, the dataset includes eight meridional transects and more than 1000 profiles between 135°E and 180°E in the North Pacific. Since the data set covers the western North Pacific widely, we can construct detailed images of the spatial distribution of natural and anthropogenic carbon in this area. The dataset also includes data from several time-series stations and revisited transects. We tried to detect the temporal change of DIC by direct comparison of available transectional data (WOCE, NOPACCS, WEST-COSMIC, *etc.*) in subarctic and adjacent areas. Offset corrections were made by comparing the concentration of DIC in the deep water at nearby stations on each cruise. A large rate of increase of DIC was detected in the intermediate water especially in the high latitude area where apparent oxygen utilization (AOU) increase also occurred. In the high latitude area (>40°N) along the 165°E section, DIC and AOU increase from 1992 to 2000 was up to 25 µmol kg^{-1} and 26 µmol kg^{-1} respectively around $26.8\sigma_\theta$, and decreased with depth down to $27.4\sigma_\theta$.

30 October, 11:50 (S2-4431)

Temporal variability of dissolved inorganic carbon at the K2 and KNOT time-series stations in the western North Pacific

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It is found in the subarctic western North Pacific that DIC contents which were corrected for AOU and Potential Alkalinity (PA) variations have increased in the intermediate water (26.6–27.1σ_θ). Data were obtained for DIC and carbon-related chemical species from 1992 to 2007 at time-series stations K2 (47°N, 160°E) and KNOT (44°N, 155°E). Corrected DIC increase rate was 0.7–1.7µmol kg^{-1} yr^{-1} during the past 15 years. The increase rate near the surface was faster than in the deeper layers PA was also increased significantly. The rate of change of CO_2 inventory in the water column was estimated to be increasing at 0.46 ± 0.14 mol m^{-2} yr^{-1}.

30 October, 12:10 (S2-4361)

Seasonal to decadal variability in phosphate in the upper ocean

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We document seasonal (70°S–70°N) to decadal (0°–70°N) basin-scale variability of phosphate content (PC) anomaly in the upper water column using objectively analyzed anomaly values from the World Ocean Database 2005 for the period 1955–1998. The amplitude of the seasonal PC is largest in the upper 75 m in the 35°–60° latitude belt of each hemisphere. The global extra-tropical (>20° latitude) seasonal net change in PC is large, about ±0.5 µmol kg^{-1}. We report significant sub-surface inter-decadal variability in the 75–150m layer with peak-to-peak variations of up to ±0.1 µmol kg^{-1} and oscillations of about 8–12 years that can be attributed to thermocline-depth variability. The North Pacific is the largest contributor to the seasonal and decadal-scale global phosphate content variability.

30 October, 14:00 (S2-4170)

Decadal trend of summer nutrient content in the North Pacific HNLC region

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Decadal-scale variation of nutrient content in the summer mixed layer of the North Pacific HNLC region was investigated by integrating historical nutrient data since 1970. HNLC-averaged phosphate concentration showed significant decadal variation, with peaks in the 1970s and 1990s and troughs in the 1980s and 2000s. Plots of phosphate vs temperature also showed significant shifts between the peak phase and trough phase, indicating these decadal changes are caused by nonconservative processes such as changes in biological processes. Multi-decadal negative trends were also observed for both phosphate and silicate. Unlike the decadal-scale oscillations, these trends seemed to be related to temperature-linked processes, such as a multi-decadal decrease of vertical mixing due to ocean warming. Some studies indicate that primary production in the subarctic north Pacific has been diminished in recent decades, and our present analysis shows that the recent decrease of upward nutrient transport is larger than that of export production in the North Pacific HNLC region. This imbalance may have generated an anomalous ocean carbon sink of 12×10^{12}gC for the last 30 years, as predicted by the model study of Sarmiento *et al.* [1998; *Nature* 393: 245–249].

30 October, 14:20 (S2-4102)

Decadal change in N/P/Si ratio over the North Pacific subpolar region

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Based on four multidecadal hydrographic time series of biogeochemical properties over the North Pacific subpolar region, we found extensive linear trends of these properties in both surface and subsurface waters. These trends were superimposed on a clear bidecadal periodicity of 18 years, which had opposite phase in the eastern and western North Pacific. Despite decreasing trends in dissolved oxygen and an increase of PO_4, N* in the subsurface water showed a significant increasing trend. Additionally, N* in the surface water had also a significant increase with a decrease of Si. Considering the decrease of N/P and increase of Si/N in diatoms under iron-deficient conditions due to the recent weakness of formation of North Pacific Intermediate Water near the Sea of Okhotsk, this finding may be evidence that a shift of phytoplankton has already occurred due to increased surface water stratification and depletion of iron derived from deep water.

30 October, 14:40 (S2-4352)

Interannual variability of winter oceanic CO_2 along 137°E in the western North Pacific

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A twenty-four year record of CO_2 partial pressure (pCO_2) in surface waters between 3°N and 30°N along 137°E in the western North Pacific in winter exhibits significant interannual variation that differs in different regions. Detrended pCO_2 normalized to mean temperature had large variations in the equatorial region that corresponded to oceanographic conditions related to the El Niño–Southern Oscillation (ENSO). Applying the empirical orthogonal function technique, it was found that about 40% of the variance was accounted for by the 1st component, associated with ENSO. A larger contribution from ENSO was especially prevalent in the area south of 15°N. Another mode with opposing effects south of 8°N and north of 19°N was found with about a 20% contribution. Variations of pCO_2 may be associated with redistributions of the warm pool in the southern region and with the mixed layer processes in the northern region.

30 October, 15:00 (S2-4226)

Ventilation variability in the North Pacific as simulated by a coupled climate model

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While the Pacific Decadal Oscillation is the most studied mode of variability in the North Pacific Ocean, it does not describe all of the observed variability, particularly in the central Aleutians and adjacent parts of the Bering Sea. We present a new study with the CM2.1 global coupled climate model developed at GFDL for the IPCC Fourth Assessment Report. We demonstrate that this model has a relatively reasonable Pacific Decadal Oscillations, but that it exhibits an additional mode of variability involving the rate of ventilation of the Bering Sea. This mode is particularly evident when examining simulations involving an ideal age tracer, which show large changes in ideal age propagating out of the Bering Sea region and spreading throughout the subpolar North Pacific. The mechanism behind this variability is primarily due to changes in winds that result in changes in the rate of freshwater export from the surface Bering Sea. Increased winds destabilize the halocline and lead to higher surface temperatures in the Bering. Under global warming, this variability shuts off, resulting in a slower warming of the Central and Western Bering Sea.

30 October, 15:20 (S2-4137)

Reemergence of winter SST anomalies and spring chlorophyll-*a* concentration in the central North Pacific

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The North Pacific Subtropical Mode Water (NPSTMW) shows two types of 'reemergence' of winter sea surface temperature (SST) anomalies. One is 'co-located' reemergence in the same region as the NPSTMW formation region and the other is 'remote' reemergence in the region distant from the NPSTMW formation region. It is shown that these reemergence phenomena have a strong impact on chlorophyll-a concentration in both reemergence areas. It is shown that spring chlorophyll-a concentration in the NPSTMW formation area can be explained directly by the winter mixed layer depth there. Further, fall chlorophyll concentration in the formation area is modeled well from the previous winter mixed layer depth. This is the manifestation of co-located reemergence phenomenon. On the other hand, the chlorophyll-a concentration in the remote reemergence area, *i.e.*, the central North Pacific, can be modeled by the mixed layer depth of NPSTMW formation region during the previous winter and winter mixed layer depth in the remote reemergence region in a given year. That is, the winter mixed layer depth in the NPSTMW formation area can be regarded as a measure of amount of nutrient entrained in the NPSTMW.

30 October, 16:00 (S2-4124)

The North Pacific Ocean in the enhanced greenhouse

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Global climate change and accumulation of anthropogenic CO_2 are superimposed on a large background of natural interannual and interdecadal variability. Understanding variability requires consideration of anthropogenically induced changes that have occurred throughout the modern era of ocean observation. The overall warming trend in the North Pacific is more gradual than in other major ocean basins. However, the North Pacific is particularly vulnerable to anthropogenic ocean acidification because the carbonate saturation horizon is naturally shallow. Using the Canadian Centre for Climate Modelling and Analysis global coupled climate-carbon model, we illustrate some recent trends in North Pacific warming, anthropogenic CO_2 accumulation, and carbonate undersaturation. Compared with observations, the model shows greater storage of anthropogenic CO_2 in the North Pacific relative to other regions of the world ocean. Future trends projected from IPCC emission scenarios suggest that the shoaling of the calcite and aragonite saturation horizons in the North Pacific is accelerating.

30 October, 16:20 (S2-4068)

Interannual variability of the biological pump in the northwestern North Pacific

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Based on seasonal variability in surface nutrients and pCO_2 measurements, it is suspected that the biological pump in the North Pacific Western Subarctic Gyre (WSG) works well for uptake of atmospheric CO_2. In order to study the precise mechanism of the biological pump in the WSG, JAMSTEC has conducted time-series sediment trap experiments since 1998 at several stations such as KNOT (44°N, 155°E) and K2 (47°N, 160°E). In general, material fluxes increase in late spring and decrease in winter. Although chemical composition of settling materials changes seasonally, biogenic opal is predominant in the annual average and plays an important role in transporting organic carbon to the ocean interior. A higher ratio of organic carbon to inorganic carbon flux (Co/Ci) and a higher ratio of organic carbon flux at depth to primary productivity (transfer efficiency) than other oceans indicates the efficiency of the biological pump for uptake of CO_2 is high in the WSG. Approximately 8 years quasi-time-series data of material fluxes shows a small, but significant, long-term increase in $CaCO_3$ flux while opal flux and organic carbon

flux did not show significant change, resulting in a decreased ratio of biogenic opal to $CaCO_3$ flux. Increase in $CaCO_3$ flux coincides with increase of coccolithophorids in the WSG reported recently. However time-series sediment trap data in the WSG is still insufficient to determine whether this long-term change is significant or not, and whether this change is attributed to global warming or natural decadal change such as the Pacific Decadal Oscillation.

30 October, 16:40 (S2-4466)

Annual carbon fluxes in the coastal Northwest Pacific

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Carbon fluxes are disproportionately large in coastal regions relative to the open ocean, especially where upwelling occurs along the western margins of continents. These fluxes are also highly variable both spatially and temporally due to the nature of upwelling. This variability makes it difficult to integrate fluxes to produce annual cycles, particularly as so few data exist. We use the results of a research cruise (North American Carbon Program, NACP) in May and June, 2007 conducted on the RV *Wecoma* in combination with a coastal carbon model (Ianson and Allen, Global Biogeochem. Cycles, 2002, doi:10.1029/2001GB001451) to estimate annual carbon fluxes in the northern regions of the west coast of North America. In addition we discuss total carbon inventories in these regions and their use as integrators of annual productivity and net air–sea CO_2 exchange.

30 October, 17:00 (S2-4511)

No recent uptake of anthropogenic CO_2 by the East/Japan Sea

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Changes in the inventory of anthropogenic CO_2 in the East/Japan Sea were determined from high-quality alkalinity, total inorganic carbon, and nutrient data collected during three surveys in 1992, 1999, and 2007. A resulting mean annual uptake rate of anthropogenic CO_2 during the period between 1992–1999 is 0.7 ± 0.4mol m^{-2} yr^{-1}, which is in sharp contrast to a negligible rate of uptake of anthropogenic CO_2 observed during the period between 1999–2007. Such considerable reduction in the uptake of anthropogenic CO_2 could be attributed to reduced efficiency in the transport of anthropogenic CO_2 to the interior of the East Sea during the recent years. Our observations indicate that minor disturbances in the global or regional climate system will potentially change the intensity of deep water formation, which directly affects the uptake of anthropogenic CO_2 by the East Sea. Regular monitoring of carbon and hydrographic parameters in the East Sea will therefore provide information on variations that may occur in the global ocean at much longer time scales. In this way, the East Sea can serve as a site for monitoring decadal variability in oceanic CO_2 uptake.

30 October, 17:20 (S2-4272)

Variability of the carbon cycle and productivity in the China Seas during 1960-2006: A three-dimensional physical-biogeochemical modeling study

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The biological productivity and carbon cycle in marginal seas contribute significantly to global budget estimates. The key factors regulating productivity and carbon fluxes vary regionally, for example in the China seas (Yellow Sea, East China Sea, and South China Sea). In this study, a Pacific basin physical-biogeochemical model is used, which is driven with daily air–sea fluxes from the NCEP reanalysis for the period from 1960 to 2006. The analysis is

focused on the similarities and discrepancies in modeled simulated primary productivity and the partial pressure of carbon dioxide (pCO_2) in the China Seas. On the seasonal time scale, modeled air–sea CO_2 flux in the China Seas ranges from a sink during winter to a source in summer. The Yellow Sea has the strongest seasonal variability, and the South China Sea the weakest. Temperature and biological productivity regulation of pCO_2 are compared for the different regions and over time. The model results suggest that temperature plays a dominant role in controlling the spatial and temporal variations of pCO_2, especially in the South China Sea. Biological productivity during spring is important in determining pCO_2 in the Yellow Sea and East China Sea. In general, pCO_2 increased in the China Seas between 1960 and 2006, which is due to the anthropogenic increase of atmospheric pCO_2. The interannual and decadal variation of biological productivity and the carbon cycle in the China Seas, along with anthropogenic CO_2 uptake, will be discussed.

30 October, 17:40 (S2-4114)

Physico-biological oceanography coupling of planktonic production and the influence on carbon cycle in the South China Sea

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Through multidisciplinary observations of phytoplankton community structure, size structure of biomass and production, new production, PDOC (DOC produced by phytoplankton through photosynthesis) production, bacterial production and the governing factors, the spatial and temporal distributions of community structure and standing stock and production of lower trophic levels of the SCS ecosystem were systematically elucidated. Remotely sensed monthly mean primary production during 7 years (1998-2004) was derived using the VGPM model validated by sea truth data, obtaining an annual mean carbon fixation rate of 48.3×10^6 t a^{-1}, to which the contributions of the coastal zone, shelf, and open sea were 38%, 29%, and 33% respectively. Size fractionation showed that the contribution of picoplankton to biomass and production of phytoplankton community was the largest (>50%), particularly for the subsurface chlorophyll maximum. Through combination analysis of side-fractionated chlorophyll and FCM measurements, it was revealed that the bottom up effects of bacterioplankton were mainly controled by photosynthetic picoplankton, particularly *Synechococcus*. The intrusion and flux (2 Sv, annual mean) of Kuroshio water to the SCS through Luzon Strait and its seasonal variation were elucidated using an ocean model. The causative link "monsoon-circulation-nutrients-phytoplankton" was clearly revealed at the large scale (ca. 3.5×10^6 km^2). The major mesoscale eddies, *i.e.* cyclonic cold eddies and anticyclonic warm eddies were identified in summer and winter. Cold eddies exhibited low temperature, high salinity, low oxygen, high nutrient concentrations, high chlorophyll and high primary production, and the opposite features were exhibited in the warm eddies. Nutrient enrichment experimenmts in the anticyclonic eddies revealed that phytoplankton was limited by multiple nutrients, and species succession from dinoflagellates to diatoms and size succession from small to large phytoplankton were observed. A 3-D physical-biogeochemical coupled model was developed and applied to study the variation of physical features, the responses of the ecosystem of the SCS, the biogeochemical controls on the carbon cycle and the spatial and temporal patterns of CO_2 sources and sinks. It was found that SCS was a CO_2 sink during winter, and a source during other seasons; in the annual mean for the whole SCS, it was a weak source with an annual net flux of 12.6×10^6 t a^{-1} to the atmosphere.

S2 Posters

Poster S2-4087

Responses of phytoplankton assemblage and organic carbon dynamics to CO_2 increase

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To investigate the responses of phytoplankton assemblage and organic carbon dynamics to CO_2 increase, a CO_2 manipulation experiment was conducted in the Sea of Okhotsk in the summer of 2006. Surface water with a natural phytoplankton assemblage was incubated in 8-L bottles with bubbling air containing different concentrations of CO_2 (180, 380, 750, and 1000ppm). Temporal changes in phytoplankton pigments and particulate and dissolved organic carbon (POC and DOC) were observed for 14 days. The surface water of the sampling site was depleted in nutrients, so phytoplankton abundance in the bottles remained at a low biomass of 0.1–0.3µg chlorophyll-*a* L^{-1} during the course of the experiment. If the values at the end of the experiment were compared in each treatment, the fucoxanthin/chlorophyll-*a* ratios decreased with increasing CO_2, indicating the relative abundance of fucoxanthin-containing phytoplankton such as diatoms would be sensitive to a change in CO_2. This result may have been derived from the higher efficiency of C-fixation by Rubisco in diatoms than other algal groups. The concentration of 19'-hexanoyloxyfucoxanthin decreased to near zero during the experiment in all treatments, therefore we could not determine the response of 19'-hex-containing phytoplankton such as prymnesiophytes, including coccolithophores, to the CO_2 gradient using pigment data. While no significant difference was observed for change in POC between treatments, the amount of DOC accumulation decreased with increasing CO_2. The continuing increase in atmospheric CO_2 concentration may cause changes in phytoplankton composition and organic carbon flow in the nutrient-depleted surface water in the subarctic regions.

Poster S2-4158

Spatial and temporal variation of bacterioplankton population in the southern Yellow Sea, China

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Bacterioplankton abundance and growth and grazing rates were measured during winter, spring, summer, and autumn in the southern Yellow Sea of China from October 2000 to June 2004. Sampling took place on sixteen survey cruises covering the entire central and southern Yellow Sea (32°–37°N, 121°–125.5°E). Interannual variability was small relative to seasonal and spatial variability. Heterotrophic bacterial biomass, derived from cell counts (assuming 20fg C $cell^{-1}$), was ca. 2.4µg C l^{-1} in winter and increased to 15.6µg C l^{-1} in spring. *Synechococcus* biomass, derived from cell counts (assuming 294fg C $cell^{-1}$), was ~2.3µg C l^{-1} in winter and increased to 17µg C l^{-1} in spring. The contribution of *Synechococcus* biomass (CB) to phytoplankton biomass (PB) was greatest in spring, followed by autumn, summer, and winter. The annual average contribution was 36%. The ratio of heterotrophic bacterial biomass to phytoplankton biomass was greatest in summer, followed by autumn, spring, and winter, and was 61% on average. The main grazer on *Synechococcus* was nano-zooplankton (<20µm) and on heterotrophic bacteria was micro-zooplankton (<200µm). The main grazers on bacterioplankton changed with season, and the grazing rate was higher in winter than in spring. The Q_{10} for *Synechococcus* growth was 1.16, and for heterotrophic bacteria ranged from 2.55 to 3.46; bacterial growth rates were affected by temperatures <14°C.

Poster S2-4235

Calcium and alkalinity in the Okhotsk Sea and adjacent basins

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One of the most fundamental unanswered questions in oceanography is to find an additional source of calcium (Ca) or an unaccounted for sink of alkalinity (Alk) in the ocean, because the amount of dissolved Ca supplied by rivers is not large enough to account for the amount of Alk that has presumably been removed as calcium carbonate deposits. In this respect, studying the Ca and Alk distribution in high latitude marginal seas such as the Okhotsk Sea is of exceptional interest, because there is a complete absence of Ca data in this sea in the western oceanographic data archives. The first extensive study of Ca and Alk distributions in the Okhotsk Sea and in the Amur River and estuary were carried out by Russian scientists in 2002–2005. It was revealed that surface and deep waters of the Okhotsk Sea are enriched in Ca and Alk in comparison with Subarctic Pacific waters. Probable reasons for this feature of the Okhotsk Sea are considered: oxidation of organic matter, mixing of water masses with different preformed values of Alk and Ca, sea ice melting, river water supply, and seabed influence. The Ca and Alk budgets for the Okhotsk Sea are determined by the water exchange with the Subarctic Pacific, Amur River run off, and the supply of Soya Current water. It is estimated that annually approximately 0.13×10^{12} mole of dissolved Ca and 0.26×10^{12} mole of Alk are generated inside the Okhotsk Sea, which are presumably accumulated as calcium carbonate deposits at an average rate of 0.23 mmol m^{-2} d^{-1} over the whole of the Okhotsk Sea.

Poster S2-4255

Comparison of seasonal characteristics in carbon biogeochemistry among the subarctic North Pacific stations described with a NEMURO-based marine ecosystem model

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A NEMURO-based sixteen-compartment marine ecosystem model is applied to Stations A7 (41.5°N, 145.5°E) and KNOT (44°N, 155°E) in the subarctic western North Pacific and Station PAPA (50°N, 145°W) in the subarctic eastern North Pacific. Model results show significant west-east differences in seasonal characteristics of physical environmental conditions and carbon biogeochemistry, such as larger seasonal amplitudes in partial pressure of CO_2 at the sea surface $(pCO_2)_{sea}$ at Stations A7 and KNOT than at Station PAPA. The sea-to-air CO_2 flux increases at Stations A7 and KNOT when calculated using daily wind data, instead of climatological wind data which have been used in most of the previous studies. The increase is attributed to the strong winds in late winter in the daily wind data, suggesting that the sea-to-air CO_2 flux was probably underestimated in previous studies and that frequent monitoring of winds and $(pCO_2)_{sea}$ is necessary to reduce uncertainties in estimating air–sea CO_2 flux.

Poster S2-4305

Evaluation of changes in ocean circulation and anthropogenic CO_2 storage based on CFCs age in the western North Pacific

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We made observations of chlorofluorocarbons (CFCs) along 165°E from arctic to tropical regions in 2001 and 2006 in the western North Pacific. By comparing with data taken by NOAA in 1987 and 1992, we evaluate the CFCs

concentration, the CFCs water mass age, and the inventory of anthropogenic CO_2. The concentrations of CFCs have greatly increased in surface and subsurface waters. The isopleths of the higher CFCs concentration in the subsurface water in higher latitude extend to the south and to the deep layer. The distribution of the water mass age derived from *p*CFCs showed no significant temporal variability, except in the subarctic–subtropical transition zone, where the meridional positions of the fronts are variable, indicating that no significant change in ocean circulation occurred in this region. Higher concentrations of anthropogenic CO_2 were observed in the surface and subsurface waters between 20–30°N, and deeper and shallower penetration was observed around 30°N and 10°N respectively. The anthropogenic CO_2 concentration is increasing but the rate of increase is variable in space and time depending on the distribution of water mass age and the change in the rate of atmospheric CO_2 increase. The rates of increase of the water column inventories for anthropogenic CO_2 at 28°N as calculated by the method of Gruber *et al.* (1996, *GBC* 10: 809–837) are 5.6 $gC/m^2/yr$ (1987–1992), 9.6 $gC/m^2/yr$ (1992–2001), and 11.8 $gC/m^2/yr$ (2001–2006).

Poster S2-4306

Decadal changes of phytoplankton activity during spring in the southern East/Japan Sea

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Decadal changes of phytoplankton activity during spring in the southern East/Japan Sea have been investigated through analysis of ocean color data from the CZCS (1979–1986) and SeaWiFS (1998–2005) and *in-situ* data from the World Ocean Database 2005. In the CZCS period, surface chlorophyll *a* concentrations in April were more than twice as large as the average concentration during winter. The frequency distributions of chlorophyll *a* concentration in April were skewed toward high values. Vertical profiles of chlorophyll *a* concentrations during spring showed formation of maximum chlorophyll *a* concentrations below the surface mixed layer. In the SeaWiFS period, abnormally high surface chlorophyll *a* concentrations were also detected in April. However, the frequency distribution of the concentration in April was nearly Gaussian. Maximum chlorophyll *a* concentrations during spring were concentrated in the surface mixed layer. Stratification of the upper water column in the CZCS period was intense, but no distinct decadal changes in the springtime mixed layer depth were detected. These conditions indicate that the intensified stratification reduced nutrient supply to the surface mixed layer and suppressed the spring bloom in the CZCS period. In addition, these decadal changes are consistent with the "early summer hypothesis" of Chiba and Saino [2002, *MEPS* 231:23–35].

Poster S2-4316

The effect of bubble injection on concentrations of N_2 and Ar in the western North Pacific

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An improved gas chromatographic system was constructed to analyze oceanic dissolved N_2 and Ar with higher accuracy and shorter analytical time. Using our improved analytical technique, we observed the concentrations of N_2 and Ar in subsurface waters of the western North Pacific. Based on these data, we propose a new concept for estimating the amount of bubble injection (B). As each water mass had a significantly different value of B in this region, it is possible that we can use B as an index of the sea surface state when each water mass was formed in the sea surface mixed layer. Moreover, based on the values of B, we estimated the preformed dissolved oxygen and the preformed CFCs to define the exact saturation state.

Poster S2-4318

Long term variation of phytoplankton in the Yellow Sea in spring

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A comparative analysis of netplankton field data in the Yellow Sea in the spring of 1959, 1985, and 2006 was carried out. The results showed that the distribution pattern of phytoplankton had no clear change. There were two areas with high abundance. The larger extends from the north coast of the Shandong Peninsula to coastal waters of Liaoning Province. The smaller is north of the Yangtze River Estuary. Phytoplankton abundance showed a significant increase in the early 21st century. Phytoplankton cell number in spring of 1959 and 1985 was less than 1×10^6 cells/m^3. In April 2006, it reached 2×10^7 cells/m^3. There was a clear change of community structure. The dominant species in March and April 1959 was *Hemiaulus sinensis*. Other species included *Chaetoceros* spp., *Thalassionema nitzschoides*, *Skeletonema costatum* and *Asterionella japonica*. In May 1985, the dominant species were *Skeletonema costatum* and *Bacteriastrum hyalinum*. In April 2006, the dominant species were *Skeletonema costatum*, *Thalassiosira* spp. *Pseudonitzschia pungens* and *Eucampia zodiacus*. These changes may be attributable to global warming and eutrophication.

Poster S2-4358

Development of *p*CO_2 measuring buoy in the surface ocean

Yukihiro **Nojiri**[1], Hitoshi Mukai[1], Hiromichi Tsumori[1], Takeshi Egashira[2], Katsumoto Kinoshita[2] and Hideshi Kimoto[2]

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A small and energy-saving drifting buoy for the measurement of the partial pressure of CO_2 (pCO_2) in the surface ocean was developed using a gas–liquid equilibrator made of a membrane tube and a nondispersive infrared (NDIR) sensor. This buoy is 1.5 m wide, 1.15 m high and the total weight is about 110 kg. 70 cycles of measurements can be operated with a Li-ion battery. One cycle of measurement consists of the atmospheric and ocean CO_2 measurements and the calibration of NDIR by standard gases. Two standard gas cylinders are installed in the buoy. Sea surface temperature and salinity are also measured. In order to test the buoy system, moored and drifting experiments were carried out in coastal areas of Japan. Water sampling was done in both experiments and total carbon dioxide and alkalinity were measured. Although the difference between the value of ocean pCO_2 measured by the buoy and that estimated from the total carbon dioxide and alkalinity was approximately 5 μatm, very similar time series of changes of pCO_2 in the buoy and water sampling results were observed during the both experiments.

Poster S2-4364

Decadal increases of anthropogenic CO_2 in the subtropical and tropical oceans along the WOCE P10 line

Akihiko **Murata**, Yuichiro Kumamoto, Ken'ichi Sasaki, Shuichi Watanabe and Masao Fukasawa

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We occupied the WOCE P10 line along 149°E and the northern extension to the coast of Hokkaido, Japan in the period from 25 May to 2 July, 2005 using the JAMSTEC vessel R/V *Mirai*. During the cruise, we measured CO_2 system parameters such as dissolved inorganic carbon (DIC), total alkalinity (TA), and pH at almost half of the CTD stations. The estimated precision was 1.1μmol kg^{-1} (n = 209), 1.8μmol kg^{-1} (n = 207), and 0.0006 pH unit (n = 203) for DIC, TA, and pH, respectively. Using high-quality data for DIC and dissolved oxygen, we examined decadal increases of anthropogenic CO_2 (ΔnC_T^{CAL}) along the P10 line based on the method of Murata *et al.* (2007, *JGR*, 112, C05033, doi:10.1029/2005JC003405). In latitude 24°–30°N, ΔnC_T^{CAL} was calculated to be 10.4μmol kg^{-1}and

4.3μmol kg^{-1} for Subtropical Mode Water (sigma theta = 25.2) and North Pacific Intermediate Water (sigma theta = 26.8), respectively. The ΔnC_T^{CAL} in other water masses will be reported in the meeting.

Poster S2-4517

Is diel vertical migration important to oceanic carbon export flux?

Pete Davison, David M. Checkley, Jr. and Tony **Koslow**

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The active transport of carbon out of the surface ocean by migrating fish that form the deep scattering layer is poorly known, but potentially large. Biomass measurements and CTD profiles from the CCE-P0704 cruise were combined with physiological and mortality rates from the literature using a computer model. The model results indicate an overall fish mediated transport of 0.7-3.2 mg C m^{-2} d^{-1} in the California Current. The fish carbon flux is similar to estimates of the migratory zooplankton flux from other ecosystems (2-3 mg C m^{-2} d^{-1}, summarized in Al-Mutairi and Landry, 2001), and is 6-7% of the passive carbon flux measured concurrently with sediment traps. The measured fish biomass is biased low due to net avoidance. We hope to measure this bias on future CCE-LTER cruises by combining quantitative sonar data with mesopelagic trawl sampling.

S3 CCCC/FIS Topic Session
Towards ecosystem-based management: Recent developments and successes in multi-species modeling

Co-sponsored by GLOBEC

Co-Convenors: *Vera Agostini (U.S.A.), Shin-ichi Ito (Japan), Jae-Bong Lee (Korea) and Jake Schweigert (Canada)*

Ecosystem-based management is becoming a focus for many fisheries and their management agencies worldwide. Much of the success of this initiative will require improvements in understanding the interactions and linkages among species at both the lower trophic level (LTL) and higher trophic level (HTL) within regional ecosystems. The recent success of modeling tools such as NEMURO.FISH in linking LTL forcing to the forecasting of fish growth for a number of pelagic forage species is encouraging. Ecosystem-based management will require the extension of this and/or similar approaches to multi-species systems. A variety of modeling tools is already in wide use to address this issue, including Ecopath/Ecosim, NEMURO, various IBM models, and others. This session will focus on contrasting different approaches to multi-species modeling and evaluating their performance as a vehicle for assessing and forecasting the effects of climate change on ecosystem function. We encourage presentations that will highlight critical ecosystem interactions relevant for fishery management, and discuss how knowledge of these interactions will move us closer to ecosystem-based fishery management.

Tuesday, October 30, 2007 09:00 – 18:00

09:00 ***Introduction by convenors***

09:10 **Yunne Shin and Morgane Travers (Invited)**
Coupling ROMS-NPZD and OSMOSE models for an end-to-end modelling of the Benguela upwelling ecosystem (S3-4283)

09:40 **Villy Christensen, Joe Buszowski, Robyn Forrest, Fang Gao, Carie Hoover, Joe Hui, Sherman Lai, Jeroen Steenbeek, William Walters and Carl Walters (Invited)**
Ecopath with Ecosim 6: New generation ecosystem modeling package (S3-4136)

10:10 **Maki Suda (Invited)**
Two-species population dynamics model for Japanese sardine and chub mackerel using object oriented modelling (S3-4081)

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

11:00 **Michio J. Kishi, Kenneth A. Rose, Shin-ichi Ito, Bernard A. Megrey, Francisco E. Werner, Maki Noguchi-Aita, Taketo Hashioka, Yasuhiro Yamanaka, Yasuko Kamezawa, Kazuto Nakajima and Daiki Mukai**
Overview of application of the NEMURO-bioenergetic coupled model on north-western Pacific fishes (S3-4182)

11:20 **Jason S. Link, Laurel Col, William Overholtz, John O'Reilly, Vincent Guida, Jack Green, David Dow, Debra Palka, Chris Legault, Joseph Vitaliano, Carolyn Griswold, Michael Fogarty and Kevin Friedland**
Evaluating the role of small pelagics in the Gulf of Maine: EMAX scenarios of energy flow (S3-4382)

11:40 **Jake Rice**
"Charmingly simple models" – Adding climate to size-based fish community models (S3-4294)

12:00 **Kray Van Kirk, Terrance J. Quinn II and Jeremy Collie**
Estimating predation mortality with a three-species model in the Gulf of Alaska (S3-4145)

12:20 **Zach A. Ferdaña and Michael W. Beck**
Ecosystem-based management for the seas: A planning application using spatial information on marine biodiversity and fishery production (S3-4244)

12:40 ***Lunch***

14:00 **Sarah Gaichas, Garrett Odell, Robert Francis and Kerim Aydin**
Fishing the Gulf of Alaska marine food web: Do predator prey interactions imply ecosystem thresholds? (S3-4246)

14:20 **Ivonne Ortiz, Robert Francis and Kerim Aydin**
Effects of space and scale in the marine food-web structure of the Aleutian Archipelago (S3-4131)

14:40 **Jeremy S. Collie, Kiersten L. Curti and John H. Steele**
End-to-end models of the Georges Bank ecosystem: Implications for ecosystem-based fisheries management (S3-4123)

15:00 **N. Taylor, D. Preikshot, N. Mantua, R. Peterman, B. Dorner, G. Ruggerone, C. Walters, K. Myers, T. Walker and R. Hilborn**
The effects of ocean carrying capacity, density-dependent growth and mortality on Pacific salmon (S3-4418)

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

16:00 **Motomitsu Takahashi, Hiroshi Nishida, Akihiko Yatsu and Yoshiro Watanabe**
Contrasting growth responses to climate-ocean regimes develop alternative population dynamics between anchovy and sardine in the western North Pacific (S3-4371)

16:20 **Takeshi Okunishi, Yasuhiro Yamanaka and Shin-ichi Ito**
A migration model of Japanese sardine using artificial neural network (S3-4269)

16:40 **Young Il Seo, Joo Il Kim, Taek Yun Oh, Sun Kil Lee, Chang Ik Zhang, Jae Bong Lee and Jung Hwa Choi**
Stock assessment of small yellow croaker considering the impact of yellow goosefish predation in the East China Sea of Korea (S3-4456)

17:00 **Shin-ichi Ito, Taizo Morioka, Yasuhiro Ueno, Satoshi Suyama and Masayasu Nakagami**
Experimental approaches to improve the accuracy of NEMURO.FISH saury growth model (S3-4197)

17:20 ***Summary and wrap up***

S3 Posters

S3-4191 **Fumitake Shido, Yasuhiro Yamanaka, Shin-ichi Ito, Taketo Hashioka, Daiki Mukai and Michio J. Kishi**
A two-dimensional fish model simulating biomass and population of Pacific saury

S3-4503 **Fatos Hoxhaj**
Ecosystem modeling on the coastal area of Albania

S3 Oral Presentations

30 October, 09:10 (S3-4283) Invited

Coupling ROMS-NPZD and OSMOSE models for an end-to-end modelling of the Benguela upwelling ecosystem

Yunne **Shin** and Morgane Travers

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Recent emphasis has been put on end-to-end modelling to explore food webs functioning and structure and how they are impacted by the combined effects of fishing and climate changes. In this study, we develop an end-to-end model by coupling two existing models, one of low trophic levels (ROMS-NPZD) and one of high trophic levels (OSMOSE). ROMS-NPZD is a 3D biogeochemical model representing phytoplankton and zooplankton seasonal dynamics forced by a hydrodynamics model. OSMOSE is a 2D individual-based model representing the dynamics of several species of fish, linked through opportunistic and size-based trophic interactions. These models are coupled through a two-way predation process: according to fish size, plankton biomass serves as available prey field, and predation from fish is explicitly represented as a plankton mortality term variable over space and time. Using this end-to-end model, we first study the effects of a two-way coupling versus a one-way forcing of the fish model with plankton biomass field in the Benguela upwelling ecosystem. Outputs of the coupled model are then confronted to multiple patterns observed at different hierarchical levels. Finally, a set of simulations are presented to investigate the potential cascading effects induced by overfishing small pelagic fish or predatory fish in the Benguela ecosystem.

30 October, 09:40 (S3-4136) Invited

Ecopath with Ecosim 6: New generation ecosystem modeling package

Villy **Christensen**, Joe Buszowski, Robyn Forrest, Fang Gao, Carie Hoover, Joe Hui, Sherman Lai, Jeroen Steenbeek, William Walters and Carl Walters

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The Ecopath with Ecosim approach and software has been under constant development over nearly two decades, and it has during this time grown to be the most widely used approach for ecosystem modeling and ecosystem-based management of marine resources. We recently released the newest version, EwE6, after a re-programming in a new integrated development environment (.Net) to achieve two objectives, (1) enable us to develop alternative user interfaces, *e.g.*, in form of computer games, and (2) to enable ecosystem model developers to link to the software and its databases. We encourage modelers to develop modules that link to the software to explore the rich data made available through the more than 300 published EwE models more fully. In this presentation, we give an overview of the new EwE6 with emphasis on new features, and provide examples of how to link new modules to the software. Most facilities from EwE5 have been ported to EwE6, and new have been added. Notably, the spatial modeling part has been enhanced, *e.g.*, to include data linkages to temporal and spatial reference and forcing data, strict differentiation, better handling of migrating species, and an option for individual based modeling (IBM).

30 October, 10:10 (S3-4081) Invited

Two-species population dynamics model for Japanese sardine and chub mackerel using object oriented modelling

Maki **Suda**

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A two-species population dynamics model was constructed for Japanese sardine *Sardinops melanostictus* and chub mackerel *Scomber japonicus* off the Pacific coast of Japan. Japanese sardine and chub mackerel have exhibited dramatic changes in stock abundance. The simulation captures these fluctuations well during the period 1976-2000 using this model. This population dynamics model has three sub-models, *Ocean*, *Recruitment* and *Stock*. Sub-model *Ocean* is a spatial model of population dynamics of the early life stages of Japanese sardine and incorporates the influence of environment factors (sea surface temperature, food density and the location of the Kuroshio axis) and interspecific relationship (chub mackerel, jack mackerel *Trachurus japonicus*, anchovy *Engraulis japonica*, saury *Cololabis saira*, common squid *Todarodes pacificus*, and skipjack tuna *Katsuwonus pelamis*). Sub-model *Recruitment* is an extended Ricker spawner-recruit model of chub mackerel and incorporates the water temperature of spawning area and the stock biomass of sardine. Sub-model *Stock* is an age-structured model which calculates the natural mortality, catch, and spawning biomass of sardine and chub mackerel, respectively. The initial simulations were carried out using stock number data of sardine and chub mackerel in 1976. As the output data of 1976-2000, yearly egg data of sardine, recruitment data of chub mackerel, stock data and catch data were obtained. This model can be applied to simulate stock development of Japanese sardine and chub mackerel under various environmental conditions to examine the effectiveness of different management policies.

30 October, 11:00 (S3-4182)

Overview of application of the NEMURO-bioenergetic coupled model on north-western Pacific fishes

Michio J. **Kishi**[1,2] , Kenneth A. Rose[3], Shin-ichi Ito[4], Bernard A. Megrey[5], Francisco E. Werner[6], Maki Noguchi-Aita[2], Taketo Hashioka[2], Yasuhiro Yamanaka[7], Yasuko Kamezawa[7], Kazuto Nakajima[7] and Daiki Mukai[7]

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Since NEMURO, NEMURO.FISH and NEMURO.SAN were developed, many applications have been carried out on North Pacific pelagic fishes including, Pacific saury, Pacific herring, sardine, anchovy, salmon, and squid. A 50 year time series of inter-annual lower trophic level biomass variability was modeled using 3D-NEMURO. A fisheries bioenergetic model (NEMURO.FISH) was coupled to the 3D-NEMURO results to predict fish growth. We review all of the applications here. The bioenergetic salmon model showed clear inter-decadal differences in growth using 3D-NEMURO results. 3D-NEMURO has also been used to calculate the change of lower trophic level biomasses under global warming scenarios. The bioenergetic squid model showed differences in growth as well and the possible change of its migration route. These results and the future possibility of NEMURO applications will be discussed in the context of biomass based management.

30 October, 11:20 (S3-4382)

Evaluating the role of small pelagics in the Gulf of Maine: EMAX scenarios of energy flow

Jason S. **Link**[1], Laurel Col[1], William Overholtz[1], John O'Reilly[2], Vincent Guida[3], Jack Green[2], David Dow[1], Debra Palka[1], Chris Legault[1], Joseph Vitaliano[3], Carolyn Griswold[2], Michael Fogarty[1] and Kevin Friedland[2]

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The role that small pelagics play in the Gulf of Maine ecosystem is of critical ecological and economic importance. To address this and related issues, the Energy Modeling and Analysis eXercise (EMAX) has developed a network model of the entire food web of the northeast US Gulf of Maine ecosystem. The model includes 36 network biomass nodes across a broad range of trophic levels, with the present emphasis to particularly elucidate the role of small pelagics. Various model configurations were constructed and psuedo-dynamic scenarios were evaluated to explore how potential changes to the small pelagic fishes can affect the rest of the food web. Our results show that small pelagic fishes are clearly keystone species in the ecosystem. Other targeted species, protected species, and non-targeted species all show compensating dynamics when small pelagics are altered, but none themselves directly have large or notable impacts on the small pelagics. Alternatively, when small pelagic biomass is greatly altered, it can have substantial impacts on these upper trophic level nodes. Conversely, lower trophic levels have the ability to notably alter small pelagic nodes and ultimately how the system functions but are themselves not largely affected by small pelagic nodes. This implies that much of how this ecosystem functions is bottom-up, at least from a broad systemic perspective as in this exercise. We discuss these scenarios in the context of further developing ecosystem approaches to fisheries (EAF), recognizing that a more holistic, integrated perspective will be required as we continue to move towards EAF.

30 October, 11:40 (S3-4294)

"Charmingly simple models" – Adding climate to size-based fish community models

Jake **Rice**[1] for the PWG[2]

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For several years the PWG has been developing "charmingly simple models" (CSM) of fish communities which simultaneously model the effects of tropho-dynamic interactions and fishing. These models achieve great economy in number of parameters by making use of the mature theory of life history invariants, and the assumption that predation in the sea can be represented by size based interactions. Pope *et al.* (2006) demonstrated that a model with 13 "species", differing in $L_{infinity}$ (maximum length), needed only 15 parameters to be able to represent six of seven properties of the fish community of the North Sea as well or better that either MSVPA (with several thousand parameters) or Ecopath (with several hundred). The model allowed the consequences of different fishing strategies (target species and F levels), to be explored, taking into account how the fishing strategy altered the predator and prey fields, and predation mortality by size and L_{inf} "species". Gislason *et al.* (in press) added dynamics at the early life history stages of the "fish" in the community, providing a biological dynamic for a scaling parameter required in the original CSM. Pope *et al.* (in press) adds a temperature term to three of the equations in the CSM, making both recruitment and predation dynamics vary with temperature. These modifications increase the parameters in the model to approximately 20 (depending on what options are chosen), but allow the model to explore the consequences of fishing strategies on fish communities over their life history and under different environmental conditions.

The paper will present the key features of the CSM and these two extensions, including main assumptions and key equations. Results of model tests showing that the model does indeed reflect real-world situations will also be presented. Finally, a few scenarios will be presented to illustrate how the model can be used to explore consequences of changing fishing strategies and changing water temperatures, in models simple enough that the causes of the dynamics can be tracked accurately through the community interactions. Such size-based approaches may present powerful alternatives to species (or species-group) based models, for exploring effects on climate change on fisheries yields and sustainable fishing strategies.

30 October, 12:00 (S3-4145)

Estimating predation mortality with a three-species model in the Gulf of Alaska

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Traditional fisheries stock assessment models have been criticized because they generally involve only a single species and do not encompass the complexity of species interactions. In reality, these models do incorporate predation mortality under the umbrella of natural mortality, set at a pre-determined level. Recent studies have attempted to quantify predation separately from natural mortality to add biological realism and to improve model fit. Building upon their work, and in keeping with the recommendation from the U.S. Commission on Ocean Policy to move towards an ecosystem-based approach to fisheries management, we developed a multispecies age-structured assessment model (MSASA) for the Gulf of Alaska, including arrowtooth flounder, Pacific cod, and walleye pollock. We model a flexible predation mortality derived from stomach data and a constant residual natural mortality. Estimated parameters include age-specific predation, species preference, and annual ingestion. The incorporation of predation mortality into the model significantly alters the dynamics of all three species. Predation tends to target younger age-classes, requiring increases in recruitment estimates to compensate for the reduction in the number of individuals that eventually make up the spawning biomass, as compared to a single-species model with fixed natural mortality. Consequently, critical weak points are created within a web of species connected by predator-prey relationships. Estimating mortality and calibration parameters for three species simultaneously is considerably more complicated than for single species models. The advantage of greater biological realism of MSASA comes at the expense of greater uncertainty in parameter estimation.

30 October, 12:20 (S3-4244)

Ecosystem-based management for the seas: A planning application using spatial information on marine biodiversity and fishery production

Zach A. **Ferdaña** and Michael W. Beck

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Ecosystem-based management (E-BM) considers the cumulative impacts of different sectors and is intended to reverse the order of management priorities to start with the ecosystem rather than the species. Although genuine in its approach, transitioning this concept into information and ultimately decision-making is complicated and the path to its realization is unclear. Here we provide a practical example of how to take spatial information on marine biodiversity and fishery production, two decision support tools, and an overarching planning framework in order to demonstrate E-BM along the coasts and in the seas of the Northern California Current. We will present an overview of a planning framework that incorporates fisheries-based ecosystem modeling and biodiversity conservation decision support tools. Designing linkages between conservation planning and fisheries modeling have been gaining momentum, illustrated here by the design of an integrated approach that utilizes information on marine ecosystems, habitats, and species in the Oregon and Washington portions of the Northern California Current in the United States. Within this framework we will demonstrate the use of the two most widely used decision support tools for biodiversity conservation and fishery production objectives, Marxan and Ecopath with Ecosim, respectively. This is one of the first examples where both tools are used to provide initial planning solutions that fulfill multiple management objectives. If we are to realize ecosystem-based management in our planning efforts one practical and powerful way is to take a multiple objective approach, making information and analyses transparent to decision makers and advancing integrated tool development.

30 October, 14:00 (S3-4246)

Fishing the Gulf of Alaska marine food web: Do predator prey interactions imply ecosystem thresholds?

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Fishery management enforces stock-level mortality thresholds to promote sustainable yield for fish populations. Considering that multiple interacting stocks are fished simultaneously in most marine ecosystems, it is important to determine whether there also ecosystem-level fishing thresholds affecting sustainability. We developed a dynamic food web model for the Gulf of Alaska continental shelf with over 120 functional groups to explore a range of predator prey functional responses and to determine how fishing might affect ecosystem dynamics. “True” functional response parameters describing predator prey interactions in this ecosystem are unknown and difficult to measure, but these parameters strongly influence model behavior. We generated millions of potential ecosystems by selecting functional response parameters randomly from wide ranges, which resulted diverse and potentially complex functional responses for each predator prey pair. We considered an ecosystem generated in this manner “successful” if all species coexisted for 50 years. Then, we simulated different fishing intensities on each system, and measured the fraction of successful ecosystems among millions of randomly constituted instances. We found that, absent heavy fishing, the model Gulf of Alaska tolerated extremely wide variation in functional response parameters for most species, implying substantial ecosystem robustness to changes in the details of individual species interactions. However, we found a clear threshold effect between moderate and heavy exploitation rates where fishing damages the robustness of the ecosystem. Beyond this fishing threshold, it became difficult to prevent extinction, and system attributes differed greatly from moderately fished systems.

30 October, 14:20 (S3-4131)

Effects of space and scale in the marine food-web structure of the Aleutian Archipelago

Ivonne **Ortiz**[1], Robert Francis[2] and Kerim Aydin[3]

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Most current ecosystem based management is carried out at the scale of a stock’s distribution or a management region. However, food-web structure can change depending on the scale and geographic coverage of the data pooled together within a region. Over 20,000 stomach samples were used to build thirteen standardized static food-web models, each covering 2-longitudinal-degrees along the Aleutian Archipelago from 170°E to 164°W. Food-webs have 26 functional groups and were based on seven predators, their prey (18 groups), and area-specific fisheries removals (1 group). The predators include Steller sea lions, planktivorous and piscivorous seabirds, Atka mackerel, Pacific Ocean perch (POP), walleye pollock, and Pacific cod. The area-specific feeding habits of the predators were estimated from stomach and scat samples; the prey groups were selected based on strong links. There is an overall gradient of coastal to oceanic characteristics as one moves from east to west with diets being primarily piscivorous in the east and primarily planktivorous towards the west. Despite this general shift, there is no single spatial pattern that is common to all functional groups. Three general food web structures arise, for the western, central, and eastern Aleutian Islands. Understanding changes in food web structure across space and multiple scales help distinguish local from ecosystem-wide trophic relationships and fisheries effects. This, in turn, can support a better allocation of resources and policy design that helps achieve ecosystem goals at both stock-wide and local scales.

30 October, 14:40 (S3-4123)

End-to-end models of the Georges Bank ecosystem: Implications for ecosystem-based fisheries management

Jeremy S. **Collie**[1], Kiersten L. Curti[1] and John H. Steele[2]

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Georges Bank, a shallow submarine plateau in the northwest Atlantic, supports a productive and well-studied ecosystem. Large-amplitude changes have been observed during the past four decades, particularly in the fish community. Several modeling approaches have been applied to identify the forcing variables that underlie these dynamics. In this talk we focus on two approaches: food-web and age-structured multispecies models. Food-web models of the Georges Bank ecosystem indicate that fish populations are tightly coupled to production at lower trophic levels, which in turn depends on climate-driven fluctuations in nutrient supply. A shift from benthic to pelagic consumers accompanied an overall increase in fish production. Among the demersal fish, commercially important species have been replaced functionally by non-commercial species. Tight coupling of the energy budget implies that recovery of commercially important species (*e.g.* cod) will require reciprocal decreases in some other species. Dynamic models are needed to explain the transitions in species composition from one decade to another. Age-structured multispecies models indicate that predation mortality rates are high, especially on juvenile cod, haddock, herring, and silver hake. For prey species, such as silver hake, variations in predation mortality can affect year-class size. The implication for ecosystem-based fisheries management is that total fish production is influenced by climate. Within each climatic regime, multispecies management strategies are required to meet the biological objectives for individual fish species.

30 October, 15:00 (S3-4418)

The effects of ocean carrying capacity, density-dependent growth and mortality on Pacific salmon

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We fit 112 run-size time series to a stage-structured, spatially-explicit model of North Pacific salmon stocks (**M**odel for **A**ssessing **L**inks **B**etween **EC**osystems) that predicts abundance and growth to vary with habitat capacity and total salmon density. We show that models parameterized with marine density-dependent effects are more likely than those parameterized without. We compare the performance of zooplankton time-series data, EcoSim and Numero model outputs at predicting how changes in ocean capacities affect salmon numbers and body size. While density-dependent growth, survival and carrying capacity parameters are confounded, the conclusion is that data are better fit assuming that there is some limit on total salmon production, be it one, or a combination of marine carrying capacities, or density-dependent effects on growth or survival. Thus, an individual salmon stock's production is linked to ocean capacity but also to the abundance of other overlapping wild and hatchery stocks, via the sum of harvest and hatchery policies in all regions.

30 October, 16:00 (S3-4371)

Contrasting growth responses to climate-ocean regimes develop alternative population dynamics between anchovy and sardine in the western North Pacific

Motomitsu **Takahashi**[1], Hiroshi Nishida[2], Akihiko Yatsu[3] and Yoshiro Watanabe[4]

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We examined how climate-ocean regimes in the central North Pacific may explain the alternation between anchovy and sardine dominated states in the western North Pacific. Late larval and early juvenile anchovy and sardine were collected in the Kuroshio-Oyashio transitional waters using a subsurface trawl net in May-June during 1996-2002. Based on changes in sea surface temperature and Pacific decadal oscillation, we defined 1996-1998 as a cool state and 1999-2002 as a warm state. Growth rate during the late larval and early juvenile stages was backcalculated using otolith daily increments. Sardine grew faster in the cool state compared to the warm state, and the growth rates negatively correlated with those of anchovy during the study period. Temperature optimum is lower for steno-thermic sardine (17.6^{o}C) than eury-thermic anchovy (21.4^{o}C). Growth rate positively correlated with the available prey density in the optimum temperature ranges of 16-18^{o}C for sardine and in > 18^{o}C for anchovy. Sardine was distributed in the optimum ranges of temperature and food availability in the cool state but scattered in the unfavorable ranges in the warm state. In contrast, anchovy was distributed below the optimum temperature range in the cool state, while the distribution expanded to the optimum range in the warm state. Decadal variations in state of the Kuroshio Extension were responsible for the changes in larval transport and their ambient temperature and food availability.

30 October, 16:20 (S3-4269)

A migration model of Japanese sardine using artificial neural network

Takeshi **Okunishi**[1,2], Yasuhiro Yamanaka[1,2,3] and Shin-ichi Ito[4]

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A two-dimensional individual-based model of fish bioenergetics was developed to simulate migration and growth of Japanese sardine in the western North Pacific. Fish movement is controlled by reactive movement or spawning movement, and passive transport according to ocean currents. Reactive movement governs search for local optimal habitats, which are estimated by the spatial distribution of forage and a temperature function. Spawning migration is modeled by an artificial neural network (ANN), with an input layer composed of five neurons that receive the environmental information (present sea surface temperature, temperature change experienced, current speed, day length and distance from land), an output layer composed of eight neurons whose output indicates migration directions. The fish move according to a previously determined direction that is implemented as weight in the ANN. To assign the weights of the ANN, three case studies were conducted. Case 1; the ANN is trained with standard back propagation method with optimum training data (ideal spawning migration routes). Case 2; a genetic algorithm (GA) is used to adjust the weights. The GA is a heuristic technique that uses the principles of evolution by crossover, mutations and natural selection to search for optimal solutions to a problem. Case3; the weights of the ANN is decided by a combination method of case1 and case 2. In case 1, most fish did not return the spawning ground. In case 2, a large number of fish represented a different spawning migration strategy. In case 3, the model can reproduce realistic spawning migration of Japanese sardine.

30 October, 16:40 (S3-4456)

Stock assessment of small yellow croaker considering the impact of yellow goosefish predation in the East China Sea of Korea

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Yellow goosefish (*Lophius litulon*) is a common species, and important not only commercially as groundfish catch but also ecologically due to its role in the food web as a predator. Small yellow croaker (*Larimichthys polyactis*) represents more than 45% of its total diet composition, which is over 1,000 MT in Korean marine ecosystems. While small yellow croaker is one of the most important species ecologically and economically in Korean waters, the fish stock has been decreasing due to overfishing and ecosystem impacts, such as predation mortality. A rebuilding program for the stock is needed to restore the population to its former level of abundance. We assessed the impact of yellow goosefish predation on small yellow croaker using a multi-species virtual population analysis (MSVPA) model. The adult population estimates from the single-species stock assessment and MSVPA were also compared. This study showed that the abundance of small yellow croaker stock was influenced by the predation of yellow goosefish as well as fishing activity. Finally, a rebuilding plan for small yellow croaker was developed that considered the foraging ecology of yellow goosefish and the commercial fishing intensity.

30 October, 17:00 (S3-4197)

Experimental approaches to improve the accuracy of NEMURO.FISH saury growth model

Shin-ichi **Ito**[1], Taizo Morioka[2], Yasuhiro Ueno[3], Satoshi Suyama[3] and Masayasu Nakagami[3]

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An ecosystem based bioenergetics model NEMURO.FISH (North Pacific Ecosystem Model for Understanding Regional Oceanography. For Including Saury and Herring) successfully reproduced realistic growth of Pacific saury. However, while a lot of parameters were determined based on field observations, several parameters are unknown and the values of those parameters were assumed based on herring data. Assumptions about unknown parameters may result in an incorrect interpretation of saury growth response to climate or anthropogenic forcing. To minimize uncertainty in the bioenergetics model, rearing experiments of Pacific saury were conducted. Eggs of saury were caught in Japanese coastal waters and they were incubated in a 12 Kl pool with 20 deg C water temperature. Hatched larvae were reared with an adequate food supply. The reared saury showed rapid growth compared with the natural situation. The consumption rate of reared saury was relatively smaller than observed from at-sea samples based on wet weight. However, it became much greater than observed values when they are estimated based on energy. Combined with other experiments that changed the available food supply, the feed conversion efficiency was estimated at 28 %. This value is much smaller than was assumed in the original saury model (61%). Estimates of respiration, egestion and excretion were much higher than estimated by the original model. The normal water temperature for saury is lower than 20 deg C especially in the juvenile and immature adult stages. Therefore, other rearing experiments using different water temperature are necessary and would be expected to improve the model performance.

S3 Posters

Poster S3-4191

A two-dimensional fish model simulating biomass and population of Pacific saury

Fumitake **Shido**[1], Yasuhiro Yamanaka[1,2,3], Shin-ichi Ito[4], Taketo Hashioka[2], Daiki Mukai[1] and Michio J. Kishi[1,2]

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Combining two models, a population dynamics model for estimating fish density in numbers and a bioenergetics model for their wet weight, enables us to calculate changes in fish biomass. For simulating biomass of Pacific saury (*Cololabis saira*), we developed a two-dimensional fish model combined NEMURO.FISH as a fish bioenergetics model with a simplified population dynamics model. We assumed that the mortality rate of saury is a function of their knob length (nearly same as body length). We used the current field produced by a ocean general circulation model (Sakamoto *et al*., 2005), and zooplankton and temperature data predicted by NEMURO (Hashioka and Yamanaka, 2007). The model accurately simulated cumulative observed survival up to the juvenile stage. The observed wet weight of saury and their geographical distribution relative to the seasonal migration are also accurately simulated. From biomass and density in numbers, we would calculate the zooplankton biomass grazed by saury. As a next step, we will simulate some interaction between fish and zooplankton biomass, using our fish model and an ecosystem model, e-NEMURO, including the microbial loop system and having the potential to resolve prey zooplankton biomass variability for larvae and juvenile fish.

Poster S3-4503

Ecosystem modeling on the coastal area of Albania

Fatos **Hoxhaj**

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Following a description of protected areas along the Albanian coast, their peculiarities and unique management problems under the projected change of natural systems, the paper proposes an improved approach to ecosystem based management using modeling techniques. In order to investigate the interactions between fish and the coastal environment a 3-D Coupled Hydrodynamical-Ecological Model is employed. This is a multi-purpose model for water mass dynamics and the pollution transport in the coastal waters or specific restricted zones. It is coupled to biological, resuspension and contaminant models, and resolves mesoscale to seasonal scale processes. The aim is to predict the effect of the changing conditions on the biota and to simulate the input and dispersion of contaminants. The program has been developed over the period of 1998–2007 by a multinational European group. A hydrometeorological component deals with a general module for currents, waves, salinity temperature, and the atmosphere influence (wind vector, atmospheric pressure, air temperature, surface solar heat flux). A microbiological module deals with a particular aspect for the dynamics of microplankton, detritus, dissolved inorganic nitrogen and oxygen. It is necessary to forecast future states of the Albanian coastal ecosystem undergoing natural change, subject to erratic human intervention caused by changing economic conditions in Albania. This paper summarizes recent developments in this area and provides several case histories of areas where theoretical analyses appear to have direct practical relevance.

S4 FIS Topic Session
Ecosystem approach to fisheries: Improvements on traditional management for declining and depleted stocks

Co-Convenors: *Yukimasa Ishida (Japan), Gordon H. Kruse (U.S.A.), Ted Perry (Canada), Vladimir I. Radchenko (Russia) and Chang-Ik Zhang (Korea)*

An ecosystem approach to fisheries (EAF), which recognizes the complexity of ecosystems and the interconnections between its component parts, has been recently advocated by many fisheries management bodies. In PICES countries, some fisheries resources are in high abundance and healthy, but others are decreasing or already depleted. Most causes of stock declines can be ascribed to climate changes and overfishing. Stocks in declining or depleted conditions require prompt, appropriate management actions, perhaps including ecosystem approaches. This session invites papers that examine: (1) major factors responsible for the status of fish stocks, particularly those that are decreasing or depleted; (2) limits to traditional fishery management measures to address causes of stock declines; (3) new perspectives on fishery management that promote sustainable fishery management from an ecosystem perspective; and (4) case studies of rebuilding plans for depleted stocks – their successes and failures. Manuscripts contributed to this session will be considered for publication in the journal *Fisheries Research* following peer-review. Submission deadline of manuscripts is November 30, 2007.

Thursday, November 1, 2007 09:00 – 17:20

09:00 ***Introduction by convenors***

09:10 **Stratis Gavaris (Invited)**
Science support for fisheries management decisions in an Ecosystem Approach context (S4-4201)

09:40 **R. Ian Perry, Benjamin Planque, Simon Jennings, Keith Brander, Philippe Cury and Christian Möllmann**
Sensitivity of marine systems to climate and fishing: Concepts, issues and management responses (S4-4203)

10:00 **Jae Bong Lee, Anne B. Hollowed and Chang-Ik Zhang**
Comparing ecosystem variations between eastern and western North Pacific using ecosystem indicators (S4-4428)

10:20 **Tetsuichiro Funamoto, Satoshi Honda, Keizo Yabuki and Akihiko Yatsu**
Suggestion of management measures for two walleye pollock stocks around northern Japan (S4-4258)

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

11:00 **Alan Sinclair and Doug Swain (Invited)**
Collapse and lack of recovery of cod (*Gadus morhua*) in the Northwest Atlantic: Lessons for fisheries management (S4-4071)

11:30 **Vladimir I. Radchenko**
Problems of TAC forecast development for multi-species fisheries in the Sakhalin-Kuriles region (S4-4127)

11:50 **Hee Won Park, Chang-Ik Zhang, Suam Kim, Donald Gunderson, Jae Bong Lee and Jong Hee Lee**
Ecosystem-based fisheries resource assessment and management system in Korea (S4-4259)

12:10 **Masahide Kaeriyama and Hideaki Kudo**
Sustainable fisheries management of Pacific salmon (*Oncorhynchus* spp.) based on the ecosystem approach (S4-4066)

12:30 ***Lunch***

14:00 **Kevin T. Hill (Invited)**
Decline and recovery of Pacific sardines along the Pacific coast of North America: The roles of climate and fishing (S4-4390)

14:30 **Ashleen J. Benson, Sean P. Cox and Aaron Springford**
An evaluation of stock structure in Pacific herring (S4-4122)

14:50 **Hiroshi Nishida, Masayuki Noto, Atsushi Kawabata and Chikako Watanabe**
Assessment of the Japanese sardine (*Sardinops melanostictus*) stock in the northwestern Pacific for Japanese management system (S4-4422)

15:10 **Melissa A. Haltuch, André E. Punt and Martin W. Dorn**
Evaluating biomass reference points in a variable environment (S4-4061)

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

15:50 **Gordon H. Kruse and Jie Zheng**
Recovery of the Bristol Bay stock of red king crabs under a rebuilding plan (S4-4073)

16:10 **Inja Yeon, Mi Young Song, Myoung Ho Shon, Hak Jin Hwang and Yang Jae Im**
Possible new management measures for stock rebuilding of blue crab, *Portunus trituberculatus* (Miers), in western Korean waters (S4-4461)

16:30 **Thomas C. Wainwright, William T. Peterson, Peter W. Lawson and Edmundo Casillas**
Environmental indicators and Pacific salmon conservation (S4-4398)

16:50 **Weimin Quan, Liyan Shi and Yaqu Chen**
The food web in the Yangtze River estuary: A synthesis of existing knowledge (S4-4049)

17:10 ***Summary and wrap up***

S4 Posters

S4-4046 **Ronald W. Tanasichuk**
The effects of variations in euphausiid and Pacific hake biomasses on the productivity of British Columbian stocks of Pacific herring (*Clupea pallasi*)

S4-4052 **Liyan Shi, Weimin Quan and Yaqu Chen**
Faunal utilization of created inter-tidal oyster reef in the Yangtze River estuary

S4-4082 **Caihong Fu, Beiwei Lu and Jake Schweigert**
Searching for major factors responsible for the decline of the eulachon population in the Fraser River using artificial neural networks

S4-4189 **Yongjun Tian**
Interannual-interdecadal variations in the abundance of spear squid *Loligo bleekeri* in the southwestern Japan/East Sea: Impacts of the late 1980s climatic regime shift and trawl fishing with recommendations for management

S4-4190 **Yukimasa Ishida, Tetsuichiro Funamoto, Satoshi Honda, Keizou Yabuki, Hiroshi Nishida and Chikako Watanabe**
Review of Japanese sardine, chub mackerel, and walleye pollock fisheries management from the view point of ecosystem approach

S4-4260 **Chang-Ik Zhang and Jong-Hun Na**
Biomass and acceptable biological yield of crucian carp (*Carassius cuvieri*) in the Namyang Estuary Reservoir

S4-4278 **Carrie A. Holt, André Punt and Nathan Mantua**
Incorporating climate information into rebuilding analyses for overfished groundfish stocks

S4-4325 **Man-Woo Lee and Chang-Ik Zhang**
Changes in the structure and function of the Southeastern Yellow Sea ecosystem: An application on the fisheries management

S4-4344 **Sun Kil Lee, Young Il Seo, Joo Il Kim, Taek Yun Oh and Won Seok Yang**
Rebuilding stock of the Yeo-Ja Bay ecosystem in the Southern Sea of Korea – Dominant group and ecosystem structure of the Yeo-Ja Bay

S4-4349 **Toyomitsu Horii and Yoshiyuki Nakamura**
An approach to recover abalone resources by TAC control based on RPS trends calculated with production model

S4-4379 **William R. Bechtol and Gordon H. Kruse**
Environmental constraints to rebuilding of Kodiak red king crab

S4-4392 **Chang-Ik Zhang, Jae Bong Lee, Sun Kil Lee and Bernard A. Megrey**
Structure and function of three marine ecosystems in Korea: A comparative study

S4-4423 **Todd W. Miller, Koji Omori, Hideki Hamaoka and Hidejiro Onishi**
Marine versus terrestrial sources of production to the Seto Inland Sea, Japan

S4-4459 **Inja Yeon, C.I. Zhang, M.H. Shon, Y.J. Im and H.J. Whang**
An ecosystem-based assessment of the blue crab stock and management strategy in the Yellow Sea

S4-4488 **Peter S. Rand, Peter A. McHugh and Matthew Goslin**
Completion of a global assessment of sockeye salmon *(Oncorhynchus nerka)* status using IUCN criteria

S4 Oral Presentations

1 November, 09:10 (S4-4201) Invited

Science support for fisheries management decisions in an Ecosystem Approach context

Stratis **Gavaris**

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Fisheries management planning is a hierarchical process that translates objectives to strategies, 'what' will be done and strategies to tactics, 'how' it will be done. A strategy is specified by an indicator of the human pressure and a reference for that indicator to signal when an unacceptable condition occurs. The Ecosystem Approach is a progressive evolution of fisheries management that extends strategies beyond consideration of productivity for only the harvested resources to productivity, biodiversity and habitat of the ecosystem and then integrates the cumulative effects across all managed human activities. Two types of management decisions are invoked by the planning process, decisions on the level of a tactic to achieve a strategy and decisions about the reference for a strategy to satisfy the objectives. Science support for decisions to achieve a strategy can be provided by determining the state of the indicator in relation to its established reference as a response to alternative levels of the tactic. This is facilitated by judicious selection of an indicator that measures the response to the pressure resulting from the managed human activity. In contrast, realizations of characteristics pertinent to the objectives do not readily measure a simple response to a pressure resulting from a managed human activity because they are influenced by a variety of other forces and processes. Therefore, performance of a strategy cannot be evaluated by simple examination of realized trends of a characteristic. Science support for decisions about a suitable reference for a strategy must be inferred from ecosystem dynamics.

1 November, 09:40 (S4-4203)

Sensitivity of marine systems to climate and fishing: Concepts, issues and management responses

R. Ian **Perry**[1], Benjamin Planque[2], Simon Jennings[3], Keith Brander[4], Philippe Cury[5] and Christian Möllmann[6]

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4 ICES/GLOBEC Secretary, International Council for the Exploration of the Sea, Palægade 2-4, DK-1261, Copenhagen K, Denmark
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6 Institute for Hydrobiology and Fisheries Science, University of Hamburg, Olbersweg 24, D-22767, Hamburg, Germany

Modern fisheries research and management must understand and take account of the interactions between climate and fishing, rather than try to disentangle their effects and address each separately. This presentation discusses how fishing and climate forcing interact at the levels of the individual, population, community, and ecosystems to bring these levels into states that are more sensitive to climate forcing. Fishing is unlikely to alter the sensitivities of individual finfish and invertebrates to climate forcing. It will remove individuals with specific characteristics from the gene pool, thereby affecting structure and function at higher levels of organisation. Fishing leads to a loss of older age classes, spatial contraction, loss of sub-units, and alteration of life history traits in populations, making them more sensitive to climate variability at interannual to interdecadal scales. Fishing reduces the mean size of individuals and mean trophic level of communities, decreasing their turnover time leading them to track environmental variability more closely. Marine ecosystems under intense exploitation evolve towards stronger bottom-up control and greater sensitivity to climate forcing. Because climate change occurs slowly, its effects are not likely to have immediate impacts on marine systems, but will be manifest as the accumulation of the interactions between fishing and climate variability. Management approaches need to maintain the resilience of individuals, populations, communities and ecosystems to the combined and interacting effects of climate and fishing.

1 November, 10:00 (S4-4428)

Comparing ecosystem variations between eastern and western North Pacific using ecosystem indicators

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This study examines major similarities and differences between different regional marine ecosystems using ecosystem indicators. The integrative effects of fishing on community structure and processes were estimated by trophic structure (TSI), fish community health (FCH) and fish trophic level (FTI) indices. TSI differs from the trophic level of the catch by instead focusing on what remains in the ecosystem. FTI and FCH indices were estimated using data on trophic level by species or group and biomass (or spawning biomass) to quantify changes in the trophic structure of fish communities. We distinguished FTIs from FCHs in five ecosystems in the western and eastern North Pacific (NP): East/Japan Sea (EJS), Yellow Sea (YS), East China Sea (ECS), eastern Bering Sea (EBS) and Gulf of Alaska (GOA). Reference directions of changes in the western NP (EJS, YS, ECS) ecosystems declined owing to heavy fishing pressures and damaged trophic structures since the reference year of 1975, while in the eastern NP (EBS, GOA) ecosystems these measures have been increasing and/or leveling off since the 1980s. Variations in reproduction potential by guild (*e.g.*, crab from EJS and EBS) showed different patterns in the western and eastern NP. By comparing FTI and FCH of reproductively active fish across guilds and ecosystems, we can monitor whether recruitment overfishing is occurring within the guild or ecosystem. By integrating various data to summarize the state and functioning of exploited ecosystems, such ecosystem comparisons can help provide intuitive explainations of the underlying processes to policy makers and non-scientists.

1 November, 10:20 (S4-4258)

Suggestion of management measures for two walleye pollock stocks around northern Japan

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The biomasses of Japanese Pacific stock (JPS) and northern Japan Sea stock (JSS) of walleye pollock around northern Japan have been decreasing in recent years, and the current biomasses of both stocks are lowest on record. Recruitment per spawning (RPS) has been low since 1996 for JPS and 1989 for JSS, suggesting that the recent stock declines of both stocks are driven mainly by poor environmental conditions. Especially, relationships between RPS and sea surface temperature are observed for both stocks. On the other hand, a stock-recruitment relationship is not apparent for either of the stocks. Thus, for both stocks, the minimum spawning stock biomasses (SSB) at which good recruitments were produced in the past are defined as the limit biomass (Blimit). It is thought that the chance of obtaining good recruitment is greatly reduced when SSB is below Blimit. Management measures to maintain current SSB above Blimit should be taken for JPS. This management measure aims to increase the recruitment when environmental condition improve. On the contrary, for JSS, it is important to rebuild the SSB even under recent poor environmental condition, because the current SSB is below Blimit. It is also important for both stocks that the fishing pressure on immature fish would be restricted even when good recruitments would occur. Therefore, pre-recruit surveys and model predictions are needed to forecast the recruitment precisely.

1 November, 11:00 (S4-4071) Invited

Collapse and lack of recovery of cod (*Gadus morhua*) in the Northwest Atlantic: Lessons for fisheries management

Alan **Sinclair**[1] and Doug Swain[2]

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Research conducted since the collapse of Atlantic cod (*Gadus morhua*) stocks in eastern Canada has revealed a number of important demographic changes related to their production and recovery potential. Fishery effects beyond the simple reduction in stock size have been implicated in a large number of these changes. A primary factor in the collapse of the species and its slow recovery was an undetected increase in adult natural mortality that occurred in the mid 1980s. The high natural mortality persists and is delaying recovery efforts. Analytical methods are being developed to detect changes in natural mortality, and further work is needed. Atlantic cod stocks had recovered rapidly in the late 1970s from a previous period of overfishing. However, the demographic conditions for the stocks were exceptionally favourable for recovery because of very high juvenile survival rates and high growth rates. Both of these factors were directly influenced by fishing. This previous rapid recovery together with the undetected increase in natural mortality led to an overly optimistic expectation for the rate of recovery when fisheries were closed in the early 1990s. There has also been a change in trophic structure of the marine ecosystems from a condition dominated by large predatory demersal fish to one dominated by smaller demersal organisms and small pelagic species. Lucrative fisheries have developed on burgeoning marine invertebrates such as shrimp and crab. There is diminishing societal interest in recovering Atlantic cod if this may jeopardize these new fisheries.

1 November, 11:30 (S4-4127)

Problems of TAC forecast development for multi-species fisheries in the Sakhalin-Kuriles region

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The Sakhalin and Kurile Islands form an unique archipelago system with south/north extent at 1000 and 1500 km, respectively. Marine fish stocks contribute almost 28% of the total allowable catch (TAC) of all fisheries species, squid were about 40%, and brown algae were 22% of TAC. For the last ten years, the marine fish portion varied from 39.1% (in 1999) to 79.4% (in 2005) in relation to interannual variability of pink salmon harvest. Squid varied from 14.4% (in 2001) to 22.5% (in 2002), and brown algae ranged from 0.13 (in 1996) to 1.6% (in 2002). TAC is established for all fished species combined into 56 one- and multi-species groups. Permitted bycatch is limited to 2% of the weight for all specialized fishery types. Real catch composition almost never meets these prescriptions. Bycatch utilization is low owing to technical difficulties and fishery regulations. A significant part of the fishery catch is discarded. In 2004-2006 quota realization rates remained low: 54.1-60.3% of the total, and only 39.4-55.2% for the coastal fishery. All fisheries in the Sakhalin-Kurile region can be divided into 40 specialized fishery types. TAC could be distributed among them based on the average catch composition in previous years. Quotas for fishery ventures could be divided by their portions based on the primary fished species for each specialized fishery type. Such an approach will allow decreases in the number of fishery species with annual TAC determinations, improvement of fishery statistics, promotion of fishery gear and methods development, and conversion bycatch into fisheries production.

1 November, 11:50 (S4-4259)

Ecosystem-based fisheries resource assessment and management system in Korea

Hee Won **Park**[1], Chang-Ik Zhang[1], Suam Kim[1], Donald Gunderson[1], Jae Bong Lee[2] and Jong Hee Lee[1]

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In Korea there is interest in using an ecosystem-based approach in the assessment and management of fisheries resources. The plan is to use the procedure as early as 2009. A practical method is proposed for assessing fishery resources at the ecosystem level to achieve this goal. It makes use of objectives, indicators, and reference points. A two-tier system is used to accommodate the quantity and quality of the available data. It is hoped that assessment and management at this elevated level will prevent significant and potentially irreversible changes in marine ecosystems caused by fishing. The complexity and usefulness of the method is demonstrated by applying it to the Tongyeong marine ranch and the large purse seine fishery in Korea.

1 November, 12:10 (S4-4066)

Sustainable fisheries management of Pacific salmon (*Oncorhynchus* spp.) based on the ecosystem approach

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Pacific salmon (*Oncorhynchus* spp.) play an important role as a keystone species in the North Pacific Ocean ecosystem, where they are influenced by natural factors, such as the long-term climate change and human impacts including the global warming. The carrying capacity of Pacific salmon links is tied to long-term climate change, and relates to density-dependent effects at both population and species levels. For instance, the residual carrying capacity of chum salmon (*O. keta*) was positively correlated with body size of adult salmon and negatively correlated with age at maturity. Wild chum salmon decreased about 50% from the 1930s to the 1990s, despite the significant increase in hatchery salmon. This indicates that fisheries management has limitations at a population level, and that the biological interaction between wild and hatchery populations of Pacific salmon should be considered. Global warming has affected growth and survival of Asian chum salmon since the 1990s, such as a positive effect pn the Hokkaido population and negative influence for the Iwate and Korean populations. Based on the IPCC-A2 scenario, the Hokkaido chum salmon population is predicted to lose its migration route to the Okhotsk Sea by 2050, and to collapse by 2100 owing to global warming effects. The objective of this presentation is to address the framework of sustainable fisheries management for Pacific salmon based on the ecosystem approach.

1 November, 14:00 (S4-4390) Invited

Decline and recovery of Pacific sardines along the Pacific coast of North America: The roles of climate and fishing

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Pacific sardines have a well-documented history with respect to population dynamics, fishing, and climate change. The resource supported one of the largest fisheries in the western hemisphere during the 1930s, but fisheries rapidly collapsed from Canada to Mexico. By the late-1960s, sardine only occurred off the southern Baja California Peninsula. Studies of sardine scale-deposition rates in marine sediments indicate extended periods of high and low abundance even in the absence of fishing (Baumgartner *et al.* 1992). The collapse during the mid-20th century is now widely attributed to a shift to cooler ocean climate conditions in the mid-1940s, coupled with low surplus production and heavy overfishing during the 1950s and 1960s. The most recent recovery began after a return to warm ocean conditions in the late 1970s, punctuated by El Niño events (1983, 1992, and 1998) and expansion of the population to northern feeding habitat. California declared the resource 'recovered' in 1998 – fostered, in part, through a shift to

conservative management policy. In anticipation of an expanded coast-wide sardine fishery, a U.S. federal fishery management plan (FMP) was implemented in 2000 (PFMC 1998). The FMP adopted California's conservative management approach, but also introduced use of environmental information into management advice. Under the federal FMP, annual catch limits for U.S. fisheries are established using a harvest control rule that accounts for current biomass, the need for a forage reserve, recent environmental conditions, and stock distribution across international borders, so is probably the first, albeit simple, example of an 'ecosystem approach to fisheries'.

1 November, 14:30 (S4-4122)

An evaluation of stock structure in Pacific herring

Ashleen J. **Benson**, Sean P. Cox and Aaron Springford

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The stock concept underpins all traditional approaches to defining and managing fish stocks. However, in many cases the population that is defined for fisheries management (*i.e.*, a stock) represents the geographic extent of human influence more than any ecologically significant unit. Uncertainty about stock structure greatly complicates assessment efforts, and may be a contributing factor in both fishery management failures and population collapse. While some might advocate abandoning traditional approaches in favour of ecosystem-based management, we contend that the limitations of single-stock management can be overcome by careful consideration of the spatial complexity that is known to exist within many fish populations. By emphasizing the importance of spatial processes, fisheries scientists can begin to bridge the gap between traditional, single-species and ecosystem-based management. It is necessary to extend the stock concept to include diversity in life-history characteristics and distribution, and to develop techniques for sub-stock delineation in the marine environment, where genetic methods are limited by the high dispersal rates of many species. We present an analysis of the stock structure of Pacific herring in the Strait of Georgia that is based on the historical locations of spawning in this region. We apply statistical techniques that range from simple empirical methods to Bayesian spatial statistics, in order to determine the sufficiency of the current stock definitions. This work is fundamental to developing an operational approach to biodiversity conservation in a single species context.

1 November, 14:50 (S4-4422)

Assessment of the Japanese sardine (*Sardinops melanostictus*) stock in the northwestern Pacific for Japanese management system

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Stock assessment of the Japanese sardine *(Sardinops melanostictus)* in the northwestern Pacific was conducted by Virtual Population Analysis, egg production census and pre-recruit surveys. The stock size has continuously decreased from 1987 (19 million tons) to 2003; the stock biomass estimate for 2003 was about 130 thousand tons. The spawning success (RPS, number of recruits/spawning biomass) has been 18 individuals/kg on average during the recent 5 years. Under the recent ocean regime, among small pelagic species, such as anchovy, saury and Japanese common squid with short longevity, are more abundant than Japanese sardine. From an historical perspective, the current stock status of Japanese sardine would not be in a condition for rapid stock recovery. However, egg abundance has increased from the minimum level ($30 *10^{12}$) in 2002 to $100*10^{12}$ in 2005 and pre-recruit density in Kuroshio-Oyashio transition region, the key area for the recruitment of small pelagic species in the northwestern Pacific, was more abundant in 2005 and 2007 than 2001-2004. The acceptable biological catch (ABC), the biological criterion for the Total Allowable Catch, is set to prevent the total biomass from decreasing and to rebuild the spawning biomass. As major problem in the ABC calculation is the uncertainty in the fluctuations of recruit abundance and fish size selectivity for the fishing effort. So, some hypothetical scenarios for controlling the catch amount were examined, avoiding intensive fishing efforts on the young fishes of dominant year-class.

1 November, 15:10 (S4-4061)

Evaluating biomass reference points in a variable environment

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There is strong evidence that low frequency inter-annual environmental variability, in addition to fishing, is able to impact fish population abundance via recruitment. However, scientific advice regarding harvest strategies is often based on control rules dependent upon the estimation of biomass reference points which typically do not explicitly consider the impact of trends over time in reference points caused by environmental variability. Sustainable harvest rates based on commonly-used biological reference points such as the level of unfished spawning biomass (B_0), the spawning biomass corresponding to maximum sustainable yield (B_{MSY}), and the current size of the stock in relation to B_0 under current environmental conditions may be unsustainable under different environmental conditions. It would be expected that accounting for the impact of long-term environmental change when providing scientific advice may prevent stocks from being over- or under-harvested given changes over time in productivity or carrying capacity. Although several methods exist for estimating biomass reference points, it is unclear which methods are most robust to environmental variability. Furthermore, future projections of stock size often assume that levels of recruitment observed in the recent past provide a basis for inferring future recruitment levels. Therefore, simulation is used to evaluate alternative estimators, which differ in terms of whether a stock-recruitment relationship is estimated, for $B_{0,}$ B_{MSY}, and current spawning biomass relative to B_0. The simulations consider three life histories: a long-lived unproductive rockfish, a moderately long-lived and productive flatfish, and a moderately long-lived and productive semi-pelagic gadid with highly variable recruitment.

1 November, 15:50 (S4-4073)

Recovery of the Bristol Bay stock of red king crabs under a rebuilding plan

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Red king crab *(Paralithodes camtschaticus)* in Bristol Bay, Alaska, once supported one of the most valuable commercial fisheries in the United States. Landings peaked at 59,000 t in 1980, followed by stock collapse and fishery closure in 1983. Poor success at maintaining a healthy stock in the subsequent decade prompted a reexamination of the harvest strategy. In 1996, a stock rebuilding plan was implemented by the Alaska Board of Fisheries with a rebuilding target of 25,000 t of effective spawning biomass, the biomass of mature females estimated to have been mated in a given year. Key elements of the rebuilding plan include a fishery threshold (6,600 t) – a level of effective spawning biomass (15% of estimated pristine level) below which no fishing is allowed – and a conservative stair-step harvest strategy that established a 10% to 15% exploitation rate of mature males, depending on stock abundance. Concurrent ecosystem-based management approaches by the North Pacific Fishery Management Council included a prohibited species catch limit that constrains king crab bycatch by groundfish trawl and scallop dredge fisheries and a ban of mobile bottom-contact gear from two habitat areas – the Nearshore Bristol Bay Closure Area that protects juvenile crabs and their rearing habitat and an offshore Red King Crab Savings Area that protects adult crabs. Following implementation of these measures, effective spawning biomass doubled from an average of 10.9 t during 1986-1995 to 20.6 t during 1996-2005. The rebuilding target of 25,000 t of effective spawning biomass was attained in 2005.

1 November, 16:10 (S4-4461)

Possible new management measures for stock rebuilding of blue crab, *Portunus trituberculatus* (Miers), in western Korean waters

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Landings of blue crab, *Portunus trituberculatus* (Miers), in Korean waters have dramatically declined from 32,000 t in 1988 to 6,000 t in 2006, during which time traditional management measures, closed season and limit size, have been applied. Consideration of ecosystem-based management measures may therefore be necessary to conserve and rebuild the stocks. Management scenario evaluations (MSE), based on stochastic fisheries data and species' biological characteristics, suggest that about 14% (7~30%) of the catch might be conserved by ocean habitat improvements, especially removal of ghost fishing gear. By expanding the closed season from Sept 1-20 each year, catches of molting (soft shell) crab may be significantly reduced, reducing indirect fishing mortality. Lengthening the spawning season closure from June 10 to June 30 would benefit crab recruitment and growth. Additional measures to protect brooding females from being caught and increase the legal minimum size limit are other potential stronger management measures. In the future, monitoring of the fishers' compliance with these measures should be conducted, and results communicated back to the fishers.

1 November, 16:30 (S4-4398)

Environmental indicators and Pacific salmon conservation

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Pacific salmon (*Oncorhynchus* spp.) are the subject of increasing conservation concerns in both the harvest and endangered species management communities along the west coast of North America. Interannual to decadal-scale environmental fluctuations have a strong influence on recruitment of Pacific salmon, as evidenced by numerous studies linking various physical climate indices (at global, regional, and local scales) with salmon abundance. In addition to these physical indicators, recent research has led to a number of biological indicators that show promise for forecasting stock abundance. We review several approaches that have been used to relate environmental indicators to stock returns, including univariate correlations, multivariate quasi-linear regressions, and qualitative approaches. To date, these approaches have seen limited adoption in the management and policy arenas, primarily because the forecasts for returning adults have not been consistently reliable. Important elements that need to be addressed include the complexity of salmon life histories (especially interactions between freshwater and marine conditions), climate-driven regime shifts and ecosystem phase transitions resulting in transitory correlations between indicators and populations, and communications between the scientific and management/policy communities. We propose that forecasting tools include a suite of indicators that capture the broad array of ecosystem metrics that encompass the physical forces and biological conditions that influence salmon recruitment.

1 November, 16:50 (S4-4049)

The food web in the Yangtze River estuary: A synthesis of existing knowledge

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The Yangtze River estuary is the largest estuary and estuarine fishing grounds of China, and contains very high biodiversity. This study showed that a continuum of mesozooplankton, macrobenthos, suprabenthos and fishes assemblages forms along the salinity gradient, consistent with the ecocline model for estuaries. In the upper part of the estuary, the ecosystem is dominated by freshwater species, but the lower part is dominated by oligohaline and marine polyhaline species. Gut content analysis was used to divide fish species into four trophic assemblages in the estuary. Most fish species belong to benthophagic or mixed feeding fish. A four trophic level food web structure is

set up, and two classical food chains are recognized. In the upper and middle part of the estuary, the estuarine food web is highly dependent on the infauna and suprabenthos from the intertidal and subtial zone. However, mesozooplanton plays the key role in food web structure of the lower part of the estuary. The Yangtze River estuary is seriously destroyed by human activities, such as overfishing, environmental pollution (eutrophication), bio-invasion (cordgrass *Spartina alerniflora* and jellyfish) and large-scale projects. A series of changes in food web structure have been documented, including shortening of food chain length, increasing dominance of lower trophic level fishes, and an altered food web base from detritus-dominated to algal-dominated. So far, the influence of human activities on the Yangtze River estuarine food web is much less well understood, and needs to be further studied in future.

S4 Posters

Poster S4-4046

The effects of variations in euphausiid and Pacific hake biomasses on the productivity of British Columbian stocks of Pacific herring (*Clupea pallasi*)

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There are five major herring populations (Strait of Georgia, West Coast Vancouver Island (WCVI), Central Coast, North Coast, Queen Charlotte Islands (QCI)) in British Columbia. All of them have an inshore, juvenile life history phase. Fish subsequently move offshore to complete rearing and then repeat inshore-offshore migrations to spawn in spring and feed and overwinter offshore. I have found that recruitment variability in all stocks can be explained using an environmentally-dependent Ricker stock-recruit relationship. It includes a competitive interaction with Pacific hake (*Merluccius productus*) and/or an effect of euphausiid (*Thysanoessa spinifera*) or zooplankton biomass variability. Variations in adult age-specific natural mortality rates in all stocks are explained as a function of age and, except for QCI herring, *T. spinifera* biomass variability. Recruit size of WCVI herring varies with calanoid copepod (*Calanus marshallae*) biomass. Adult growth rates are affected by initial size and *T. spinifera* biomass. Subsequent calculations suggested that the persistent depression of *T. spinifera* productivity has resulted in a two order of magnitude suppression of WCVI herring egg production. There was no detectable effect of fishing. I will present additional “what if” scenarios to show what egg production would have been under various states of *T. spinifera* productivity and hake biomass.

Poster S4-4052

Faunal utilization of created inter-tidal oyster reef in the Yangtze River estuary

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A total 74 km^2 artificial oyster reef was added to the artificial concrete dam in the navigational channel of the Yangtze River estuary in 2002 and 2004. The created reef plays an important role in conserving biodiversity, restoring the ecosystem and supporting estuarine fishery production. The colonization of the artificial reef by oysters and other taxa was examined. The oyster population in the created reef showed a rapidly exponential growth, and the total standing stock of the oyster in 2005 has reached about 1.07×10^6 t. The standing stocks of nutrients and heavy metals accumulated by the oyster from dams were: N – 1462×10^3 kg, P – 100×10^3 kg, Cu – 24745 kg, Zn – 58257 kg, Pb – 609 kg, Cd – 254 kg, Hg – 0.18 kg and As – 329 kg. Total ecological service value of the oyster reef was estimated at about 8.27×10^6 RMB·a^{-1}, which included habitat value of about 5.10 $\times10^6$ RMB·a^{-1} and an environmental value of about 3.17 $\times10^6$ RMB·a^{-1}. The latter is equivalent to treating about 7.31×10^6 t combined sewage each year and corresponds to a large municipal sewage plant with treatment capacity about 20000 t·d^{-1}. The

created oyster reef has become an important nursery, breeding and forage habitat for many species, such as decapods (*e.g.*, *Scylla serrata*, *Eriocheir sinensis*) and fishes (*e.g.*, *Lateolabrax japonicus*, *Coilichthys lucidus*). The created reef has also become the important fishing ground of the estuary. There is evidence that the created oyster reefs can quickly acquire the equivalent ecological function of their natural counterparts.

Poster S4-4082

Searching for major factors responsible for the decline of the eulachon population in the Fraser River using artificial neural networks

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Eulachon (*Thaleichthys pacificus*) is an ecologically important and culturally significant species in North America. The commercial eulachon fishery in the Fraser River (British Columbia, Canada) has been closed since 1996 due to concern about low population levels. In this paper, we investigated six potential factors that might be responsible for this population decline using artificial neural networks. The factors that we tested included monthly mean temperature and discharge of the Fraser River, the Pacific Decadal Oscillation index, the El Niño Southern Oscillation index, a spawning biomass index derived from the eulachon commercial catch in the Fraser River, and offshore shrimp trawl fishing effort. These six factors were used as predictors and the eulachon commercial catch in the Fraser River as output target series in the artificial neural networks. The sum of squared errors of the neural network predictions from the normalized observed catches was used as the objective function. We compared forecasting accuracy among different combinations of predictors, time lags of one to four years, number of hidden neurons from two to four, and four cross validation schemes (eulachon catches from year 1941 to 1958, 1955 to 1968, 1969 to 1982, and 1983 to 1996 were used as validation data respectively). The forecasting accuracy was measured in terms of the Pearson correlation coefficient between the observed catches and the model predictions. Despite some missing values in the Fraser River water temperature data, this time series was found to be the most important factor that explained the observed eulachon population decline.

Poster S4-4189

Interannual-interdecadal variations in the abundance of spear squid *Loligo bleekeri* in the southwestern Japan/East Sea: Impacts of the late 1980s climatic regime shift and trawl fishing with recommendations for management

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A climatic regime shift from cool to warm conditions in the Tsushima Warm Current (TWC) occurred in the late 1980s in the Japan Sea. Spear squid *Loligo bleekeri* is widely distributed in Japanese costal waters and is a commercially important species for coastal fisheries in Japan. Catch from the southwestern Japan Sea reached a maximum of 13,700 tons in 1977, but decreased to less than 100 tons in recent years and the stock is at the point of collapse. Analysis of monthly trawl catch data for the southwestern Japan Sea during 1975-2004 shows a decadal variation pattern with a change from positive to negative anomalies around the late 1980s; this pattern corresponds well with increases in water temperature in TWC in late 1980s, indicating that decadal variability in spear squid is largely affected by the climatic regime shift. Catch per unit effort decreased sharply during the fishing season; DeLury analysis showed that average fishing mortality during 1989-2000 was about 3 times higher than during 1975-1988, and the exploration rate increased from 50% to 80% during the last three decades. Geographic Information System mapping showed that loliginid squid almost disappeared from the south of Tsushima Island, with decreases in distribution and abundance corresponding to the warming and northward shift in winter sea temperatures front of TWC. These results suggest that decadal patterns of squid variation were largely forced by the regime shift, while fishing has a large impact on the interannual variation and the collapse of the stock.

Poster S4-4190

Review of Japanese sardine, chub mackerel, and walleye pollock fisheries management from the view point of ecosystem approach

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Garcia *et al.* (2003) listed operational objectives and measures to ensure that an ecosystem approach to fisheries is more successful than conventional management. Japanese sardine, chub mackerel, and walleye pollock stocks are in very low abundance in Japan in recent years. We reviewed the existing measures for these stocks from the view point of an ecosystem approach. For Japanese sardine, protections of selected marine areas are already in place. Tosa Bay is one of the main spawning areas for Japanese sardine and plays an important role as a protected area, because large-scale purse seine fisheries are prohibited. However, recovery of reproductive capacity and biological diversity is needed, because spawning stock biomass (SSB) ($7.2x10^5$ton) is below the limit reference point of spawning biomass (B_{limit}) ($22.2x10^5$ton), and the age composition of catch is mainly age 0 and 1 years. For chub mackerel, stock recovery measures to reduce effort have taken place since November 2003. However, recovery of reproductive capacity and biological diversity is still needed, because the SSB ($11x10^5$ton) is below the B_{limit} ($45x10^5$ton), and the age composition of catch is mainly age 0 and 1 for this stock, as well. Priority setting is also needed between purse seine and spoon net fisheries. In the case of walleye pollock, measures to protect immature fish have been taken. However, maintaining reproductive capacity is needed for the Pacific stock, because the SSB ($23.7x10^5$ton) is above but close to the B_{limit} ($16.1x10^5$ton). For the North Japan Sea stock, recovery of the reproductive capacity is needed, because the SSB ($8.5x10^5$ton) is below the B_{limit} ($14.0x10^5$ton). Priority setting is also needed among trawl, longline, and gillnet fisheries.

Poster S4-4260

Biomass and acceptable biological yield of crucian carp (*Carassius cuvieri*) in the Namyang Estuary Reservoir

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This study estimates biomass and potential yield and provides management guidance of crucian carp (*Carassius cuvieri*) in the Namyang Estuary Reservoir in Korea. Population characteristics, including growth parameters, survival rate, instantaneous coefficients of natural and fishing mortalities, and age at first capture were obtained from biological samples of the crucian carp. The von Bertalanffy growth parameters estimated from a non-linear regression were TL_∞ = 41.04 cm, K = 0.147/year, and t_0 = -0.73. Survival rate (S) of the crucian carp was 0.478. The instantaneous coefficient of natural mortality (M) was estimated to be 0.443/year and the current fishing mortality (F) was estimated as 0.296/year for the crucian carp. The age at first capture (t_c) was determined to be 2.46 years. The population biomass of the crucian carp (*Carassius cuvieri*) was estimated as 657.62 mt using a biomass-based length cohort analysis. The estimated acceptable biological yield of the crucian carp (*Carassius cuvieri*) in the reservoir was 359.06 mt.

Poster S4-4278

Incorporating climate information into rebuilding analyses for overfished groundfish stocks

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Population abundances of several groundfish species on the U.S. west coast have declined dramatically over the last several decades, largely due to overfishing. The Magnuson-Stevens Fishery Conservation and Management Act requires rebuilding plans for stocks that have been overfished (stocks with spawning outputs that have dropped below minimum stock size thresholds). Previous studies suggest that climate variability may influence rockfish populations, yet rebuilding plans for overfished stocks have so far ignored those effects. Our goal is to identify biological and physical indicators of conditions in the California Current that have influenced recruitment of groundfish species over the past ~50 years and incorporate this information into rebuilding analyses for overfished stocks. One challenge to testing hypotheses about oceanographic effects on recruitment has been the limited availability of *in situ* oceanographic data at fine time and spatial scales. We will combine coarse-scale *in situ* observations with satellite-derived measures of ocean condition to test hypotheses at finer space and time scales than previously possible (25 km spatial and 3-10 day temporal resolution). Another challenge is degradation in power due to multiple tests of a large number of environmental indices. Using a hierarchical modeling approach, we will increase power by combining information from various species and assessment regions. Specifically, we will test two hypotheses that relate recruitment success to: variability in upwelling habitat at fine time and spatial scales, and the timing of the spring transition from coastal downwelling to upwelling conditions, which is associated with changes in larval groundfish habitat and feeding.

Poster S4-4325

Changes in the structure and function of the Southeastern Yellow Sea ecosystem: An application on the fisheries management

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The living marine resources in the Yellow Sea have been heavily exploited, and thus major commercial species have been almost depleted. The Yellow Sea ecosystem has been more influenced by anthropogenic factors than by any other factor and it has exhibited more fishery-induced changes than any other marine ecosystem in the world. It is scientifically meaningful to compare the structure of this marine ecosystem over different time periods, which would be useful to provide some implications for the management of fisheryresources at the level of the ecosystem. The objective of this study is to compare the state of the Yellow Sea ecosystem among three periods – the late 1960s, early 1980s and early 2000s – by analyzing the structure and function of the ecosystem components using data from bottom trawl surveys and commercial fisheries, based on the Ecopath/Ecosim model, and to explore impacts of fishing on the ecosystem and their living resources for the resource management.

Poster S4-4344

Rebuilding stock of the Yeo-Ja Bay ecosystem in the Southern Sea of Korea – Dominant group and ecosystem structure of the Yeo-Ja Bay

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The Yeo-Ja Bay ecosystem (YBE) is located in the southern sea of Korea and is surrounded by the Yeo-Su and Go-Hung Peninsula. It is a typical coastal embayment that has an area of 318 km^2 and average depth of 10 meters. While the YBE is most important area for habitat and spawning ground of organisms inhabiting the southern sea of Korea, the fish stock has been decreasing due to overfishing and environment pollution. Therefore, it is necessary to

manage and rebuild for the YBE. In this study, we conducted surveys every three months each year from 2005 to 2007 using small trawl gear and beam trawls to study seasonal changes of dominant species and abundance. The dominant species in the YBEs were crustaceans, such as *Thalamita sima*, *Oratosquilla oratoria* and *Crangon hakodatei*, and dominant fishes were *Argyrosomus argentatus* and *Muraenesox cinereus*. We collected the ecological information and divided groups by self-organized mapping (SOM) of all organisms. We divided all organisms into 18 groups in Yeo-Ja Bay. We estimated trophic levels of every group by Pauly's equation. Using the ecosystem model, ECOPATH, we constructed the structure of the YBE. Also, we made a comparative study of the origin of the prey based on an analysis of the composition of the stable isotope for major species in the YBE. Finally, considering the ecosystem and commercial fishing intensity, a management and rebuilding plan for the YBE will suggested for further discussion.

Poster S4-4349

An approach to recover abalone resources by TAC control based on RPS trends calculated with production model

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Abalone is one of the most important coastal fishery resources in Japan, and the stock enhancement projects by means of reseeding have been implemented in the last 30 years. However, the abalone catches have decreased rapidly since 1970s, and not started increasing in many areas. The causes of the decline were not fully understood, but assumed to be mainly overexploitation and changes in marine environmental conditions.

The Ojika Island, off western Kyushu, is one of the greatest abalone production areas, and the annual catches by diving fishery were around 60 tons until the 1980s. Afterwards, the catches were rapidly decreased to less than 10 tons level since 2003. Based on the statistics of daily catches and fishing efforts, the yearly changes of stock size, fishing mortality and recruits were calculated with production model. According to the results, the peak of the stock size was calculated to be 217 tons in 1985, and the size was decreased to less than 40 tons in 2004. Since the values of recruits per spawning stock biomass (RPS) were thought to be stable in 1983-1997, the decline of the stock size in the period was caused by overexploitation. However, the RPS values were reduced after 1998 when a global resume shift was supposed to be occurred.

TAC control based on the stock assessment was employed since 2006, and the catches have been limited to 3 tons. An exact evaluation of RPS values is thought to be essential for the success of the resources recovery.

Poster S4-4379

Environmental constraints to rebuilding of Kodiak red king crab

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Gulf of Alaska waters around Kodiak Island once supported the world's largest fishery for red king crab (*Paralithodes camtschaticus*). Fishery harvests occurred at low-levels beginning in the 1930s, but increased rapidly in the 1960s to a peak harvest of 42,800 mt in 1965. However, stock abundance declined dramatically in the late 1960s, and again in the early 1980s. The history of the fishery included a variety of management measures, such as time and area closures and changes to minimum size limits. Despite these efforts, the stock was ultimately recognized as depleted, and a commercial fishery closure since 1983 has not resulted in a stock recovery. We describe the use of numerical modeling in a retrospective analysis to understand the conditions surrounding the rise, collapse, and continued depleted status of the red king crab stock around Kodiak Island. The first step in this approach was the estimation of annual king crab spawning stock abundance and recruitment during 1960 to the present. A subsequent step was the analysis of temporal changes in the stock biogeography with respect to oceanographic conditions, ecological factors, and historical harvests. Of particular interest was the relationship of red king crab abundance and recruitment to environmental and ecological factors such as ocean conditions (*e.g.*,

temperature effects on match-mismatch of crab larvae and *Thalassiosira* prey, and larval advection by currents) and predation (*e.g.*, Pacific cod *Gadus macrocephalus*) during crab early life history. Based on our findings, we discuss the implications, and potential constraints, to stock rebuilding.

Poster S4-4392

Structure and function of three marine ecosystems in Korea: A comparative study

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Comparative analyses are a powerful way to evaluate similarities and differences in ecosystem structure and function. We identified key areas of differences and similarities in the structure and function of three marine ecosystems – the East/Japan Sea (EJS), Yellow Sea (YS) and East China Sea (ECS) in Korea. Common modeling approaches, such as Ecopath models were applied to three marine ecosystems with important commercial fisheries, and set of macrodescriptor metrics from systems ecology were used to examine large-scale ecological characteristics for each ecosystem. Macrodescriptor metrics were calculated with Ecopath diet matrices, which were provided by food web information. The degree to which components of a system are affected by each other were measured by the number of interactions per component of a system (*i.e.*, connectivity) and by the proportion of all possible connections within a system that are realized (*i.e.*, connectance). Food web connectance showed that average number of trophic steps from primary producers to apex predators was longest in the EJS, and that trophic pathways were more linear in the YS. The EJS and ECS had pelagic and benthic foodwebs, while the YS was mainly pelagic. Other macrodescriptor metrics, such as linked pathways starting from a group and returning to it, were described to compare ecological attributes for the three marine ecosystems.

Poster S4-4423

Marine versus terrestrial sources of production to the Seto Inland Sea, Japan

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The Seto Inland Sea (SIS) is linked to the Pacific Ocean and Sea of Japan, yet it also receives organic/inorganic inputs with varying levels of urban, industrial, and agricultural development. To determine the relative importance of terrestrial versus marine-derived production to the SIS, we measured carbon and nitrogen stable isotopes of particulate organic matter (POM) and zooplankton, and carbon isotopes of dissolved organic (DOC) and inorganic carbon (DIC) from five major river systems draining into the SIS, six subsystems within the SIS, and a Pacific Ocean site. Results showed that $\delta^{13}C$ values from the SIS more closely resembled $\delta^{13}C$ of marine production, indicating that POM and zooplankton within the SIS were largely derived from a marine source. However, the relative influence of river and anthropogenic inputs to the SIS varied by subsystem. From spatial comparisons of $\delta^{15}N$ of POM and zooplankton, a distinct east-west separation of the SIS was observed, with eastern subsystems exhibiting high $\delta^{15}N$ values associated with river inputs from areas of heavy urban and industrial development (low salinity, high nitrate and phosphate, low dissolved oxygen). Patterns in $\delta^{13}C$ of POM also showed a similar east-west trend that was likely related to greater benthic-pelagic coupling and predominance of diatoms. Zooplankton $\delta^{13}C$ values were more variable, but generally showed a similar trend of ^{13}C-enrichment relative to subsystem differences in primary production and benthic-pelagic coupling. The SIS therefore consists of subsystems that have unique biological characteristics due to terrestrial and marine inputs and benthic-pelagic coupling.

Poster S4-4459

An ecosystem-based assessment of the blue crab stock and management strategy in the Yellow Sea

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Annual catches of blue crab, *Portunus trituberculatus*, have declined substantially from 18,000 t in 2002 to 4,500 t in 2006. Traditional management measures have been implemented, such as closed seasons during the spawning period since 1974 and a size limit of 5 cm in carapace length since 1996. In addition, the habitat of blue crab along the west coast of Korea has been degraded due to anthropogenic activities, such as sand mining, land reclamations, and coastal pollution. Under these conditions, management was not successful in maintaining the stock condition. In 2006, a stock rebuilding program for blue crab, based on the adoption of an ecosystem approach to management, started to enhance the stock. The focus of this paper is on demonstrating the usefulness of the Zhang *et al.*'s ecosystem-based assessment to the Yellow Sea blue crab stock.

Poster S4-4488

Completion of a global assessment of sockeye salmon *(Oncorhynchus nerka)* status using IUCN criteria

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We assembled data from ca. 300 monitored populations of sockeye salmon (*Oncorhynchus nerka*) across the Pacific Rim, including populations from the USA (States of Washington and Alaska), Canada (Province of British Columbia) and Russia (Kamchatka). Using this database, we evaluated the status of sockeye salmon at both global and regional scales according to IUCN Red List criteria version 3.1. We provide Red List classifications for sockeye salmon at both the species level and for a total of 69 regional populations defined by genetic differentiation and freshwater ecoregional groupings. For our species-level assessment, we relied on IUCN Red List geographic-range criteria; at the regional population level, we compared recent trends in abundance (*i.e.*, adult escapement) for indicator subpopulations to quantitative decline-based criteria. Endangered populations were observed within each nation, with the greatest concentration observed in southern British Columbia, a region of high within-species diversity. This effort constitutes an important step in understanding and defining approaches towards listing Pacific salmon species on the IUCN Red List. We conclude by describing on-going and future plans for IUCN salmonid assessments and our efforts to partner with agencies to improve access to salmon population data across the Pacific Rim.

S5 FIS/CCCC/BIO Topic Session Fisheries interactions and local ecology

Co-sponsored by ICES

Co-Convenors: Kerim Y. Aydin (U.S.A.), Masahide Kaeriyama (Japan), Jason Link (U.S.A.) and Elizabeth A. Logerwell (U.S.A.)

Ecosystem models are often employed to evaluate the effects of fishing and to distinguish natural variability from human impacts. These models typically operate at large spatial and temporal scales, which are appropriate for their goals and objectives. However, these models would benefit from better information on local-scale processes as there are likely to be bottlenecks at short time scales and small spatial scales that are critical to understanding recruitment variability. Similarly, there may be critical foraging interactions that happen at local scales, particularly for central place foragers such as marine mammals and seabirds. Small-scale effects of fishing such as “localized depletion” may have ecosystem-level consequences. More information on local-scale survival, foraging, movement, reproduction and pelagic habitat selection would allow food-web and population dynamics modelers to make better scenarios of the effects of natural variability and/or fishing on ecosystems. Papers are solicited on the following topics: (1) current ecosystem models and the assumptions that require further research; (2) techniques for assessing climate impacts on predator-prey interactions at top trophic levels; (3) techniques for assessing local-scale dynamics of survival, foraging, movement, reproduction and pelagic habitat selection; and (4) techniques for assessing prey field response to fishing.

Wednesday, October 31, 2007 09:00 – 15:40

09:00 ***Introduction by convenors***

09:05 **Motoko R. Kimura and Hiroyuki Munehara (Invited)**
A breakdown of habitat isolation among coastal fish by artificial habitat modification (S5-4192)

09:35 **Mitsuhiro Nagata, Yasuyuki Miyakoshi, Takanori Iwao and Masahide Kaeriyama**
Survivals of Hokkaido chum salmon affected by coastal seawater temperature during their early ocean life (S5-4060)

09:55 **Ikue Mio, Hideaki Kudo and Masahide Kaeriyama**
Are foraging habits of Pacific salmon (*Oncorhynchus* spp.) reflected in food habits in the North Pacific? (S5-4090)

10:15 **Sangdeok Chung and Suam Kim**
Relationship between Pacific cod (*Gadus macrocephalus*) catch and environmental factors off eastern Korea (S5-4264)

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

10:55 **Orio Yamamura (Invited)**
Assessment of predation mortality of juvenile pollock in the coastal area (S5-4281)

11:25 **Susanne F. McDermott, Elizabeth A. Logerwell, Ivonne Ortiz and V. Haist**
Fishery interaction and availability of Atka mackerel prey for Steller sea lions: Results from local abundance and movement study of Atka mackerel (S5-4062)

11:45 **Jeremy T. Sterling, Rolf R. Ream, Devin S. Johnson and Thomas S. Gelatt**
The role of physical processes in the summertime life of the northern fur seal (S5-4291)

12:05 **M. Elizabeth Conners and Peter T. Munro**
Localized depletion experiment for Bering Sea Pacific cod (S5-4370)

12:25 **Jason S. Link and Josef Idoine**
Mortality of shrimp *Pandalus borealis*: Local influence of predation in the Gulf of Maine (S5-4381)

12:45 ***Lunch***

14:00 **Michel J. Kaiser, Jan G. Hiddink and Hilmar Hinz (Invited)**
Fishing and climate modifies habitat use and availability for fish (S5-4359)

14:30 **Jung Hwa Choi, Jong Hwa Park, Dae Soo Chang, Jung Nyun Kim, Hak Jin Hwang, Mi Young Song, Joo Il Kim, Young Il Seo, Sung Il Lee and Sang Chul Yoon**
Designing fish management boundaries in Korean waters using Self-Organizing Maps (SOM) (S5-4271)

14:50 **Bernard A. Megrey, Kenneth A. Rose, Shin-ichi Ito, Douglas E. Hay, Francisco E. Werner, Michio J. Kishi, Yasuhiro Yamanaka, Maki Noguchi-Aita, Jake F. Schweigert and Matthew B. Foster**
Using model experiments to explore the impact of basin-scale climate forcing on localized upper-trophic-level marine ecosystem production (S5-4389)

15:10 **B.K. Wells, J.C. Field, J.A. Thayer, C.B. Grimes, S.J. Bograd, W.J. Sydeman, F.B. Schwing and R. Hewitt**
Untangling the relationships between climate, prey, and top predators in an ocean ecosystem (S5-4454)

15:30 ***Summary and wrap up***

S5 Posters

S5-4042 **V.F. Bugaev**
The correlation between the abundance of sockeye salmon *Oncorhynchus nerka* of the Kamchatka River by periods of different state of stock abundance dynamics of Kamchatkan pink salmon *Oncorhynchus gorbuscha*

S5-4043 **V.F. Bugaev, B.B. Vronsky, L.O. Zavarina and Zh. Kh. Zorbidi**
The analysis of the interactions between generations of the Kamchatka River salmons including sockeye, chinook, chum and coho

S5-4188 **Sungtae Kim, Sukgeun Jung and Jinyoung Kim**
Distribution, feeding and growth of Japanese Spanish mackerel (*Scomberomorus niphonius*) in the southern Korean sea

S5-4207 **Kimberly Rand**
Longitudinal growth differences in Atka mackerel (*Pleurogrammus monopterygius*): Using a bioenergetic model to identify underlying mechanisms

S5-4212 **Paige Drobny, Brenda Norcross and Nate Bickford**
Age, growth and movement of the squid species *Berryteuthis magister* in the Eastern Bering Sea

S5-4217 **Feng-ao Lin and Jingfeng Fan**
The analysis of reasons for mass-death of culturing pufferfish (*Fugu rubripes*) caused by 0# light oil spilled on the sea

S5-4256 **Zhaohui Zhang, Shufeng Ye and Mingyuan Zhu**
Ecosystem services valuation of coastal aquaculture

S5-4279 **Kenji Konishi, Tsutomu Tamura and Koji Matsuoka**
Recent feeding habits of sei whale *Balaenoptera borealis* in pelagic waters of the western North Pacific based on data collected from 2002 to 2006

S5-4319 **Sung Il Lee, Hyung Kee Cha, Sang Chul Yoon, Young Seop Kim, Dae Soo Chang and Jae Hyeong Yang**
Age and growth of *Arctoscopus japonicus* in the East/Japan Sea

S5-4368 **Shusaku Kobayashi, Takaomi Arai, Kentaro Honda, Yuji Noda and Kazushi Miyashita**
Brown trout (*Salmo trutta*) movements between a stream and the sea in Hokkaido, northern Japan

S5-4372 **Jarrod A. Santora, Christian S. Reiss and Richard R. Veit**
Annual spatial variability of krill influences seabird foraging behavior near Elephant Island, Antarctica

S5-4395 **Richard D. Brodeur and Cheryl A. Morgan**
The Columbia River plume as an ecotone and habitat for juvenile chinook salmon

S5-4411 **L. Godbout, M. Trudel, J. Irvine, C. Wood, K. Larsen, K. McKeegan, M. Grove and A. Schmitt**
A stable isotope method to discriminate the orgin of nerkids (*Oncorhynchus nerka*) in BC lakes

S5-4427 **Sandi Neidetcher and Elizabeth A. Logerwell**
Spatial and temporal patterns in Pacific cod reproductive maturity in the Bering Sea

S5-4490 **Oleg A. Ivanov and Vitaly V. Sukhanov**
Species structure of epipelagic nekton of the Okhotsk Sea

S5 Oral Presentations

31 October, 09:05 (S5-4192) Invited

A breakdown of habitat isolation among coastal fish by artificial habitat modification

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Artificial habitat modifications can break down habitat isolation that is a barrier for interspecies mating, causing hybridization between previously isolated species. Such human-caused hybridizations sometimes lead to extinctions of many plant and animal populations, and have large impacts on ecosystems. Coastal areas are often disturbed by artificial habitat modification such as constructions of fishing ports and land reclamation. We demonstrate that the habitat isolation among three species of greenling was broken down due to the construction of a breakwater in a coastal area in Japan. On natural coastal reef, *H. octogrammus* and *H. agrammus* breed in shallow seaweed beds, while *H. otakii* breeds in deeper water, showing clear habitat segregation. However, the three species concurrently occurred in artificial habitats, *e.g.* breakwaters. A steep slope of breakwater and a complex structure of tetrapods generated a heterogeneous environment in which a shallow environment with thick seaweed and a deep environment with thin seaweed coexisted. In this artificial habitat, unidirectional hybridization between *H. octogrammus* females and both *H. agrammus* and *H. otakii* males was observed frequently, whereas hybridizations of other combinations were not observed. Specifically, it should be noted that 43.2% of the egg masses in breeding territories of *H. otakii* males were deposited by *H. octogrammus* females. The results suggest that *H. octogrammus* and *H. otakii* are at risk of hybridizing due to the breakdown of habitat isolation. We discuss impacts on coastal ecosystems caused by artificial habitat modification, giving an example the case of *Hexagrammos* species.

31 October, 09:35 (S5-4060)

Survivals of Hokkaido chum salmon affected by coastal seawater temperature during their early ocean life

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While Hokkaido chum salmon maintain a high abundance of over 40 million fish, recent return rates have varied between 2.6% and 7.2%. High mortality of chum salmon occurs in their early ocean life. Although an optimal seawater temperature for chum salmon juveniles after seaward migration has been reported to be between 8°C and 13°C in the coastal water, little is known about the influence of cool seawater on distribution and growth of juveniles. Recent studies in eastern Hokkaido showed that cool seawater environment below 8°C strongly restricted migrating behavior of juveniles: they aggregated so densely in the narrow littoral zone that they could not grow faster than those which expanded to coastal area during warmer conditions. These results suggest that the duration of below 8°C in the coastal water after seaward migration may affect the survival of chum salmon. In order to test this scenario, we analyzed relationships between return rates of chum salmon and periods of cool water below 8°C during early ocean life in the coastal regions of Hokkaido. We used average daily-SST in the coastal water from 4km to 37km offshore, which were estimated from daily SST analysis of JMA and satellite (NOAA and MTSAT) observations. These analyses suggest the longer the periods of cool seawater during early ocean life of chum salmon are, the lower their return rate might be, with the exception of the Japan Sea.

31 October, 09:55 (S5-4090)

Are foraging habits of Pacific salmon (*Oncorhynchus* spp.) reflected in food habits in the North Pacific?

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Diet composition of Pacific salmon (*Oncorhynchus* spp.), in general, is considered to depend on the availability and relative abundance of the food items. However, there are a few studies on the interaction of diel vertical distribution between prey organisms and salmon. We examined the feeding habits of Pacific salmon collected by non-selective drift gillnets aboard the T/V *Oshoro-maru* (Hokkaido University) in the North Pacific in the summer 2006, to examine the relationship of diel vertical distributions between salmons and prey organisms. In the stomachs of sockeye (*O. nerka*) and pink salmon (*O. gorbuscha*), *Neocalanus cristatus* and a squid (*Berryteuthis anonychus*) occupied the inside of the pyloric. An amphipod (*Themisto pacifica*) and eupausiids dominated the inside of the esophagus. *T. pacifica* and pteropods were found randomly in the stomach of chum salmon. Pacific salmon were distributed in the 0-50m depth zone at daytime, and 0-10m depth zone at nighttime (Ishida *et al.*, 2001). Prey inside the pyloric and esophagus were fed on during daytime and nighttime by salmon, respectively, because of 24 hours in the gastric evacuation rate (Brett and Higgs, 1970). These results and information on the life history of prey animals (Marlowe and Miller, 1975; Mackas *et al.*, 1993; Iguchi and Ikeda, 2004) suggest that sockeye and pink salmon will feed on nekton (*e.g. B. anonychus*) and zooplankton (*e.g. N. cristatus*) in the comparatively deeper layer during the daytime and zooplankton such as *T. pacifica* and eupausiids during the nighttime in the surface layer, and that chum salmon may mainly forage zooplankton (*e.g. T. pacifica* and pteropods) in the surface layer during day and night. Thus, the feeding ecology of Pacific salmon will be influenced by the diurnal changes in vertical distribution of prey animals.

31 October, 10:15 (S5-4264)

Relationship between Pacific cod (*Gadus macrocephalus*) catch and environmental factors off eastern Korea

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The catch of Pacific cod (*gadus macrocephalus*) has increased in Korean waters recently, but biological characteristics as well as recruitment processes are yet to be explained. The relationship between Pacific cod catch and environmental characteristics in eastern Korea was investigated using Cross-Correlation Function (CCF) analysis. Catches (1970-2005) were collected from the Korean fisheries yearbook and bimonthly seawater temperature (1970-2005) at depths and biomass of zooplankton groups (1979-2002) in coastal areas were obtained from the Korea Oceanographic Data Center. In general, there was negative correlation between total catch from eastern Korea and Arctic Oscillation Index (AOI), and the highest correlation ($r = -0.384$, $P < 0.05$) was shown with a time-lag of 4 years. CCF analysis indicated that cod catch was also significantly correlated with August temperature at 50 m in the spawning grounds with a time-lag of 3 years. Also, we found a relationship between cod catch and zooplankton biomass. For example, catch was significantly correlated with February euphausiid biomass with a time-lag of 4 years ($r = 0.417$, $P < 0.05$) in the coastal area off eastern Korea.

31 October, 10:55 (S5-4281) Invited

Assessment of predation mortality of juvenile pollock in the coastal area

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Post-settlement predation is one of the most important sources of mortality in walleye pollock, and it plays an important role in determining year class strength. A consecutive, local scale survey has been conducted to quantify pollock mortality off the southeastern coast of Hokkaido Island (Doto area), where there is an important nursery

ground for Japan Pacific Population (JPP). Sampling was continued on a monthly basis for 3 yrs in a depth-stratified design with a bottom depth interval of 30 m, using a small fishing vessel (7.3 t) equipped with a Danish seine. Based on the results of 1) density estimatation 2) stomach contents analysis and 3) experimentally or bibliographically obtained daily ration of predators, monthly predation impact was estimated. Severe mortality occurred in winter and autumn, reflecting the size-dependent aspect of predation (*i.e.* higher vulnerability of younger (smaller) pollock). Kamchatka flounder *Atheresthes evermani* and plain sculpin *Myoxocephalus jaok* were primary and secondary predators, respectively, and their distribution resulted in the highest average monthly predation pressure in the 90 m stratum (1.4 t km-2) followed by 120m and 90m. Based on these results, cumulative mortality of 2003 and 2004 year classes was estimated to be 176 and 163 thousand tons in the western Doto area (3169 km^2). The present result partly elucidates the recent low level of recruitment per spawning (RPS) of JPP pollock.

31 October, 11:25 (S5-4062)

Fishery interaction and availability of Atka mackerel prey for Steller sea lions: Results from local abundance and movement study of Atka mackerel

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Atka mackerel (*Pleurogrammus monopterygius*) are the most abundant commercially exploited groundfish in the Aleutian Islands, Alaska. They display a highly aggregated patchy distribution centered around island passes and areas of high currents which is reflected in the fishery. Atka mackerel are batch spawners with males guarding nests demersally up to 6 months of the year. Females aggregate in large schools close to the spawning grounds, presumably to feed. Atka mackerel is the predominant prey of the endangered Steller sea lion in the Aleutian Islands. 10- to 20-nautical mile trawl exclusion zones have been established around rookeries to protect prey abundance. This study estimated the movement and local abundance of Atka mackerel with a mark recapture experiment using an integrated tagging model. Atka mackerel were tagged, released, and recovered from 2000 – 2006 in 4 local areas inside and outside of trawl exclusion zones in the Aleutian Islands. Population abundance was examined with respect to Steller sea lion prey energetic requirements within the trawl exclusion zones. Atka mackerel local movement patterns across these harvest boundaries was related to local fishing patterns and the interaction between fishery and prey abundance was examined.

31 October, 11:45 (S5-4291)

The role of physical processes in the summertime life of the northern fur seal

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In the eastern Bering Sea, the extent and duration of winter sea ice, cyclonic and anticyclonic eddies, episodic storm systems, and on-shelf physical processes play a significant role in the timing and distribution of the spring bloom and in sustaining primary and secondary production throughout the summer. We examined the hypothesis that these oceanographic and atmospheric processes further influence the spatial and temporal dynamics of food webs supporting northern fur seals (*Callorhinus ursinus*) resulting in seasonal and inter-annual variability in fur seal foraging areas. Satellite telemetry data collected from two rookeries (Reef and Vostochni) on St. Paul Island, AK over 8 seasons was modeled at hourly intervals. Storm events and cold and warm years were identified, and remotely sensed sea surface height data, walleye pollock biomass, and on-shelf bottom temperatures were spatially and temporally joined with seal locations. Findings indicate that in cold years the spatial distribution of the "cold pool", a seasonal product of the winter ice cover, can occupy ~ 46% of Vostochni foraging habitat causing walleye pollock and in turn fur seals to shift westward into warmer waters. In oceanic waters, seals foraged mostly along the edges of eddies. Both oceanic and shelf foragers changed their foraging distribution after strong storms passed through the region – shelf foragers shifted northward while oceanic foragers became more dispersed and spent less time foraging at eddy edges. Consequently, meteorological variability and coupled physical oceanographic processes in the Bering Sea influence both the distribution and foraging success of northern fur seals.

31 October, 12:05 (S5-4370)

Localized depletion experiment for Bering Sea Pacific cod

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Regulation of fisheries in Alaska includes measures to protect endangered Steller sea lions (*Eumetopias jubatus*). One concern has been whether intensive fish harvests can create localized depletion that could affect sea lion foraging success. We conducted a field experiment to determine if an intensive trawl fishery in the Bering Sea creates a localized depletion in the abundance of Pacific cod (*Gadus macrocephalus*). The results of the experiment strongly indicated no difference between stations within a regulatory no-trawl zone and in an immediately adjacent trawled area. These results imply an absence of localized depletion effects at the scale of the experiment, although fishing effects may still occur at different spatial and temporal scales. Corollary studies suggest that cod in the study area were highly mobile over short time scales, violating the assumption of a closed population in the exploited area. Localized depletion is strongly dependent on assumed spatial and temporal scales. Movement of the target organism is critical in determining regional effects of fishery removals.

31 October, 12:25 (S5-4381)

Mortality of shrimp *Pandalus borealis*: Local influence of predation in the Gulf of Maine

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As part of a northern shrimp (*Pandalus borealis*) stock assessment, we evaluated the role of predatory removals relative to shrimp population dynamics and model outputs. Food habits data from NEFSC bottom trawl surveys were evaluated for a wide range of pandalid shrimp predators in the localized region of the Gulf of Maine where these shrimp occur, delineated by survey strata corresponding to areas used to assess northern shrimp. The total amount of food eaten and the type of food eaten were the primary food habits data examined. From these basic food habits data, diet composition of pandalids, per capita consumption, total consumption, and the amount of shrimp removed by these shrimp predators were calculated. Combined with abundance estimates of these predators, when summed the total amount of shrimp consumed was calculated. Contrasts to other estimates of biomass were conducted to place this source of mortality into context and to fully explore assumptions about assessment model parameters. Key results showed that: 1. Total consumption of shrimp is on the same order of magnitude of independent estimates of stock biomass, but can be a bit higher; 2. Total consumption of shrimp exhibits similar trends as other biomass estimates; 3. The results suggests higher shrimp biomass in the ecosystem than previously thought; 4. Total consumption of shrimp is suggestive of a higher M than the 0.25 previously used. Implications for future estimates of life history, abundance, biomass, mortality and fishing are discussed.

31 October, 14:00 (S5-4359) Invited

Fishing and climate modifies habitat use and availability for fish

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Fishing disturbance at the seabed lowers benthic biomass and production, but the extent to which this occurs differs greatly among different habitat types and among different regimes of natural disturbance. Using field-validated modelling approaches, it is possible to predict the extent to which fishing disturbance has affected benthic production and to predict likely recovery rates as a result of fishery closures. Inferences from fishers' observations suggest that some fish species are not well protected by fishery closures, for example plaice in the North Sea appear to have 'followed the fishery' after the implementation of the North Sea 'plaice box'. In addition to fishing disturbance, the regime of natural disturbance to seabed communities is altering with changing climatic conditions. Coastal benthic communities are tightly coupled to factors such as wave stress that act as sources of mortality or

affect food supply to the seabed. Consequently, changes in climatic forcing are likely to lead to spatial changes in the extent and distribution of benthic communities in the coastal zone with consequent effects on trophic interactions with dependent fish species.

31 October, 14:30 (S5-4271)

Designing fish management boundaries in Korean waters using Self-Organizing Maps (SOM)

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Fisheries management is intended to conserve ecosystems for sustainable usage and to maximize some specified biological, social or economic benefits from the fishery while minimizing costs. Fish distribution patterns and biological aspects, are important factors for decisions about fisheries management rules. We implemented self-organizing maps (SOM) to classify the demersal fish community in the Korean EEZ area using bottom trawl data collected from 2004 to 2005. The SOM accordingly classified the samples into four groups of communities, and the groups corresponded to the geographical regions of the sampling sites. The west and east sea regions were characterized by lower numbers of species and lower diversity, whereas higher numbers of species and greater diversity were characteristic of the south sea region. The distribution patterns of biomass and individual data were not different. The distribution patterns responded to different the environmental conditions of the regional ecosystems.

31 October, 14:50 (S5-4389)

Using model experiments to explore the impact of basin-scale climate forcing on localized upper-trophic-level marine ecosystem production

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Using the NEMURO family of models, two numerical simulation model experiments are described where, within one ocean basin, a common 50 year basin-scale climate forcing scenario is used to drive multi-trophic level subarctic marine ecosystem models. Particular emphasis is given to the response of localized upper trophic level pelagic marine fish growth dynamics. In the first experiment, the same model is applied to Pacific herring over a wide geographic area in the eastern north Pacific while in the second experiment the same model is applied to two pelagic species with different life histories, Pacific herring and Pacific saury, in two distinct ocean regions off of Japan and California. With this approach, we narrow the observed local response and model dynamics to reflect local conditions and eliminate differences related to the model formulations in each region. In general, results show the impact of long-term climate variability on upper trophic level ecosystem response at multiple locations and between species with different life histories. Patterns that emerged included inverse relationships between water temperature and zooplankton densities, out-of-phase herring growth dynamics between basin locations, in-phase growth dynamics between herring and saury within one basin location, synchronous temporal response and

asynchronous herring growth response among different basin locations, and the relative importance of temperature and zooplankton to predicted herring growth responses between locations.

31 October, 15:10 (S5-4454)

Untangling the relationships between climate, prey, and top predators in an ocean ecosystem

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Successful ecosystem-based conservation of marine resources will benefit from quantitative indicators of ecosystem productivity, particularly if such indicators quantify and incorporate the relationships between physical and biological components of the ecosystem simultaneously. Despite previous explorations of relationships between physical processes (*e.g.*, wind indices, advection and retention of coastal waters, sea surface temperature, coastal sea level, and the temporal aspects of these factors) and resulting biological responses, explicit understanding of mechanistic connections has been elusive. We use path analysis and partial least squares regression to visualize and quantify links between biological and physical components in the California Current ecosystem and to predict reproductive success at three trophic levels. We examine the applicability of this approach using a hierarchical pattern of environmental indices and relationships previously described in the literature, and quantitative measures of zooplankton, fish, and seabird productivity. We show each trophic level and community production can be modeled using environmental and biological data in a manner that provides a comprehensive evaluation of physical and biological connectivity and mechanisms. Importantly, our approach to modeling an ecosystem represents a practical middle ground between simple correlative methods typically employed and a complete mechanistic understanding of all physical and biological mechanisms regulating variability in reproductive success.

S5 Posters

Poster S5-4042

The correlation between the abundance of sockeye salmon *Oncorhynchus nerka* of the Kamchatka River by periods of different state of stock abundance dynamics of Kamchatkan pink salmon *Oncorhynchus gorbuscha*

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For many years the dominant (highly abundant) generations of pink salmon of West and East Kamchatka were in odd years (up to 1984). In 1985 pink salmon of West Kamchatka had changed the return of dominant generations from odd to even years. For the period 1985-2006 the returns of East Kamchatkan pink salmon dominant generations still were in the odd years, but West Kamchatkan pink salmon dominant generations had been observed in the even years. The growth rate of two largest structural components of the Kamchatka River sockeye salmon, including the stock “A” (the age of fishes 2.3) and the fishes from the low part of the river, migrating for the feeding to the Azabachye Lake being underyearlings (the group “E”, the age of fishes 1.3), has been studied from scale structure and body length of mature fishes by the periods 1978-1984 and 1985-2005. It is demonstrated, that in 1978-1984 the correlation between the scale radii of sockeye salmon (of the stock “A” and the group “E”) and the abundance of the mature part (MP) of sockeye salmon stock “A”, of the group “E” and of all the Kamchatka River sockeye salmon was negative in all cases, whereas in 1985-2005 the correlation became positive. It is revealed, that

in 1978-1984 the correlation between sockeye salmon length in different years of growth (the stock "A" and the group "E") and the abundance of the MP of sockeye salmon of the stock "A", the group "E" and all the rest Kamchatka River sockeye salmon in almost all cases was negative, whereas in 1985-2005 it became wholly positive. There are the grounds to suggest that in the whole for the stock "A" the abundance of mature fishes has been more strongly influenced by the conditions during the sea period of life, compared to that for the group "E" which may be more strongly influenced by the conditions during the freshwater period.

Poster S5-4043

The analysis of the interactions between generations of the Kamchatka River salmons including sockeye, chinook, chum and coho

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The analysis of salmon generation abundances for 1957-1997 has been carried out at two levels of detail: by the annual data and by the means for periods of three years. Because the age of maturity is different in different species, this approach allows us to make a more objective assessment of the tendencies in the abundance fluctuations by species. The analysis carried out suggests a very poor negative correlation between the generation abundances of sockeye salmon and chinook salmon of the Kamchatka River for 1957-1997, although the correlation is not significant ($r = -0.267$, $P > 0.05$, $n = 41$) based on the data given. When analyzing the data on three generations this negative correlation is stronger and highly significant ($r = -0.701$, $P < 0.001$, $n = 14$). A positive significant correlation ($r = 0.538$, $P < 0.001$, $n = 41$) has been observed between the generation abundances of sockeye salmon and chum salmon of the Kamchatka River for 1957-1997. The correlation persists ($r = 0.701$, $P < 0.001$, $n = 14$) when analyzing the means by groupings of three generations. A poor negative significant correlation ($r = -0.428$, $P < 0.05$, $n = 24$) has observed between the generation abundances of sockeye salmon and coho salmon for 1974-1997, but when analyzing the means by groupings of three generations on the data this correlation is not significant ($r = -0.437$, $P > 0.05$, $n = 8$). A correlation between the generation abundances of chinook salmon and chum salmon of the Kamchatka River has not been observed for 1957-1997 ($r = -0.074$, $P > 0.05$, $n = 41$). There is no correlation observed when analyzing the means by groupings of three generations ($r = -0.093$, $P > 0.05$, $n = 14$). The positive correlation between the generation abundances of chinook salmon and coho salmon of the Kamchatka River for 1974-1997 is very strong and highly significant ($r = 0.852$, $P < 0.001$, $n = 24$). It also can be observed when analyzing the means by groupings of three generations ($r = 0.862$, $P < 0.01$, $n = 8$).

Poster S5-4188

Distribution, feeding and growth of Japanese Spanish mackerel (*Scomberomorus niphonius*) in the southern Korean sea

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We have been investigating whether spatial and temporal matches between predator and prey species could be critical for the growth and distribution of Japanese Spanish mackerel (*Scomberomorus niphonius*). As a first step, we examined the relationship between growth and distribution of mackerel to spatial and temporal variability of their major prey species, Pacific anchovy (*Engraulis japonicus*), in the Korean sea in 2005-2006. Growth rate was estimated from length-frequency distributions. Commercial catches of both mackerel and anchovy coincidentally peaked in winter. Spatially, catches of mackerel were high in the western coastal waters of Jeju Island whereas anchovy catches were high in the northern coastal waters. Annual catch of anchovy was higher in 2005 than in 2006, but feeding incidence was slightly higher in 2006 (67.7%) than in 2005 (65.3%). We will further investigate the spatio-temporal relationship between the two species by utilizing fishery-independent catch data and developing a spatially-explicit model for predicting anchovy migration and production.

Poster S5-4207

Longitudinal growth differences in Atka mackerel (*Pleurogrammus monopterygius*): Using a bioenergetic model to identify underlying mechanisms

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Atka mackerel (*Pleurogrammus monopterygius*) comprise the largest biomass of groundfish in the Aleutian Islands, Alaska. Atka mackerel have shown a significant size cline decreasing longitudinally from east to west. Previous research excluded genetic variation as a potential cause for this size cline within our study areas. The study areas were located at Seguam pass in the east (average 5 year old fish weighing 732 g and 39 cm FL) and Amchitka in the west (average 5 year old fish weighing 575 g and 36 cm FL). The objective of this study was to examine the underlying mechanisms contributing to the observed growth differences using a bioenergetic model. Prey quantity, prey quality and thermal experience were examined as potential factors contributing to the differences in growth. The model used was initially parameterized for an adult walleye pollock. To verify model estimates, observed Atka mackerel consumption was compared to model estimated consumption. The model accurately estimated annual Atka mackerel prey consumption. The model was then used to make a relative comparison between the two study areas. Results indicate that prey quality was the main factor contributing to growth differences. At Seguam Pass, Atka mackerel were eating a more energetically rich diet consisting of euphausiids and fish whereas at Amchitka copepods dominate the diet with little to no consumption of fish. A stable isotope analysis further supported the diet differences between the two study areas. The model suggested that prey quantity and the fish's thermal experience contributed little to observed differences in growth.

Poster S5-4212

Age, growth and movement of the squid species *Berryteuthis magister* in the Eastern Bering Sea

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Though the gonatid squid, *Berryteuthis magister*, is found throughout the Subarctic Pacific and is a central prey species in the ecosystem, their life history characteristics are poorly known. For this study, *B. magister* samples from a research cruise in 2004 and bycatch from the commercial pollock fishery in 2006 in the Eastern Bering Sea were analyzed. Statoliths were extracted, ground and polished to estimate age. Length at age was used to model growth. Trace elements in the statoliths were examined using a Laser Ablation Inductively Coupled Mass Spectrometer (LA-ICP-MS) to differentiate squid into stocks, track movement patterns of individual squid, and determine if the location where the squid were captured is the same as the location that they hatched. Three cohorts were identified with the elemental composition of the statolith core revealing three different hatching locations. Juvenile squid and adult squid captured at the same time and location had different elemental composition at the edges of their statolith. Those differences suggest that the two ages of squid inhabit different parts of the water column. Statistical analysis also revealed that the location of capture and the location at which the squid hatched were different indicating horizontal and/or vertical movement. It appears that there was an ontogenetic shift with respect to depth of the water column and location in the Eastern Bering Sea. *Berryteuthis magister* is not currently a targeted fishery species however it has the ability to become one quickly. This information will add to the sparse information that fisheries managers use to set the total allowable catch (TAC). The information about locations and life history movement of *Berryteuthis magister* in the Eastern Bering Sea can be used to track changes in distribution and life history characteristics as the Bering Sea ecosystem continues to change.

Poster S5-4217

The analysis of reasons for mass-death of culturing pufferfish (*Fugu rubripes*) caused by 0# light oil spilled on the sea

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The results for pufferfish indicate that the upper and lower surface of live fish gills appeared to be red with no mucus and anabrosis, while the upper surface of dead fish gills were khaki with mucus and anabrosis accounting for about 30 percent, and the lower layer was red or pink. Fresh fish liver was pink with the capillaries distributed but dead fish liver was pink and white with blood. The results of microbial detection showed that the number of heterotrophic bacteria, *vibrio* spp., filamentous fungi, and petroleum-degrading bacteria in dead fish gills was 8.1×10^5cfu/g, 6.0×10^4cfu/g, 1.2×10^5cfu/g and 1.1×10^6cfu/g respectively, which was about 80, 200, 120 and 2200 times more than those in the live fish gills (5.6×10^4cfu/g, 3.0×10^2cfu/g, $< 1.0\times10^3$cfu/g, 5.0×10^2cfu/g). This clearly shows that the gill tissue of dead pufferfish was polluted by oil, because normally there isn't such a high concentration of hydrocarbon-degrading bacteria in fish gill tissue (1.1×10^6cfu/g). A mass of petroleum-degrading filamentous fungi in pufferfish gills can result in serious loss of gill function and eventually to death by asphyxia. The pathology results of these pufferfish support this conclusion.

Poster S5-4256

Ecosystem services valuation of coastal aquaculture

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As a main activity along the coast of the world, marine aquaculture not only provides seafood to human beings, but also contributes to marine ecosystem services. A valuation study was conducted in Sanggou Bay, a typical and intensive marine aquaculture area in the Yellow Sea of China. The results show that the total value of ecosystem services (VES) in Sanggou Bay was 7.34×107 USD from 2003 to 2004, of which provision services, regulating services, and culture services accounted for 51.29%, 17.34%, and 31.37%, respectively. The average value of marine aquaculture was 5.13×105 USD/km^2, 1.27-fold the global average value in coast (4052 USD/ha, concluded by Costanza *et al.*, 1997). Among the farming species, kelp (*Laminaria Japonica*) contributed the biggest part of ecosystem services (2.15×107 USD), followed by abalone (*Haliots discus hannai*) and sea cucumber (*Apostichopus japonicus*). However, the phytoplankton in the ecosystem only provided a small proportion (9.68×105 USD). The results show that aquaculture activities not only contributed to the local economy (51.29%), but also contributed to environmental regulation and social culture (48.71%). The results also suggest that marine aquaculture activities are important to maintain and promote ecosystem services, especially macroalgae farming. We should not only focus on marine aquaculture production, we also should give more consideration to environmental regulation and social culture services in management.

Poster S5-4279

Recent feeding habits of sei whale *Balaenoptera borealis* in pelagic waters of the western North Pacific based on data collected from 2002 to 2006

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North Pacific sei whales *Balaenoptera borealis* spend the summer in sub arctic waters and associated transition zones. Although this species seems to play an important role in the ecosystem, its feeding habits have not been documented for almost two decades. The purpose of this study is to examine recent feeding habits of the sei whale in the western North Pacific. The stomach contents of 389 sei whales sampled by the Second Phase of Japanese Whale Research Program under Special Permit in the western North Pacific (JARPN II) were examined. Whales were sampled from May to September during the years 2002-2006 in the longitudinal sector from the Pacific coast of

Japan to 170°E and the latitudinal range between 35° and 50°N. Each of the prey categories was plotted on a map based on the locality of sampling, and then correlated with information on sea surface temperature (SST). The main prey items of sei whales were species that aggregate near the surface, such as copepods (mostly *Neocalanus plumchrus* and *N. cristatus*), euphausiids (mostly *Euphausia pacifica*), Japanese anchovy (*Engraulis japonicus*) and Pacific saury (*Cololabis saira*). Prey species distribution was closely related to SST of 10-20°C for all survey years. Japanese anchovy (mostly larger than 100mm) was the most commonly found prey species except in 2005, and the anchovy accounted for stomach content weights greater than 500kg. These results were compared to previous studies based on commercial whaling data in the western North Pacific.

Poster S5-4319

Age and growth of *Arctoscopus japonicus* in the East/Japan Sea

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Age and growth of *Arctoscopus japonicus* were investigated from samples randomly collected in the East Sea of Korea from January, 2005 to December, 2006. Ages were determined from annuli in otoliths and annuli were formed between December and January once a year. Also, the main spawning period of *Arctoscopus japonicus* is estimated to be between November and December, thus rings were considered to be annual marks. Sagittal sections and transverse sections were used for determining the age of *Arctoscopus japonicus* and we compared the results of sagittal sections with those of transverse sections. The relationships between total length and total weight and growth parameters were estimated with error structure to provide accuracy. For the relationship between total length and total weight, a multiplicative error structure was assumed because variability in growth increased as a function of the length. The variability in growth was constant as a function of age, revealing an additive error structure. The von Bertalanffy growth parameters estimated from a non-linear regression method were L_∞ = 31.56 cm, K = 0.228/year, t_0 = -0.523 years for female and L_∞ = 21.86 cm, K = 0.382/year, t_0 = -0.182 years for male. The growth of females and males was different.

Poster S5-4368

Brown trout (*Salmo trutta*) movements between a stream and the sea in Hokkaido, northern Japan

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In Hokkaido, northern Japan, introduced brown trout (*Salmo trutta*) were recently observed. But there has been insufficient information to discuss the mechanisms and degree of natural expansion of its range. Using acoustic telemetry and otolith analyses, we aimed to understand how it possibly has spread and the risk of natural expansion in the future. From November 2006 to May 2007, five acoustic receivers were set upstream within three kilometers of the mouth of Hekirichi River, southwest Hokkaido. Seven brown trout (395-688mm, mean 499mm), including mature females were caught with a weir and electrofishing. Acoustic transmitters were attached on tagged fish and released. Five of seven fish migrated upstream and stayed three weeks to three months at specific pools and emigrated from the river to the sea. An individual stayed in two upstream pools until early January, but the signals were lost after January fourth. The other individual's presence was confirmed at two upstream receivers, but it left there after the signal was received in February. Our results suggested that brown trout in the study area include the sea-run form (sea trout: *S. trutta* morpha trutta). Sea trout may return to the Hekirichi River for spawning or overwintering in early winter and emigrate from streams to the sea in late winter to early spring. To examine the latter hypothesis, we are currently conducting otolith chemistry analyses of 47 sea trout (137-592mm TL, 1-4+age) captured in the coastal sea off the study area.

Poster S5-4372

Annual spatial variability of krill influences seabird foraging behavior near Elephant Island, Antarctica

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We investigated the influence of krill patchiness on seabird foraging behavior to understand how inter-annual variation in krill distribution influences patch dynamics between krill and seabirds. At sea surveys were conducted near Elephant Island for three years (2004-2006) during the Antarctic Marine Living Resources (AMLR) program. Standardized strip-transect surveys were used to map seabirds, and a combination of acoustic and net surveys was used to map krill. We measured patch size of krill and seabirds to ask whether patch dynamics of krill influence where seabirds choose to forage. We found that the spatial association of krill and predators was influenced by the size and arrangement of krill patches. Consequently, we found opposing behavioral responses by Cape Petrels (*Daption capense*) and Chinstrap Penguins (*Pygoscelis antarctica*) to krill patches. Cape Petrels were spatially associated with krill when krill patches were clumped, whereas penguins preferred regions where krill patches were arranged in a more uniform fashion. Interestingly, we found that the relationship between abundance and patchiness of krill and krill predators was negative, indicating that when krill is less abundant, patches are more likely to be found in fewer areas. This study provided important insight on inter-annual patch dynamics of krill and krill predators at local scales. Such information could be used to interpret and predict potential interactions between seabirds and krill fisheries operating near Elephant Island.

Poster S5-4395

The Columbia River plume as an ecotone and habitat for juvenile chinook salmon

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The Columbia River plume is a dynamic coastal feature influenced by variable river flow, wind forcing, and tidal forcing. Enhanced production and accumulation of prey within the plume may increase availability of food during salmon early ocean survival. Physical and biological sampling was conducted along a cross-shelf transect through the plume during May 1999. Based on multivariate analyses (PCA and Cluster Analyses) on 11 variables, the stations at 15, 20, and 25 nautical miles (nm) from shore were distinct from those inshore (4-10 nm) and offshore (30-50 nm) and were considered the core of the plume. Five variables (temperature at 3 m, salinity at 3 and 10 m, silicate and nitrate) accounted for 96% of this difference. Subsurface plankton tows (meter net) revealed differences in plankton composition at stations 10-20 nm. Surface neuston tows showed a distinction between inshore (< 20 nm) and offshore stations. Overall plankton biomass was substantially higher at the outer stations. Stomach contents of juvenile Chinook salmon collected in and out the plume were compared with meter net zooplankton and neuston samples from the same stations Substantial inshore-offshore variability in diet composition and overall stomach fullness was observed, with a breakpoint occurring beyond 20 nm. Comparisons of matched similarity matrices showed that the stomach composition was more similar to the neuston (Spearman $\Delta = 0.572$) than to the meter net composition ($\Delta = 0.331$). Thus, although juvenile Chinook salmon were abundant in the plume, feeding conditions and success were not necessarily better for them compared to non-plume waters.

Poster S5-4411

A stable isotope method to discriminate the origin of nerkids (*Oncorhynchus nerka*) in BC lakes

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Many lakes in British Columbia contain sockeye salmon as well as the non-anadromous form, kokanee; some lakes also contain residual sockeye (non-anadromous fish with anadromous parents). Unfortunately, these three forms of *Oncorhynchus nerka* cannot be visually distinguished as juveniles. Our inability to differentiate among these forms hampers our ability to assess the status of populations as well as to evaluate the effectiveness of conservation measures and fishery management practices. Here, we report the results of a pilot study that uses the ratio of stable sulphur isotopes ($\delta^{34}S$) in the otoliths of fish of known origin from various BC lakes to discriminate sockeye from kokanee. $\delta^{34}S$ was also measured in sockeye and kokanee eggs and zooplankton. Sockeye eggs were 10 to 15 ‰ more enriched than kokanee eggs, as was their diet. Our results demonstrate links between the mother's diet and eggs and the otolith of their progeny. $\delta^{34}S$ proved to be a useful chemical marker to infer anadromous and non-anadromous origins of *Oncorhynchus nerka.*

Poster S5-4427

Spatial and temporal patterns in Pacific cod reproductive maturity in the Bering Sea

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As part of a North Pacific Research Board funded project, the Fisheries Interactions Team is using histology to validate a six-stage gross maturity key for Pacific cod, *Gadus macrocephalus,* in the Bering Sea. Pacific cod is an important species in Alaska, economically and ecologically, but little is known of its spawning dynamic. While knowledge of spawning processes provides valuable insight into human- and climate-effects on marine fish populations. The objective of this project is to identify spatial and temporal patterns in Pacific cod spawning in the Bering Sea. We will accomplish this objective by making maps of the distribution of cod at various maturity stages during all seasons of the year. The maps will be based on maturity data collected by fisheries observers deployed throughout the Bering Sea using the six-stage key. The results will provide information on the spatial connectivity of Pacific cod spawning aggregations, particularly during winter when cod spawning occurs. We will also relate the spatial patterns of cod spawning to habitats previously identified as having different levels of fishing effect on living structure in the Bering Sea. This will provide information on the human-related impacts of habitat disturbance on Pacific cod reproduction.

Poster S5-4490

Species structure of epipelagic nekton of the Okhotsk Sea

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Nekton species structure of the Okhotsk Sea was analyzed based on data trawl surveys conducted in 1980-2005. Various aspects of dynamics of integrated parameters (numerical quantity) of nekton and separate dominating species (*Theragra chalcogramma*, *Clupea pallasii*, *Leuroglossus schmidti*, *Mallotus villosus*, *Sardinops melanostictus*, *Oncorhynchus gorbuscha*, *Limanda sakhalinensis*) are considered. The species structure of nekton is interpreted as the ordered list of species making it together with their abundances. This distribution is presented in the form of a rank curve. The rank curve of the nektonic species is well described by the so-called model of

geometric series or the model of Motomura. Based on this model potential species richness of epipelagic nekton accounted for 480 ± 2 species. This estimation on 13% exceeds the total number of species noted in ours catches. Dynamics of nekton has been studied from the point of view of three time scales - daily, seasonal and interannual. According to these time scales speed of succession has been calculated. For unit of a time scale one month has been chosen. Speed of daily succession has amount 8.794 $months^{-1}$, seasonal - 0.138 $months^{-1}$, interannual - 0.036 $months^{-1}$.

S6 MEQ Topic Session
The relative contributions of off-shore and in-shore sources to harmful algal bloom development and persistence in the PICES region

Co-Convenors: Hao Guo (China) and Vera L. Trainer (U.S.A.)

There is increasing recognition that some harmful algal blooms (HABs) affecting coastal waters may not have local origins but are advected from offshore waters. This session will highlight recent advances in studying the processes involved in near-shore *versus* off-shore development and transport of harmful algal blooms in the coastal waters of the PICES region. Of particular interest are field studies where the relative importance of local *versus* remote development of HABs has been assessed. The session invites papers describing known off-shore and near-shore initiation sites, seedbeds, and the physical factors that facilitate transport of HABs to coastal sites where they may impact fisheries.

Tuesday, October 30, 2007 09:00 – 12:40

09:00 ***Introduction by convenors***

09:10 **Michael Foreman, Wendy Callendar, Amy MacFadyen, Barbara Hickey, Vera Trainer, Angelica Peña, Richard Thomson and Emanuele Di Lorenzo (Invited)**
Juan de Fuca Eddy generation and its relevance to harmful algal bloom development along the outer Washington coast (S6-4085)

09:40 **Luzviminda M. Dimaano, Lewelen A. Arcaya, Joseph Chester M. Malaca, Francis Martin M. Mirasol and Mark Joseph D. Tan**
The distribution of three toxic epiphytic dinoflagellates as potential bioindicators of anthropogenic pollutants in the reefs of San Fernando, La Union, Philippines (S6-4026)

10:00 **Amoreena MacFadyen, Barbara Hickey, Vera Trainer and William Cochlan**
The Juan de Fuca Eddy – An initiation site for toxigenic *Pseudo-nitzschia* blooms impacting the Washington coast (S6-4297)

10:20 **Tatyana A. Mogilnikova, Elena M. Latkovskaya, Izolda A. Mitrakovich, Natalya V. Konovalova, Irina V. Motylkova, Tatyana G. Koreneva, I Ken Chi, Ludmila Yu. Gavrina and Maria A. Smirnova**
Toxic phytoplankton in Aniva Bay and environment conditions of development (S6-4084)

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

11:00 **Mingyuan Zhu, Mingjiang Zhou and Ruixiang Li (Invited)**
HAB process in the coastal water of Zhejiang province, East China Sea (S6-4313)

11:30 **Angelica Peña and Michael Foreman**
Biophysical modeling of the Juan de Fuca Eddy in the Pacific Northwest (S6-4377)

11:50 **Xuelei Zhang, Z.J. Xu and M.Y. Zhu**
Impact of atmospheric dust on phytoplankton growth in the Yellow Sea and western Pacific (S6-4077)

12:10 **Douding Lu and Dedi Zhu (Invited)**
Blooms of dinoflagellates in the East China Sea – Possible linkages to physical processes (S6-4196)

S6 Posters

S6-4074 **Hao Guo, Huan Wang, Bin Liang and Bin Chen**
Application of a Fluorescence *In-Situ* Hybridization (FISH) method to detect *Alexandrium* spp.

S6-4135 **Zohreh Ramezanpour, Javid Imanpour and Karim Mehdinezhad**
Harmful bloom of invasive algae in the southern Caspian Sea

S6-4213 **Chunjiang Guan, Hao Guo and Wen Zhao**
Accumulation and elimination of *Alexandrium tamarense* toxins by the scallop, *Argopectens irradias*

S6-4257 **Yaobing Wang, Binxia Cao, Yan Yin and Hao Guo**
The relationship between algical bacteria and *Alexandrium tamarense*

S6-4334 **Zongling Wang, Ruixiang Li, Mingyuan Zhu, Xiao Liu, Yanju Hao and Xihua You**
The density-dependent interspecific competition between *Prorocentrum donghaiense* and *Alexandrium tamarense*

S6 Oral Presentations

30 October, 09:10 (S6-4085) Invited

Juan de Fuca Eddy generation and its relevance to harmful algal bloom development along the outer Washington coast

Michael **Foreman**[1], Wendy Callendar[1,2], Amy MacFadyen[3], Barbara Hickey[3], Vera Trainer[4], Angelica Peña[1], Richard Thomson[1] and Emanuele Di Lorenzo[5]

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Recent studies indicate that the Juan de Fuca Eddy, a summer nutrient-rich retentive feature off the entrance Juan de Fuca Strait, is an initiation site for the toxigenic phytoplankton *Pseudo-nitzschia* that impact shellfish along the outer Washington coast. As part of ECOHAB PNW, a project funded by the Ecology and Oceanography of Harmful Algal Blooms program, six field programs in 2003-2006 have been combined with bio-physical modelling to better understand the development and transport of these HABs. In this presentation, we will describe physical model simulations showing that the eddy is generated by enhanced wind and tidally-driven upwelling off Cape Flattery. Variations in the winds and tides will be shown to not only change the location and intensity of this eddy, but also in some cases, to reduce the upwelling and transport the offshore toxic water to the coast.

30 October, 09:40 (S6-4026)

The distribution of three toxic epiphytic dinoflagellates as potential bioindicators of anthropogenic pollutants in the reefs of San Fernando, La Union, Philippines

Luzviminda M. **Dimaano**, Lewelen A. Arcaya, Joseph Chester M. Malaca, Francis Martin M. Mirasol and Mark Joseph D. Tan

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The current status on the distribution of the three toxic *ciguatera*-causing epiphytic dinoflagellates, namely *Gambierdiscus* sp., *Ostreopsis* sp. and *Prorocentrum* sp., as bioindicators of anthropogenic pollutants was studied from April to October 2006. Abiotic factors including temperature, pH, dissolved oxygen (DO), and metal concentrations were measured in order to correlate these factors with toxic dinoflagellate populations in the surrounding coastal areas. The cells were counted using an improvised Sedgewick Rafter counting chamber and statistically analyzed using one-way ANOVA to compare means per species and per sampling collections. The results showed that majority of the dinoflagellates during the entire study were *Gambierdiscus* sp., *at a* mean density of 27.186 cells per gram algae. Temperature and DO were notably lower at locations where *Gambierdiscus* sp. was found. Moreover, the mean population counts of both *Prorocentrum* and *Ostreopsis* were 18.47 and 21.334 cells per gram alga, respectively.

30 October, 10:00 (S6-4297)

The Juan de Fuca Eddy – An initiation site for toxigenic *Pseudo-nitzschia* blooms impacting the Washington coast

Amoreena **MacFadyen**[1], Barbara Hickey[1], Vera Trainer[2] and William Cochlan[3]

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In 2002, the ECOHAB-PNW program was initiated to examine the physiology, toxicology, ecology and oceanography of toxigenic species of *Pseudo-nitzschia* on the Washington shelf. The working hypothesis of the project is that the Juan de Fuca Eddy is an initiation site for toxic *Pseudo-nitzschia* that impact the Washington coast and that cells in coastal upwelling sites are less likely to develop toxicity. Events at the coast occur when blooms are advected from the eddy to razor clam sites. We re-examine this hypothesis after four years of field studies. One of our studies (September 2004) coincided with the highest concentrations of *Pseudo-nitzschia* cells and domoic acid ever measured in this region We use the survey data to emphasize characteristics of the eddy that may be important to the development and sustenance of these large, toxic blooms. The presence of the eddy causes large inputs of nutrients to the region through two mechanisms: doming of deep water within the eddy and enhanced cross-shelf advection of Juan de Fuca Strait outflow. Eddy surface circulation becomes more retentive during periods of weak winds or when frequent northward reversals occur. Retentive circulation patterns combined with persistent nutrient supply may favor *Pseudo-nitzschia* bloom development in this region. For toxic blooms present in the eddy to impact the coast requires first a period of sustained upwelling, during which time currents in the southern margin of the eddy are directed southeastward allowing particles to escape the eddy, followed by a storm with associated onshore advection.

30 October, 10:20 (S6-4084)

Toxic phytoplankton in Aniva Bay and environment conditions of development

Tatyana A. **Mogilnikova**, Elena M. Latkovskaya, Izolda A. Mitrakovich, Natalya V. Konovalova, Irina V. Motylkova, Tatyana G. Koreneva, I Ken Chi, Ludmila Yu. Gavrina and Maria A. Smirnova

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Toxic phytoplankton species composition, seasonal changes in abundance and environmental conditions in Aniva Bay were observed during 2003-2005. The paralytic shellfish toxin-producing dinoflagellate *Alexandrium* was the primary harmful species observed. The greatest abundance of *Alexandrium tamarense* was found from May-July when increasing temperature and maximum concentration of nutrients were observed. The seasonal appearance of species such as *Dinophysis* began in August during the warmest period after the peak of nutrient concentrations in June. Minimum concentrations of nutrients were observed in July and August. In October and December, the numbers of *Dinophysis* species continued to increase. Species of *Pseudo-nitzschia* were detected during all sampling periods, including April through December. Numbers of *Pseudo-nitzschia* spp. increased in August and achieved their peak in October. The appearance of each toxic species has a unique seasonality in this region. The seasonal occurrence of certain harmful algal species corresponds to changes in ecological conditions. For example, in May, a high level of fine-grain sediment, as well as organic and metal pollution in water and sediment were observed in coastal areas. In September, river run off was elevated. The concentration of nutrients and pollutants at open-sea stations sampled in May was dependent on tides and water depth. The level of pollutants in sediment was correlated with the sediment grain size. Metal concentrations in sediment (except Hg and Zn) were highest in southeast areas of Aniva Bay.

30 October, 11:00 (S6-4313) Invited

HAB process in the coastal water of Zhejiang Province, East China Sea

Mingyuan **Zhu**[1], Mingjiang Zhou[2] and Ruixiang Li[1]

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Since 2002, 12 cruises were conducted to study large-scale HABs in the coastal waters of Zhejiang province, East China Sea. The HABs occurred in the area between 27-31°N in a water depth of 30-50 m. The main causative species were *Prorocentrium donghaiense (dentatum)*, *Alexandrium catenella* and *Karenia mikimotoi*. There was a succession from a diatom bloom to a dinoflagellate bloom. The dinoflagellate bloom consisted of 4 stages, including initiation, development, proliferation and dispersal. Temperature, salinity and nutrients were important factors for the development and persistence of the bloom. Although blooms moved towards the coast, often the high turbidity of coastal waters prevented the HAB from reaching the beach. A preliminary hypothesis describing the mechanism of large-scale dinoflagellate blooms will be discussed.

30 October, 11:30 (S6-4377)

Biophysical modeling of the Juan de Fuca Eddy in the Pacific Northwest

Angelica **Peña** and Michael Foreman

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Recent studies suggest that the Juan de Fuca Eddy, a summer nutrient-rich retentive feature off the Washington and British Columbia coasts, may be an initiation site for toxic *Pseudo-nitzschia* blooms that impact shellfish along the outer Washington coast. In this presentation, we will describe a bio-physical model developed to study factors influencing phytoplankton bloom dynamics. The biological model includes two size classes of phytoplankton and zooplankton, nitrate, ammonia and silicate. Model results are analyzed to explore the influence of the eddy on the growth of phytoplankton. We seek to understand 1) the environmental factors that makes the Juan de Fuca Eddy more viable for the growth and sustenance of phytoplankton, and 2) likely conditions for shoreward transport of phytoplankton blooms. This study is part of ECOHAB PNW, a project funded by the Ecology and Oceanography of Harmful Algal Blooms program to investigate the formation, toxicity, and transport of *Pseudo-nitzschia* spp. blooms in the Juan de Fuca Eddy.

30 October, 11:50 (S6-4077)

Impact of atmospheric dust on phytoplankton growth in the Yellow Sea and western Pacific

Xuelei **Zhang**, Z.J. Xu and M.Y. Zhu

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Sand and dust storm-derived atmospheric loads to coastal oceans have been an environmental concern. In the Northwest Pacific region, the Yellow Sea is an area that receives considerable atmospheric dust. It is estimated that, during a strong sand-dust storm, the atmospheric dust load from “dry” precipitation will be higher than normal wet precipitation caused by rain. Laboratory incubations were performed to study the impact of such high dust loads on phytoplankton growth. A load of 40 mg dust per liter of water from the West Pacific Ocean stimulated the growth of an inoculated diatom. The same level of dust load, however, did not trigger a significantly greater level of phytoplankton growth, either in shipboard experiment in the Yellow Sea or in a laboratory experiment with coastal water from Qingdao, on the western shore of the Yellow Sea. Analysis of the nutrient content indicates nitrogen concentrations may be responsible for the differential impacts of dust loads on phytoplankton growth in these experiments. These results suggest that the impact of atmospheric dust load on phytoplankton growth may be dependent on the background nutrient levels in the seawater.

30 October, 12:10 (S6-4196) Invited

Blooms of dinoflagellates in the East China Sea – Possible linkages to physical processes

Douding **Lu** and Dedi Zhu

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Extensive blooms of dinoflagellates, caused primarily by *Prorocentrum donghaiense* Lu in the spring, have been a recurrent phenomenon for the last decade in the East China Sea (ECS). More recently, *Karenia mikimotoi*, an ichtyotoxic species, has also formed massive blooms either by itself or co-occurring with *P. donghaiense*. Field observations have suggested that populations of these dinoflagellates have initiated in the subsurface layer in offshore waters where they are influenced by the Taiwan warm current (TWC). For instance, the density of *P. donghaiense* exceeded 10,000cells/L in early April 2004 and became the dominant phytoplankton species in subsurface micro thin layers near the 50 m isobath where an inoculum of the causative species was found and resulted in the subsequent development of massive blooms. In late April 2005, *K. mikimotoi* became dominant in an offshore subsurface layer after a diatom bloom followed by dominance of *P. donghaiense* and *Scrippsiella trochoidea*. This led to the development of the first large-scale bloom of *K. mikimotoi* recorded in the ECS which caused severe damage to farmed caged fish in inshore waters in late May and early June. Offshore subsurface layers can therefore act as incubators for subsequent massive blooms of *P. donghaiense* and *K. mikimotoi*, which are subsequently advected to inshore regions. Physical processes in the spring such as termination of monsoons, water stratification, and the advance of the TWC play an important role in forming large-scale blooms of dinoflagellates in the ECS. More studies and long-term monitoring projects are required for further elucidating the population dynamics of these HAB species in order to establish an effective early warning system in the future.

S6 Posters

Poster S6-4074

Application of a Fluorescence *In-Situ* Hybridization (FISH) method to detect *Alexandrium* spp.

Hao **Guo**[1], Huan Wang[2], Bin Liang[1] and Bin Chen[1]

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In this study, the 5.8S rRNA along with the flanking internal transcribed spacers and the 5' portion of the large-subunit (LSU) rDNA of three strains of *Alexandrium* (YA, QA, 669), were amplified, sequenced, and used to design specific probes for species detection. A Fluorescence *In-situ* Hybridization (FISH) technique was used to detect *Alexandrium* species using fluorescein labeled probes targeted to LSU rRNA (Alexp1). The ITS and LSU length of the 3 *Alexandrium* strains, YA, QA and 669, were 660bp and 656bp, 652bp and 698bp, 696 and 702bp respectively. Specific amplifications were obtained using each pair of primers and BLAST searches of the ITS sequences were used to compare with other ITS and LSU sequences of *Alexandrium* spp. in GenBank. Results showed that strains QA and YA were 99% identical to *Alexandrium tamarense*, and *Alexandrium catenella* in Genbank, so they were classified as *A. catenella* types. Strain 669 was 99% identical to *A. minutum*. FISH results showed that Alexp1 is an ideal probe to specifically label *A. tamarense* (QA strain) and *A. catenella* (YA strain). Green fluorescence from the targeted cells was observed using epifluorescent microscopy, while *A. minutum cells* did not fluoresce when incubated with the Alexp1 probe. In addition *A. tamarense* and *A. catenella* labeled by probe Alexp1 could be easily distinguished from other algal cells using fluorescence microscopy. The routine application of this technique in monitoring programs will allow for rapid detection of toxic *Alexandrium* species in field samples.

Poster S6-4135

Harmful bloom of invasive algae in the southern Caspian Sea

Zohreh **Ramezanpour**[1], Javid Imanpour[2] and Karim Mehdinezhad[1]

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In this study, the occurrence and pattern of algal blooms were examined from March 2001 to September 2006 in the southern basins of the Caspian Sea, Northern Iran. Water and air temperature, wind speed and direction, and fluctuation of the Caspian Sea level were measured. Our study revealed the presence of two types of harmful algal blooms. The first bloom occurred in September 2005 from the Bandar Anzali region to the Chaboksar region (ca. 200 km in length) and the main phytoplankton species was *Nodularia spumigena*. The bloom was characterized by opaque cotton-like filaments densely extended over the surface of the water. The surface water temperature was 27^{o}C; the pH and salinity were 8.4 and 9-12 ppt, and average concentrations of nitrate and phosphate were 0.004 and 0.033 mg.l^{-1}, respectively at the time of bloom. In the recent years the pattern of bloom in the southern Caspian Sea is similar to that of the Baltic Sea which experiences blooms of *N. spumigena* every year. The second bloom was observed in March 2006 with *Rhizosolenia calcaravis* as the primary bloom-forming species. The bloom was characterized by a homogenous, thin, transparent layer of colloidal detritus particles in the water column. Both of these algae are non-native and invasive to the Caspian Sea ecosystem. Changes in the ecosystem of the Caspian Sea due to pollution, oil extraction and climate change have accelerated the occurrence of harmful algal blooms, These blooms have detrimental impacts on native species, resulting in significant changes in phytoplankton diversity and a dramatic decline (ca. 70%) of invaluable native fish species such as sturgeon.

Poster S6-4213

Accumulation and elimination of *Alexandrium tamarense* toxins by the scallop, *Argopectens irradias*

Chunjiang **Guan**[1], Hao Guo[1] and Wen Zhao[2]

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[2] Dalian Fisheries University, Dalian, 116023, PR China

Using a PSP (Paralytic Shellfish Poisoning) toxin-producing strain of *Alexandrium tamarense*, we studied the timing of toxin accumulation and elimination of PSP toxins in *Argopectens irradias*. The PSP toxicity was studied by following the standard PSP mouse bioassay developed by the Association of Official Analytical Chemists (AOAC). *Alexandrium tamarense* was cultured to an average density of 1.26×10^{4} /ml for a total of about 50 L culture. The toxicity of the alga was 2.18×10^{-6} MU/cell. The results show that PSP content increased with time in both visceral and muscle tissue during a two-week accumulation period during which scallops were fed with *A. tamarense*. The average toxin level in scallop viscera was 49.4MU/g, with an average of 10.0MU/g in muscle tissue. This level is 2.5 times higher than the sanitation standard (4.0MU/g of muscles). The highest value was 61.0MU/g in the viscera. In summary, the viscera accumulated greater concentrations of toxin than muscle tissue. Scallops that had accumulated toxins were transplanted for two weeks into a field environment containing no toxic algae. The PSP content of the scallops decreased to 7.9MU/g viscera and 1.6 MU/g muscles two weeks after being transplanted, but did not reach the sanitation standard. Under the experimental conditions, the toxin depuration rate of shellfish toxin was 12% daily. This study worked toward the development of a sanitary shellfish industry and better management of PSP toxin-impacted shellfish in China.

Poster S6-4257

The relationship between algical bacteria and *Alexandrium tamarense*

Yaobing **Wang**[1], Binxia Cao[2], Yan Yin[2] and Hao Guo[1]

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Alexandrium tamarense is one primary species of harmful algae that not only leads to massive mortalities of wild and farmed fish and causes serious destruction to marine ecosystem, but also threatens the health of humans. However, bacteria are abundant in marine ecosystems and possess the qualities of rapid replication and host-specificity. Recently certain algicidal bacteria have been studied for their ability to control harmful algal blooms. However, a study of the interactions between bloom microalgae and algicidal bacteria as well as the potential ecological impacts on the use of these bacteria as a mitigation tool is necessary. In our study, three strains of algicidal bacteria that were isolated from the body of seaweed, the surface of the sediment and from seawater along the Dalian coast, showed an algal-lysing effect on the harmful alga, *A. tamarense*. This algical effect was proportional to the concentration of the three strains of bacteria. At a high concentration (10^{10}cells/mL), the algical effects of these bacteria were more marked in *A. tamarense* in the exponential growth phase than in the lag phase. Notably, these bacterial strains did not lyse the cells of other algae species, such as *Heterosigma akashiwo*, *Prymnesium parvum, Dunaliella salinq*, and *Dicrateria* sp., rather promoted their growth. The results showed the three strains of bacteria have special algical properties against *A. tamarense*. After morphological examination and molecular analysis, the identity of the bacteria was confirmed as *Pseudoalteromonas*.sp., *Shewanella* sp. and *Polaribacter* sp., respectively. The mechanisms of algal cell lysis and the possibility of HAB control by biological methods will be discussed.

Poster S6-4334

The density-dependent interspecific competition between *Prorocentrum donghaiense* and *Alexandrium tamarense*

Zongling Wang, Ruixiang Li, Mingyuan Zhu, Xiao Liu, Yanju **Hao** and Xihua You

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In this paper, we have studied the population dynamics and interspecific competition of two important HAB species, *Prorocentrum donghaiense* and *Alexandrium tamarense*, in the East China Sea. The results show that there are conditions under which these species either bloom together or singly. For example, at a low concentration of phosphate, *P. donghaiense* is always the winner. However, at high concentration of phosphate, the results of the competition depend on the initial inoculating cell density of the two species, which will determine whether the two species will competitively exclude each other or coexist. The results are consistent with field data indicating that the two species causing red tides in the East China Sea can either co-exist or bloom as a single species.

S7 MEQ/FIS Topic Session Coldwater biogenic habitat in the North Pacific

Co-Convenors: Glen S. Jamieson (Canada), J. Anthony Koslow (U.S.A.) and Jin-Yeong Kim (Korea)

Some of the fauna that are most vulnerable to physical disturbances are the long-lived, slow growing and physically fragile species (corals and sponges) that provide biogenic habitat in deep water. It is increasingly recognized world-wide that deepwater biogenic habitat has not been conserved in the past, with the result that the conservation of such habitat has become a high priority in many jurisdictions. At least in the eastern Pacific, large areas have been established to exclude bottom trawling to protect deep-water corals and sponges. Considerable effort is being expended to identify and determine their distributions and to assess their ecological role as fishery habitat. This session welcomes presentations that describe: 1) distributions of deepwater biogenic habitat in the PICES regions; 2) threats to biogenic habitat species in the area; 3) the ecological role of biogenic structures as habitat for commercial and other species; and 4) the management measures applied or developed to conserve these species and the habitat they provide.

Tuesday, Oct. 30, 2007 14:00 – 18:10

14:00 **Alex D. Rogers (Invited)**
Biogenic habitats in the deep sea: Biodiversity and interactions with fisheries (S7-4480)

14:30 **Malcolm Clark, Derek Tittensor and Alex D. Rogers**
Seamounts, deep-sea corals, and fisheries in the Pacific Ocean (S7-4465)

14:50 **Curt E. Whitmire and M. Elizabeth Clarke**
Census of deep-sea/cold-water corals off the western coast of the United States (S7-4393)

15:10 **Jonathan Heifetz, Douglas Woodby, Jennifer R. Reynolds and Robert P. Stone**
Deep sea coral distribution and habitat in the Aleutian Archipelago (S7-4048)

15:30 **Amy R. Baco**
Population genetic structure of the deep-sea precious coral *Corallium secundum* from the Hawaiian archipelago based on microsatellites (S7-4446)

15:50 ***Coffee / tea break***

16:10 **Glen S. Jamieson**
Deep-water biogenic habitat in Pacific Canada: Challenges to its conservation (S7-4039)

16:30 **Jeffrey B. Marliave and Donna M. Gibbs**
Ecological function as rockfish nursery habitat of cloud sponges in Howe Sound and Strait of Georgia, British Columbia (S7-4245)

16:50 **Jin-Yeong Kim, Hyung-Kee Cha, Kwang-Ho Choi, Jong-Hwa Park and Sukgeun Jung**
Long-term change in dominant fishery species and their cold-water habitats in the Korean coastal waters (S7-4340)

17:10 **W. Waldo Wakefield and Brian N. Tissot**
Ecological associations between structure-forming invertebrates and demersal fishes on Heceta Bank, Oregon (S7-4421)

17:30 **Edward J. Gregr and Glen S. Jamieson**
An ecological classification of sponge and coral habitat in Pacific Canadian waters (S7-4385)

17:50 **Doug Woodby, Dave Carlile and Lee Hulbert**
Predictive modeling of coral and sponge distribution in the central Aleutian Islands (S7-4399)

S7 Posters

S7-4474 **Jessica L. Finney, E.J. Gregr, Glen S. Jamieson and S. Patton**
Predicting suitable habitat for deep sea coral in British Columbia

S7-4501 **Sung Eun Park, Won Chan Lee, Hyun Taik Oh, Sok Jin Hong, Rae-Hong Jung and Sang Pil Yoon**
Numerical experiments on the stably stratified flow over a shallow seamount in a channel

S7 Oral Presentations

30 October, 14:00 (S7-4480) Invited

Biogenic habitats in the deep sea: Biodiversity and interactions with fisheries

Alex D. **Rogers**

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Scleractinian corals form spectacular cold-water coral reef communities on continental slopes, seamounts and banks from <200m depth to approximately 1,500m in many parts of the world. The corals generate a complex three dimensional framework that is inhabited by a diverse range of associated species. Some of these animals are obligate associates of the corals, although for most the relationship between framework-building species and associates is unknown. Scleractinia do not form the only biogenic habitats in the deep sea. Octocorals also form habitat, especially in the North Pacific, but also elsewhere in the world. Hexactinellid sponges are also important habitat-forming species on continental margins. It has been demonstrated that deep-water biogenic habitats are vulnerable to the impacts of trawling. Such impacts are not restricted to scleractinian reefs but also to other biogenic habitats which are likely to show a low resilience to trawling. In addition, other types of fishing gear, including static long lines, also show a by-catch of emergent epifauna. Whether this by-catch is significant in terms of the abundance and biomass of animals on the seabed is not understood at present. It is important that environmental and fisheries managers recognise the range of biogenic habitats on continental slopes, seamounts and banks and that trawling as a fishing method is not the sole focus of ecosystem-based fisheries management and conservation in the deep-ocean.

30 October, 14:30 (S7-4465)

Seamounts, deep-sea corals, and fisheries in the Pacific Ocean

Malcolm **Clark**, Derek Tittensor and Alex D. Rogers

National Institute of Water & Atmospheric Research, Private Bag 14-901, Wellington, New Zealand. E-mail: m.clark@niwa.co.nz

Seamounts are widespread features of the world's underwater topography, and may number 10s of thousands in the Pacific Ocean. They can support high biodiversity and unique biological communities. They are often highly productive, and bottom trawl fisheries target deepwater commercial fish species such as orange roughy, oreos, alfonsino, pelagic armourhead and redfishes. However, seamount habitat is ecologically vulnerable to such exploitation. In this talk we present results of recent studies by CenSeam (the Census of Marine Life programme on seamounts) that examine the relationships between seamounts, deepwater corals, and fisheries. The known distribution of stony corals worldwide is related to their physical environment, and then applied to potential seamount locations derived from satellite altimetry to estimate the likelihood of the seamount having suitable conditions for corals. Habitat suitability is then related to the distribution and depth ranges of deepwater trawl fisheries to assess their vulnerability. The North Pacific has a broad band of predicted habitat for stony corals at depths down to 250m, which becomes more restricted with depth. The South Pacific was similar, although habitat suitability was widespread through the 750m to 1250m depth range. This makes deeper seamounts in the South more vulnerable to fisheries targeting orange roughy and oreos, while the North Pacific seamounts are mainly at depths for species like alfonsino, pelagic armourhead and some of the shallower *Sebastes* spp. Careful management is required for all these seamount fisheries to avoid overexploitation of the fish stocks, and associated damaging effects of trawling on the coral habitat.

30 October, 14:50 (S7-4393)

Census of deep-sea/cold-water corals off the western coast of the United States

Curt E. **Whitmire** and M. Elizabeth Clarke

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Conservation of deep-sea or cold-water corals has become an important consideration in the last decade for many government agencies, institutions and conservation organizations throughout the world. Before conservation strategies can be developed, however, an initial census of coral taxa and their locations in the region of interest must be completed. As part of a nationwide effort to document what is known about their locations, habitats, ecological interactions and risk to stressors, we have completed such an initial census for the continental margin off the western coast of the United States. Observations of corals were compiled from a variety of data sources including the taxonomic literature, museum records, video from underwater vehicles, observations from fishery observers, and catch records from bottom trawl surveys. This review has revealed some interesting spatial patterns in the distribution of higher coral taxa in the region. For example, during bottom trawl surveys sea fans (Order Gorgonacea) are most frequently observed off southern California as compared with areas north of Point Conception, California. Also, the occurrence of sea pens and whips (Order Pennatulacea) increases with water depth. With the implementation of recent area closures to bottom-contact fishing gears, we also had the opportunity to evaluate how much of known coral habitats off the western coast of the United States are currently protected from gear impacts. Finally, while there is substantial data on cold-water corals in the region, we will detail gaps in information and make recommendations for future research.

30 October, 15:10 (S7-4048)

Deep sea coral distribution and habitat in the Aleutian Archipelago

Jonathan **Heifetz**[1], Douglas Woodby[2], Jennifer R. Reynolds[3] and Robert P. Stone[1]

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A unique feature of the Aleutian Archipelago is a highly diverse and abundant coral and sponge community. Coral abundance far exceeds that reported for other high latitude areas of the world, and there are many endemic species. Habitat mapping of seventeen sites covering 2,600 km^2 at depths of 30 – 3,800 m coupled with visual observations to 2,950 m were used to collect ecological information and develop predictive models that relate coral and sponge distribution to environmental characteristics. Habitats of bedrock and cobble supported the highest densities of corals. Diversity of corals and sponges increased from deep to shallow water. For the predictive model, the most important factors were depth and slope. Models of coral and sponge presence/absence north of the Aleutian Archipelago were more successful than models south of the Archipelago. The most damage and disturbance to coral and sponge communities occurred at depths < 800 m which generally corresponded to the depth limit of the majority of fisheries that use bottom contact gear. There was a consistent positive relationship between damage and disturbance levels and intensity of bottom trawling, whereas results varied for other gear types. Some commercial fish and crab species aggregate in coral habitat, making these habitats at risk to fishing gear impacts. Protective measures implemented in the Aleutian Islands include restricting bottom trawling to historically fished areas. While this protective measure may halt the expansion of bottom trawling to areas not fished, the conservation of coral and sponge habitat in fished areas is still of primary concern.

30 October, 15:30 (S7-4446)

Population genetic structure of the deep-sea precious coral *Corallium secundum* from the Hawaiian archipelago based on microsatellites

Amy R. **Baco**

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Deep-sea precious corals (*Gerardia* sp., *Corallium lauuense*, and *Corallium secundum*) in the Hawaiian Archipelago have supported a profitable fishery, yet little is known about the life history of the exploited species. Studies of shallow-water corals have indicated significant genetic structure between populations, even in species capable of long distance dispersal. If significant genetic structure exists in seamount and Island populations of deep-sea precious corals, this could suggest that elimination (through overharvesting) of a bed of precious corals would result in loss of overall genetic diversity in the species. Here I discuss results based on microsatellite studies of the precious coral, *Corallium secundum*, from 11 sites in the Hawaiian Archipelago collected between 1998 and 2004, and compare the population genetic structure of *Corallium secundum* to the results for *Corallium lauuense*. Microsatellite studies of *Corallium lauuense* indicated significant heterozygote deficiency in most populations, suggesting recruitment in most populations is from local sources with only occasional long-distance dispersal events. Also, two populations appear to be significantly isolated from other populations and may be separate stocks. In contrast, *Corallium secundum* populations have little heterozygote deficiency and separate into 3 distinct regions. In addition to having fisheries management implications for these corals, the results of these studies also have implications for the management and protection of seamount fauna. The precious corals represent a subset of a highly diverse, abundant deep-sea coral fauna in Hawaii. I will conclude with brief highlights from exploratory deep-sea coral cruises in 2003 and 2004 in the Hawaiian Archipelago.

30 October, 16:10 (S7-4039)

Deep-water biogenic habitat in Pacific Canada: Challenges to its conservation

Glen S. **Jamieson**

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Like most other countries, Canada is belatedly realizing that it has significant, largely unprotected biogenic habitat in the form of both cold-water corals and sponges. These species are relatively long-lived, slow growing, physically fragile and because they are emergent from the sea floor, are particularly vulnerable to physical damage from fishing gears such as trawls, longlines and traps. British Columbia to date has the world's only known living sponge reefs, with four relatively large offshore complexes covering about 1000 km^2 now closed to trawling, but also many smaller, nearshore, deepwater, currently unprotected reefs. There is currently no specific spatial protection for corals in British Columbia, and coral-specific surveys have yet to be conducted in identified areas of high coral bycatch. In contrast to Atlantic Canada, which has only around 27 documented species, but a number of coral-specific fishing closures, the north-east Pacific has a relatively high coral diversity, with at least 109 coral species projected to occur in British Columbia alone. Substantial trawl closures for biogenic habitat recently have been recently established in American waters both north and south of British Columbia, so the relative current lack of biogenic habitat management protection and its slow rate of introduction in British Columbia is noteworthy. Reasons for this situation are considered, and possible future protective measures evaluated.

30 October, 16:30 (S7-4245)

Ecological function as rockfish nursery habitat of cloud sponges in Howe Sound and Strait of Georgia, British Columbia

Jeffrey B. **Marliave** and Donna M. Gibbs

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Extensive colonies of cloud sponges, *Aphrocallistes vastus*, known as sponge gardens, occur on rock cliffs and ledges in the Strait of Georgia, BC, where these biogenic habitats are known to function as nursery habitat for early juvenile stages of the quillback rockfish, *Sebastes maliger*. Cloud sponges not only occur as gardens attached to rock

substrates, but also as bioherms or reefs of living cloud sponges growing on accumulated skeletal architecture of dead cloud sponges. In Howe Sound, relatively rare examples of such cloud sponge bioherms occur at depths accessible to scuba divers. Community biodiversity on these Howe Sound cloud sponge bioherms was found to be relatively low, with very little function as nursery habitat for rockfish. This is in contrast to the nursery function of cloud sponge gardens on steep rocky shorelines in the Strait of Georgia, where cloud sponges are a primary habitat for young quillback rockfish. In Howe Sound, the most abundant habitat of suitable complexity for juvenile quillback rockfish at their preferred depth range is cobble. Quillback rockfish are abundant in both regions. Predictability of geographic distribution probably determines relative significance of inert versus biogenic habitat in terms of ecological function.

30 October, 16:50 (S7-4340)

Long-term change in dominant fishery species and their cold-water habitats in the Korean coastal waters

Jin-Yeong **Kim**, Hyung-Kee Cha, Kwang-Ho Choi, Jong-Hwa Park and Sukgeun Jung

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There is growing evidence that temperature condition of Korean coastal waters is changing from the sub-arctic/temperate to the subtropical because of global warming. As a consequence, biomass and biodiversity of benthic algae has decreased, seaweed forests have been deteriorated and barren rocky shore area has expanded. In the eastern sea of Korea, various cold-water fishes spawn in the reefs and seaweeds of coastal area during winter and migrate offshore during spring-summer. Conditions in the spawning habitats could be critical in recruitment levels of those fishes by influencing spawning density, hatch rate and larval mortality. Dominant fishery species in the coastal coldwater areas include cod, herring, atka mackerel and sandfish. Commercial catches of cod and herring were high during the 1930s, but were collapsed in the 1940s. Catches of atka mackerel and sandfish peaked in the 1980s and have been decreasing since the 1990s. We will relate commercial catches of dominant species to variations in environmental factors in the cold-water habitats with emphasis on recovering biogenic habitats and rebuilding fish stocks.

30 October, 17:10 (S7-4421)

Ecological associations between structure-forming invertebrates and demersal fishes on Heceta Bank, Oregon

W. Waldo **Wakefield**[1] and Brian N. Tissot[2]

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There has been increasing interest in the importance of structure forming benthic invertebrates, especially cold-water corals, in marine ecosystems. Corals and other megafaunal invertebrates, such as crinoids and sponges represent a major component of the marine biodiversity and contribute to the structural complexity of these ecosystems. We describe patterns in the distribution and abundance of megafaunal invertebrates and the associations between these invertebrates and rockfishes (*Sebastes*) and other demersal fishes on Heceta Bank, Oregon: an important fishery area in the Pacific NW. Using the ROPOS ROV and Delta submersible, we conducted 44 dives on Heceta Bank from 2000-2002 and quantified the abundance and distribution of megafaunal invertebrates, fishes and physical habitats. We analyzed fish-invertebrate-habitat associations at three spatial scales: through observations on physical contact between fishes and invertebrates (meter scale), through nearest-neighbor analysis of spatial associations (10-100s m), and within and among habitat patches (100-1000s m). Although fishes were observed to co-occur with invertebrates in distinct assemblages which varied among habitats, few fishes were observed in physical contact with structure-forming invertebrates. From analysis of spatial associations between fishes and structure-forming invertebrates, several fish species were found more often adjacent to large invertebrates than predicted by their local abundance. Thus, it is likely that some fishes and invertebrates co-occur in the same types of habitats but functional relationships between these two groups of organisms remain to be demonstrated. Regardless of their associations with fishes, these structure-forming invertebrates clearly contribute to the diversity of their ecosystem.

30 October, 17:30 (S7-4385)

An ecological classification of sponge and coral habitat in Pacific Canadian waters

Edward J. **Gregr** and Glen S. Jamieson

SciTech Environmental Consulting, 2136 Napier Street, Vancouver, BC, V5L 2N9, Canada. E-mail: ed@scitechconsulting.com

The classification of habitat depends critically on the correct translation of physical characteristics into measures of habitat suitability. The concepts of Disturbance and Adversity, first proposed for classifying the landscape, represent two axes of a habitat template that is intended to characterize life history traits of species by considering their functional role, rather than the trait itself. The approach has been adapted to the benthic marine habitat in Atlantic Canada, and the biological significance of the resulting classification has been demonstrated. We applied the method to Pacific Canadian waters and, using available data, developed definitions of Disturbance and Adversity unique to the region. We assessed how the resulting classification corresponded to known distributions of sponges and corals, and evaluated how these species related to the Disturbance and Adversity axes we defined. Such classifications will be essential for estimating species distributions, and for identifying representative marine areas, and areas of high species diversity.

30 October, 17:50 (S7-4399)

Predictive modeling of coral and sponge distribution in the central Aleutian Islands

Doug **Woodby**, Dave Carlile and Lee Hulbert

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Logistic regression models were used to predict the probability of presence/absence for deep-sea corals and sponges in the central Aleutian Islands from 50 to 3000 m depth. Explanatory variables included depth, slope, and rugosity. Bottom substrate type derived from multibeam mapping was not included as a factor in the logistic models because there was disagreement in substrate classification by remote sonar methods in comparison to visual observations from a submersible and remotely operated vehicle. Models were evaluated based on a cross validation procedure. Models of occurrence north of the Aleutian chain were more successful than models for areas to the south of the chain. Model success was related to prevalence of the taxonomic group. Based on the predictive model, there are large swaths of sea floor below 200 m with potential coral garden habitat (highly diverse coral and sponge communities), particularly north of the Aleutian Islands arc and in Amchitka Pass.

S7 Posters

Poster S7-4474

Predicting suitable habitat for deep sea coral in British Columbia

Jessica L. **Finney**[1], E.J. Gregr[2], Glen S. Jamieson[3] and S. Patton[4]

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Deep sea corals provide valuable habitat for fish and other organisms but are subject to damage by hook and line gear, traps and bottom trawling. Damage done by trawlers is particularly devastating. Between 1996 and 2002, 295 tonnes of coral and sponges were recorded as bycatch in the British Columbia (BC) trawl fishery. Precise distribution of corals in BC waters remains largely unknown, so predicting locations of suitable coral habitat for later verification may be a cost-effective first step in the protection of these rare and/or valuable species. An earlier coast-wide modeling study produced habitat suitability maps for two species of coral on the Pacific coast, but the analysis used limited BC data and the resolution was in tens of square kilometers. This study utilizes all available BC coral data layered over available habitat data on a 500 m square grid. Resulting model predictions of suitable coral habitat locations in BC at a higher resolution than earlier studies are presented.

Poster S7-4501

Numerical experiments on the stably stratified flow over a shallow seamount in a channel

Sung Eun **Park**, Won Chan Lee, Hyun Taik Oh, Sok Jin Hong, Rae-Hong Jung and Sang Pil Yoon

Marine Environment Research Team, National Fisheries Research and Development Institute, Busan, 619-902, R. Korea
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Seamounts are undersea mountains that rise from the sea floor but which do not penetrate the sea surface. In general, the biological productivity around seamounts is much higher than that of the surrounding waters. Numerical experiments with the Princeton Ocean Model were performed to investigate topographic and water column stratification effects around a shallow seamount on a current system in a channel. It was found that both water column stratification and bottom topography of the channel influenced currents around the seamount. When a Karman vortex was formed behind the seamount due to bottom topography, it affected water movement only in the lower layers around the seamount. The vortex resulted in density stratification in the lower water column, with decreased water density shifting the isopycnic layer from the upper to lower region in front of the seamount, causing water at the back of the seamount to flow along the isopycnic surface. The result was that the vertical velocity pattern around the seamount is characterized by opposite flow directions on the two sides of the seamount, *i.e.*, downward in front of the seamount and upwards behind it. Upward flow, however, did not seem to have any significant influence on the surface layer, even though strong upward flows were found on the flanks of the seamount. These flow features may help transport animals to seamounts, and thereby maintain the biological communities there.

S8/S10

MONITOR/TCODE Topic Session
Recent advances in ocean observing systems: Scientific discoveries, technical developments, and data management, analysis and delivery

Co-Convenors: John (Jack) A. Barth (U.S.A.), Kyu Kui Jung (Korea), S. Allen Macklin (U.S.A.), Young Jae Ro (Korea) and Verena Tunnicliffe (Canada)

S8 Given the rapid development of ocean observing systems across the North Pacific, it is timely to discuss their use for scientific discovery and ecosystem research, and to describe the technical advancements in ocean sensors, observational platforms, and improvements in data management and exchange. By providing sustained interdisciplinary observations of atmospheric and oceanic processes, observing systems can capture important events influencing ocean ecosystems. Advanced sensors and platforms are creating new opportunities for deciphering ecosystem dynamics. With the increase in data return across observatories, it is critical that data management and interchange be addressed. Papers are welcome on: scientific discoveries made possible by ocean observing systems; observed climate impacts on ocean ecosystems and fisheries; advanced ocean sensors including optical, acoustic and genomic devices; autonomous platforms including underwater vehicles and vertical profilers; data management and exchange; and interoperability among ocean observatories. The intention is to have a mixture of scientific and technical talks on ocean observing systems. The session is complemented by commercial and academic displays around the theme of ocean observatories:

AXYS Technologies Inc., Sidney, B.C. (dbryan@axys.com)
Canadian Scientific Submersible Facility, Sidney, B.C. (operations@ropos.com)
NEPTUNE Canada, University of Victoria, Victoria, B.C. (neptune@uvic.ca)

S10 Profound changes have occurred in the North Pacific climate system, in the composition, abundance and distribution of its living marine resources, and in the human societies that depend on the North Pacific Ocean and its resources. New and novel techniques are needed to handle the ever-increasing volume of scientific data and to understand its meaning with respect to climate variability, anthropogenic impacts and the combined impacts that these changes have already had, and can be expected to have, on North Pacific ecosystems. This session will address methods such as high-volume data management, cabled observatories, regime shift detection and prediction, and ocean observing systems. Presentations describing links with climate and ecosystem change in the Arctic and relating to the International Polar Year Projects are also welcome. Oral presentations and electronic posters are encouraged.

Thursday, November 1, 2007 09:00 – 17:20

09:00 ***Introduction by convenors***

09:05 **John Dower, Ian Beveridge and Richard Dewey (Invited)**
Drinking from the fire hose: Moving from the limitations of under-sampled field data to the prospect of "always on" data streams (S8/S10-4434)

09:30 **Mairi M.R. Best, B.D. Bornhold, S.K. Juniper and C.R. Barnes**
NEPTUNE Canada regional cabled observatory: Science plan (S8/S10-4452)

09:50 **Benoît Pirenne (Invited)**
The NEPTUNE Canada Cabled Observatory Data Management System: Capturing and delivering terabytes of data each day (S8/S10-4443)

10:15 **David G. Foley**
Delivery and application of oceanographic satellite data in the era of integrated ocean observing systems (S8/S10-4380)

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

11:00 **Hidekatsu Yamazaki, Yuji Kitade and Yusaku Kokubu (Invited)**
Developing a diagnostic system to assess red tide of Tokyo Bay (S8/S10-4430)

11:25 **Toshiro Saino (Invited)**
An ocean observing system for carbon cycle studies (S8/S10-4432)

11:50 **Young Jae Ro and Kwang Young Jung**
Integrative approach for the coastal dynamics and ecosystem in the Kangjin Bay, South Sea, Korea (S8/S10-4027)

12:10 **John A. Barth, R. Kipp Shearman, Anatoli Erofeev, Tristan Peery, Murray D. Levine, Walt Waldorf and Craig Risien**
Autonomous underwater glider observations off central Oregon and the Oregon Coastal Ocean Observing System (OrCOOS) (S8/S10-4440)

12:30 ***Lunch***

14:00 **Svein Vagle (Invited)**
Continuous monitoring of marine mammals, natural and man made noise in Georgia Strait and Saanich Inlet using the VENUS observatory (S8/S10-4442)

14:25 **David W. Welch and George Jackson**
POST – A permanent continental-scale ocean observing array for fisheries research: Performance and scientific relevance (S8/S10-4165)

14:45 **Steven S. Rumrill**
A question-based approach to environmental monitoring within the South Slough National Estuarine Research Reserve, Oregon, USA (S8/S10-4426)

15:05 **Sonia D. Batten**
The CPR: Antique technology observing today's oceans (S8/S10-4184)

15:25 ***Posters introduction***

15:40 ***Coffee / tea break***

16:00 **Hanna Na, Kuh Kim and Kyung-Il Chang**
Accuracy of surface current velocity measurements obtained from HF radar along the east coast of Korea (S8/S10-4391)

16:20 **Todd D. O'Brien, David L. Mackas, Mark D. Ohman and remaining WG-125 members**
Issues and methods for analyzing zooplankton time series – Sample applications of the SCOR WG125 toolkit (S8/S10-4386)

16:40 **Liying Wan, Jiang Zhu, Changxiang Yan, Hui Wang, Laurent Bertino and Zhanggui Wang**
A "dressed" ensemble Kalman filter for data assimilation using the Hybrid Coordinate Ocean Model (S8/S10-4254)

17:00 **Ferdenant A. Mkrtchyan, Vladimir F. Krapivin, Vitaly I. Kovalev and Vladimir V. Klimov**
Spectroellipsometric technology for remote ecological monitoring of the aquatic environment (S8/S10-4435)

S8/S10 Posters and E-Posters

S8/S10-4109 **Ferdenant A. Mkrtchyan and Vladimir F. Krapivin**
GIMS-Technology in remote monitoring of aquatic ecosystems

S8/S10-4121 **Vladimir F. Krapivin and Ferdenant A. Mkrtchyan**
Expert system for operational environmental diagnostics

S8/S10-4154 **Elena Dmitrieva, Vladimir Ponomarev, Natalia Rudykh, Nina Savelieva and Igor Rostov**
Data integration from different sources for the study of long-term variability in the ocean - Atmosphere system over the Japan/East Sea (E-Poster)

S8/S10-4155 **Igor Rostov, Natalia Rudykh, Vladimir Rostov, Alexander Pan, Anton Gavrev, Elena Dmitrieva, Valentina Moroz and Olga Trusenkova**
New electronic atlases on oceanography of the Eastern Asia seas (E-Poster)

S8/S10-4173 **Mingsen Lin and Lei Huang**
A study of algorithms for extraction of ocean parameters from a spaceborne microwave radiometer

S8/S10-4211 **E.D.Vjazilov, N.N. Mikhailov, I.D. Rostov, N.I. Rudykh, V.I. Rostov and E.V. Dmitrieva**
National unified system of information on the World Ocean condition of Russia: Improvement and operational details (E-Poster)

S8/S10-4234 **Jie Su, Yaobing Wang and Di Yang**
Research on the stability of *Escherichia coli* as an indicator for detecting fecal pollution in seawater

S8/S10-4242 **Thomas C. Royer and Chester E. Grosch**
Coastal freshwater discharge in the Northeast Pacific using an updated hydrology model

S8/S10-4296 **S. Allen Macklin, Bernard A. Megrey, Kimberly Bahl and Ruguang Yin (cancelled)**
Pacific-wide marine metadata management and delivery: The PICES Metadata Federation (E-poster)

S8/S10-4329 **Chuanlin Huo, Zhengxian Yang, Quan Wen and Daoming Guan**
Development and implementation of a multi-sectoral marine environmental monitoring programme for Bohai Sea

S8/S10-4355 **Yong Yao and Shenglin Ye**
Application of satellite altimeter data in analysis and prediction of the sea surface wind and wave fields over the China Sea and Western Pacific Ocean

S8/S10-4365 **Murray D. Levine**
Long-term times series on the Oregon shelf: The importance of high-frequency processes

S8/S10-4409 **Albert J. Hermann, Christopher W. Moore, Sarah Hinckley, Carolina Parada, Elizabeth L. Dobbins and Dale B. Haidvogel**
Immersive visualization online: A modern approach for the rapid exploration of Eulerian and individual-based models (E-Poster)

S8/S10-4417 **Edward D. Cokelet, Calvin W. Mordy, Antonio J. Jenkins, W. Scott Pegau and Margaret E. Sullivan (cancelled)**
Underway oceanographic measurements from an Alaskan state ferry

S8/S10-4441 **John A. Barth, Murray D. Levine, Walt Waldorf, Andrew Barnard, Bruce Rhoades, Alex Derr, John Koegler and Daniel Whiteman**
A vertical profiling mooring for coastal observations: Coastal Autonomous Profiling and Boundary Layer System (CAPABLE)

S8/S10-4447 **Mike F. Henry, Sonia D. Batten, K. David Hyrenbach, Ken H. Morgan and Bill J. Sydeman**
The meso-scale response of subarctic North Pacific seabird community structure to lower trophic level abundance and diversity

S8/S10-4450 **Kathy J. Kuletz, Elizabeth A. Labunski, David B. Irons and Shannon Fitzgerald (cancelled)**
The Alaska Pelagic Seabird Observer Program: A tool for tracking changes in seabird distribution in the North Pacific

S8/S10-4451 **Gitai Yahel, Ruthy Yahel, Timor Katz, Boaz Lazar, Barak Herut and Verena Tunnicliffe**
Fish activity, a major mechanism for nutrient and carbon recycling from coastal marine sediments

S8/S10-4460 **Peter G. Phibbs and Stephen Lentz**
Technology for cabled ocean observatories and their vertical profiler systems

S8/S10-4487 **Joon-Yong Yang, Kyu-Kui Jung, Hee-Dong Jeong, Young-Sang Suh and Chang-Su Jung**
A real-time coastal information system for aquaculture environmental monitoring

S8/S10-4492 **Susan Banahan**
An overview of the Ocean Observatories Initiative (OOI) network

S8/S10-4518 **John A. Barth, R. Kipp Shearman, Anatoli Erofeev, Tristan Peery, Murray D. Levine, Walt Waldorf and Craig Risien**
Autonomous underwater glider observations off central Oregon and the Oregon Coastal Ocean Observing System (OrCOOS)

S8/S10-4519 **Yoshiyuki Kaneda**
Dense Ocean floor Network system for Earthquakes and Tsunamis (DONET)

S8/S10 Oral Presentations

1 November, 09:05 (S8/S10-4434) Invited

Drinking from the fire hose: Moving from the limitations of under-sampled field data to the prospect of "always on" data streams

John **Dower**[1,2], Ian Beveridge[1] and Richard Dewey[1]

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One key incentive underlying the development of the current generation of cabled undersea observatories is the prospect of having access to data streams that are "always on". The assumption is that, with a continuous stream of data, researchers will be able to monitor ocean environments and to explore oceanographic phenomena at temporal resolutions that can only rarely be approached by traditional ship-based sampling. Certainly, the ability to observe "event scale" phenomena in the oceans, and to respond to such events adaptively via user-controlled sampling schemes, will significantly improve our understanding of the interplay between physics, biology and chemistry in the oceans. At the same time, however, dealing with continuous data streams will also require a paradigm shift in the sorts of questions that oceanographers pose, and in the tools that we use to analyze our data. For instance, biological oceanographers are typically limited to collecting field data on a monthly or seasonal basis. Thus, the questions posed, and the statistical techniques used to analyze the collected data, reflect the inherent undersampling of the environment. Using data collected by the VENUS observatory over the past 20 months as examples, we will explore how moving to an "always on" operational mode has provided opportunities to pose previously unanswerable questions while also offering considerable challenges as we learn to "drink from the fire-hose".

1 November, 09:30 (S8/S10-4452)

NEPTUNE Canada regional cabled observatory: Science plan

Mairi M.R. **Best**, B.D. Bornhold, S.K. Juniper and C.R. Barnes

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In 2008, NEPTUNE Canada will complete the installation of an 800 km long regional cabled ocean observatory across the northern Juan de Fuca Plate. At inshore Folger Passage, Barkley Sound, understanding controls on biological productivity will help evaluate the effects that marine processes have on fish and marine mammals. Experiments around Barkley Canyon will allow quantification of changes in biological and chemical activity associated with nutrient and sediment transport around the shelf/slope break and through the canyon to the deep sea. There and north along the mid-continental slope, shallowly buried gas hydrates allow monitoring of changes in their distribution, depth, structure, properties and venting, particularly related to earthquakes, slope failures and regional plate motions. On the abyssal plain, ODP borehole monitoring systems will track realtime changes in crustal temperature and pressure, particularly as they relate to events such as earthquakes, hydrothermal convection or regional plate strain at this mid-plate site. At Endeavour Ridge, complex interactions among volcanic, tectonic, hydrothermal and biological processes will be quantified where new volcanic seafloor is created. Across the network, high resolution seismic information will elucidate tectonic processes such as earthquakes and strain, and a tsunami system will allow determination of open ocean tsunami amplitude, propagation direction, and speed. NEPTUNE Canada will transform our understanding of biological, chemical, physical, and geological processes across an entire tectonic plate from the shelf to the deep sea. Real-time continuous monitoring and archiving allows scientists to capture the temporal nature and characteristics of these natural processes in a way never before possible.

1 November, 09:50 (S8/S10-4443) Invited

The NEPTUNE Canada Cabled Observatory Data Management System: Capturing and delivering terabytes of data each day

Benoît **Pirenne**

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NEPTUNE Canada is the first large cabled ocean observatory to be deployed. By this time next year, it will receive continuous, real-time data from about 120 instruments hosting over 500 sensors. Moreover, authorized users will be able to send commands to some instruments in order to change their configuration or pilot them. The wide variety of sensors will record physical parameters of the ocean floor, image its changing features and listen continuously for marine mammals or seismic rumbling of the Earth's crust. HDTV cameras will transmit high-quality imagery to shore dominating all other instruments in data volume. All this data will be available freely and immediately to anyone subscribing to the data flow. Users will be able to search and request archived data for statistical analysis, data processing, *etc.* A key feature of the data management system will enable users to program an arbitrarily complex algorithm for detecting deviation from expected norms of a particular data stream. A positive detection is considered an event to which a reaction can be associated. Reactions will span the whole gamut of possibilities from sending a message to a mobile phone, to sending commands to other instruments responsible for follow-up observations of the event.

1 November, 10:15 (S8/S10-4380)

Delivery and application of oceanographic satellite data in the era of integrated ocean observing systems

David G. **Foley**

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Resource managers and researchers interested in obtaining information concerning the marine environment must often navigate a bewildering array of formats and data delivery mechanisms to get the information they require. The ongoing emergence of national and regional components of the US integrated ocean observing system (IOOS) presents a unique opportunity to standardize the generation, archival, and delivery of marine data products. The OceanWatch North Pacific Demonstration project was initiated to develop the tools needed to effectively deliver a variety of environmental products to several projects linked to the stewardship of living marine resources. The OceanWatch Thematic Real-time Environmental Distributed Data Server provides each of these projects (and the general public) with access to a full suite of satellite data products, including sea surface temperature, sea surface height, chlorophyll, and vector winds, along with a number of derived products. Additionally, historical data sets and long-term means for each parameter are made available at the same location to allow the users to place measurements from a given period within the context of the regional ocean dynamics. In return, the individual members of the participating projects help us to identify inadequacies in the OceanWatch system, and continue to collaborate in our efforts to improve the system. Partners have been very enthusiastic about client-side delivery tools and the idea of custom "data casting". It is hoped that application-oriented demonstrations such as this may serve as models by which the various elements of IOOS will evolve to meet the needs of their customers.

1 November, 11:00 (S8/S10-4430) Invited

Developing a diagnostic system to assess red tide of Tokyo Bay

Hidekatsu **Yamazaki**, Yuji Kitade and Yusaku Kokubu

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Tokyo Bay is a semi-closed bay surrounded by over 20 million people along the coast. Due to the heavy population and advanced industrialization, the number of red tide incidents increased from 1960 to 1980. After the peak occurrence in 1982, the number of observed red tide stays at a constant level due to regulation in domestic discharge

and increased levels of sewage treatment. Despite the fact that extensive surveys and monitoring for the red tide in Tokyo Bay are conducted, no clear dynamical mechanism has been identified to the onset of the red tide. In order to predict the onset of red tide, we are developing a diagnostic system that makes use of several field observation data sets and a three dimensional hydrographic numerical model (GETM). The field data sets include: 1) a thermistor-chain monitoring station at the bay mouth; 2) ADCP surveys mounted on a ferry at the bay mouth; 3) microstructure observation data at the bay mouth; and 4) a monitoring station for hydrographic conditions inside the bay. We are blending these data sets into the hydrographic model in order to develop the target diagnostic system. We also discuss future plans to improve the predictability.

1 November, 11:25 (S8/S10-4432) Invited

An ocean observing system for carbon cycle studies

Toshiro **Saino**[1,2]

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An ocean primary productivity profiling system, comprising a fast repetition rate fluorometer installed on a profiling buoy tethered to an underwater winch was developed. The system has capabilities of acoustic communication between the profiling buoy and the winch, and iridium phone communication between the profiling buoy and the shore based laboratory. The buoy is normally connected to the winch with a latch at ca. 150m and pops up once a day to make profiling measurements according to the pre-set schedule. The schedule can be modified by sending commands through the iridium phone communication thereby avoiding predicted storms. A custom-made FRRF (Diving Flash) processes the measured fluorescence signal in real time and transmits a depth profile of calculated temporal values of primary productivity per unit biomass. The FRRF measures instantaneous gross primary productivity *in situ* as demonstrated by comparing the FRRF profiling measurements with depth profiles of oxygen-17 anomaly in dissolved oxygen, both with 2 hours intervals from 0400 to 2000. Designs for an ocean observing system focused on monitoring the processes of the carbon cycle, such as gross primary production, net community production, community respiration, export flux, gas exchange coefficient, *etc.*, in the near surface oceans will be presented.

1 November, 11:50 (S8/S10-4027)

Integrative approach for the coastal dynamics and ecosystem in the Kangjin Bay, South Sea, Korea

Young Jae **Ro** and Kwang Young Jung

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This study was conducted to understand aspects of the ecosystem involving physical and biological processes in the Kangjin Bay, South Sea, Korea for the period from 2003 to 2006. Innovative approaches for this study included developing a real-time monitoring system to record the coastal water state variables every ten minutes through the period and numerical modeling of physical and ecosystem processes. The study was designed to identify causes of the mass mortality of the large-arc shell (*Scapharca broughtonii*) occurring in the summer season following the release of water from the Nam-Gang Dam. Several hypotheses were proposed for the mortality including degraded water quality, nutrient and food material deficiency, and post-spawning health conditions bivalve. Each hypothesis was closely examined and discarded leaving a single significant cause to be the Dam water release and resultant hypoxia. To support this conclusion, the complex processes affecting the ecosystem in the Kangjin Bay should be understood in detail. Numerical approach to assess and examine the role of each process is an ultimate goal. To implement the ecosystem model, step-by-step modeling is desirable to advance to the complete sets of modules of physico-bio-chemical interaction of the ecosystem components. These approaches will be presented.

1 November, 12:10 (S8/S10-4440)

Autonomous underwater glider observations off central Oregon and the Oregon Coastal Ocean Observing System (OrCOOS)

John A. **Barth**, R. Kipp Shearman, Anatoli Erofeev, Tristan Peery, Murray Levine, Walt Waldorf and Craig Risien

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Beginning in April 2006, we have used an autonomous underwater vehicle glider to sample a cross-shelf transect along the Newport Hydrographic Line off central Oregon (44 39.1'N). The section runs from the 20-m isobath out about 90 km, and takes 3-7 days to complete. The glider undulates from the surface to 2-3 m above the bottom (200 m maximum) with an along-track resolution ranging from 100 m in shallow water to 400 m in deep water. Position and oceanographic data are relayed to shore every 6 hours *via* Iridium cell phone. The glider is equipped with a conductivity-temperature-depth instrument and several optical instruments (chlorophyll fluorescence, colored dissolved organic matter fluorescence, light backscatter for a measure of particles, and dissolved oxygen). The benefits of autonomous sampling include low cost relative to comparable ship-time and a continued presence in the ocean for increasing the chances of observing intermittent, unpredictable (possibly important) processes. The glider transects are contributing to the new Oregon Coastal Ocean Observing System (OrCOOS), a sub-regional part of the Northwest Association of Networked Ocean Observing Systems (NANOOS). OrCOOS maintains a mid-shelf mooring, 10 miles offshore from Newport, with physical, bio-optical and dissolved oxygen sensors. The near real-time glider and mooring observations, supplemented by ship-based measurements, were used to track and understand the evolution of the extreme hypoxia event off central Oregon during summer 2006.

1 November, 14:00 (S8/S10-4442) Invited

Continuous monitoring of marine mammals, natural and man made noise in Georgia Strait and Saanich Inlet using the VENUS observatory

Svein **Vagle**

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The coastal waters of British Columbia are populated by numerous marine mammals for whom acoustics are the primary means of communications. A cabled underwater observatory like VENUS represents a unique opportunity to monitor and track these marine mammals as they move through the straits and inlets covered by the observatory 24 hours a day 365 days a year. Of central interest is to better understand communications within and between whale pods and the relationship between the mammals and man made underwater noise, such as generated by shipping. Here we discuss some of the great scientific opportunities such systems represent and some of the practical challenges experienced from more than 12 months of operating a hydrophone array on VENUS.

1 November, 14:25 (S8/S10-4165)

POST – A permanent continental-scale ocean observing array for fisheries research: Performance and scientific relevance

David W. **Welch**[1] and George Jackson[2,3]

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POST, the Pacific Ocean Shelf Tracking array, is currently the world's largest telemetry system for studying the movements and survival of marine fish. It is also the exemplar for the global Ocean Tracking Network (OTN), which has received $45M in seed money and commitments from partnering organizations levering a total of $160M of support. OTN will form "an array of POST arrays", sitting on the continental shelves of all continents on the planet. We review POST from the twin perspectives of (a) technical operation and maintenance of a large-scale ocean observing system, and (b) the scientific performance of the array in addressing key questions concerning the management of west coast salmon and sturgeon populations. 2006 saw the deployment of the first phase of the

permanent POST array. The permanent array uses a short range wireless link to allow remote data upload to a surface vessel without physical retrieval of the equipment—resulting in a year-round monitoring capability and substantial efficiency in operations. These units have sufficient battery power to operate on the seabed for up to seven years before replacement is necessary. *In situ* equipment performance has met or exceeded target performance levels (<10% operational losses per year from all sources), making continuous operation of the system economically feasible. Scientific performance has been excellent, with very high detection rates for tagged fish crossing individual listening lines (~95%). As a result, relatively small numbers of tagged animals can provide statistically rigorous (precise and accurate) estimates of survival at sea over many months or years, as well as seamless measurements in both freshwater and the coastal ocean. This provides the opportunity to begin conducting explicit experiments in the ocean to test scientific hypotheses directly. We provide several examples to illustrate the methodology and clarify the roles of POST and the global OTN as an important monitoring system.

1 November, 14:45 (S8/S10-4426)

A question-based approach to environmental monitoring within the South Slough National Estuarine Research Reserve, Oregon, USA

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Pacific northwest estuaries exhibit substantial diversity in geomorphology, and they differ considerably in the spatial and temporal extent of influence by riverine inputs versus oceanic forcing. For example, Oregon's large drowned river-mouth estuaries are typically dominated by river discharges (*i.e.*, Columbia, Umpqua, Coquille) or by tidal inputs (Tillamook, Yaquina, Coos Bay / South Slough). A simple conceptual model unifies these different types of estuaries and includes inputs from the moist maritime climate and regional Pacific Ocean into three hydrogeomorphic components: (1) nearshore/marine-dominated; (2) estuary/mesohaline; (3) riverine/watershed. The atmospheric and marine forcing signatures within each estuary typically vary seasonally between the wet (Nov-Apr) and dry seasons (May-Oct). A case history of ambient status and trends monitoring is presented for the South Slough, a tidal inlet of the greater Coos estuary (southern Oregon). Datasets collected over the past decade by the South Slough National Estuarine Research Reserve / System-Wide Monitoring Program (SWMP) include real-time measurements (every 5 min) of local meteorological parameters, near real-time measurements (every 30 min) of estuarine water parameters, and monthly measurements of estuarine nutrients. These time-series datasets have been incorporated into the national backbone of the US Integrated Coastal Ocean Observing System (ICOOS). Ambient status and trends monitoring by the South Slough NERR SWMP is focused to address the following question: *"to what extent are chlorophyll levels and nutrient dynamics within the South Slough estuary driven by oceanic forcing and seasonal upwelling events versus watershed inputs?"* This example of question-based monitoring contributes to the emerging effort to develop an ecosystem-based approach to management of the Coos estuary as an integrative component of the Oregon nearshore marine ecosystem.

1 November, 15:05 (S8/S10-4184)

The CPR: Antique technology observing today's oceans

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First designed in the 1920s and in routine use in the Atlantic since the 1930s, the Continuous Plankton Recorder (CPR) is an ocean observing tool that has been used in the north Pacific since 2000 and still retains its relevance. It was the sampler of choice in 2000 because it is reliable, cost-effective, samples on the scale of an entire ocean and, while not a perfect sampler, its limitations are mostly well-known. Earlier this year, the GOOS Scientific Steering Committee endorsed the north Pacific CPR survey as an ocean observing tool. Data from the seven years of sampling in the North Pacific have already shown responses in open ocean plankton to changes from cool to warm ocean conditions, from which we can start to make predictions on responses to future climate changes. This presentation describes and presents results from the survey, and ends with some thoughts on development of the north Pacific CPR survey.

1 November, 16:00 (S8/S10-4391)

Accuracy of surface current velocity measurements obtained from HF radar along the east coast of Korea

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A High Frequency (HF) radar system is deployed along the east coast of Korea. The system operates near 13 MHz and provides surface current velocities up to 70 km offshore with spatial resolution of 3 km. Acoustic Doppler Current Profilers (ADCPs) from the East Sea Real-time Ocean Buoy (ESROB) array also produce surface current velocity at a single point with a fast response. The accuracy of HF radar observation is evaluated by comparison with the *in situ* ADCP data. The HF radar-derived current velocities exhibit reasonable agreement with the ADCP data. These validated HF radar data can be used to analyze the temporal and spatial characteristics of the surface currents off the coast and also can represent an approach for a spectrum of coastal ocean applications related to fisheries, ecosystems, and search and rescue operations.

1 November, 16:20 (S8/S10-4386)

Issues and methods for analyzing zooplankton time series – Sample applications of the SCOR WG125 toolkit

Todd D. O'Brien[1], David L. **Mackas**[2], Mark D. Ohman[3] and remaining WG-125 members

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Upper-ocean zooplankton biomass and community composition vary strongly at a range of time scales (*e.g.* decadal, interannual, seasonal, and diel), and also at a range of spatial scales. Detection and interpretation of variability at one time scale typically requires data transformation, averaging and filtering to reduce aliasing from other scales. A variety of these methods have been applied to zooplankton time series. In this paper, we illustrate how choice of method can influence the output time series, and introduce the SCOR WG125 tool-kit of numerical choices and methods.

1 November, 16:40 (S8/S10-4254)

A "dressed" ensemble Kalman filter for data assimilation using the Hybrid Coordinate Ocean Model

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Computation costs incurred by an ensemble Kalman filter (EnKF) are much larger than with simpler assimilation schemes, such as optimal interpolation (OI) and three-dimensional variation (3DVAR), limiting EnKF's usefulness when cost matters. To compensate, ensemble optimal interpolation (EnOI), a crudely simplified implementation of the EnKF, sometimes is substituted. Although EnOI is less costly than EnKF, it uses a stationary forecast covariance based on a set of snapshots taken from a long model run. To compromise between computation cost and more desirable dynamic covariance, we "dress" a small dynamic ensemble with a larger number of static ensembles to form an approximate dynamic covariance. This method requires much less computational burden than EnKF. To "dress," we perturb a dynamic ensemble seed from model runs by adding anomalies from some static ensembles. This dressed EnKF (DrEnKF) scheme is tested by assimilating actual Pacific altimetry data using the Hybrid Coordinate Ocean Model (HYCOM) over a four-year period. The size of the dynamic ensemble seeds is 10 and the static ensemble is 100, taken from a long run of the model. Each dynamic seed is dressed by 10 static ensembles.

Performance is compared with that from an EnKF assimilation run that uses 100 dynamic ensembles. Temperature and salinity fields from the DrEnKF and EnKF, when compared to observations from Argo floats and the OISST dataset, yield similar root mean square errors (RMSE) at every model level. Error covariance matrices from the DrEnKF and the EnKF also show good agreement.

1 November, 17:00 (S8/S10-4435)

Spectroellipsometric technology for remote ecological monitoring of the aquatic environment

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The creation of multichannel polarization optical instrumentation is applicable to real-time ecological control of the aquatic environment. Efficient solution of these multiparametric problems depends on the precision of ellipsometric devices and the possibility of using a wide spectral range. Spectral measurements in an aquatic environment provide an information basis for the application of modern algorithms for recognition and identification of pollutants. This multichannel spectroellipsometric system will differ from modern foreign analogues by the use of a new and very promising method of ellipsometric measurements, an original element base of polarization optics and a complex mathematical approach to estimating the quality of a water object subjected to anthropogenic influence. Also, unlike foreign analogues, the system has no rotating polarization elements. This increases the signal-to-noise ratio and long-term stability of measurements, simplifying and reducing the price of multichannel spectroellipsometers. The system will be trainable for recognition of pollutants of the aquatic environment, *e.g.*, heavy oil spills, industrial waste, red tides, that have led to serious degradation of the environment. Further, we describe a number of studies demonstrating the potential of such remote sensing techniques for monitoring water pollution.

S8/S10 Posters and E-Posters

Poster S8/S10-4109

GIMS-Technology in remote monitoring of aquatic ecosystems

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The basic scheme of collection and processing of information in a geoinformation monitoring system recognizes that effective monitoring of investigated objects is possible with complex use of methods of simulation modeling, collection and information processing. One of the basic tasks of environmental geoinformation monitoring is to automate data processing of measurements, say from a water surface, with the principal goal of phenomena detection and classification. The methods and algorithms of cluster and discriminant analysis for classification and qualitative interpretation of remote sensing data characterizing the water surface are considered. Classification of water masses using remote sensing measurements is an important problem. Various algorithms from the theory of image recognition, statistical decision-making and cluster analysis are used to solve this problem. A mathematical model describing background characteristics of water-surface spottiness is proposed. Operational software for this model is realized. Results from application of this software to satellite data processing for the Atlantic, Pacific and Arctic regions are given.

Poster S8/S10-4121

Expert system for operational environmental diagnostics

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An expert system for operational environmental diagnostics (ESOED) realizes GIMS-technology (GIS+Model), applying methods and algorithms of mathematical modeling to land-based and remote observations of the environment. Links between experiments, algorithms, and models of environmental processes and subsystems realize effective procedures for operational control and diagnosis. ESOED functions include:

- acquisition and accumulation of data by means of *in-situ* and remote methods and their analysis with subsequent subject processing;
- systematic observation and evaluation of the environment;
- evaluation and synthesis of knowledge concerning the atmosphere, soil-plant cover and water-medium change;
- predetermination of forecasting diagnostics of environmental change under anthropogenic forcing;
- analysis of tendencies in environmental processes when anthropogenic scenarios are realized; and
- identification of causes of ecological disturbances and danger warnings.

We present a working methodology for the combined use of modeling technology and microwave remote sensing measurements in the assessment of environmental processes and biospheric subsystems dynamics. We illustrate this methodology with computer calculations of global change dynamics for various scenarios, and provide perspective for developed methodology application to the study of global environmental change, including radiative-forcing problems related to the carbon cycle.

E-poster S8/S10-4154

Data integration from different sources for the study of long-term variability in the ocean - Atmosphere system over the Japan/East Sea

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We offer an approach for joint analysis of oceanographic, hydrological and meteorological information through use of an interconnected relational databases model. The conceptual model of databases set where connections between objects are carried out by the common attributes describing space-time coordinates is created. Approbation of the system recognize perspectives of same researches continuation with use of the most up-to-date data presentations (including aggregation) as multivariate cubes for carrying out of researches by methods Data Mining. For the statistical analysis of data files with a different degree of detailed elaboration methods of correlation and cluster analysis were used. There are revealed some features of the multiscale variability of Amur river discharge, hydrological characteristics in Okhotsk and Japan/East seas (salinity, sea surface temperatures (SST), ice extent) and SST of Northwest Pacific and also their ambiguous for the various time periods statistical relationships with anomalies of meteorological factors, indexes of circulation of an atmosphere and ocean, and solar activity.

E-poster S8/S10-4155

New electronic atlases on oceanography of the Eastern Asia seas

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For many years, the Pacific Oceanological Institute (POI) has developed technologies for the collection, accumulation, processing and long-term storage of data on the ocean environment to support POI studies in the western Pacific. With the help of the relational database management system, several problem-oriented oceanographic data bases have been created. Use of modern information technologies ensures generation of capacious electronic oceanographic information-reference systems, thematic data bases, atlases and their delivery to users through computer networks and on CD-ROM. Several versions of POI information products are partly presented on CD-ROMs and web pages <http://pacificinfo.ru/cdrom/>, <http://pacificinfo.ru/climate/>. Newly developed for 2007 are:

- Oceanographic atlas of the South China Sea,
- Tidal atlas of the Bering, Okhotsk, Japan/East and East-China seas,
- Atlas of typical surface wind and vorticity fields over the Japan/East Sea and adjacent land, and
- Ice conditions of the Far Eastern seas. Part 3: The Japan/East Sea.

The systems provide quick access to raw data, gridded data, analytical means and attributive information. The developed systems allow construction of dynamic images of maps and pictures from user-specified characteristics. Systems development is conducted by the principle of "modules" that allows improving a product while it is in service.

Poster S8/S10-4173

A study of algorithms for extraction of ocean parameters from a spaceborne microwave radiometer

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We examine retrieval algorithms for ocean parameters from the microwave radiometer on the HY-2 satellite, and use the AMSR-E data with performance characteristics similar to the HY-2 satellite radiometer to validate the results. Two kinds of retrieval algorithms – the non-linear iterative algorithm and the multiple linear regression algorithm, are built to retrieve global ocean surface wind speed, sea surface temperature, vertically integrated water vapor and vertically integrated cloud liquid water. After the algorithm is completed, we examine AMSR-E brightness temperature data. The retrieved result validation by TMI product and buoy data shows that the non-linear iterative algorithm has some problems that conflict with the ocean algorithm and need more modification to the optimize mathematical techniques before application; in contrast the multiple linear regression algorithm shows good results.

E-poster S8/S10-4211

National unified system of information on the World Ocean condition of Russia: Improvement and operational details

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Russia actively forms the most complete local, regional and global data bases on different aspects of oceanography, hydrometeorology, marine biology and ecology. It develops modern technologies for data management and creates information products, as well. During the last seven years, many of these products were produced within the Federal Target Program “The World Ocean”. The most important part of that program is the subprogram “United System of Information on the World Ocean Condition” (ESIMO, http://oceaninfo.ru/). ESIMO development assists solution of many problems on data observation, collection, processing and storage by using national and international information systems and by cooperation with international information projects. ESIMO is realized by organizations of different Federal Departments under eight projects. It is the most significant National Program in the field of data management. The Principal Coordinator of ESIMO development is the All-Russia Research Institute of Hydrometeorological Information – World Data Centre “B” (RIHMI-WDC/B) of Roshydromet (http://www.meteo.ru). Twenty-two centers of ESIMO were established in Russia by the end of 2006. In 2007, the first ESIMO line was brought into operation. It was realized in the form of a horizontal web portal (http://wwww.oceaninfo.ru), integrating information resources in the field of oceanography and sea activity. The portal is an instrument of information resource management. It allows users to gain access to varied information kept in different formats (html, xml, ftp, databases) by many organizations, including foreign, and use it for scientific studies and decision making.

Poster S8/S10-4234

Research on the stability of *Escherichia coli* as an indicator for detecting fecal pollution in seawater

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With coastal populations and animal husbandry increasing, fecal contamination has become a serious environmental problem that affects many coastal waters in the world. It degrades water quality and influences aquatic biology and marine ecosystems, and can induce red tides. Currently, a variety of Microbial Source Tracking (MST) methods are applied to identify fecal pollution sources. A key element of MST is the chosen tracking indicator. An ideal MST indicator would be non-pathogenic, rapidly detected, easily enumerated, and have survival characteristics that are similar to those pathogens of concern. *Escherichia coli* have long been used as an indicator of fecal contamination of water, identifying water quality and assessing potential health risk. To apply in marine settings, it is necessary to understand *E. coli* life history in seawater. In this study, the survival of *E. coli* K12 marked with a green fluorescent protein plasmid (GFP) was tested in the sea. The DNA fingerprint patterns obtained from the strains by rep-PCR were analyzed using the software GelCompar™. *E. coli* environmental stability and *E. coli* special genomic stability are analyzed and evaluated in order to testify the feasibility of this organism as an indicator of fecal contamination source tracking.

Poster S8/S10-4242

Coastal freshwater discharge in the Northeast Pacific using an updated hydrology model

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The coastal freshwater discharge model for the Northeast Pacific that was published in 1982 using QuickBasic programming language has been rewritten using MATLAB. The revised model produces monthly mean freshwater discharge rates at the northern Gulf of Alaska from 1931 though 2006 using coastal air temperature and precipitation. This coastal freshwater discharge, that is generally in excess of 25,000 cubic meters per second, helps to drive the Alaska Coastal Current, a nearshore flow that sweeps along the coast of the Northeast Pacific Ocean from the Columbia River to the Aleutian Island chain and into the Bering Sea through Unimak Pass. It influences the advection of heat, salt and nutrients into this region. The new version of the model incorporates discharges from glacial melting, river discharge and a more complete estimate of the freshwater contributions from the coasts of British Columbia and Washington State. Recent increases in the melting rate of the coastal mountain glaciers in Alaska are accelerating this freshwater discharge. The revised model has been tuned using the hydrographic data from the U.S. Northeast Pacific GLOBEC program that sampled the hydrography from 1997 through 2004. Spectral analysis of the input parameters and the resultant discharges were made. This revised model and the input data are available at www.nprb.org.

E-poster S8/S10-4296 (Cancelled)

Pacific-wide marine metadata management and delivery: The PICES Metadata Federation

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The member countries of PICES separately maintain vast quantities of marine ecosystem data. To support detection and prediction of ecosystem change in the North Pacific Ocean, it is beneficial to discover data holdings with a single search, rather than having to access each country's records, perhaps stored in different languages and formats. We are creating a "metadata federation" of member countries (Canada, Peoples Republic of China, Japan, Republic of Korea, Russian Federation, and USA) of the North Pacific Marine Science Organization (PICES). Through English-language coding of metadata using the Federal Geographic Data Committee standard, acquisition, installation and configuration of Z39.50 communications software on a public-access server and registration with a clearinghouse, it is possible for any metadata-serving agency to become part of the PICES Metadata Federation. The federation enables an Internet user to search the collected metadata holdings of any or all members, thus providing access to information across national holdings in a single search. To date, metadata collections from Japan, the Russian Federation, Republic of Korea and USA are federated. China is in the process of joining. This activity supports PICES' goals: (1) to promote and co-ordinate marine scientific research in the northern North Pacific and adjacent marginal seas, particularly northward from 30 degrees north; (2) to advance scientific knowledge about the ocean environment, global weather and climate change, living resources and their ecosystems, and the impact of human activities on them; and (3) to promote the collection and rapid exchange of scientific information on these issues.

Poster S8/S10-4329

Development and implementation of a multi-sectoral marine environmental monitoring programme for Bohai Sea

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Bohai Sea is a semi-enclosed and large-sized internal sea of China. On one hand, the health of the Bohai Sea environment plays a very important strategic role in China since the peripheral area of the Bohai Sea is an economically and socially developed region. On the other hand, the Bohai Sea is facing many environmental pressures and problems of resource utilization. Therefore, the Chinese government has made efforts to develop marine environmental monitoring programmes and capacity. However, it remains a great challenge to develop effective operational linkages among various marine environmental monitoring efforts in China. Based on the Memorandum of Agreement for the Bohai Environmental Management Demonstration Project of GEF/UNDP/IMO PEMSEA, a multi-sectoral marine environmental monitoring plan was formulated and executed, in consideration of current programs and action plans. The main objective of the project is to develop and implement effectively a multi-sectoral marine environmental monitoring program for Bohai Sea. In this presentation, the specific objectives, the operation and implementation, and the relevant activities of the project are introduced, and the achievements and problems of the pilot plan implemented are discussed.

Poster S8/S10-4355

Application of satellite altimeter data in analysis and prediction of the sea surface wind and wave fields over the China Sea and Western Pacific Ocean

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Altimeter wave height data are available 24 hours a day, in all weather, forming a dataset of high-quality, large-space coverage, and long duration. It not only has invaluable contributions to marine theory and numerical wave prediction research, but also for statistics research and application to the sea surface wind and wave fields. To date, China does not have satellite altimeter, but it has done extensive statistics pioneering research with foreign altimeter data. It has successfully conducted research on the effective distribution of wave height in the South China Sea and East China Sea, and then examined the effective distribution and wave-class distribution of wave heights in both its coastal waters and the Pacific Northwest. Studies are available on the entropy of wave height field, the distribution of the wave height composition of China waters and the Pacific Northwest; the South China Sea encountered higher waves for many years. We illustrate a comprehensive and multi-angle wave height condition for Chinese coastal waters and the Pacific Northwest. This study presents summary statistics and distribution of the wave condition of the world oceans, including the China Sea and the western Pacific sea. This work has significant relevance for maritime navigation, offshore oil drilling and other activities at sea.

Poster S8/S10-4365

Long-term times series on the Oregon shelf: The importance of high-frequency processes

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There are many challenges in maintaining a continuous moored station on the Oregon shelf. One must consider both environmental factors, such as strong currents and high waves, as well as human factors, such as shipping and fishing. We review our experiences and approaches in dealing with these issues. The scientific gains that can result from long-term time series are many. Obviously, variations in quantities such as monthly averaged currents and hydrography are important for tracking interannual and climatic variability. However, variations in high-frequency

processes, ranging from tidal to internal wave to turbulence, are also important to be able to understand and model the coastal ocean over long time scales. Several examples of potential interest to both physical and biological oceanographers are shown.

E-poster S8/S10-4409

Immersive visualization online: A modern approach for the rapid exploration of Eulerian and individual-based models

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Stereo-immersive visualization is a powerful and increasingly economical tool for the rapid exploration of 3-D ecosystem and fish life history model output. By taking advantage of human binocular vision, this approach allows the user to experience and interact with model features as “virtually real” objects in our three-dimensional world. Increasingly, such model output (and data) can be retrieved online, *e.g.* through Live Access Server technology. Here, a portable immersive system (a “Geowall”) will be used to illustrate the 3-D structure of output from an online set of spatially nested physical and biological models of circulation, plankton, and fish in the coastal Gulf of Alaska. Elements of this set include circulation and lower trophic level dynamics at ~3-km resolution, and a spatially explicit Individual-Based Model of walleye pollock, *Theragra chacogramma*. Immersive techniques are especially powerful at revealing: 1) the structure of spatially patchy fields, such as phytoplankton (rendered as a “fog” of concentration); 2) three-dimensional flows near topography (rendered as 3D vectors); 3) spatial tracks of individuals and the prey fields they experience along those paths (rendered as color-coded symbols moving through space). Participants will be given the opportunity to choose online data interactively, then “fly through” and examine these and other fields of interest.

Poster S8/S10-4417 (Cancelled)

Underway oceanographic measurements from an Alaskan state ferry

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An oceanographic monitoring system aboard the Alaska Marine Highway System ferry *Tustumena* has operated for three years in the Alaska Coastal Current (ACC). At 4-m depth, the underway system measures (1) temperature and salinity - basic physical variables, (2) nitrate - an essential phytoplankton nutrient, (3) chlorophyll fluorescence - an indicator of phytoplankton concentration, (4) colored dissolved organic matter fluorescence - an indicator of terrestrial runoff, and (5) optical beam transmittance - an indicator of suspended particle concentration. The instrumentation has several unique aspects. (1) It has been designed with an automatic freshwater, back-flushing system to remove debris and reduce fouling. (2) Data are relayed to the laboratory hourly via a two-way Iridium telephone link providing the capability to discover problems quickly and upload software changes if necessary. (3) It is one of the first underway-monitoring systems to utilize an MBARI-designed ISUS (in situ ultraviolet spectrometer) nitrate meter. As such, a few problems had to be overcome to get consistent results.

The measurements show a climate signal. The ACC was warmer in 2005 than 2006 with a summer temperature difference of ~2°C. This interannual difference is consistent with the Pacific Decadal Oscillation (PDO) climate index that changed from warmer to more-neutral temperatures between 2005 and 2006. Simultaneous measurements of nitrate and chlorophyll fluorescence show different regimes along the ferry route. Some locales have low nitrate and high chlorophyll implying phytoplankton blooms depleting nutrients. Others show high nitrate and low chlorophyll implying that vertical mixing replenishes the nitrate and impedes primary production by carrying cells below the photic zone.

Poster S8/S10-4441

A vertical profiling mooring for coastal observations: Coastal Autonomous Profiling and Boundary Layer System (CAPABLE)

John A. **Barth**[1], Murray D. Levine[1], Walt Waldorf[1], Andrew Barnard[2], Bruce Rhoades[2], Alex Derr[2], John Koegler[2] and Daniel Whiteman[2]

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A partnership between OSU and WET Labs is developing a Coastal Autonomous Profiling and Boundary Layer System (CAPABLE). CAPABLE will be equipped with sensors to measure the ocean temperature, velocity, salinity, nitrate content, dissolved oxygen level, suspended particle load, and chlorophyll concentration. Knowledge of these parameters is critical to assessing the state of the coastal ecosystem and for monitoring changes due to natural and anthropogenic forcing. CAPABLE consists of three components: (1) the ExTended ENdurance Autonomous Moored Profiler (xTEN AMP*)* based on a winch-on-board design capable of profiling a 200 m water column 8 times per day at 0-0.3 m/s. The system telemeters data to shore via radio or Iridium phone and is planned for 6-month deployments. The xTEN AMP carries a battery pack which can be recharged from a bottom-mounted power system; (2) the Shallow Coastal Upward Looking Profiler Integration Node (SCULPIN) housing the battery recharge system, a deployment/recovery system and a set of instruments to obtain high-resolution velocity profiles and for making measurements in the bottom boundary layer; (3) the Surface Boundary Buoy (SBB) making detailed observations in the air and the upper-ocean region The SBB also provides a platform for collecting and telemetering data to shore. CAPABLE has been built and tested at a mid-shelf site off central Oregon, a region with considerable surface waves and coastal currents. Future plans include long-term testing at a 200-m site with CAPABLE's full instrument suite and hooking CAPABLE to an underwater cable or deep-water mooring system.

Poster S8/S10-4447

The meso-scale response of subarctic North Pacific seabird community structure to lower trophic level abundance and diversity

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Understanding the mechanisms that structure communities and influence biodiversity are fundamental goals of ecology. To test the hypothesis that the abundance and diversity of upper-trophic level predators (seabirds) is related to the underlying abundance and diversity of their prey (zooplankton) and ecosystem-wide energy availability (primary production), we initiated a monitoring program in 2002 that jointly and repeatedly surveys seabird and zooplankton populations across a 7,500 km British Columbia-Bering Sea-Japan transect. Seabird distributions were recorded by a single observer (MH) using a strip-width technique, mesozooplankton samples were collected with a Continuous Plankton Recorder, and primary production levels were derived using the appropriate satellite parameters and the Vertically Generalized Production Model (Behrenfeld and Falkowski 1997). Each trophic level showed clear spatio-temporal patterns over the course of the study. The strongest relationship between seabird abundance and diversity and the lower trophic levels was observed in March/April ('spring') and significant relationships were also found through June/July ('summer'). No discernable relationships were observed during the September/October ('fall') months. Overall, mesozooplankton abundance and biomass explained the dominant portion of seabird abundance and diversity indices (richness, Simpson's Index, and evenness), while primary production was only related to seabird richness. These findings underscore the notion that perturbations of ocean productivity and lower trophic level ecosystem constituents influenced by climate change, such as shifts in timing (phenology) and synchronicity (match-mismatch), could impart far-reaching consequences throughout the marine food web.

Poster S8/S10-4450 (Cancelled)

The Alaska Pelagic Seabird Observer Program: A tool for tracking changes in seabird distribution in the North Pacific

Kathy J. **Kuletz**[1], Elizabeth A. Labunski[1], David B. Irons[1] and Shannon Fitzgerald[2]

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In the past few decades, large-scale, regional changes have occurred in all marine regions of Alaska. Seabirds are wide-ranging apex predators and are indicators of changes in marine ecosystems. Seabirds spend most of the year offshore, yet our data gaps are greatest for that portion of their lives. In 2006 and 2007 we reinstituted a pelagic seabird observer program that will enable researchers to make decadal and regional scale comparisons of seabird abundance and distribution. Although we used gps-integrated laptop computers for surveys, our protocol ensured that data were compatible with those collected in the 1970-1980's, currently in the North Pacific Pelagic Seabird Database. With a grant from the North Pacific Research Board (NPRB), the U. S. Fish and Wildlife Service reinstituted an at-sea observer program in collaboration with NOAA Fisheries and several NSF-funded programs. We placed seabird observers on ships of opportunity, primarily research vessels that covered large grids and collected oceanographic, plankton, and fisheries data. This effort will continue through 2010 as part of a multidisciplinary study of changes in the Bering Sea ecosystem, also funded by NPRB. In 2006-2007 we joined 24 cruises with over 300 days at sea and surveyed over 30,000 km of transects, primarily in the Bering Sea. This type of program is a foundation for testing hypotheses related to distributional shifts by wide-ranging apex marine predators. Having readily-accessible and current data on seabird distribution will also assist managers on issues related to fisheries, shipping, oil exploration, and catastrophic spills.

Poster S8/S10-4451

Fish activity, a major mechanism for nutrient and carbon recycling from coastal marine sediments

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Sediments underlying deep ocean basins accumulate carbon, nutrients and many trace compounds and contaminants. We used an ROV and a suite of acoustic, optic, and geochemical measurements to quantify short-term sediment resuspension events caused by flatfish activity. The study was conducted in conjunction with the deployment of the first node of the VENUS underwater observatory in the NE Pacific fjord, Saanich Inlet (BC, Canada). Resuspension of sediments by physical agents is negligible. We surveyed the seafloor from 180 to 85m transitioning from the deep anoxic zone (no fish) to shallower, oxygenated zones where flatfish abundance reached 0.6 per square meter. Turbidity levels near the bottom and the degree of bottom disturbance were correlated with benthic fish abundance. In situ sampling of the sediment clouds created by fish and resuspension simulations measured an immediate increase of ammonia, phosphorus and silica concentration (166%, 53%, and 3% respectively) and a drop in oxygen levels within the cloud. No change was detected in nitrate or nitrite concentrations. The resuspension rate was substantial, with over 100 disturbances m^{-2} day^{-1}; fish rework >40% of the seabed daily. This resuspension activity could reduce organic carbon sequestration by circa 230 mg C m^{-2} day^{-1}, equivalent to ~1/2 of its downward flux and enhances near-bottom turbidity, oxygen demand, and nutrients regeneration. To date, these processes are missing from geochemical models. Exploitation of ground fish stocks is likely to have a significant effect on geochemical cycles over the continental shelf.

Poster S8/S10-4460

Technology for cabled ocean observatories and their vertical profiler systems

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Developed over the course of over six years, NEPTUNE Canada will be the first ocean observatory to power a wide variety of deepwater undersea science instruments and to link them with the global Internet. The development of NEPTUNE Canada network poses many challenges. The network must deliver high bandwidth, high power, while being manageable and reliable. NEPTUNE Canada addresses these challenges using a combination of commercial submarine telecommunications equipment, commercial off-the-shelf equipment intended for enterprise applications, and newly developed components. A single, optically amplified fiber pair and distributed Optical Add-Drop Multiplexing (OADM) branching units provide two diverse optical paths to each node. Each optical path has an effective capacity of 2 Gb/s, making 4 Gb/s bandwidth available to each node during normal operation. The powering solution employs a constant voltage scheme capable of providing up to 10 kW at each node and over 120 kW total. An intermediate voltage of 400V is used for distribution with the node and from the node to instrument platforms. Cabled ocean observatories provide an opportunity for scientists to study not only the seabed but also the water column in real time. Significant progress is being made on the development of vertical profiling instrument platforms that are suitable for connection to a cabled observatory. The advantages and disadvantages of each technology will be considered.

Poster S8/S10-4487

A real-time coastal information system for aquaculture environmental monitoring

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A real-time coastal information system has been developed for monitoring aquaculture environments in Korea. Each system is deployed on a fish farm. There, sensor data (temperature, salinity and dissolved oxygen), play a crucial role in nowcasting/forecasting coastal ocean conditions and reducing the potential for mass mortality caused by an abnormal change of water quality. Compared with an offshore moored buoy system, the coastal system has advantages of direct data distribution to fishermen at the farm and rapid maintenance of equipment due to easy access. To avoid disruption of the data stream and identify malfunctions needing repair, bimonthly preventive maintenance and daily monitoring of measured data are systematized. Confidence intervals calculated by a statistical algorithm operating on accumulated data are applied to incoming data streams to detect outliers and other problems. These methods help insure data throughput and quality. In addition, the system has various ways of distributing data. Information is provided to the public through an Internet homepage and by e-mail, if requested. A display unit connected to equipment at the farm gives the measured data directly to fishermen, enabling them to operate their farms with scientific guidance. Finally, a large display unit is installed at the local fish market to show measured data at the nearest station along with tide and weather information.

Poster S8/S10-4492

An overview of the Ocean Observatories Initiative (OOI) network

Susan **Banahan**

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The National Science Foundation’s Ocean Observatories Initiative (OOI) will support the construction and operation of an interactive, integrated ocean observing network. This network is designed to provide the transformative technology to enable next-generation studies of fundamental ocean processes. The OOI is a research-driven network design and will afford observations at coastal, regional, and global scales in support of investigations into climate variability and ocean ecosystems, biogeochemistry, coastal processes, mixing dynamics, plate-scale geodynamics,

fluid-rock interactions, and the sub-seafloor biosphere. The elements of the OOI include highly capable ocean buoys, arrays of fixed and re-locatable moorings, autonomous underwater vehicles, and cabled seafloor networks. These elements will be integrated through a system-wide cyberinfrastructure allowing for remote control of instruments, adaptive sampling, and near-real time access to data. As construction of the network progresses, there will be opportunities to pursue new avenues of research, develop new sensor technologies, and expand ways to communicate scientific information to research communities, students, decision-makers, and the general public. The planning for construction is now underway. This presentation will provide an overview of the planning activities and current network design. The OOI is administered by the Joint Oceanographic Institutions which focuses on the science, technology, education, and outreach for an emerging network of ocean observing systems. For more information see http://www.joiscience.org/ocean_observing.

Poster S8/S10-4518

Autonomous underwater glider observations off central Oregon and the Oregon Coastal Ocean Observing System (OrCOOS)

John A. **Barth**, R. Kipp Shearman, Anatoli Erofeev, Tristan Peery, Murray Levine, Walt Waldorf and Craig Risien

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Beginning in April 2006, we have used an autonomous underwater vehicle glider to sample a cross-shelf transect along the Newport Hydrographic Line off central Oregon (44 39.1’N). The section runs from the 20-m isobath out about 90 km, and takes 3-7 days to complete. The glider undulates from the surface to 2-3 m above the bottom (200 m maximum) with an along-track resolution ranging from 100 m in shallow water to 400 m in deep water. Position and oceanographic data are relayed to shore every 6 hours *via* Iridium cell phone. The glider is equipped with a conductivity-temperature-depth instrument and several optical instruments (chlorophyll fluorescence, colored dissolved organic matter fluorescence, light backscatter for a measure of particles, and dissolved oxygen). The benefits of autonomous sampling include low cost relative to comparable ship-time and a continued presence in the ocean for increasing the chances of observing intermittent, unpredictable (possibly important) processes. The glider transects are contributing to the new Oregon Coastal Ocean Observing System (OrCOOS), a sub-regional part of the Northwest Association of Networked Ocean Observing Systems (NANOOS). OrCOOS maintains a mid-shelf mooring, 10 miles offshore of Newport, with physical, bio-optical and dissolved oxygen sensors. The near real-time glider and mooring observations, supplemented by ship-based measurements, are being used to track and understand the evolution of the extreme hypoxia event off central Oregon during summer 2006.

Poster S8/S10-4519

Dense Ocean floor Network system for Earthquakes and Tsunamis (DONET)

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In the Japanese seismogenic zone, the Nankai Trough is well known as the mega-thrust earthquake zone generating tsunamis with the interval of 100-150 years. The hypocenters of both the 1944 Tonankai and 1946 Nankai earthquakes were located off the Kii peninsula. Based on simulation and structure research, we proposed and have begun deployment of a dense ocean floor observatory network system. This advanced dense ocean floor observatory network system has useful functions as follows:

1) Redundancy, extension and advanced maintenance systems using a looped cable system, junction boxes and ROV/AUV *etc.*;
2) Rapid evaluation and notification for earthquakes and tsunamis;
3) Provides observed data such as ocean floor deformation derived from pressure gauges to improve simulation and modeling research on mega-thrust earthquakes, This means the data assimilation, will be quite important to improve simulation research;
4) Understanding of the interaction between the crust and upper mantle around the subduction zone;
5) Developing advanced technology.

In this project, another ocean floor deformation monitoring system and new cable system with in-line sensors are under development.

S9 POC/CCCC/MONITOR Topic Session Operational forecasts of oceans and ecosystems

Co-sponsored by ICES

Co-Convenors: Michael G. Foreman (Canada), Shin-ichi Ito (Japan), Skip McKinnell (PICES) and Francisco E. Werner (U.S.A.)

Numerical models of ocean dynamics are becoming increasingly sophisticated and are now used to forecast future ocean states. The forecasts vary in geographic scale from local embayments to the global ocean, and on temporal scales, from one day to several years. Improvements in ocean forecasting will contribute directly to forecasts of fisheries where the linkages between ocean dynamics, fish migration, and fishery ground formation are understood. Likewise, lower trophic level (LTL) ecosystem models have been coupled to numerical models of ocean circulation and tested at many sites. LTL models can now anticipate the production of planktonic prey and biomass when the state of the ocean is captured accurately by ocean circulation models. Moreover, fish growth and recruitment models are starting to be coupled to LTL ecosystem models. The growing interest in ecosystem-based management, and the need to develop a management/decision policy will no doubt rely upon forecasts from coupled physical-ecosystem models. To fully realize the potential of model-based products for ecosystem-based management, a relatively high predictability of ocean structures is essential. This session will review the current status of operational ocean prediction models, discuss the ability of physical models to forecast ecosystem state and clarify the approaches needed for future studies and improvements. Ideally, we seek papers describing operational forecasts of oceans and/or ecosystem-state and, more importantly, evaluations of their performance. Operational forecasts can be based on numerical or statistical models, and comparisons of these two approaches are welcome.

Friday, November 2, 2007 09:00 – 17:15

09:00 ***Introduction by convenors***

09:10 **Masafumi Kamachi, Toshiya Nakano, Satoshi Matsumoto, Norihisa Usui, Yosuke Fujii and Shiroh Ishizaki (Invited)**
An example of operational ocean data assimilation and prediction (S9-4268)

09:40 **Shin-ichi Ito, Shigeho Kakehi, Yasumasa Miyazawa, Takashi Setou, Kosei Komatsu, Manabu Shimizu, Akira Kusaka, Kazuyuki Uehara, Yugo Shimizu, Akira Okuno and Hiroshi Kuroda**
Predictability of location of the Kuroshio Extension and the Oyashio First Branch by JCOPE (S9-4198)

10:00 **Yasumasa Miyazawa, Takashi Kagimoto and Kosei Komatsu**
Water mass structure in the Kuroshio-Oyashio mixed water region reproduced by JCOPE2 (S9-4100)

10:20 ***Coffee / tea break***

10:50 **Einar Svendsen (Invited)**
Operational oceanography and the ecosystem approach (S9-4180)

11:20 **Alain F. Vézina, Charles Hannah and Mike St. John (Invited)**
A top-down approach to modelling marine ecosystems in the context of physical-biological modelling (S9-4240)

11:50 **Susan E. Allen, A. Kathleen Collins, Douglas J. Latornell and Rich Pawlowicz**
Predicting the timing of the spring bloom in the Strait of Georgia (S9-4108)

12:10 **Edmundo Casillas and William Peterson**
Recent high-frequency variability in the PDO and ocean conditions in the northern California Current: Impacts on ecosystem structure and salmon growth and survival (S9-4408)

12:30 ***Lunch***

14:00 **Albert J. Hermann, Thomas M. Powell, Wei Cheng and Sarah Hinckley**
Performance of NEMURO with the Regional Ocean Modeling System (ROMS) for the Coastal Gulf of Alaska (S9-4406)

14:20 **Wei Cheng, Al Hermann, Sarah Hinckley and Ken Coyle**
Interannual variability in the Gulf of Alaska: A perspective based on a coupled bio-physical model (S9-4401)

14:40 **William Crawford and Ian Perry**
Eastern Gulf of Alaska: Climate variability, future projections and ecosystem impacts (S9-4072)

15:00 **Elena I. Ustinova and Yury D. Sorokin**
Statistical forecasting of ice cover in the Far-Eastern Seas (S9-4301)

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

15:40 **Hiroaki Tatebe, Ichiro Yasuda and Hiroaki Saito**
Horizontal transport of *Neocalanus* copepods in the subarctic and northern subtropical North Pacific (S9-4328)

16:00 **Changshui Xia, Fangli Qiao,Yongzeng Yang and Guansuo Wang**
The circulation and water exchange of the Bohai Sea from a wave-tide-circulation coupled model (S9-4308)

16:20 **George V. Shevchenko and George G. Novinenko**
Monitoring of temperature conditions in the Sea of Okhotsk (S9-4098)

16:40 **Yury I. Zuenko, E.I. Ustinova, V.N. Vdovin, V.A. Nuzhdin, Z.G. Ivankova and N.T. Dolganova**
Temporal lags between changes of climatic indices and some components of the Japan/East Sea ecosystem (S9-4477)

17:00 ***Summary and wrap up***

S9 Posters

S9-4075 **Yong-Kyu Choi, Young-Sang Suh, Ki-Tack Seong, Sang-Woo Kim, Won-Deuk Yoon, Woo-Jin Go, In-Seong Han and Joon Yong-Yang**
Bimonthly variation of synoptic features in hydrography and nutrient in the Southern Sea of Korea

S9-4366 **J.J. Colbert, Thomas C. Wainwright and Bernard A. Megrey**
Linking the NEMURO suite into the Earth Systems Modeling Framework

S9 Oral Presentations

2 November, 9:10 (S9-4268) Invited

An example of operational ocean data assimilation and prediction

Masafumi **Kamachi**, Toshiya Nakano, Satoshi Matsumoto, Norihisa Usui, Yosuke Fujii and Shiroh Ishizaki

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Recent developments in observing systems, modeling and data assimilation methods enable us to estimate and predict ocean states operationally. As a result, seasonal to interannual forecasting, fisheries, marine safety, offshore industry, management of shelf/coastal areas, security applications, and improved information for related fields (marine biogeochemical process and numerical weather prediction) are among the expected beneficiaries of ocean data assimilation and prediction. We discuss the current status of operational ocean data assimilation and prediction in two categories: “Ocean Weather” (mesoscale to coastal ocean states) and “Ocean Climate” (the oceanic component in the climate system). It is shown how ocean observing systems play an important role in understanding ocean phenomena through data assimilation; water mass and its pathways are analyzed through data assimilation; recent operational predictions of ocean state are performed; long range variability is analyzed with ocean reanalysis. These issues are discussed with examples mainly adopted from the projects related to the Meteorological Research Institute ocean data assimilation system MOVE/MRI.COM. Possible future developments are also addressed.

2 November, 9:40 (S9-4198)

Predictability of location of the Kuroshio Extension and the Oyashio First Branch by JCOPE

Shin-ichi **Ito**[1], Shigeho Kakehi[1], Yasumasa Miyazawa[2], Takashi Setou[3], Kosei Komatsu[3], Manabu Shimizu[3], Akira Kusaka[4], Kazuyuki Uehara[5], Yugo Shimizu[1], Akira Okuno[3] and Hiroshi Kuroda[3]

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An operational ocean prediction system (JCOPE: Japan Coastal Ocean Predictability Experiment) was investigated to evaluate the reproducibility and predictability of the position of the Kuroshio Extension (KE) and the Oyashio First Branch (OFB) mixed water region. The JCOPE-system uses a data assimilation method to incorporate data from satellites, ARGO floats, and ships. The data assimilation successfully reconstructed the appropriate position of KE, although the OFB was not accurately reproduced. The predicted positions of the KE and OFB deviated from the observed position. However, the predictions had a tendency to follow the data assimilated reanalysis values rather than the purely simulated values. These results showed that the predictability of KE and OFB strongly depends on the initial conditions. The inclusion of data collected during coastal surveys by local fisheries institutions resulted in improvements of the initial conditions as well as the OFB’s predictability. However, the results also showed that the horizontal scale for the optimal interpolation is inadequate to resolve the typical oceanic structure in the mixed water region. To further improve the reproducibility and predictability, the horizontal scale for the optimal interpolation needs to be changed.

2 November, 10:00 (S9-4100)

Water mass structure in the Kuroshio-Oyashio mixed water region reproduced by JCOPE2

Yasumasa **Miyazawa**[1], Takashi Kagimoto[1] and Kosei Komatsu[2]

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Nowcast skills of operational ocean prediction systems (JCOPE: Japan Coastal Ocean Predictability Experiment) are investigated with emphasis on the water mass structure in the Kuroshio-Oyashio mixed water region. The first version of the JCOPE system (JCOPE1) has acceptable skill for the Kuroshio region but it did not properly reproduce the oceanic conditions in the mixed water region. JCOPE1 has been updated to a second version (JCOPE2). We discuss the sensitivity of modifications adopted in JCOPE2 including: 1) use of 3D variational assimilation instead of multivariate optimum interpolation, 2) addition of the in-situ temperature/salinity data obtained from the local fishery agencies to the original in-situ data archive for data assimilation, and 3) the change of the horizontal advection and viscosity-diffusion schemes built into the POM-based OGCM. Nowcast skill for metrics of the typical features of the mixed water region are examined in detail, including: the water mass property in the mixed water region, southward latitude of the Oyashio First Branch, and both the position and intensity of the Kuroshio Extension.

2 November, 10:50 (S9-4180) Invited

Operational oceanography and the ecosystem approach

Einar **Svendsen**

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With the aim of giving advice to management and the public, output from new integrated ecosystem based systems needs to deliver operational products as required by the users (hindcast, nowcast and forecast). Under the umbrella of GEOSS and GMES, building a sustainable Marine Core Service (for ocean “weather forecasting” and climate) is underway through the ongoing MERSEA EU-project and the proposed MyOcean project. An approach towards ecosystem based research and management means, with respect to science, “to consider the most important driving forces on and the processes within the ecosystems”. Due to the large system variability (in time and space), this demands a much broader knowledge of the state and dynamics of marine systems than is generally available from measurements alone. Therefore extensive use of “bottom up” numerical biophysical models are needed in combination with observations and “top down” population dynamics models and statistical tools. An example of a 3-year prediction of northeast Arctic cod recruitment is given. The main driving forces on many systems are climate/physics and the fishers or fisheries management. In some oceanic areas additional drivers include fertilization, pollution, introduction of new species and habitat disturbance. The physics has a direct impact on all trophic levels, but also indirectly through “bottom up” effects on the food chain via primary and secondary production. Therefore it is essential that the physics being used as input to biochemical models is of high quality and has a resolution relevant for the biochemical processes.

2 November, 11:20 (S9-4240) Invited

A top-down approach to modelling marine ecosystems in the context of physical-biological modelling

Alain F. **Vézina**[1], Charles Hannah[1] and Mike St. John[2]

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Coupled physical-biological models have become reasonably proficient at simulating physically-driven features such as spring blooms. However, demands for marine ecosystem models are shifting to predicting functional diversity and ecosystem change. Much work is needed to develop the ecosystem models that can deal with such

questions without getting bogged down into unmanageable complexity. We argue that we need systematic ways to add complexity to ecosystem models, specifically a top-down approach that takes explicitly into account high-level rules about how ecological networks are organized. We will draw on complexity theory and food web ecology to gain insights into potential high-level rules that could be explored in developing complex marine ecosystem models. We will also look at potential avenues for the implementation of such approaches in the context of operational forecasting and illustrate them with examples from current work. We see convergence among the lower trophic levels, multispecies and theoretical food web modelling communities and, in that context, cross-fertilization of ideas needs to be encouraged.

2 November, 11:50 (S9-4108)

Predicting the timing of the spring bloom in the Strait of Georgia

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The Strait of Georgia is a semi-enclosed coastal sea with strong estuarine circulation. The growing season starts with a classic spring-bloom followed by strong summer productivity. We have coupled a one-dimensional vertical-mixing model that uses a K-Profile parameterization of the boundary layer to a NPZD-class of biological model with 2-12 compartments. Two-dimensional physical processes, such as the estuarine circulation are parameterized. The model is forced with hourly meteorological data and daily river data. The factors that control the arrival time of the spring bloom were determined using the coupled biophysical model. A statistical model generated from the dynamical model has been used successfully to predict the timing of the spring bloom in 2006 and 2007. Predictions were made at the end of February and blooms occur from the beginning of March to mid-April. Methods to use the dynamical model in a prediction mode will be discussed.

2 November, 12:10 (S9-4408)

Recent high-frequency variability in the PDO and ocean conditions in the northern California Current: Impacts on ecosystem structure and salmon growth and survival

Edmundo **Casillas** and William Peterson

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Recently, the northeast Pacific has experienced high-frequency variability in the PDO pattern: cool phase from 1999-2002; warm phase from late 2002-2006; cool from 2006 to present. Thus, nature has handed us a natural experiment that allows us to determine in what ways and how quickly marine organisms respond to strong climate variability. We use our 12-year time series of hydrography and zooplankton collected off Newport OR and our 10-year time series of hydrography, zooplankton and pelagic fish collected off Washington and Oregon to investigate the response of the pelagic marine ecosystem to recent changes in state of the North Pacific. Ecosystem indicators have been developed from these time series as metrics to describe interannual variability in ocean conditions, and to forecast recruitment variability of salmon in Pacific Northwest waters. We communicate our results through a website; the site includes information on the status of the northern California Current ecosystem on a seasonal basis, and provides a one-year lead forecast of returns of coho salmon and a two-year lead forecast of Chinook returns, based on the "stoplight" approach. Our ability to manage fishery resources in the future will depend in part on our ability to forecast the impact of changing ocean conditions as a result of global climate change. We suggest that use of a complete set of ecosystem observations, from physics to fish, will become a requirement if we are to understand fully how variations in physical climate forcing will affect fisheries and marine ecosystem productivity.

2 November, 14:00 (S9-4406)

Performance of NEMURO with the Regional Ocean Modeling System (ROMS) for the Coastal Gulf of Alaska

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Two widely used community ocean models – the Regional Ocean Modeling System (ROMS) and the North Pacific Ecosystem Model for Understanding Regional Oceanography (NEMURO) – have recently been merged. ROMS is a 3D, primitive equation circulation model that includes multiple options for physical data assimilation; these could be valuable assets for the use of NEMURO in 3D ocean hindcasting/forecasting. Here, we describe initial testing of NEMURO performance in ROMS (without assimilation), in simple 1D, 2D and 3D cases. In particular, we explore the behavior of NEMURO-ROMS in the Coastal Gulf of Alaska, as compared to the 4-box NPZD model of Powell *et al.*, and the 11-box, multi-size-class NPZ model with iron limitation of Hinckley *et al.*

2 November, 14:20 (S9-4401)

Interannual variability in the Gulf of Alaska: A perspective based on a coupled bio-physical model

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A coupled 3D bio-physical model is used to investigate temporal and spatial variability of the physical and lower trophic level biological processes in the Gulf of Alaska, with a focus on understanding mechanisms regulating upper ocean stratification and control by the latter on biology. The physical model is an ocean general circulation model based on Regional Ocean Modeling System (ROMS), and the biological model uses 11 boxes to represent key lower trophic level components in the region including limitation by nitrogen (ammonia, nitrate) and micronutrients (iron). To help interpret results from the fully coupled model, a 2-dimensional model is developed to test the sensitivity of modeled stratification to parameters in the K-profile Parameterization (KPP) mixing scheme, and to variable surface momentum and buoyancy flux forcings. In particular, we investigate the sensitivity of stratification to coastal freshwater input when various background mixings are added to KPP. Our results highlight the need to further improve near-surface vertical mixing parameterizations in ocean models.

2 November, 14:40 (S9-4072)

Eastern Gulf of Alaska: Climate variability, future projections, and ecosystem impacts

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We discuss recent changes in species composition associated with variability of ocean temperatures and currents over the Canadian west coast and adjacent American shelves. Ocean temperatures oscillated over the past decade due to changes in winds over the Gulf of Alaska. Highest winter-average surface temperatures in 70 years of observations along the coast were in 1997-1998, but coldest temperatures ever measured at 100 to 200 m depth arrived four years later, in 2002. The summers of 2004 and 2005 experienced the warmest pelagic near-surface temperatures in 50 years of observations, but by 2007 temperatures were again significantly below normal. These events brought major changes in ecosystems. Zooplankton populations shifted between boreal species and southern

species as temperatures fell and rose. Hake extended their range far to the north in warm summers of 1998 and 2005. Juvenile salmon on the continental shelf survived in greater numbers in cooler years. Seabirds experienced their worst ever breeding year in 2005 when persistent upwelling winds of spring and summer were late in arriving. Some of these changes are attributed to ocean temperatures, others to changes in prey and predators at critical life stages. Many of these changes are noted in state of the ocean reports prepared annually by Canadian and American scientists over the past eight years. Based on these past changes, we will provide a scenario of species dominance in ocean temperatures expected by 2050 as predicted by a recent application of IPCC climate models to temperatures of the North Pacific Ocean.

2 November, 15:00 (S9-4301)

Statistical forecasting of ice cover in the Far-Eastern Seas

Elena I. **Ustinova** and Yury D. Sorokin

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In Far-Eastern seas with seasonal ice cover, the extent of freezing is an important indicator of environmental large-scale change. At present, statistical long-range forecasting of sea-ice cover is possible mainly because of low-frequency, quasi-periodic variation that has been revealed in studies of these characteristics. Periods with confidence levels ≥95% (significant contributions of ice cover variance) were used to select independent variables in multiple regressions. An harmonic component method was used to estimate the tendencies of mean winter ice cover in the Bering and Okhotsk Seas and Tatar Strait. Although this method has a problem of reliability in estimating the periods, it does allow for approximate long-range forecasts. The first attempts to forecast long-term ice cover variability in the Far-Eastern Seas were undertaken by us in 1998. Since then, the prognosis curves have changed because of significant changes in the characteristics of ice cover variability in recent years. A new "scenario" has been constructed. In the Bering Sea, expectations were developed using wavelet analysis which produces, a more accurate reflection of recently-observed values of sea-ice extent. For predictions of changes in the ice regime over short time scales (month and season), atmospheric characteristics are used. In this case, the errors of the forecast are related to extreme events. The formation of strong winter atmospheric anomalies over the Far-Eastern region causes a fast response in large ice cover anomalies. As a result, the lag period in the winter 2000-2001 was only of 10-20 days.

2 November, 15:40 (S9-4328)

Horizontal transport of *Neocalanus* copepods in the subarctic and northern subtropical North Pacific

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Horizontal transport and survival rate of copepods of the genus *Neocalanus* in the subarctic region of the North Pacific are investigated by particle tracking experiments that consider their seasonal vertical migration. It is shown that *N. flemingeri* is transported to more distant regions from their initial positions than *N. plumchrus* and *N. cristatus*. In the Bering Sea (BS), 11% of the small forms of *N. flemingeri* are transported southward out of the BS and reach the Transition Domain (TD) across the SubArctic Front (SAF). In contrast, 7% of *N. flemingeri* (large form) initially in the Okhotsk Sea (OS) enter the North Pacific and reach the TD. The pathways from the OS/BS to the TD are near the east coast of Japan and the Kuril Islands. These species are transported in the waters of OS/BS origin with colder temperatures and most of *N. flemingeri* survive until they reach the TD. Of the *N. flemingeri* (small form) initially in the TD, 25% reach the eastern boundary current region and only a half of these survive in the surface layer. This pattern is also common to *N. plumchrus* and *N. cristatus*. The cross-SAF transport of *Neocalanus* copepods may transport about 850 KtC/yr from the subarctic to the subtropical region. A large part of this cross-SAF carbon transport occurs along the Oyashio coastal intrusion. The magnitude of the cross-SAF transport of *Neocalanus* copepods is large enough to provide prey to sustain the Pacific saury (*Cololabis saira*) in the Mixed Water Region.

2 November, 16:00 (S9-4308)

The circulation and water exchange of the Bohai Sea from a wave-tide-circulation coupled model

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The Bohai Sea is a shallow semi-enclosed bay with an average water depth of 18 m that is located at the northern end of the Yellow Sea. The circulation and water exchange of the Bohai Sea is studied using a Wave-Tide-Circulation coupled model. The simulated temperature and current fields agree well with observations. The results show that circulation patterns of the Bohai Sea are influenced by tidal residual currents, winds and baroclinic currents. It is shown that in the offshore area of the Yellow River delta there is a north-northeastward current that reaches the offshore area off Qinhuangdao year round. This current is mainly the tidal residual current. The results also indicate that the density residual currents are robust in summer. The water exchange ability of the Bohai Sea is also studied using the half-life time concept.

2 November, 16:20 (S9-4098)

Monitoring of temperature conditions in the Sea of Okhotsk

George V. **Shevchenko** and George G. Novinenko

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Temperature conditions have a significant impact on marine ecosystems, so their rapid changes and significant anomalies are of interest to hydrobiologists, managers of fishery companies, *etc.* In 1996 SakHNIRO deployed a TeraScan station to monitor the Okhotsk Sea surface temperature. We now have a 10-year time series that provides enough for detail statistical analysis, in particular to calculate multiyear mean SST values (norms) and anomalies. Multiyear mean values were calculated for 15'×15' squares with time intervals of 10 days and 1 month. Root-mean-square errors (σ) were calculated for each spatial cell and each time interval. Estimates of the statistical significance of SST anomalies were also obtained. Water temperature anomalies that exceed σ are of interest for detailed studies, while anomalies which exceed 2σ may be dangerous for marine ecosystems. Anomalies which exceed 2σ were observed rarely and they usually occupied <10% of the Sea of Okhotsk square. Negative anomalies prevailed; positive anomalies with a square >10% were observed only twice (summer 1998 and spring 2002). The most frequent negative anomalies were observed in August-October, 2002. Probably a high cyclonic activity caused the negative anomalies in the Sea of Okhotsk during this period. We have also analyzed relatively small-scale anomalies in the areas adjacent to Sakhalin Island. Well-defined anomalies were more often observed in the nearshore zone which is most important for fishery especially for salmon fishing.

2 November, 16:40 (S9-4477)

Temporal lags between changes of climatic indices and some components of the Japan/East Sea ecosystem

Yury I. **Zuenko**, E.I. Ustinova, V.N. Vdovin, V.A. Nuzhdin, Z.G. Ivankova and N.T. Dolganova

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Semi-centennial climatic indices (PDO, AOI, NPI, ENSO, ALPI, *etc.*), sea surface temperature (SST) and subsurface temperature (SubST) and their relations with zooplankton abundance and composition, and populations of the main fishes and squids in the Japan/East Sea are considered. Statistical relations between the data series are investigated and possible mechanisms for temporal lags in the correlations are analyzed. The PDO, NPI, and ALPI are the most important indices for the thermal regime of the Japan Sea. They have significant positive (NPI, ALPI) or negative (PDO) correlations that are synchronous or quasi-synchronous (lag < 1 year) with SST. These correlations reflect a predominant decadal cycling of SST with cold periods in 1960s, 1980s, and early 2000s and warm periods in 1950s, 1990s, and recently. At lower trophic levels, zooplankton abundance in the Japan/East Sea changes synchronously with SubST in summer. Periods of higher abundance are characterized by a dominance of

large-sized copepods. As a result, zooplankton biomass increased sharply in 1990s, then decreased in early 2000s, and began to increase again recently.

The most abundant fishes of interest in the Japan/East Sea are of subtropical origin including anchovy, saury, sardine, and mackerel. Although the Japanese common squid inhabits the surface layer, both its stock size and catch have a synchronous positive correlation with SubST. Likewise, the annual catch of saury has similar correlation with the SubST in shelf zone but with a 1-2 year lag that corresponds to its life duration. Opposite to the short-lived squid and saury, fluctuations of other subtropical fish catches are negatively related to SST (winter) and SubST (summer) with a prominent lags: 2-3 years for sardine, 7-10 years for mackerel, and 8-11 years for anchovy. The lag for sardine could be explained by the age of its entering the fishery, but the long lags for other species exceed their life cycle and are possibly connected with interspecies interactions. Annual catches of demersal fish species such as greenling, pollock, and flounders on the shelf of Primorye have more complex correlations with environmental factors that are determined by both stock fluctuations and features of their distribution and fisheries.

In contrast to near-synchronous responses by individual species to temperature, it appears that ecosystem responses to climatic changes are more delayed, in the sense that more time is necessary to reorganize the ecosystem.

S9 Posters

Poster S9-4075

Bimonthly variation of synoptic features in hydrography and nutrient in the southern Sea of Korea

Yong-Kyu **Choi**, Young-Sang Suh, Ki-Tack Seong, Sang-Woo Kim, Won-Deuk Yoon, Woo-Jin Go, In-Seong Han and Joon Yong-Yang

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Hydrographic and nutrient observations in the southern Sea of Korea during the period October 2004 to August 2005 were analyzed. A distinct haline front was seen in October, but a thermal front appeared in December and lasted until April. The distributions of temperature and salinity showed weak features in June. In August, the thermal front was found clearly again and low saline water covered the region of the open sea. Vertical stratification developed in June and intensified in August. In other words, the distribution of nutrients in relation to temperature and salinity showed consistent patterns in winter due to the effects of mixing. The distribution of nutrients in relation to temperature and salinity showed wide ranges in summer due to the inflow of low saline water. We did not find linear relationships of nutrients versus temperature and salinity in spring and autumn.

Poster S9-4366

Linking the NEMURO suite into the Earth Systems Modeling Framework

J.J. **Colbert**[1], Thomas C. Wainwright[2] and Bernard A. Megrey[3]

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The Earth Systems Modeling Framework (ESMF) is a toolset for structuring, linking and running models of earth's ecosystems. It allows modelers to utilize, extend and link three-dimensional models of earth's atmosphere and oceans, thus providing a framework for interoperation of models developed by a diverse scientific community. We have developed ESMF software components for the NEMURO plankton model and the NEMURO.FISH fish

bioenergetics model, allowing them to be linked with a number of different ocean circulation models. We demonstrate this system with an example application to plankton and fish populations that inhabit the northeast Pacific coastal shelf west of central Oregon. Local coastal climate and ocean patterns drive the dynamics of this upwelling zone, bringing nutrient-rich deep water to the surface that feeds this ecosystem from the bottom up. The model will be used to explore the spatial and temporal dynamics of the large zooplankton and forage fish that are critical to the population dynamics of the higher trophic level fish and fisheries. This software will be made available and can be linked, within ESMF, to a variety of physical circulation and biological models at local, regional, or global scales. Next steps will include further code validation and verification, adding support for other NEMURO-related models and developing links to web-based visualization tools.

S11 BIO/FIS/POC Topic Session Phenology and climate change in the North Pacific: Implications of variability in the timing of zooplankton production to fish, seabirds, marine mammals and fisheries (humans)

Co-Convenors: Elizabeth A. Logerwell (U.S.A.), David L. Mackas (Canada), Shoshiro Minobe (Japan) and William J. Sydeman (U.S.A.)

Ecosystems of the North Pacific Ocean are characterized by strong seasonal variability in productivity. The Intergovernmental Panel for Climate Change projections indicate that substantial changes in phenology (timing events) and the biological interactions that depend on the seasonal cycle are likely. Several mechanistic hypotheses have been set forth to explain changes in fish production in relation to phenology, including "match-mismatch" and "optimal environmental window", yet there have been few tests of these ideas. In light of climate change predictions and recent changes in phenology in some North Pacific ecosystems (*e.g.*, late upwelling in the California Current in 2005/2006), the session will focus on the implications of changes in the timing of seasonal zooplankton production to upper trophic level organisms through changes in their trophic ecology, physiology and behavior. Physical environmental changes that influence phenology also are within the scope of this session. Papers which test hypotheses, present new theoretical treatments, and/or provide models of life history variation are encouraged. In particular, integrated, multi-trophic level, multi-disciplinary analyses are sought. We anticipate publication of the papers from this topic session in primary literature.

Friday, November 2, 2007 09:00 – 17:10

09:00 ***Introduction by convenors***

09:10 **Joël M. Durant (Invited)**
Match-mismatch, trophic interactions and climate change (S11-4045)

09:40 **Ronald W. Tanasichuk**
The effect of variations in timing and magnitude of euphausiid productivity on return variability of Somass River sockeye (*Oncorhynchus nerka*) salmon (S11-4047)

10:00 **Rubén Rodríguez-Sánchez, Marlene Manzano, Héctor Villalobos, Mati Kahru, Daniel Lluch-Belda and Sofía Ortega-García**
Possible mechanisms underlying abundance changes of Pacific sardine (*Sardinops caeruleus*) in the California Current System during the last warming regime (1980-1997) (S11-4053)

10:20 **Jennifer E. Purcell**
Effects of temperature and light on the phenology of jellyfish (S11-4063)

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

11:00 **Benjamin J. Laurel, Thomas P. Hurst and Lorenzo Ciannelli**
An experimental examination of temperature interactions in the 'match-mismatch' hypothesis for Pacific cod larvae (S11-4091)

11:20 **Yulia N. Tananaeva and Marat A. Bogdanov**
SST and ice conditions' variability in different parts of North West Pacific, its influence on phytoplankton production and fishery resources (S11-4105)

11:40 **Richard J. Beamish, Ruston M. Sweeting and Chrys M. Neville**
Managing a Strait of Georgia ecosystem (S11-4125)

12:00 **Sanae Chiba and Kosei Sasaoka**
Climatic forcing and phytoplankton phenology over the North Pacific 1997-2006 (S11-4138)

12:20 ***Lunch***

13:30 **Yutaka Watanuki, Motohiro Ito, Tomohiro Deguchi and Shoshiro Minobe (Invited)**
Timing of breeding and prey switching in Rhinoceros Auklets; match-mismatch of the phenology explains between year variation of chick growth (S11-4177)

14:00 **Andrew Thomas, Peter Brickley and Stephanie Henson**
Large-scale time and space patterns of chlorophyll phenology in the NE Pacific (S11-4183)

14:20 **Sonia D. Batten and David L. Mackas**
Changes in development timing and cohort width of *Neocalanus plumchrus* / *flemingeri* copepods in the eastern North Pacific (S11-4185)

14:40 **Kazuaki Tadokoro, Yuji Okazaki and Hiroya Sugisaki**
Decadal scale variations in developmental timing of *Neocalanus* copepod populations in the Oyashio waters, western North Pacific (S11-4193)

15:00 **Atsushi Tsuda, Takumi Nonomura, Mitsuhiro Toratani and Sachihiko Itoh**
Food availability for Japanese sardine larvae in the Kuroshio extension area (S11-4178)

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

15:50 **Steven J. Bograd, William J. Sydeman and Christine Abraham**
The phenology of coastal upwelling in the California Current System (S11-4206)

16:10 **Lorenzo Ciannelli, Benjamin J. Laurel, Thomas Hurst, Janet Duffy-Anderson and Michael Behrenfeld**
Environmental effects on food and larval mismatch (S11-4225)

16:30 **William T. Peterson, Leah Feinberg, Tracy Shaw, Jennifer L. Menkel and Jay Peterson**
Phenology of coastal copepod species: Implications for productivity at various trophic levels in the Oregon upwelling zone (S11-4407)

16:50 **Douglas F. Bertram, Anne Harfenist and April Hedd**
Cassin's Auklet nestling diet reveals latitudinal variation in surface timing of *Neocalanus cristatus* prey biomass in BC: Mismatch likelihood is greater in warmer, southern waters (S11-4457)

S11 Posters

S11-4400 **Rana W. El-Sabaawi, Akash R. Sastri and John F. Dower**
Potential consequences of interannual variability in lower trophic level dynamics on energy transfer in the Strait of Georgia

S11-4520 **Christine L. Abraham, William J. Sydeman and G. Vernon Byrd**
Seabird-sockeye salmon co-variation in the eastern Bering Sea: Phenology as an ecosystem indicator and salmonid predictor?

S11 Oral Presentations

2 November, 09:10 (S11-4045) Invited

Match-mismatch, trophic interactions and climate change

Joël M. **Durant**

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There is now evidence that climate is changing and with it the trophic interactions on which we base our understanding of marine systems. Several mechanistic hypotheses have been set forth to explain changes in fish production in relation to phenology. Among them, the "match-mismatch" hypothesis elaborated by David Cushing is proving to be more and more useful to understand animal recruitment in the context of global climate change. While primarily developed for fish the match-mismatch hypothesis is currently used in all systems, terrestrial, limnic and marine alike, mainly to explain the changes in phenology. Starting by the original hypothesis I will present some results on fish and seabirds illustrating its use to explain ecosystem functioning. However, recruitment control is more complex than the sole trophic/temporal processes described by the original match-mismatch hypothesis. I will present extensions of the hypothesis including spatiotemporal and trophic relationship components and finish with evolutionary considerations.

2 November, 09:40 (S11-4047)

The effect of variations in timing and magnitude of euphausiid productivity on return variability of Somass River sockeye (*Oncorhynchus nerka*) salmon

Ronald W. **Tanasichuk**

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I used information on juvenile migration timing and diet, euphausiid and zooplankton biomass variability, potential competitive and predator marine fish biomasses, and stock (smolt, total return and spawner abundances) to learn about the biological basis of Somass River sockeye (*Oncorhynchus nerka*) return variability. Sockeye juveniles migrate through the Somass River and Barkley Sound to the continental shelf in May. Euphausiids (*Thysanoessa spinifera*, 3–5 mm) are the key prey item. Euphausiid biomass variation in Barkley Sound explains return variability for 11 of the 12 lake (Sproat, Great Central)-age (3.2, 4.2, 4.3, 5.2, 5.3, 6.3) groups. There was a mismatch between migration timing and the timing of the peak biomass of 3–5 mm *T. spinifera* in 8 of 13 years.

2 November, 10:00 (S11-4053)

Possible mechanisms underlying abundance changes of Pacific sardine (*Sardinops caeruleus*) in the California Current System during the last warming regime (1980–1997)

Rubén **Rodríguez-Sánchez**[1], Marlene Manzano[2], Héctor Villalobos[1], Mati Kahru[3], Daniel Lluch-Belda[1] and Sofía Ortega-García[1]

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Given the sensitivity of Pacific sardine to ocean-climate variability, sardine distribution patterns show the role of oceanic fronts in determining their aggregation and influencing their recruitment in the California Current System (CCS), presumably as the forage habitat of young sardines. The latitudinal distribution of young-sardine monthly abundance-indices seems to follow seasonal advection changes of CCS, suggesting recruitment is related to the frontal zone where the California Current (CalC) and inshore California Countercurrent (CcC) converge parallel alongshore. From 1980 to 1997, analysis of interannual changes in sardine seasonal patterns show progressive

latitudinal-distribution changes of relative abundances. This suggests poleward changes of favorable conditions for young sardines along the frontal zone between Baja California and California. We made, as a proxy for the interannual variability along the frontal zone, monthly time-series of frequency of SST fronts for four different areas along the California–Baja California coast using the single-image, edge-detection method applied to monthly satellite data from the AVHRR Pathfinder v5. The relation of sardine-abundance and front-frequency indices suggests recruitment increases where optimal front-frequency levels are found and declines where they are suboptimal. Interannual changes in the latitudinal position of population levels along the frontal zone suggest a progressive interannual increase of northward advection of CcC after the 1976–1977 regime shift, whereas CalC southward advection weakened. Our results explain the return of the sardine to the northern part of CCS after the 1980s. Alongshore spatial comparison is a key part of our analysis. The same information (sardine and front indices) analyzed for any single area alone (*e.g.* interannual changes in the timing of seasonal front-frequency levels and sardine abundance variability off California) is less informative? and could? lead to different conclusions.

2 November, 10:20 (S11-4063)

Effects of temperature and light on the phenology of jellyfish

Jennifer E. **Purcell**

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Problem outbreaks of jellyfish and warming of the oceans are being reported at unprecedented rates. Models forecast continued changes in temperature, salinity, and solar radiation (insolation) as consequences of global warming. As consumers of microplankton, mesozooplankton, and ichthyoplankton, jellyfish are important members of the food webs, with direct and indirect effects on higher and lower trophic levels. Many species with a swimming jellyfish stage also have a benthic stage that asexually produces buds and new jellyfish (ephyrae). In this study, polyps of moon jellyfish, *Aurelia labiata*, from Puget Sound, Washington, USA were tested in 9 combinations of temperature (7, 10, 15°C) and salinity (20, 27, 34) in the dark, and in 9 combinations of photoperiod (12, 8, and 4h d^{-1}) and light intensity (1-screen, 2-screens, opaque) at ambient salinity (27) and temperature (12°C). Both high temperature and high light accelerated production of ephyrae from the benthic polyps. Each 1°C warming accelerated ephyra production by 4.2–6.6d. Polyps with the greatest light exposure produced ephyrae 30–40d before those in other treatments. In addition, more ephyrae were produced with increasing temperature; for each 1°C warming, polyps increased ephyra production by 8.8–11.3%. Thus, warming ocean temperatures may cause jellyfish to appear earlier, persist longer, and perhaps survive through the winter, increase jellyfish populations, and broaden or shift species' distributions. Predictions for insolation trends in the future are less clear than for temperature. The many factors affecting all members of the complex ocean food webs make predictions of future changes difficult.

2 November, 11:00 (S11-4091)

An experimental examination of temperature interactions in the 'match-mismatch' hypothesis for Pacific cod larvae

Benjamin J. **Laurel**[1], Thomas P. Hurst[1] and Lorenzo Ciannelli[2]

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The impact of climate change on the growth, survival and distribution of Bering Sea fish species is uncertain, but will likely depend on each species' physiological response to temperature. We measured how temperature mediated the vital rates of Pacific cod larvae (*Gadus macrocephalus*) under 'matches' and 'mismatches' in food availability. The first experiments examined the developmental rates of eggs and larvae in the absence of food among five temperature treatments *i.e.*, 0, 2, 4, 6, 8°C. The growth and survival of early and late hatching larvae were followed separately for each temperature treatment. Among all temperatures, the early hatching larvae were smaller but had more lipid reserves and survived longer after hatch in the absence of food than late hatching larvae. In a second experiment, we examined growth and survival of Pacific cod larvae under match-mismatch conditions at two temperatures (3 and 8°C). The 'match-mismatch' experiment demonstrated that cold environments lessen the consequences of prey timing and magnitude, but may expose larvae to longer periods of size-dependent predation. At high temperatures, match-mismatches in prey significantly impacted growth and survival, with early mismatches

in food (LF-HF treatment) having less severe consequences, likely due to the availability of yolk reserves and the potential for compensatory growth. The ecological implications of these results are discussed in addition to approaches of integrating these data into spatially-explicit models of larval survival in the Bering Sea and evaluating impacts of predicted changes in lower trophic level productivity.

2 November, 11:20 (S11-4105)

SST and ice conditions' variability in different parts of North West Pacific, its influence on phytoplankton production and fishery resources

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Water temperature in the high latitude regions affects greatly the biological processes. We analyzed weekly and monthly sea surface temperature (SST), ice cover and chlorophyll-a maps sets by VNIRO and NASA years. Also we use information about catch, biomass and reset coefficient for pink salmon and pollack (by VNIRO). Date and speed of spring warming-up affects the duration and intensity of the spring phytoplankton bloom. The earlier warming-up begins, the longer the warming lasts. In such case pycnocline forms earlier and reaches a shallower depth. The phytoplankton bloom begins earlier, is brief, and peak chlorophyll concentrations are rather high. When the warming-up begins later, we have the opposite situation. The water temperature is the most important factor for survival of Pacific salmon during their wintering. The natural mortality of pink salmon within this period is more then 90%. The most favorable water area for pink salmon winter dwelling is the subarctic frontal zone to the north of the Aleutian Islands. This area has smaller amplitude of temperature anomalies then the western part of the frontal zone. The 5°C isotherm may be considered as the north-west boundary of pink salmon wintering area. Obviously, in severe winters it moves farther to the south-east than in moderate winters. The correlation between pink salmon stock of South East Sakhalin and location of 5°C isotherm is nearly 0.79. SST and the ice conditions are also very important for life cycle of pollack (*Theragra chalcogramma*). So, correlation between Sea of Okhotsk ice cover and Spawning Stock Biomass is nearly 0.85.

2 November, 11:40 (S11-4125)

Managing a Strait of Georgia ecosystem

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The Strait of Georgia ecosystem changed dramatically over the past 100 years and is expected to change even more dramatically in the next 100 years. During the last century large predatory fishes such as lingcod and a variety of rockfish species were fished to very low abundances. Presently, Pacific hake are the dominant fish species, possibly because most of the large predators were removed. Since the 1970s, seals have substantially increased in abundance, because the large Pacific hake biomass provides an abundant food source. Pacific cod and capelin have virtually disappeared. Large numbers of hatchery-reared Pacific salmon continue to be added to the strait despite the knowledge that the original attempt to double salmon catch has failed. The recreational fishery for coho salmon has also collapsed as marine survival plummeted since the late 1980s. The Strait of Georgia is about 1°C warmer than it was 100 years ago and this warming continues. In addition, it appears that there may be a trend towards earlier primary production. As a consequence, the percentage of hatchery coho salmon is declining and species such as juvenile pink and chum salmon are becoming dominant. An ecosystem approach that incorporates biological, physical and social sciences is needed to ensure that human interventions are not harming the resiliency of the ecosystem to adapt to changes in the climate and ocean environment.

2 November, 12:00 (S11-4138)

Climatic forcing and phytoplankton phenology over the North Pacific 1997–2006

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Retrospective studies of zooplankton community have revealed close relationships between lower trophic level phenology and and decadal scale water temperature anomalies both in the eastern and western subarctic North Pacific. Sea-saw like temperature anomaly variations in the eastern and western NP induced by the Aleutian Low dynamics changed peak and duration of productive season almost at the same timing but in opposite phase between the east and west. However, those studies were based on the data taken within small regions. In this study, we attempted to obtain basin-scale phenology pattern in the lower trophic levels using ocean color satellite remote sensing data for 1997–2006. Based on the 10 day composite of satellite Chl *a* data, timing of spring bloom was estimated yearly for every 1 × 1 degree grid within the range of 40–60ºN and 140ºE–120ºW. PCA revealed regionally specific phenology pattern. Climatic and hydrographic forcing, which might be responsible for the interannual and spatial phenology pattern, will be discussed in the presentation.

2 November, 13:30 (S11-4177) Invited

Timing of breeding and prey switching in Rhinoceros Auklets: Match-mismatch of the phenology explains between year variation of chick growth

Yutaka **Watanuki**[1], Motohiro Ito[1], Tomohiro Deguchi[2] and Shoshiro Minobe[3]

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In the seasonal environment, parents of birds are hypothesized to adjust the timing of breeding so that they encounter peak food availability when they require highest energy. There is evidence, however, suggesting that they often do not, *i.e.* match-mismatch hypothesis. This could occur if 1) predators do not predict the time of peak prey availability and 2) different factors control the phenology of predator and prey. We report the between year variations of the timing of breeding and prey switching, and the chick growth response of piscivorous seabirds; Rhinoceros Auklets *Cerorhinca monocerata* breeding at Teuri Island in the Sea of Japan. Anchovy *Engraulis japonicus* is a profitable prey in terms of foraging and provisioning efficiency, and expands its distribution to the north with the water of 13 C SST during the early summer. Parents switched their prey to anchovy when this warm water appeared in the southern edge of their potential foraging range. On the other hands, the timing of egg-laying seemed to be affected by the spring air temperature. Therefore, in the years when parents lay eggs earlier but anchovy comes within a range later in the season, the proportion of anchovy in the chick diet, and hence chick growth, was smaller. These indicate that parents choose profitable prey but are unable to forecast the timing of peak food availability.

2 November, 14:00 (S11-4183)

Large-scale time and space patterns of chlorophyll phenology in the NE Pacific

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The impacts of interannual variability and climate change on oceanic ecosystems are manifested not only as anomalies in seasonal means and/or extremes, but also through changes in phenology that potentially have strong implications for trophic linkages. Surface chlorophyll concentrations are the trophic link between physical/chemical processes in the upper ocean and ecological response at higher trophic levels. Ten years (1997–2006) of daily satellite color data is used to quantify and spatially map climatological seasonal cycles of surface chlorophyll concentration, their interannual variability and possible trends over the northeast Pacific, with a focus on the California Current system. Maps quantify locations of strongest shifts. Strongest temporal signals in these patterns

are associated with the 1997–98 El Nino and delayed spring development in 2005. Space patterns show strong regionality in the magnitude of phenological variability, strongest in the Pacific Northwest coastal areas and weaker offshore of regions associated with upwelling. Time and space patterns of phenology shifts in chlorophyll are compared to local wind patterns, large-scale circulation features from concurrent altimeter data and basin-scale climate signals.

2 November, 14:20 (S11-4185)

Changes in development timing and cohort width of *Neocalanus plumchrus* / *flemingeri* copepods in the eastern North Pacific

Sonia D. **Batten**[1] and David L. Mackas[2]

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Neocalanus plumchrus / *flemingeri* copepods make up a large proportion of spring mesozooplankton biomass and are a valuable nutritional source for many higher trophic levels. Copepodites through to sub-adult stage are present in surface waters for a relatively short period of time each spring, and the date of maximum biomass has been calculated as the date when 50% of the population were at the sub-adult, CV stage. This index allows quite a precise date to be calculated from relatively infrequent sampling and interannual comparisons between 1957 and 2004 have demonstrated that the timing of peak abundance is significantly advanced in warmer years. However, recent data from the Continuous Plankton Recorder survey, which samples the surface NE Pacific more frequently during spring, has found that maximum numbers of CV copepodites occur after the 50% point is reached so that maximum biomass occurs some weeks later than predicted by this index (although comparisons between years show that the magnitude of the timing shift is similar). Comparisons with depth-stratified profiles from the BIONESS show that this is not just due to single-depth near-surface sampling by the CPR. We speculate on the cause of this change which could be related to the width of the cohort (which appears to now be narrower, at least in warm years) or the length of time that the CV stage needs to spend in the surface accumulating lipid before beginning diapause. A narrower cohort has implications for predators who will have less time to take advantage of this food source.

2 November, 14:40 (S11-4193)

Decadal scale variations in developmental timing of *Neocalanus* copepod populations in the Oyashio waters, western North Pacific

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

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Three species of *Neocalanus* are important for investigating long-term variation in mesozooplankton community because they dominate the biomass in the subarctic North Pacific. Their life cycle is one year except for a few biennial *N. flemingeri* stocks, and they grow in the surface layer and migrate into mid-subsurface layer to spawn after growing. The development timing of the population would be changed due to environment change such as regime shift and/or global warming. Therefore investigating the variation in developmental timing is important to clarify the process of the ecosystem change in the subarctic North Pacific. To clarify the decadal scale variation in developmental timing of three species of *Neocalanus* copepod populations in the Oyashio waters, we investigated the variations in timing of the peak biomass from 1960 to 2000 by using the Odate collection. The timing of the peak biomass of *N. flemingeri* and *N. cristatus* were delayed in early 1960's and the mid 1970’s and mid 1990’s. Annual mean biomass of both species increased when the peak was delayed. The timing of the peak biomass of *N. plumchrus* was also delayed in early 1960’s, however the timing became late gradually after early 1970’s. The timing of *N. plumchrus* didn’t have clear relationship with their annual mean biomass. We will discuss the relationship between development timing of three species of *Neocalanus* copepods and oceanographic condition.

2 November, 15:00 (S11-4178)

Food availability for Japanese sardine larvae in the Kuroshio extension area

Atsushi **Tsuda**[1], Takumi Nonomura[1], Mitsuhiro Toratani[2] and Sachihiko Itoh[1]

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The Kuroshio extension area of the North Pacific is an important nursery ground for Japanese sardine and anchovy. Nauplii of medium-sized copepods such as *Calanus* spp. are suggested to be a most suitable food for early developmental stages of small pelagic fish. Then, food availability for sardine and anchovy has to be evaluated both by copepod biomass and environmental factors (food available to the copepods and temperature). We investigated the egg-production rate of medium-sized copepods *(Calanus sinicus, C. jashnovi* and *Neocalanus gracilis*) in the Kuroshio extension area during the spawning and early developmental season of Japanese sardine. High egg-production rates were observed for *C. sinicus* and *C. jashnovi* under a medium temperature range (15–20°C) and high chlorophyll concentration (>0.5 mg m^{-3}). *Calanus* spp. were abundant north of Kuroshio Extension. In contrast, *N. gracilis* were distributed mainly in the re-circulation area of Kuroshio extension and showed no reproductive activity in this season. Consequently, the local egg-production rates were high at the north of the Kuroshio Extension during February and March. Satellite image analysis also confirm that the northern area of Kuroshio Extension is a good environment for sardine survival, and that the KE area expanded south in April. Retrospective studies suggested that recirculation area is important for the survival of Japanese sardine larvae and ultimately determined the population size. However, our results suggest that recirculation area is not a good environment for the larval survival and that the northern area of Kuroshio Extension should be the primary area for larval survival.

2 November, 15:50 (S11-4206)

The phenology of coastal upwelling in the California Current System

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Many marine organisms have life histories adapted to seasonal events in the environment. Changes in the amplitude or phase of seasonal events can therefore significantly affect the productivity and community structure of marine ecosystems, from primary producers to fish stocks to apex predators. Such phenological effects are potentially more disruptive than those associated with interannual climate events and decadal climate shifts. Thus, any set of indicators of ecosystem state would need to include those that quantify changes in the seasonal cycle of dominant physical processes. Phenology plays a particularly critical role in the California Current System (CCS), in which ecosystem productivity and structure is driven largely by the seasonal cycle of coastal upwelling. The impact of an anomalous seasonal cycle was particularly evident in 2005, when the onset of coastal upwelling was delayed by several weeks in the northern CCS, resulting in multi-trophic ecosystem anomalies. We build on the foundation of the historical Upwelling Index, which has been applied effectively for years in fisheries oceanography research, by developing a set of indicators that quantify the timing, evolution, intensity, and duration of coastal upwelling in the CCS. Understanding the causes and ecosystem consequences of phenological changes in upwelling is critical, as global and regional climate models project significant variability in the timing and magnitude of coastal upwelling accompanying various climate change scenarios.

2 November, 16:10 (S11-4225)

Environmental effects on food and larval mismatch

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It is well established that the spatial and temporal match of newly hatched fish larvae with their food resources leads to a greater survival. However, the outcome of a mismatch, though thought to have negative consequences on survival, is poorly defined. For example, fish larvae overcome periods of starvation by consuming their nutritional reserves, yet water temperature, the primary environmental factor mediating metabolic rates in poikilotherms, is generally overlooked in models of food limitation. Hence fish larvae have the potential of overcoming the negative effects of spatial and temporal food mismatches if the background environmental conditions are permissive. In this study we use a spatially- and temporally-explicit modeling framework to assess the effect of environmental variability on the survival of Pacific cod larvae in the southeast Bering Sea. Our focus is on the effects of water temperature and timing and location of the spring phytoplankton bloom. In the model, we combine experimental rates of larval survival in relation to water temperature with satellite remote-sensing estimates of net primary productivity and sea surface temperature to predict survival success of cod larvae up to the time of encounter with their food resources. Simulations are made from 1998 to 2006, a span that covers a period of extreme warming in the southeast Bering Sea. Our results will demonstrate whether water temperature can counteract the negative effects of a food mismatch on cod larvae and will be discussed in the light of recent theories about year class strength of gadids in the Bering Sea

2 November, 16:30 (S11-4407)

Phenology of coastal copepod species: Implications for productivity at various trophic levels in the Oregon upwelling zone

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We have been sampling hydrography, chlorophyll and zooplankton in the Oregon upwelling zone at stations across the continental shelf off Newport, biweekly, since 1996. Over this 12 year period, we have found significant correlations between interannual variations in copepod community structure (from cluster analysis) averaged for summer months, and the Pacific Decadal Oscillation (PDO). Among-year variations in copepod community structure are also pronounced, due to seasonal variations in coastal currents: the coastal northern California Current flows north in winter (due to wind-driven downwelling) and south in summer (due the wind-driven upwelling). The transition points are known as the “spring transition” and “fall transition”. Using cluster analysis, we define the dates of biological “spring” and “fall” transition as those dates when copepod community structure changed from summer/winter communities; the difference between these dates defines the “length of the biological upwelling season (BUS)”. These dates closely track the recent high-frequency variability in the PDO: warm phase from 1996–98 resulted in a late spring transition and short BUS; 4-year cold phase (1999–2002), early transition dates and long BUS, 4-year warm phase (2003–2006), late transition/short BUS, and now cold phase (2007), very early transition date. These dates are highly-correlated with coho salmon survival. The observed changes in phenology, as expressed as date of spring transition and the BUS, are not associated with directed changes due to global warming, rather, the observed changes are related to basin-scale forcing as expressed by the PDO. Correlations with other biological time series will be explored and presented.

2 November, 16:50 (S11-4457)

Cassin's Auklet nestling diet reveals latitudinal variation in surface timing of *Neocalanus cristatus* prey biomass in BC: Mismatch likelihood is greater in warmer, southern waters

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We report on historical (1978–1982) and more recent (1994–2000) nestling diet of Cassin's Auklet on Triangle Island (southern) and Frederick Island (northern) British Columbia, Canada. At both colonies, the nestling diet was composed largely of copepods and euphausiids, with fish contributing substantially in some of the poorer production years at Triangle Island. The copepod *Neocalanus cristatus* was the single most important prey item at both colonies. However, during warm water years such as 1996 and 1998 the timing of availability of *N. cristatus* in surface waters near Triangle Island resulted in a mismatch of prey and predator timing of breeding. In contrast, on Frederick Island, even in 1998, *Neocalanus* prey were not mismatched with predator breeding. In a cool year (2000) *N. cristatus* remained abundant throughout the chick rearing period on Triangle and appeared to increase throughout the chick rearing period on Frederick Island, consistent with increasing availability around that colony as breeding progressed. We used temperature records and a recently available equation that describes peak biomass timing for *N. plumchrus* to estimate the differences in seasonal timing of prey at latitudes near Frederick and Triangle islands. We argue that because of temperature dependent development and recruitment of *N. cristatus* that mismatches between Cassin's Auklet predators and *Neocalanus* prey are more likely to happen on Triangle than on more northerly Frederick Island. *N. cristatus* is closer to the southern end of its range near Triangle than Frederick so production is earlier and usually less protracted around Triangle Island.

S11 Posters

Poster S11-4400

Potential consequences of interannual variability in lower trophic level dynamics on energy transfer in the Strait of Georgia

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The Strait of Georgia (SoG) is one of the most productive estuaries on Canada's west coast. Between 2002 and 2005 we observed an overall decline of copepod biomass culminating in a crash of *Neocalanus plumchrus*, the biomass dominant copepod in the system. In 2005, the spring bloom in the SoG occurred several weeks earlier than usual, suggesting a classic match-match scenario. However, using a suite of novel techniques (lipid analysis, stable isotope profiles, and chitobiase-based secondary estimates) we propose that a more likely scenario involved a decline in food quality rather than food quantity per se. Shifts in fatty acid and stable isotope profiles coincided with a decline in the diversity of phytoplankton in the SoG, and an increased abundance of diatoms in surface waters. In addition, chitobiase-based secondary production rate estimates declined precipitously. Although it appears that similar events have occurred at least three times in the SoG since 1976, the potential consequences for energy flow to higher trophic levels remain poorly understood. However, given that the early spring bloom in 2005 was associated with an earlier onset of (and protracted period of) stratification, these events may serve as a conceptual model for exploring the response of the SoG zooplankton community to a warming ocean.

Poster S11-4520

Seabird-sockeye salmon co-variation in the eastern Bering Sea: Phenology as an ecosystem indicator and salmonid predictor?

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Seabirds (*Rissa* spp. and *Uria* spp.) and sockeye salmon (*Onchorhynchus nerka*) of the eastern Bering Sea share similarities in their trophic ecology. We tested the role of seabirds as indicators of food web conditions that affect sockeye salmon at sea survival by investigating co-variation between seabirds breeding on the Pribilof Islands and returns of Bristol Bay sockeyes. We examined seabird phenology (hatching dates of eggs) against sockeye returns based on the year of ocean entry. Annual seabird hatching date was inversely related to sockeye returns, with the strongest co-variation found for sockeye which entered the ocean at 2 years of age (age 2.x smolts). The mechanism supporting this co-variation is unknown, but both birds and salmon may be responding to changes in prey availability (a "bottom-up" effect). The co-variation between seabird hatching date and sockeye returns supports the idea that variation in seabird breeding parameters indicate food web conditions that also affect other upper trophic level predators in marine systems. Coupling seabird phenology with existing annual predictions for Bristol Bay salmon may improve forecasts and fishery management.

BIO Paper Session

Co-Convenors: Michael J. Dagg (U.S.A.), Michio J. Kishi (Japan) and Angelica Peña (Canada)

The theme of PICES XVI is "*The changing North Pacific: Previous patterns, future projections, and ecosystem impacts*". In this session, we welcome papers on biological aspects of the PICES XVI theme as well as papers on other aspects of biological oceanography in the North Pacific and its marginal seas (except S2 and S11 topics). Young scientists are especially encouraged to submit papers to this session.

Thursday, November 1, 2007 09:00 – 17:20

09:00 ***Introduction by convenors***

09:05 **Jun Nishioka, Tsuneo Ono and Hiroaki Saito**
Seasonal variability of micro-nutrient concentrations in the Oyashio region (BIO_P-4195)

09:25 **Shigenobu Takeda, Atsushi Tsuda, Philip W. Boyd, Paul J. Harrison, Isao Kudo, Maurice Levasseur, Jun Nishioka, Yukihiro Nojiri, Hiroaki Saito, Koji Suzuki, Mark L. Wells and C.S. Wong**
Biogeochemical responses of planktonic ecosystems during three meso-scale iron enrichment experiments in the subarctic North Pacific (BIO_P-4437)

09:45 **Nadja Steiner and Ken Denman**
Development of a mechanistic DMS model – Parameter sensitivities in a single column (BIO_P-4095)

10:05 **Jinhui Wang, Yutao Qin, Caicai Liu, Haofei Zhang, Yawei Sun and Lian Cao**
Variability of sand transport flux in the Changjiang River and its influence on the ecosystem and resources of the East China Sea (BIO_P-4174)

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

10:50 **Jeffrey J. Polovina, Melanie Abecassis and Evan A. Howell**
Changes in oceanic surface chlorophyll in the North Pacific over the past decade: Is the North Pacific getting bluer? (BIO_P-4228)

11:10 **Koji Omori, Hidejiro Ohnishi, Toru Fukumoto, Shunsuke Takahashi, Hideki Hamaoka, Miyuki Ohnishi, Kenji Yoshino, Genkai Kato and Todd W. Miller**
Two sources of primary production of sand bank ecosystems in Seto Inland Sea, Japan (BIO_P-4489)

11:30 **Suguru Okamoto and Sei-ichi Saitoh**
Impact of the Kuroshio Extension on spatial and temporal variability of chlorophyll *a* concentration (BIO_P-4120)

11:50 **Takumi Nonomura, Atsushi Tsuda, Ichiro Yasuda and Shuhei Nishida**
Distribution patterns of *Calanus sinicus* and *C. jashnovi* (Copepoda: Calanoida) in the western temperate North Pacific: Relations with the Kuroshio Extension (BIO_P-4261)

12:10 **Atsushi Yamaguchi, Naonobu Shiga, Tsutomu Ikeda, Yoshihiko Kamei and Keiichiro Sakaoka**
Interannual/latitudinal variations in abundance, biomass, community structure and estimated production of epipelagaic mesozooplankton along 155°E longitude in the western North Pacific during spring (BIO_P-4079)

12:30 ***Lunch***

14:00 **Ai Ueda, Toru Kobari and Deborah K. Steinberg**
Body allometry and chemical composition of interzonally migrating copepods in the subarctic Pacific Ocean (BIO_P-4035)

14:20 **Toru Kobari, Ai Ueda, Deborah K. Steinberg, Minoru Kitamura and Atsushi Tsuda**
Development of ontogenetically migrating copepods in the Western Subarctic Gyre (BIO_P-4112)

14:40 **Brie J. Lindsey and Harold P. Batchelder**
A *Euphausia pacifica* bioenergetic model for the California Current System (BIO_P-4293)

15:00 **Shin-ichi Ito, Kenneth A. Rose, Naoki Yoshie, Bernard A. Megrey, Michio J. Kishi and Francisco E. Werner**
Evaluation of an automated approach for calibrating the NEMURO nutrient-phytoplankton-zooplankton food web model (BIO_P-4199)

15:20 **Hiroshige Tanaka, Seiji Ohshimo and Ichiro Aoki**
Feeding habits of mesopelagic fishes off the coast of western Kyushu, Japan (BIO_P-4200)

15:40 ***Coffee / tea break***

16:00 **Oleg N. Katugin, Gennady A. Shevtsov, Mikhail A. Zuev and Anna V. Dakus**
Patterns of size structure and ecology in the northern gonate squid (*Boreoteuthis borealis*) in the Okhotsk Sea and northwestern Pacific Ocean (BIO_P-4303)

16:20 **Thomas W. Therriault, Leif-Matthias Herborg and Cathryn L. Clarke**
Predicted changes in the distribution of the non-indigenous tunicate *Styela clava* along the west coast of North America with emphasis on Canadian waters (BIO_P-4458)

16:40 **Olga Yu. Tyurneva, Vladimir V. Vertyankin, Yuri M. Yakovlev, Valery A. Vladimirov and Vladimir N. Burkanov**
Occurrence of gray whales (*Eschrichtius robustus*) of the endangered western population off the east coast of the Kamchatka Peninsula (BIO_P-4150)

17:00 **Ryosuke Okamoto, Tsutomu Tamura, Kenji Konishi and Hidehiro Kato**
Differences in foods and feeding habits in common minke and sei whales in the western North Pacific based on samples collected under the JARPN II survey project (BIO_P-4420)

BIO Paper Posters

BIO_P-4055 **Tatyana A. Belan, Elena M. Latkovskaya and Alexey V. Berezov**
Composition and distribution pattern of benthic communities of Chayvo Bay (Northeast Sakhalin Island)

BIO_P-4083 **Tatiana A. Mogilnikova, Elena M. Latkovskaya, Vladimir M. Pishchalnik, Tatiana G. Koreneva, I Ken Chi, Ludmila Yu. Gavrina, Izolda A. Mitrakovich, Maria A. Smirnova and Larisa P. Telepneva**
Microalgae development in a cold period in a coastal area of Aniva Bay

BIO_P-4104 **Elena Dulepova and Vladimir Dulepov**
Long-term fluctuation of zooplankton bioproductivity in the western Bering Sea

BIO_P-4128 **Vladimir I. Radchenko**
Estimation of diurnal vertical migration rate of the Sea of Okhotsk zooplankton with assumption of net avoidance

BIO_P-4221 **A. Jason Phillips, Richard D. Brodeur and Andrey Suntsov**
Community structure of micronekton in the Northern California Current System

BIO_P-4273 **Goh Onitsuka, Itsushi Uno, Tetsuo Yanagi and Jong-Hwan Yoon**
Effect of atmospheric nitrogen input on the lower trophic ecosystem in the Japan/East Sea

BIO_P-4304 **Alexander V. Zavolokin, Natalya S. Kosenok and Igor I. Glebov**
Abundance, distribution and feeding habits of jellyfish in the upper epipelagical of the western Bering Sea

BIO_P-4326 **Guoying Du, Yunhee Kang, Moonho Son, Jaeran Hwang, Soonmo An and Ikkyo Chung**
Spatio-temporal variation of intertidal microphytobenthos in the Nakdong Estuary, Korea

BIO_P-4343 **Pung Guk Jang, Kyoungsoon Shin, Dong Hyun Shon, Woong-Seo Kim and Dongsup Lee**
Spatial and temporal distribution of inorganic nutrients and nutrient ratios as controls on composition of phytoplankton in the western channel of the Korea Strait

BIO_P-4345 **Dong Hyun Shon, Kyoungsoon Shin, Pung Guk Jang, Young Ok Kim and Woong Seo Kim**
Effect of thermal stratification on phytoplankton community composition and nutrient limitation in the Korea Strait

BIO_P-4478 **Hyung-Ku Kang, Chang Rae Lee and Sinjae Yoo**
Comparison of vertical distribution of suspended fecal pellets and production of copepod fecal pellets in the Ulleung Basin between 2005 and 2006

BIO_P-4502 **Emiljano Rodhaj**
Fish farming development along the Adriatic coast of Albania

BIO Paper Oral Presentations

1 November, 09:05 (BIO_P-4195)

Seasonal variability of micro-nutrient concentrations in the Oyashio region

Jun **Nishioka**[1], Tsuneo Ono[2] and Hiroaki Saito[3]

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Since iron limits phytoplankton growth during the summer in the western subarctic Pacific (WSP), there is considerable interest in determining the source and seasonal timing of iron input, which can lead to a steady spring phytoplankton bloom as found in the Oyashio region, one of the most biologically productive areas in the world oceans. In this study, we investigate the annual seasonal variability of dissolved iron concentrations in the Oyashio region from 2003 to 2007. We found clear seasonal variability of dissolved iron concentrations in the surface mixed layer. The seasonal change in dissolved iron concentration was similar to that of nitrate in the surface mixed layer. The dissolved iron concentration observed in the surface mixed layer was high throughout winter (0.45 – 0.8 nM). As the spring phytoplankton bloom developed, the dissolved iron levels decreased to < 0.2 nM, and remained low during summer. In early winter, dissolved iron increased with an increase in the surface mixed layer depth. Three sources can be proposed for explaining the relatively high dissolved iron levels in the surface mixed layer before the phytoplankton bloom: 1) input of soluble aerosol iron, 2) lateral transport into the surface layer and 3) turbulent vertical mixing of dissolved iron from the subsurface layer. We will evaluate these sources quantitatively in order to understand the mechanisms influencing biological production and iron biogeochemical cycling in the Oyashio region. Additionally, these iron supply processes may explain the decadal decrease of spring net community production in the Oyashio region.

1 November, 09:25 (BIO_P-4437)

Biogeochemical responses of planktonic ecosystems during three meso-scale iron enrichment experiments in the subarctic North Pacific

Shigenobu **Takeda**[1], Atsushi Tsuda[2], Philip W. Boyd[3], Paul J. Harrison[4], Isao Kudo[5], Maurice Levasseur[6], Jun Nishioka[7], Yukihiro Nojiri[8], Hiroaki Saito[9], Koji Suzuki[10], Mark L. Wells[11] and C.S. Wong[12]

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Three successful meso-scale iron enrichment experiments have been conducted in the western (SEEDS-I & II) and eastern (SERIES) subarctic North Pacific Ocean during 2001–2004. We present a summary of key results obtained in these experiments that highlights the major differences observed in the biological and geochemical responses. All three enrichment experiments have confirmed that iron availability strongly influences primary productivity and food web structure. However, SEEDS-I differed from the other ones by its massive bloom of a chain-forming centric diatom. SERIES on the other hand caused an initial bloom of small phytoplankton followed by a larger bloom of various diatom species. SEEDS-II was conducted in the same area as SEEDS-I but resulted in a much smaller buildup of phytoplankton biomass, in which pico- and nano-phytoplankton such as *Synechococcus* and cryptophytes dominated. Several hypotheses have been proposed to explain the relatively small response of diatoms in SEEDS-II as compared to SEEDS-I, including a higher initial mesozooplankton biomass and grazing pressure, a deeper surface

mixed layer depth, difference in the initial seed populations, less supply of iron for luxury iron uptake by large diatoms, and iron limitation induced by release of organic iron-complexing ligands by the plankton assemblage. The unexpected response observed during SEEDS-II and marked differences between simulated and natural phytoplankton blooms emphasize our limited understanding of how iron affects upper ocean biogeochemical processes, as well as the complexity of ecosystem responses to iron deposition in the subarctic North Pacific Ocean.

1 November, 09:45 (BIO_P-4095)

Development of a mechanistic DMS model – Parameter sensitivities in a single column

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We have developed a marine DMS (dimethylsulfide) module and implemented it in a 1-D coupled atmosphere-ocean-biogeochemical model as an intermediate step towards completing a mechanistic sulphur cycle in a coupled Atmosphere Ocean General Circulation Model (AOGCM). The atmospheric Single Column Model (SCM) is based on the Canadian Centre for Climate Modelling and Analysis (CCCma) Atmospheric General Circulation Model (AGCM) and is nudged reanalysis data. The ocean component employs the General Ocean Turbulence Model (GOTM). A 7-component ecosystem model is embedded in GOTM, which includes inorganic carbon, oxygen and nitrogen cycling. The AGCM includes a comprehensive sulphur cycle and an ocean DMS model is now implemented. The marine sulphur model is described and evaluated within this study. Several parameters used to describe the marine sulphur cycle in models have been reported to be unknown within an order of magnitude. Our 1-D approach is used to test the models sensitivity to these parameters: A parameter variation of ±25% is applied to test the respective range of changes in the sulphur components. Additionally, the sensitivity to variations in UV radiation and nutrient limitation is tested. All simulations are first tested over 3 year runs, focusing on the annual cycle. The model is then applied to the shorter time period of the Subarctic Ecosystem Response to Iron Enrichment Study (SERIES) in July 2002, both with and without a simulation of iron fertilization. The study confirms that the response of DMSP to iron fertilization cannot be obtained with a set of constant parameters. While parameter variations simply depending on UV radiation do not significantly alter the output. Varying the DMS yield depending on both UV and nutrient limitation leads to more reasonable results. The strong DMS variation, reported for SERIES both in and outside the patch cannot be simulated, consistent with earlier suggestions that the variation arises from different causes. Simulations do not suggest a diurnal cycle larger than 2.5 nM. The model also confirms the importance of including the atmospheric concentration into gas flux calculations in case of low atmospheric boundary layer heights.

1 November, 10:05 (BIO_P-4174)

Variability of sand transport flux in the Changjiang River and its influence on the ecosystem and resources of the East China Sea

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Some direct and significant variations in the Changjiang estuary have been observed recently, including the readjustment of flux among seasons, the decline of turbidity and dissolved oxygen, the decline in sand transport flux (which reached a minimum in 2004 of 0.15 billion tons - 66% lower than the average over 1950–2000), the increase in inorganic nitrogen and silicate (although these have decreased since 2003), and the increase in phosphorous. How will these changes affect the resources and ecosystem of the East China Sea? One outcome is the frequent occurrence of harmful algal blooms over large areas. Due to the changes in the nutrient structure, the species of algal blooms have shifted between diatoms and dinoflagellates (diatoms dominated before 2000 but dinoflagellates dominated from 2001 and 2005, although most of the bloom in the Changjiang estuary was diatoms in 2006). In addition, the abundance and species composition of plankton have fluctuated, and the production of some important

commercial species has declined. The changing of runoff and sand transport flux also increase the variability and uncertainty of the ecosystem in East China Sea.

1 November, 10:50 (BIO_P-4228)

Changes in oceanic surface chlorophyll in the North Pacific over the past decade: Is the North Pacific getting bluer?

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A monthly time series of surface chlorophyll for the North Pacific derived from the SeaWiFS ocean color sensor over the period September 1997 through April 2007 is examined. In the equatorial region, between 15°N and 15°S latitudes, there is considerable interannual variability in median surface chlorophyll due to ENOS forcing with no significant linear trend. However, both in the North Pacific subtropical (15°–35°N latitude) and subarctic (35°–55°N latitude) gyres, median monthly surface chlorophyll estimates have shown a statistically significant linear decline of about 13% for the subtropical and 10% for the subarctic gyres over the decade. These declines are a response to a change in the chlorophyll density-frequency distribution. About one fourth the area of the North Pacific, north of 15°N latitude, has surface chlorophyll less than or equal 0.07mgC m^{-3}. This lowest surface chlorophyll region has increased in size at a rate of about 34,000 km^2/month resulting in an increased area of almost 4 million km^2 (about 35% of the 1998 area) over the past decade. As the region of very low surface chlorophyll expands north and east, areas of higher surface chlorophyll are replaced with lower surface chlorophyll. About one fourth of the North Pacific, north of 15°N latitude, has surface chlorophyll greater than 0.31mgC m^{-3}. The area of this region has declined at a rate of about 13,000km^2/month, resulting in a loss of about 16% of the1998 area over the past decade.

1 November, 11:10 (BIO_P-4489)

Two sources of primary production of sand bank ecosystems in Seto Inland Sea, Japan

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We examined the nutrient and trophic dynamics around straits and surrounding sand bank ecosystems of the Seto Inland Sea (SIS) of Japan. Primary production in the SIS showed one seasonal peak during the summer months, occurring primarily from well-mixed water around straits. The well-mixed waters provide continuous nutrient supply to the photic zone, however the high turbidity within these waters also limits solar radiation for phytoplankton growth. Within adjacent, more-stratified water, phytoplankton in the warm surface layer are more nutrient limited. However, the presence of sand banks, which arise from sediment deposition following the sudden decrease in water velocity between the strait and adjacent more-stratified waters, is also a source of primary production to the SIS. These sand banks are typically shallower than the phytoplankton compensation depth, negating the disadvantage of low solar irradiance from high turbidity in the well-mixed areas and providing nutrients for primary production. This condition therefore leads to relatively high primary production of phytoplankton around the sand banks. Moreover, the shallow waters of sand banks often get sufficient light to the benthic surface and high nutrients through tidal mixing, promoting bottom primary production by benthic algae. Stable isotope analysis of nekton around sand bank systems indicated that they depend on both benthic production from sand bank ecosystems and phytoplankton growth in the water column.

1 November, 11:30 (BIO_P-4120)

Impact of the Kuroshio Extension on spatial and temporal variability of chlorophyll *a* concentration

Suguru **Okamoto** and Sei-ichi Saitoh

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The Kuroshio Extension region is well known as a biologically productive region and an important fishing ground. In this study, we investigated the relationship between the Kuroshio Extension and the distribution of chlorophyll *a* (Chl-*a*) concentration from 1998 to 2005 using satellite multi-sensor remote sensing. We used ocean color (Chl-*a*, SeaWiFS) and absolute dynamic topography (ADT, AVISO) datasets, and calculated geostrophic currents from ADT. Image classification based on the seasonal variation pattern of Chl-*a* concentration was applied in the western North Pacific. As a result, the western North Pacific was quantitatively classified into three regions. Focusing on the region around the Kuroshio Extension, Chl-*a* concentration was highest (0.4 mg m^{-3}) in April and lowest (0.1 mg m^{-3}) in August or September. The area of this region was widest in 2000 and narrowest in 2005. The northern limit of this region was generally located in the same region as the meander around 144°E longitude and the northward current bifurcating from it. It is likely that geostrophic currents such as the Kuroshio Extension determine the distribution of water masses and closely relate to the extent of this region. These results suggest that the Kuroshio Extension affects the spatial and temporal variability of Chl-*a* concentration. Our results are an important step in spatially understanding the linkages between physical characteristics such as geostrophic currents and biological characteristics.

1 November, 11:50 (BIO_P-4261)

Distribution patterns of *Calanus sinicus* and *C. jashnovi* (Copepoda: Calanoida) in the western temperate North Pacific: Relations with the Kuroshio Extension

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Two *Calanus* species occur sympatrically in the western temperate North Pacific. *Calanus sinicus* is the ca. 2 mm-sized representative and is abundant in shelf waters, whereas the ca. 3 mm-sized *C. jashnovi* mainly inhabits open ocean water. However, the exact distributional ranges of both species aren't known. The present study examined the geographical distribution of *C. sinicus* and *C. jashnovi* in the western North Pacific area (27–37°N, 142–159°E) from January to March 2006, on the basis of samples in the upper 200-m. Distribution of both species was well defined by the Kuroshio Extension (KE); significantly higher abundance was observed north of the KE axis than in the southern recirculation gyre of the KE. Around the KE, the distribution of the two species showed distinct zonal differences. *C. sinicus* was broadly distributed along the KE ranging from 142 to 159°E, while *C. jashnovi* was concentrated in the eastern KE (146–159°E) and occurred only sporadically in the western KE (142–146°E). High abundance of *C. jashnovi* was observed around the Shatsky Rise in March (max.: 11,000 inds. m^{-2}). Furthermore, lipid deposition patterns showed that 83% of CV *C. jashnovi* was categorized as "not having" body lipid stores, or else having only a "small lipid mass" in March. Because lipid-rich *C. jashnovi* CV have been reported in the mesopelagic zone of the western Pacific coasts, we hypothesize that major parts of the *C. jashnovi* population reproduce in the eastern KE before March, assuming they diapause in mesopelagic zone after full lipid accumulation.

1 November, 12:10 (BIO_P-4079)

Interannual / latitudinal variations in abundance, biomass, community structure and estimated production of epipelagaic mesozooplankton along 155°E longitude in the western North Pacific during spring

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We analyzed a total of 63 mesozooplankton samples collected with Norpac nets from 0–150 m depth at latitudinal stations (35°–44°N) along 155°E in May 2002 through 2007. Year-to-year changes in temperature anomalies showed that the subtropical domain (<39°N) was warm in 2002 and 2003, while cold in 2004–2007 although the trend was obscure in the other two domains. Mesozooplankton abundance at each station varied from 40 to 1000 inds. m^{-3}. Mesozooplankton biomass was consistently higher (80–100 mg DM m^{-3}) in the transitional domain (40–42°N) than in the other domains. Cluster analyses identified five groups (A-E) with distinct community features; *e.g.* subtropical communities occurred in 2002–2003 (warm years) (Group A), gelatinous zooplankton (Appendicularia and Doliolida) predominated communities in 2004–2007 (cold years) (Group B), small Copepoda predominated communities in the transitional domain (Group C), predominated communities in the subarctic domain (43°N<) (Group D), and Salpida predominated communities in the transitional domain in 2003 (Group E). An empirical, metabolic-rate based carbon budget indicated that the food requirement of mesozooplankton herbivores was the greatest (500–650 mgC m^{-2} day^{-1}) in the transitional domain. Comparison of the production of mesozooplankton herbivores and the food requirement of mesozooplankton carnivores showed that the latter was significantly less than the former in the subarctic and transitional domains, but the latter was near equal to or exceeded the former in the subtropical domain. As an annual event, the feeding migration of epipelagic fish to the transitional and subarctic domains in summer may be caused by their utilization of the excess secondary production (= production of mesozooplankton herbivores).

1 November, 14:00 (BIO_P-4035)

Body allometry and chemical composition of interzonally migrating copepods in the subarctic Pacific Ocean

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It has recently been recognized that interzonally migrating copepods play important roles in carbon and nitrogen cycles through their diel and ontogenetic migrations. However, information on copepod weight and chemical content is needed to estimate biomass and rate process of the copepod community. Here we report body allometry and chemical composition of the dominant copepods of the community in the Western Subarctic Gyre, including *Calanus, Eucalanus, Metridia* and *Neocalanus* species. All copepod species showed an exponential increase of prosome length (PL), dry (DW), carbon (CW) and nitrogen weights (NW), and oil sac volume (OV) from copepodite stage 1 to 5 (C1 to C5), while this pattern was species specific for adults. Significant regression equations of body mass (DW, CW and NW) on PL were found for all species. Body carbon (CW/DW) was highest in copepodite stages resideing at mesopelagic depths during summer to winter, and higher in *Neocalanus* and *Calanus* than in *E. bungii* and *M. pacifica*. CW/DW increased from C1 to dormant stages ($CW_{C1\text{-}DOR}/DW_{C1\text{-}DOR}$) due to the accumulation of large oil droplets. Considering the different migration behaviors and life cycles in these species reported in previous studies, we conclude that body allometry and chemical composition for the interzonally migrating copepods may be associated with their dormancy strategies.

1 November, 14:20 (BIO_P-4112)

Development of ontogenetically migrating copepods in the Western Subarctic Gyre

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It has been recently reported that life cycles of ontogenetically migrating copepods show some geographical difference between the populations in the Gulf of Alaska and the Oyashio region. However, we have limited knowledge on development of these copepods in Western Subarctic Gyre due to few existing seasonal time series. Here we report temporal changes of abundance and stage composition for ontogenetically migrating copepods from high-frequency collected samples during June to August at the Japanese time-series site K2, and evaluate copepod development and growth. Each copepod species was more abundant during June to early July rather than late July to August. Since half of the *Neocalanus cristatus* population was comprised of C1 and C2 over the study period, no distinct cohort was observed. C1 and C2 of *N. plumchrus* were abundant, and subsequent development was evident during June to early July and they reached dormant stage C5 in August. The most predominant stage of *N. flemingeri* was C5 in June and C4 during July to August. These results indicate that *N. flemingeri* develop before June and have two overwintering stages in this area. Although C3 to C5 dominated the *Eucalanus bungii* population, C6 females and young copepodites recruited during the year appeared during July to August, indicating an early July reproductive season. These results suggest that development seasons are segregated between the species as follows: May to June for *N. flemingeri*, June to early July for *N. plumchrus*, and early July to August for *E. bungii*.

1 November, 14:40 (BIO_P-4293)

A *Euphausia pacifica* bioenergetic model for the California Current System

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An individual-based energetic model is developed for *Euphausia pacifica* larvae in the California Current System based on allometric relationships found in previous literature and recent laboratory observations. In this model, body growth depends mainly on food while development from one larval life stage to the next is entirely dependent on temperature. The effective decoupling of these two processes allows for negative growth, a phenomenon observed in euphausiids in the California Current System. Two scenarios are considered, one with and one without diel-vertical migration, to demonstrate the effect this behavior has on growth and development in the region. The model is evaluated using GLOBEC cruise data collected during the summers of 2000 and 2002. Estimates of body size based on observed temperatures and food availability are compared with observed body sizes over each cruise. Sensitivity of the model to the broad range of parameters found in the literature is examined.

1 November, 15:00 (BIO_P-4199)

Evaluation of an automated approach for calibrating the NEMURO nutrient-phytoplankton-zooplankton food web model

Shin-ichi **Ito**[1], Kenneth A. Rose[2], Naoki Yoshie[1], Bernard A. Megrey[3], Michio J. Kishi[4,5] and Francisco E. Werner[6]

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Automated calibration software PEST (Model-Independent Parameter Estimation) was applied to the NEMURO (North Pacific Ecosystem Model for Understanding Regional Oceanography) nutrient-phytoplankton-zooplankton food web model as an alternative to the usual ad-hoc calibration. In NEMURO, large zooplankton appear in the surface mixed layer in spring and retreat to the deep layers in autumn. Thus, the simulated system has two different states depending on the presence or absence of large zooplankton in the mixed layer. Prior to applying PEST to field data situations, several twin experiments were conducted to evaluate the performance of PEST. In the twin experiments, model predictions were used as virtual observations and then PEST was started with arbitrary parameter values to determine if PEST could recover the original parameter values. First, a twin experiment was conducted that included vertical ontogenetic migration of large zooplankton. In this case, PEST failed to find the original parameter values. The instantaneous discontinuity in the state of the simulated system during periods of ontogenetic migration created estimation problems for PEST. Experiments without ontogenetic migration successfully recovered model parameters. Therefore, the simplest way to apply PEST calibration to NEMURO is to exclude ontogenetic migration from the model. Another approach would be to separate the season into two distinct periods depending on the presence of large zooplankton and apply PEST to each period individually. This later approach does not have any guarantee to recover the original parameter values because the parameters are not directly dependent on the presence/absence of large zooplankton, between the two periods.

1 November, 15:20 (BIO_P-4200)

Feeding habits of mesopelagic fishes off the coast of western Kyushu, Japan

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Feeding habits of mesopelagic fishes, mainly myctophid fishes that have large biomass, were studied and compared with those of small pelagic fishes in the waters of western Kyushu, Japan (eastern part of the East China Sea), to reveal their trophic niches. Midwater-trawl surveys showed that two myctophid fishes (*Diaphus chrysorhynchus* and *Diaphus garmani*) dominated and often co-occurred in most of the samples of mesopelagic fishes. Stomach content analysis showed that *D. chrysorhynchus* fed mainly on crustacean zooplankton such as copepods (Calanoida, Poecilostomatoida), amphipods, euphausids and larval decapods (megalopa or zoea). *D. garmani* also fed mainly on crustacean zooplankton and additionally on appendicularia. On the other hand, anchovy (*Engraulis japonicus*) fed mainly on poecilostomatoid and calanoid copepods, while round herring (*Etrumeus teres*) and jack mackerel (*Trachurus japonicus*) fed mainly on calanoid copepods and larval decapods. Thus the crustacean zooplankton overlapped in the diets of pelagic and mesopelagic fishes. However, compared to pelagic fishes, mesopelagic fishes had a wider niche breadth and fed on some other organisms that were little utilized by pelagic fishes (such as appendicularia). Moreover, stable isotope ratio analysis showed that although $\delta^{15}N$ values were similar between pelagic and mesopelagic fishes, the $\delta^{13}C$ values of mesopelagic fishes were lower than those of pelagic fishes. These differences suggest that although the overlap of diet exists between pelagic and mesopelagic fishes to some extent, the potential for competition may be low, at least in a qualitative sense.

1 November, 16:00 (BIO_P-4303)

Patterns of size structure and ecology in the northern gonate squid (*Boreoteuthis borealis*) in the Okhotsk Sea and northwestern Pacific Ocean

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The northern gonate squid (*Boreoteuthis borealis*) is a widespread cephalopod in boreal waters of the North Pacific Ocean, where it is an important component in pelagic food webs. Two size cohorts of *B. borealis* are known. They differ in size-at-maturity and distribution patterns. Our study, based on the huge data set collected in expeditions of the TINRO-Centre during 1979–2004, revealed characteristic patterns of ontogenetic, seasonal, vertical and spatial distribution, and size-at-maturity structure for the squid from these two cohorts. Individuals that belong to the small-sized group of the squid are fully mature at a mantle length of less than 180 mm and are distributed over the entire Okhotsk Sea and off the Kuril chain in the ocean, primarily beyond the shelf zone. Individuals that belong to the large-sized group of the squid mature at a mantle length of over 210 mm; they are distributed mainly offshore in oceanic waters to the east of the Kuril Islands and Hokkaido, and are extremely rare in the Okhotsk Sea.

1 November, 16:20 (BIO_P-4458)

Predicted changes in the distribution of the non-indigenous tunicate *Styela clava* along the west coast of North America with emphasis on Canadian waters

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Aquatic Invasive Species (AIS) by definition are not native to the ecosystem in which they are found and pose a threat to native biodiversity and the economic wellbeing of aquatic ecosystems. A wide variety of potential vectors are available to transport AIS into Canadian waters including commercial shipping, recreational boating and aquaculture, each of which has transported non-indigenous species to the area in the past. Determining whether or not a potential invader can establish in the introduced range and what its potential distribution could be is crucial to understanding the invasion and potential management options. To this end, various ecological models ranging from simple to complex have been applied to predict the potential distribution of an invader with varying levels of success. Tunicates have received much attention, largely due to their negative impacts on shellfish aquaculture operations. One of these species is the club tunicate, *Styela clava*, a native of Asia that has been introduced to a number of countries worldwide including Canada. Simple models based on reported temperature or salinity tolerances were relatively uninformative as almost all waters were deemed suitable. In contrast, a more complex genetic algorithm for rule-set prediction (GARP) ecological niche model based on documented occurrence points provided informative projections of the potential distribution for this species. In addition to informing risk assessments, these predictions can be used to focus monitoring activities, including vectors that could transport *S. clava* to favourable environments.

1 November, 16:40 (BIO_P-4150)

Occurrence of gray whales (*Eschrichtius robustus*) of the endangered western population off the east coast of the Kamchatka Peninsula

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After their almost complete extinction, gray whales, *Eschrichtius robustus*, have been repeatedly sighted near the Pacific coast of the Kamchatka Peninsula since the middle 1980s. However, there was insufficient evidence to link them to any population. From photographic recordings of gray whales near the south-eastern coast of the Kamchatka Peninsula in 2004 and 2006, as well as along the north-eastern coast of Sakhalin Island in 2002–2006, the first data describing the migration of gray whales between these areas have been obtained. Photo-identification studies of gray whales near the Kamchatka Peninsula enabled identification and listing of 16 individuals. A catalog of gray whales sighted near Sakhalin Island in 2002–2006 was prepared by the Institute of Marine Biology, and combined with additional photographs and information, proved that five whales from the western gray whale population visited bays of south-eastern Kamchatka during their feeding period. These included two whales that migrated between the Kamchatka Peninsula and Sakhalin Island in the 2006 season. In addition to the above five whales, one more whale initially encountered and recorded near Kamchatka in 2004 was identified offshore Sakhalin Island only in 2006. The issue of the population affiliation of the remaining 10 whales sighted in the above whale groups near the Kamchatka Peninsula, but not listed in the available catalog of Sakhalin Island gray whales, remains open.

1 November, 17:00 (BIO_P-4420)

Differences in foods and feeding habits in common minke and sei whales in the western North Pacific based on samples collected under the JARPN II survey project

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The common minke whale (*Balaenoptera acutorostrata*) and the sei whale (*B. borealis*) are common baleen whale species occupying important ecological niches in sub-arctic regions of the North Pacific. Through a sampling survey by the JARPN II program (the second phase of the Japanese Whale Research Program in the Western North Pacific) in May to August 2006, we obtained stomach content samples from 100 common minke and 100 sei whales collected between the Pacific coast of Japan and 170E, and north of 35N. From our analyses, a total of seven prey species were identified in addition to some unidentified copepods and euphausiids. The minke whales preferred Japanese anchovy (*Engraulis japonicus*) and Pacific saury (*Cololabis saira*) in all areas whereas for sei whales, the most dominant prey species was Japanese anchovy in all areas, although they also preferred copepods in the middle and eastern areas. Prey preferences varied with sexual status of the whales. Mature minke whales preferred Japanese anchovy and Pacific saury while the immature animals fed on Japanese anchovy and euphausiids. Similarly the mature sei whales mainly fed on Japanese anchovy, and the immature animals fed on euphausiids and copepods. The energy content of Pacific saury is the highest among prey species identified. The Japanese anchovy has the second highest caloric value and euphausiids and copepods have caloric values lower than those two fish species. This suggests that mature animals have a clear foraging strategy directed at species with higher caloric content.

BIO Paper Posters

Poster BIO_P-4055

Composition and distribution pattern of benthic communities of Chayvo Bay (Northeast Sakhalin Island)

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Macrobenthos of Chayvo Bay was represented by marine and fresh water species adapted to strong fluctuations of salinity and temperature as well by organisms of the estuary-lagoon complex. Another group included typical marine tolerant species, which are temporary inhabitants of lagoons, including the molluscs *Mytilus trossulus*, *Spisula sachalinensis*, and *Liocyma fluctuosa*. According data obtain in 2001; six benthic communities have been detected in Chayvo Bay. The benthic assemblages are divided into three basic types: a typical marine community (*Macoma baltica + Liocyma fluctuosa* and *Spio filicornis*), a brackish-water community (*M. balthica*, *Hediste diversicolor*, *Neomysis awatchensis*) and a fresh-brackish-water community (*Kamaka kuthae*). The distribution of these types and their characteristics is determined by salinity and the sediment type. Typically marine, brackish water and fresh-brackish water communities occupied about 34, 22 and 12% of the study area, respectively. This is evidence for the strong influence of marine waters on the composition and distribution pattern of benthic assemblages in the Bay.

Poster BIO_P-4083

Microalgae development in a cold period in a coastal area of Aniva Bay

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Conditions for development of ice microalgae were investigated in Salmon Bight (Aniva Bay, Sakhalin) in 2006. Sampling of microalgae, sea water and fast ice was carried out at three stations on a direct line perpendicular to the coast at distances of 5, 25 and 100m from the shore between February 22 and April 24 2006. Samples were collected from the surface and bottom of the water column and in upper, middle and lower parts of ice cores. Total abundance and species composition of microalgae were examined. Dissolved oxygen, nutrients and chlorophyll *a* contents of water and ice samples were measured. The increase of microalgal abundance occured at the end of February and the beginning of March. The maximum abundance was in the lower part of the ice-core. There were centric species from the genus *Thalassiosira* developing mainly in the upper layer of ice, and pennate algae from the genus *Fragillaria*, forming long ribbon-shaped colonies which dominate in the lower layer of ice. In mid March plankton flora under the ice was not high; microalgal abundance was 20% of the abundance in the lower ice layer. Nutrient contents in water and ice showed seasonal, spatial and vertical variations, which reflect patterns of their input to the coastal zone and development of ice cover. Concentrations of nitrite and silica in all layers of ice increased from February to March. Concentrations of nitrate and phosphate in all layers of ice decreased from February to March. Concentrations of nitrite, nitrate and phosphate in surface and bottom parts of the water column were identical in all sampling periods; chlorophyll *a* concentration was higher in the bottom layer.

Poster BIO_P-4104

Long-term fluctuation of zooplankton bioproductivity in the western Bering Sea

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Twenty cruises were carried out in the western part of the Bering Sea between 1986–2006 in order to study fish and zooplankton communities (species composition, distribution, abundance) in relation to the physical environment. Data from these surveys were used to calculate bioproductivity of zooplankton communities in the inner shelf, outer shelf and deep water regions of the western Bering Sea. Estimating production of zooplankton species, which are food resources for pelagic fishes, is of great importance as high numbers of pelagic fishes annually undertake feeding migrations to this region from other parts of the northwestern Pacific. The zooplankton is composed of two trophic groups. The first group is phyto- and euryphagous zooplankton (mainly copepods and euphausiids). The second group is predatory zooplankton (hyperiids and chaetognaths). There was a positive correlation between the biomass of zooplankton predators and the abundance of several zooplankton taxa. Production of predators and their prey (phyto- and euryphagous zooplankton) has been determined for 1986–1990, 1991–1995, and 1996–2006. In 1986–1990 and 1996–2006 the highest average values of annual production of phyto- and euryphagous zooplankton were observed in deep-water regions. In 1991–1995, outer shelf phyto- and euryphagous zooplankton produced more organic matter than other regions. Production of predatory zooplankton was much higher in 1991–1995, especially in deep-water areas. Changes in plankton production depend on oceanological condition in the Bering Sea. Increased inflow of warm Pacific waters into the Bering Sea has affected growth rate of all plankton species. In 2003 this situation was observed in the Bering Sea (Glebova, 2005). Because of this, in the 2000s the average weighted value of the P/B-ratio rose above that of the 1990s. In the beginning of 21 century, zooplankton production in the western Bering Sea increased compared to the 1990s. All our estimates indirectly signify that in the 2000s feeding conditions are more favorable for pelagic fishes than they were in the 1990s.

Poster BIO_P-4128

Estimation of diurnal vertical migration rate of the Sea of Okhotsk zooplankton with assumption of net avoidance

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Zooplankton undergoes daily migrations from the meso- and bathypelagic depths to the upper layers. Zooplankton biomass in the Sea of Okhotsk in the 0–1000 m layer during the night-time is 1.43 times the day-time biomass (Gorbatenko, 1996). Vinogradov (1968) considered that zooplankton vertical migrations are restricted to the upper 900 m. Net avoidance by motile species is likely a main cause of the lower biomass estimation in day-time because of better lighting in the sampling layer. Differences between the night-time and day-time biomass estimations were almost 3 times for chaetognaths and 1.6 times for euphausiids. Re-calculations of vertical migration rate were made with the assumption that net avoidance for each of the 0–1000, 0–500 and 0–200 m layers was a function of sunlight penetration depth. It was found that about 9–13% of the total zooplankton biomass is redistributed to the upper 50 and 100 m layers during the night-time and about 10% (for 0–50 m) – 20% (for 0–100 m) are day-time residents at these depths. In winter, migratory activity rates decrease below 2% of the total zooplankton biomass in the upper 0–1000 m layer, and 2.5% are day-time residents in 0–100 m layer.

Poster BIO_P-4221

Community structure of micronekton in the Northern California Current System

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We examined the spatial and temporal variability in the micronekton community and oceanographic conditions between Heceta Head, Oregon (44.0°N) and Willapa Bay, Washington (46.6°N) during 13 cruises from June to November 2004, June to October 2005, and May to September 2006. Stations were every 20 km from approximately 20–100 km offshore along four transects. Micronekton were collected with a midwater trawl (336m^2 mouth opening with a 3mm mesh codend liner) towed at night at a 30 m headrope depth. Over 200,000 individuals in 100 taxa were collected, representing over 50 different families. Adult euphausiids were the dominant micronekton captured and composed over 90% by number of the total catch. *Abraliopsis felis* was the dominant squid species present and composed 82% of the total cephalopod catch. Myctophidae (lanternfishes) was the dominant fish family, representing over 70% of fish captured, and this family was composed of adult fish of mainly of three species: *Stenobrachius leucopsarus, Diaphus theta*, and *Tarletonbeania crenularis.* Other dominant taxa were juvenile rockfishes (13%), age-0 Pacific hake (7%), and northern anchovies (3%). Densities and species diversity were highest near the continental shelf break. We used cluster analysis and ordination to examine community structure and found distinct onshore and offshore assemblages. The lanternfishes showed a high degree of spatial overlap with juvenile rockfishes.

Poster BIO_P-4273

Effect of atmospheric nitrogen input on the lower trophic ecosystem in the Japan/East Sea

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Anthropogenic nitrogen emission has increased in East Asia with rapid economic growth. Atmospheric nitrogen supply to the surface layer of the marginal seas in the western North Pacific is large because these seas are adjacent to East Asia. In this study, a nitrogen based four-compartment ecosystem (NPZD) model coupled with a physical model is applied to the Japan/East Sea to show the effect of atmospheric nitrogen input on the lower trophic levels of the ecosystem. Dry and wet nitrogen deposition fluxes are simulated by the Community Multiscale Air Quality model from 1996 to 2003. Annual average nitrogen deposition from 1996 to 2003 is more than 300 kgN km^{-2} year^{-1} in the southern part of the Japan/East Sea. We carry out numerical experiments with and without nitrogen deposition to the surface layer. The results show phytoplankton blooms in spring and autumn caused by seasonal variation of mixed layer depth in both cases. The effect of atmospheric nitrogen input in the southern part of the Japan/East Sea is more significant than in the northern parts because of the relatively large deposition and low ambient nutrient concentration. In this region, primary production in summer with the atmospheric nitrogen input is more than 10 % larger than without. The effect is greatest in the summer season because nutrients are depleted in the surface layer during this post bloom period. Sensitivity analyses were carried out to examine the range of the response to variation in several parameters.

Poster BIO_P-4304

Abundance, distribution and feeding habits of jellyfish in the upper epipelagical of the western Bering Sea

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We examined the biomass, distribution and feeding habits of jellyfish based on data from trawl surveys of the upper epipelagic zone of the western part of the Bering Sea conducted in summer and fall 2002–2006. The total biomass of jellyfish increased from 1770–3226 kg per square km in summer to 1859–4214 kg per square km in fall. The scyphomedusa *Chrysaora melanaster* and the hydromedusa *Aequorea* sp. dominated the jellyfish biomass (59–99%). Distribution of these dominant species showed different patterns. *Aequorea* sp. was concentrated in the deepwater regions. *Chrysaora melanaster* occurred in all parts of the western Bering Sea and was the most abundant on the shelf near Anadir Bay. In fall 2006, most of medusae fed on planktonic crustaceans (copepods, euphausiids, amphipods, pteropods, chaetognaths, ostracods, and larvae decapods). A high proportion of *Chrysaora melanaster* diet was comprised of larvae squid and fish (*Stenobrachius leucopsarus*).

Poster BIO_P-4326

Spatio-temporal variation of intertidal microphytobenthos in the Nakdong Estuary, Korea

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The species composition and biomass of intertidal microphytobenthos (MPB) have been investigated since September 2006 at four sites in the Nakdong Estuary, southeast Korea. The chlorophyll *a* concentration showed a positive correlation with MPB abundance, and the MPB depth profiles showed an exponential decline with depth, but with different shapes associated with different sites. A MANOVA analysis revealed that the chlorophyll *a* concentration varied significantly not only with depth, month, and site, but also with combinations of these factors. The MPB biomass showed a high variation at the investigated sites, except for site D. At site D, the MPB biomass was consistently lower than at the other sites, until it increased in June 2007. At these other sites, the seasonal trends of biomass variation were difficult to discern. A species-composition cluster analysis indicated that sites close to each other and with similar sediment structures were similar in the same seasons. The species of the genus *Amphora* and *Navicula* were dominant at all four sites throughout the study period.

Poster BIO_P-4343

Spatial and temporal distribution of inorganic nutrients and nutrient ratios as controls on composition of phytoplankton in the western channel of the Korea Strait

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The Korea/Tsushima Strait is the primary inlet of seawater and advected heat into the East/Japan Sea. This survey area is well known for measuring global climate change because of a long time series of data. Until recently, however, most studies in this area, including international collaborations in the East/Japan Sea, were focused on physical oceanography. Thus, studies of the Korea Strait were rarely focused on the distribution of nutrients and other biological properties, and interactions between physical-chemical environmental factors and phytoplankton populations were poorly studied in this oligotrophic water. However, dissolved organic carbon resulting from the growth of phytoplankton is transported by the Tsushima Current to the oligotrophic water in the Ulleung Basin of the East/Japan Sea. Although the impacts of phytoplankton blooms in the western channel of the Korea Strait on ecological aspects to the East/Japan Sea are not known, this input of organic carbon should act as an important source for primary production in oligotrophic water of the East/Japan Sea. Thus, it is important to understand the

spatial and temporal distribution of inorganic nutrients and the composition of phytoplankton in the western channel of the Korea Strait. Nutrients often have major regulatory effects on phytoplankton abundance and composition. Previous studies have demonstrated that concentrations and ratios of nitrogen, phosphorus, and silica may limit phytoplankton abundance and determine the dominant phytoplankters. The spatial and temporal distribution of inorganic nutrients and the composition of phytoplankton in the western channel of the Korea Strait are related to several processes. First, nutrient inputs to the surface layer from water column mixing due to weakening of the thermocline and wind causes the growth of diatoms, typically followed by the growth of dinoflagellates. Second, the nutrient-rich bottom water flows outside to the Kuroshio Current and the Korea Strait, Bottom Cold Water. However, nutrients here are not supplied to the photic zone because of the thermocline. As a result, these nutrients are not available for the growth of diatoms, although the thermal stratification does allow for the growth of unknown small phytoplankton. Finally, nutrient inputs to the water column by water column mixing and episodic events such as typhoons may help the growth of diatoms and dinoflagellates.

Poster BIO_P-4345

Effect of thermal stratification on phytoplankton community composition and nutrient limitation in the Korea Strait

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The profile of a fixed site at station M (34.77°N, 129.13°E) in the Korea Strait was studied from March 2006 to February 2007 to understand the relationship between the annual pattern of thermal stratification and the seasonal variation of phytoplankton composition. Environmental factors including temperature, salinity and nutrient concentrations, which strongly influence the proliferation and diversity of phytoplankton were measured. The concentration of chlorophyll *a* ranged between 0.01 and 2.14 mg^{-3}. Higher concentrations of chlorophyll *a* were detected in the upper part of the thermocline during the thermal stratification between June and November 2006. A chain-forming diatom, *Chaetoceros socialis* dominated the phytoplankton population between March and May 2006 before formation of the thermocline (0.02×10^5 – 11.58×10^5 cells l^{-1}), while pico+nano sized phytoplankton (<5μm) overwhelmingly dominated the phytoplankton population during and just after thermal stratification between June 2006 and January 2007 (0.006×10^5 – 4.51×10^5 cells l^{-1}). Apart from pico+nano sized small organisms, the secondarily dominant phytoplankton population was dinoflagellates, such as *Gyrodinium* species (0.002×10^5 – 0.22×10^5 cells l^{-1}) during thermal stratification. *Chaetoceros socialis* dominated the phytoplankton community again from January 2007 until the end of experiment (0.004×10^5 – 3.0×10^5 cells l^{-1}). The mean concentration of nitrate was lower in subsurface water (<30 m) during thermal stratification (1.10 ± 0.21 μM) than that during the mixed period (3.68 ± 0.25 μM), suggesting the pico+nano sized plankton, which are nitrogen fixers, were able to dominate the phytoplankton population due to the oligotrophic conditions in the upper layer of the thermocline. The concentrations of phosphate were depleted during thermal stratification but silicate concentrations were quite stable through the study period.

Poster BIO_P-4478

Comparison of vertical distribution of suspended fecal pellets and production of copepod fecal pellets in the Ulleung Basin between 2005 and 2006

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Vertical distribution of suspended fecal pellets (SFP) in water column and production rates of fecal pellets by copepod community was studied in the Ulleung Basin, Japan/East Sea in July 2005 and April 2006. An anticyclonic eddy existed in the center of the basin in 2005 and 2006. The eddy was stratified with a seasonal thermocline and in the center of the eddy a strong subsurface chlorophyll maximum was developed at 40–50m depth in 2005. The seasonal thermocline in 2006, however, showed different pattern between stations. Experiments were made at two stations: D2 (at the periphery of the eddy) and D4 (inside the eddy). The SFP at D2 and D4 peaked at 30–50m depth with no clear difference between the day and night sampling in 2005. The SFP in 2006 showed different pattern between stations: D2 (no difference between the day and night sampling and SFP distributed through the water column until 100m depth) and D4 (SFP peaked at 10–30m depth at night and at 100m depth at day sampling). The production rates of fecal pellets by copepod community were estimated 0.57 mgC m^{-3} day^{-1} (or 115 mgC m^{-2} day^{-1} in the upper 200m) in July 2005 and 0.43 mgC m^{-3} day^{-1} (or 96.2 mgC m^{-2} day^{-1}) in April 2006. The major controlling factors for the variability of mesozooplankton fecal pellets are discussed in the context of the potential role of fecal pellets in carbon flux in the Ulleung Basin in summer and spring.

Poster BIO_P-4502

Fish farming development along the Adriatic coast of Albania

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In Albania, there are about 42 species of freshwater and diadromous fishes in the inland waters as well as some euryhaline species. Among the native species of economic importance are: the European eel, brown trout, barbel, chub, roach, tench, and the euryhaline species, *Atherina boyeri*. Marine and freshwater aquaculture in Albania have grown substantially. There are several species of introduced fishes in its inland waters. Among the most important of these are: rainbow trout, pollan, common carp, goldfish, North American bullheads or catfishes, mosquitofish, pumpkinseed, and largemouth black bass. Less abundant among the exotics are the American brook trout, European catfish, pike-perch, and silversides. The shads frequent the Albanian coasts and enter the rivers and a subspecies, the lacustris, is landlocked in some of the coastal lakes where it furnishes both food and sport. In addition to these, grey mullet, the European eel, the gilthead, sea bass, sole and the flounder enter lagoon waters seasonally to remain for one or more years during a period of nutrition and growth, and return to the sea with the onset of sexual maturity. A number of other euryhaline fishes also enter lagoons (Karavasta, Narta and Butrinti) to feed during the spring and summer. It is of particular interest that some of the most utilized fishes (rainbow trout and coregonids) have been introduced. Some brackish water species in Albania are derived from a modified capture or trap fishery where fish from the Mediterranean migrate naturally into a coastal lagoon during the spring and are then captured as they attempt to return to the sea in the autumn. A more sophisticated version of lagoon “culture” is the system of fish farms. The bureaucracy involved in licensing fish farms in the Albanian marine environments is time-consuming, and suffers from an insufficient exchange of know-how and a lack of cooperation concerning new developments.

CCCC Paper Session

Co-Convenors: Harold P. Batchelder (U.S.A.) and Michio J. Kishi (Japan)

North Pacific ecosystems and their response to climate variability have experienced intense study through GLOBEC and similar programs over the past 10 years. The PICES Climate Change and Carrying Capacity (CCCC) Program addressed the question of "how do interannual and decadal variations in ocean conditions affect the species dominance, biomass and productivity of the key zooplankton and fish species in North Pacific ecosystems?". Ultimately, a goal of the CCCC Program was to forecast possible consequences of climate variability on the North Pacific ecosystem. As the CCCC Program nears completion, it is worthwhile to examine the program's successes on addressing the key elements: climate change, carrying capacity, and forecasting. This evaluation will provide useful information for moving forward with successor PICES integrative programs like FUTURE: *Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Ecosystems*. We invite abstracts that infer processes from patterns and link climate, ocean physics, populations and ecosystems. Provocative abstracts that retrospectively examine the successes and shortcomings of the CCCC Program are welcome, as are more traditional presentations on climate, ecosystems and forecasting.

Wednesday, October 31, 2007 9:00 – 15:40

09:00 **George D. Jackson, B.R. Ward, R.S. McKinley and D.W. Welch**
Application of the POST acoustic array to a critical marine conservation problem for juvenile steelhead trout (*Oncorhynchus mykiss*) in British Columbia (CCCC_P-4383)

09:20 **Richard D. Brodeur, William T. Peterson, Toby D. Auth, Heather L. Soulen, Maria M. Parnel and Ashley A. Emerson**
Abundance and diversity of coastal fish larvae as indicators of recent changes in ocean and climate conditions in the Oregon upwelling zone (CCCC_P-4394)

09:40 **William T. Peterson, Thomas C. Wainwright and James J. Ruzicka**
Climate change scenarios for continental shelf waters of the Northern California Current: Potential impacts of changes in upwelling, stratification, seasonal cycles of production and the PDO on pelagic ecosystems (CCCC_P-4419)

10:00 **James J. Ruzicka, Thomas C. Wainwright and William T. Peterson**
A simple production model for the Oregon upwelling ecosystem: Investigating the effect of interannual variability in copepod community composition (CCCC_P-4412)

10:20 **Hao Wei and Zhenyong Wang**
Simulation on ecosystem evolution of Jiaozhou Bay for recent 40 years by modified NEMURO (CCCC_P-4499)

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

11:00 **David L. Mackas and Jackie King**
Multivariate classification of zooplankton life history strategies (CCCC_P-4384)

11:20 **Sachihiko Itoh, Ichiro Yasuda, Haruka Nishikawa, Hideharu Sasaki and Yoshikazu Sasai**
Modelling the transport and environmental variability of larval Japanese sardine (*Sardinops melanostictus*) and Japanese anchovy (*Englaulis japonicus*) in the western North Pacific (CCCC_P-4346)

11:40 **Tadanori Fujino, Kazushi Miyashita, Yasuma Hiroki, Tsuyoshi Shimura, Shinya Masuda and Tsuneo Goto**
Regime shift of mesopelagic fish – Long-term biomass index change of *Maurolicus japonicus* in the Japan/East Sea (CCCC_P-4338)

12:00 **Nandita Sarkar, Thomas C. Royer and Chester E. Grosch**
Seasonal and interannual variability of mixed layer depths along the Seward Line in the Northern Gulf of Alaska (CCCC_P-4204)

12:20 **Suam Kim, Sukyung Kang, Hyunju Seo, Eunjung Kim and Minho Kang**
Climate variability and chum salmon production and survival in the North Pacific (CCCC_P-4058)

12:40 ***Lunch***

14:00 **Harold P. Batchelder, Brie J. Lindsey and Brendan Reser**
Retentive structures, transport and connectivity in coastal ecosystems: Using a quantitative particle tracking metric to describe spatio-temporal patterns (CCCC_P-4414)

14:20 **Julie E. Keister, William T. Peterson and P. Ted Strub**
Zooplankton populations and circulation vary interannually to effect cross-shelf advection of biomass in the northern California Current (CCCC_P-4302)

14:40 **C. Tracy Shaw, Leah R. Feinberg and William T. Peterson**
Interannual variability in abundance, growth and spawning of the euphausiids *Euphausia pacifica* and *Thysaonessa spinifera* off Newport, OR, USA (CCCC_P-4405)

15:00 **Jennifer L. Menkel, William T. Peterson, Jesse F. Lamb, Julie E. Keister and T. O'Higgins**
Northern California Current (WA, OR, northern CA) hot spots of abundance for *Euphausia pacifica* and *Thysanoessa spinifera* (CCCC_P-4416)

15:20 **Brigitte Dorner, Randall M. Peterman, Cindy Bessey and Franz J. Mueter**
North-south location of the North Pacific Current and its influence on temporal variation in recruits per spawner in northeastern Pacific salmon (*Oncorhynchus*) populations (CCCC_P-4227)

CCCC Paper Posters

CCCC_P-4327 **Young-Shil Kang, In-Seong Han and Donghyun Lim**
Climate-related variations in oceanographic condition and mesozooplankton in the southwestern East China Sea after the mid 1990s

CCCC_P-4413 **Xan Augerot, Ray Hilborn, Nathan Mantua, Kate Myers, Randall Peterman, Dave Preikshot, Peter Rand, Greg Ruggerone, Daniel Schindler, Jack Stanford, Nathan Taylor, Trey Walker and Carl Walters**
The salmon MALBEC project: A North Pacific scale study to support salmon conservation planning

CCCC Paper Oral Presentations

31 October, 09:00 (CCCC_P-4383)

Application of the POST acoustic array to a critical marine conservation problem for juvenile steelhead trout (*Oncorhynchus mykiss*) in British Columbia

George D. **Jackson**[1, 2], B.R. Ward[3], R.S. McKinley[4] and D.W. Welch[5]

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The Pacific Ocean Shelf Tracking array, (POST), is an expanding telemetry array for measuring the survival and movements of fish in the Pacific Northwest, with a current geographic extent of over 2,500 km. We used POST to assess the survival of out-migrating steelhead trout (*Oncorhynchus mykiss)* smolts on both the east and west coasts of northern Vancouver Island. We found large differences in survival which match the sharp geographical differences in the conservation status of the stocks studied. The 1989/90 regime shift appears to have sharply reduced survival to adult return of east coast Vancouver Island steelhead populations, reducing these stocks to near extinction levels. In contrast, west coast stocks are in good condition. Our results indicate that large differences in survival develop between east and west coast steelhead stocks in the 1–2 week period after ocean entry, and that these differences are directly measurable with POST. In general, poor ocean survival could be due to either shifts in the abundance or distribution of predators (top down control) or changes in lower trophic levels that influence growth and survival of salmon at sea (bottom up). The large differences in survival that quickly develop are inconsistent with 'bottom up' control. We conclude that the POST array provides direct and accurate estimates of survival in the coastal ocean and useful results of where the high mortality is occurring. Further expansion of the POST array could help to identify regions of high mortality of young salmonids during their early marine migration.

31 October, 09:20 (CCCC_P-4394)

Abundance and diversity of coastal fish larvae as indicators of recent changes in ocean and climate conditions in the Oregon upwelling zone

Richard D. **Brodeur**[1], William T. Peterson[1], Toby D. Auth[2], Heather L. Soulen[2], Maria M. Parnel[2] and Ashley A. Emerson[3]

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We examined ichthyoplankton sampled from two stations, 9 and 18 km offshore of Newport, Oregon over a decade of biweekly cruises from 1996 to 2005. The ten most dominant taxa comprised approximately 87.3% of the total catch. Density of fish larvae was highest in January to March, whereas diversity peaked from March through May. The summer/fall larval fish community is comparatively much less diverse in this region, with only northern anchovy found to be indicative of this time period. Assemblage analysis of our dominant taxa revealed a pronounced seasonal pattern in community composition with winter/spring (January–May) and summer/fall (June–December) groupings clearly delineated. Both overall diversity and density of larval fishes were relatively constant through the period 1996 to 2003, with a dramatic decrease in these metrics since 2004, especially for winter/spawning (January–May) species, perhaps due to the warm ocean conditions and low productivity in recent years. During cool years (1999–2002), the ichthyoplankton assemblage was dominated by northern or coastal taxa such as smelts, sand lance, and sanddabs, whereas in warm years (1997–98 and 2003–05), southern or offshore taxa such as English sole, northern anchovy, and rockfishes were more important. These changes were related to concurrent shifts in the copepod biomass and area of origin (northern vs. southern species) off Oregon during cold and warm environmental

regimes as characterized by the Pacific Decadal Oscillation. Larval fishes may serve as key indicators for changes in marine ecosystems because of their relatively quick response time compared to adult populations.

31 October, 09:40 (CCCC_P-4419)

Climate change scenarios for continental shelf waters of the Northern California Current: Potential impacts of changes in upwelling, stratification, seasonal cycles of production and the PDO on pelagic ecosystems

William T. **Peterson**[1], Thomas C. Wainwright[1] and James J. Ruzicka[2]

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The pelagic ecosystem of the Northern California Current is usually dominated by sub-arctic species, whereas ecosystems at the southern end are dominated by tropical species. Faunal boundaries are known for Cape Blanco OR/Cape Mendocino CA, Point Concepcion CA, and Punta Baja MX. From first principles, observations and models, we will discuss several climate change scenarios: faunal boundaries may shift north due to global warming, resulting in northerly shifts in faunal types such that subtropical ecosystems might be the norm for the Northern California Current. We now observe a "warm-water plankton community" when the PDO is in positive phase (and during El Niño), and know that these events have a negative impact on resident fish species; a persistence of warm-water plankton communities would harm local fish production. Another scenario, suggested by A. Bakun, is that coastal upwelling will intensify. If true, this could offset any tendency for the ecosystem to shift towards a warm-water system. A third scenario suggests that increased input of freshwater from snow-melt will reduce the salinity of the California Current, increasing water column stratification, which will reduce the effectiveness of upwelling and favor dinoflagellates over diatoms. But, could stronger upwelling override increased stratification? A fourth scenario is that seasonal cycles of production may shift to earlier in the year, leading to a mismatch between peaks in production and the timing of "normal" breeding periods or feeding migrations by fish, birds or mammals. Finally, two questions: what surprises await us; and what will happen to the PDO?

31 October, 10:00 (CCCC_P-4412)

A simple production model for the Oregon upwelling ecosystem: Investigating the effect of interannual variability in copepod community composition

James J. **Ruzicka**[1], Thomas C. Wainwright[2] and William T. Peterson[2]

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A nitrogen-based plankton model is developed for the Oregon upwelling ecosystem. The biological model has six components: nitrate, ammonia, small phytoplankton, large phytoplankton, and zooplankton. The two phytoplankton size classes represent the different communities that exist under different upwelling conditions. Under low nutrient conditions, the phytoplankton community is composed of a diverse array of small species, and under high nutrient conditions, large diatoms are dominant. The zooplankton pool represents the copepod community. We have aimed for computational simplicity and speed by linking the biological model to a one-dimensional cross-shelf physical model. The model sacrifices the ability to resolve along-shelf processes but takes advantage of the fact that the seasonally high productivity of this ecosystem is largely driven by northerly winds and upwelling processes. This simple model serves as a platform to test lower-trophic ecosystem response to alternate parameter set combinations. It is also used to investigate the effect of inter-annual variability in copepod community composition and concomitant variability in grazing response upon zooplankton productivity, biomass, and cross-shelf distribution. Model quality is evaluated against nitrate, chlorophyll, and copepod biomass measurements made along the Newport Hydrographic Line across the central Oregon coast shelf from 1997 through 2006. Parameter sensitivity analyses show that the system is very sensitive to zooplankton grazing response parameters. As such, plankton models for systems that show large inter-annual variability in zooplankton community composition, as does the Oregon upwelling ecosystem, must account for these changes if they are to be valid over multiple years.

31 October, 10:20 (CCCC_P-4499)

Simulation on ecosystem evolution of Jiaozhou Bay for recent 40 years by modified NEMURO

Hao **Wei** and Zhenyong Wang

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The lower trophic level ecosystem model, NEMURO, developed by PICES, was modified and applied in the coastal water of Jiaozhou Bay, China. A phosphorous cycle was added to NEMURO because of its importance as a limiting nutrient in this region. Nitrogen is relatively available due to runoff of N from fertilization. Nutrient discharge from rivers, sediment–water exchange, and atmospheric deposition and exchange between the Yellow Sea were considered. The lower trophic components of the Jiaozhou Bay ecosystem are simulated for 1962–1998. The phytoplankton community structure responded to riverine increases in N and P and decreases of Si due to the dam. The ratio of small- to large-phytoplankton biomass increased in all seasons. Size of phytoplankton of Jiaozhou Bay has declined dramatically from the 1960s to 1990s. Biomass of phytoplankton has risen with increased water temperature and sea surface effective radiation, especially in autumn and winter when temperature and light limit algal growth. In numerical experiments that consider temperature trends, the annual mean biomass of phytoplankton changed consistent with temperature variation but the amplitude changed little. Comparing the annual cycle of total phytoplankton biomass in a cool year (1986) and warm year (1998), it is found that there is an early and weak bloom in spring and higher bloom in autumn during warm years. Human activities, such as altering hydrologic cycles and nutrient concentrations may have strong impacts on long term ecosystem variation in coastal enclosed waters, such as Jiaozhou Bay.

31 October, 11:00 (CCCC_P-4384)

Multivariate classification of zooplankton life history strategies

David L. **Mackas**[1] and Jackie King[2]

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Life history and reproductive strategies, morphology, and feeding niche all affect how well individual species can exploit and persist in changing ocean environments. For zooplankton, examples of potentially important factors include: presence/absence of seasonal dormancy, generation length, trophic level (herbivory vs. omnivory vs. carnivory), fecundity vs. body size, broadcast vs. brooding of eggs, depth distribution, and the degree to which morphology and trophic niche are stage/age dependent. Multivariate ordination and clustering of these life history traits can be used to group taxa into strategist guilds (*e.g.* King and McFarlane 2003 for marine fishes), then to examine how spatial, seasonal, and interannual variability of abundance maps onto guild-membership. We have applied similar methods to zooplankton reproductive, growth, mortality-avoidance strategies. We find several clusters of taxa sharing similar strategies, often but not always also sharing taxonomic affinity.

31 October, 11:20 (CCCC_P-4346)

Modelling the transport and environmental variability of larval Japanese sardine (*Sardinops melanostictus*) and Japanese anchovy (*Englaulis japonicus*) in the western North Pacific

Sachihiko **Itoh**[1], Ichiro Yasuda[1], Haruka Nishikawa[1], Hideharu Sasaki[2] and Yoshikazu Sasai[2]

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Stock abundances of Japanese sardine (*Sardinops melanostictus*) and Japanese anchovy (*Englaulis japonicus*) show dramatic out-of-phase fluctuation, which is triggered by the multidecadal environmental variability. While

correlations were found between indices of environment and survival through early life stages, description and evaluation of environmental conditions related to the fish biologies has not been sufficient. Numerical particle-tracking experiments are thus conducted to examine the transport and environmental variability of larval Japanese sardine and Japanese anchovy using the Ocean general circulation model for the Earth Simulator (OFES). As the model resolves eddies, covers the whole spawning and nursery areas, and the integration is made for several decades, seasonal and interannual Lagrangian environmental variability of the Kuroshio–Oyashio system region and Pacific coastal areas of Japan is quantitatively examined. Considering the characteristics of water mass of these areas, we distribute particles at reasonable locations compared to the observed spawning grounds and evaluate the characteristics of the transport and environmental variability experienced by each particle. Year-to-year fluctuations of destination, Lagrangian temperature, and other environmental factors experienced by the model larvae show different tendencies between sardine and anchovy because of different spawning seasons and locations. Eastward larval transport seems to be related to recruitment processes for both species. There is anomalous eastward sardine larval transport from 1987 to 1992 that corresponds to the period of extremely low recruitment rate of sardine. It is suggested that offshore transport is unfavorable for both sardine and anchovy larvae.

31 October, 11:40 (CCCC_P-4338)

Regime shift of mesopelagic fish – Long-term biomass index change of *Maurolicus japonicus* in the Japan/East Sea

Tadanori **Fujino**[1], Kazushi Miyashita[1], Yasuma Hiroki[1], Tsuyoshi Shimura[2], Shinya Masuda[2] and Tsuneo Goto[3]

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Egg numbers of *Maurolicus japonicus* – a mesopelagic fish dominant in the Sea of Japan, was analyzed from 1978 to 2005 (28 years) in the southwest Sea of Japan as an index of adult stock. Average egg number collected by a single Norpac net tow showed dynamic change. Before 1987, average egg number fluctuated at low levels, but from 1987 average egg number increased continuously to 1993 and fluctuated at high levels which were approximately double those prior to 1987. This dynamic change correlated positively with the warm current strength in the Sea of Japan (Tsushima current index), and also with a stock index of commercially important species like Japanese common squid (*Todarodes pacificus*) and Japanese anchovy (*Engraulis japonicus*). This “regime shift” is the first reported for mesopelagic fish. Since *M. japonicus* is not a fishing target, its stock change may purely reveal the regime shift occurring in the marine ecosystem. Continuous monitoring of this stock may provide a sensitive index of future regime shifts. Such an index is necessary to conduct ecosystem-based management in the Sea of Japan.

31 October, 12:00 (CCCC_P-4204)

Seasonal and interannual variability of mixed layer depths along the Seward Line in the Northern Gulf of Alaska

Nandita **Sarkar**[1], Thomas C. Royer[2] and Chester E. Grosch[2]

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Most productive marine ecosystems are in areas of upwelling, where deep nutrients are brought to the euphotic zone by Ekman pumping. The northern Gulf of Alaska is not in such an upwelling area, yet is one of the most productive marine ecosystems in the world. Other mechanisms, that include deep mixing, are required to explain how this rich ecosystem is sustained. This study contains calculations and descriptions of the across-shelf and temporal (seasonal and interannual) variabilities in the mixed layer depths (MLDs). Since the seawater here is relatively cold, salinity plays a dominant role in the determination of density. This is the first time salinity as well as temperature data have been used to calculate MLDs in the area, using data collected as a part of the GLOBEC (GLOBal ocean ECoOsystem dynamics) initiative in the area from October 1997 to December 2004. The MLDs across the shelf are deepest in late winter/early spring and shallowest in summer. In general, MLDs on the shelf are deeper than those

offshelf, with deepest MLDs near the shelf break. This annual cycle is primarily in response to freshwater discharge, winds and solar insolation. At interannual timescales, additional factors influence MLDs, such as, anticyclonic eddies and the state of ENSO (El-Niño Southern Oscillation). ENSO affects MLDs all across the Seward Line by changing the freshwater and prevailing wind fields. Mesoscale anticyclonic eddies interact with the MLDs offshore of the mid shelf region, and cause the MLDs to shoal.

31 October, 12:20 (CCCC_P-4058)

Climate variability and chum salmon production and survival in the North Pacific

Suam **Kim**[1], Sukyung Kang[2], Hyunju Seo[3], Eunjung Kim[1] and Minho Kang[1]

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The relationship between North Pacific chum salmon (*Oncorhynchus keta*) population and climate variability was investigated in the North Pacific ecosystem. Time-series for the Aleutian Low Pressure, Southern Oscillation, Arctic Oscillation, and Pacific Decadal Oscillation (PDO) indices dating back to 1950 are compared with the chum salmon catch using a cross-correlation function (CCF) and cumulative sum (CuSum) of anomalies. The results of CCF and CuSum analyses indicated that there was a major change in climate during the mid 1970s, and that the chum salmon population responded to this climate event with a time-lag. The PDO and chum salmon returns showed a highly significant correlation with a time-lag of 3 years, while the AOI with a time-lag of 6~7 years. The favorable environments for fry chum salmon might cause better growth in the coastal areas, but higher growth rate during the early stage does not seem to be related to the improved return rate of spawning adults. Rather, growth in the Okhotsk Sea or the Bering Sea during immature stages has a significant correlation with return rate, which implies the size-related mortality process. The development of a local climate index is necessary to elucidate the effect of climate variability on the marine ecosystem around the Korean Peninsula.

31 October, 14:00 (CCCC_P-4414)

Retentive structures, transport and connectivity in coastal ecosystems: Using a quantitative particle tracking metric to describe spatio-temporal patterns

Harold P. **Batchelder**, Brie J. Lindsey and Brendan Reser

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Biological processes in the ocean are sensitive to small fluctuations in physical conditions operating at scales of a few meters through the mesoscale to scales of hundreds of kilometers (megascale). Biological production, recruitment, nearshore retention, growth capacity, predator-prey interactions and transport may all be affected by physical processes operating at these scales. We are interested in quantifying mesoscale structures, by developing indices of mesoscale structures using particle tracking methods. We will illustrate our approach using examples from 10 km resolution Northeast Pacific (NEP) and 3 km resolution California Current System (CCS) ROMS models. We examine indices derived by considering (1) advection only, and (2) advection and dispersion. We examine interannual and interseasonal variability using index metrics derived from the coarser resolution NEP grid.

31 October, 14:20 (CCCC_P-4302)

Zooplankton populations and circulation vary interannually to effect cross-shelf advection of biomass in the northern California Current

Julie E. **Keister**[1], William T. Peterson[2] and P. Ted Strub[1]

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In coastal upwelling systems, the across-slope transport of zooplankton from biologically-rich coastal areas to the deep sea contributes to the productivity of offshore areas while potentially depleting nearshore populations. A

dominant mechanism of such transport is mesoscale circulation features such as eddies and filaments of the upwelling jet. Such features are common in the California Current System (CCS) and may persist several months, delivering large amounts of nearshore water and the associated biology to the deep sea. As part of the U.S. GLOBEC Northeast Pacific Program, we are studying links between climate forcings, ocean conditions, and zooplankton populations in the northern CCS. We use observational data to address the question of how interannual variability in mesoscale circulation affects the cross-shelf transport of coastal zooplankton: we use satellite altimetry to study the circulation; we use zooplankton collected off Oregon and northern California to study zooplankton variability. Our results indicate that climate effects on the cross-shelf transport of zooplankton are a complex interaction of the forcings on both circulation and population dynamics. In this presentation, we will explore the complexities of ecosystem variability including changes in climate, circulation, and zooplankton, all of which contribute to interannual variability in the delivery of zooplankton biomass to deep regions of the CCS.

31 October, 14:40 (CCCC_P-4405)

Interannual variability in abundance, growth and spawning of the euphausiids *Euphausia pacifica* and *Thysanoessa spinifera* off Newport, OR, USA

C. Tracy **Shaw**[1], Leah R. Feinberg[1] and William T. Peterson[2]

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The euphausiids *Euphausia pacifica and Thysanoessa spinifera* are the two most common species of euphausiids off the Oregon Coast. We have sampled biweekly for euphausiids off Newport, OR since 2001. Our data set includes euphausiid abundance, species composition, and life history stages as well as data from experiments on live euphausiids to investigate growth rate and egg production. In our study area, 2001, 2002 and 2006 were cooler and more productive years and 2003–2005 were warmer and less productive. However, measurements of growth using several methods (IGR experiments, cohort analysis and long-term laboratory observations) were consistent throughout this time period and showed that individual growth rates for adults were highly variable but were typically $\leq \pm 0.02$mm/d. Seasonality of spawning was determined by the presence of eggs in preserved samples. The spawning season for euphausiids in our study area was generally March–October, consistent with the upwelling season when phytoplankton blooms occur. We will examine our euphausiid data in the context of environmental conditions to investigate the effects of variations in ocean conditions on euphausiid abundance, growth and spawning.

31 October, 15:00 (CCCC_P-4416)

Northern California Current (WA, OR, northern CA) hot spots of abundance for *Euphausia pacifica* and *Thysanoessa spinifera*

Jennifer L. **Menkel**[1], William T. Peterson[2], Jesse F. Lamb[1], Julie E. Keister[3] and T. O'Higgins[1]

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We have produced large scale distribution and abundance estimates of adult and juvenile euphausiids in the northern California current. We used night time vertical net samples collected from 1998 through 2006 during multiple GLOBEC cruises. Using both the distribution patterns and the yearly oceanographic conditions we have created species-specific charts of abundance to show the areas of greatest density or "hot spots" for each species. *E. pacifica* was widely distributed in the study area with a mean overall biomass of 1.90mgC/m^3. The abundance of *E. pacifica* is significantly correlated with distance from the shelf break (p-value 0.005 Kruskal-Wallis, Chi-square), with most of the high biomass samples occurring within 10km of the shelf break. *T. spinifera* is not widely distributed in the study area, has a much lower overall biomass, 0.16mgC/m^3, and is not significantly correlated with distance from the shelf break. These results, combined with our MOCNESS net data, will contribute to the development of a standing stock biomass estimate for *E. pacifica* and *T. spinifera* and to the future modeling efforts by other GLOBEC investigators.

31 October, 15:20 (CCCC_P-4227)

North-south location of the North Pacific Current and its influence on temporal variation in recruits per spawner in northeastern Pacific salmon (*Oncorhynchus*) populations

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Understanding causes of large temporal variability in productivity of Pacific salmon (*Oncorhynchus* spp.) populations remains an important challenge. Considerable evidence on spatial coherence among salmon populations shows that shared regional-scale ocean conditions spanning hundreds of kilometers (indexed by coastal sea-surface temperature, SST) are more important drivers of temporal variation in productivity than broad-scale conditions over thousands of kilometers (indexed by the Pacific Decadal Oscillation, PDO). Nevertheless, large unexplained variation in salmon productivity (adult recruits/spawner) remains. We therefore explored the usefulness of an index of intermediate-spatial-scale processes, *i.e.*, interannual variability in north-south location of the North Pacific Current as it bifurcates off the west coast of North America. An annual time series of this “bifurcation index” (BI) was created by forcing the drifter-validated OSCURS (Ocean Surface Current Simulation) model with historical sea-level pressure fields. We then used time-series data on 120 pink, chum, and sockeye salmon populations in the Northeastern Pacific to fit multi-stock, mixed-effect models of log(recruits/spawner) as a function of (1) spawners only, (2) spawners plus region-specific SST, (3) spawners plus BI, and (4) spawners, SST, and BI. Models containing bifurcation index either had the lowest AICc or were tied for it in 7 of 9 species-region combinations. More northern locations of the Current were generally associated with higher productivity of British Columbia and Bering Sea populations but lower productivity of central Gulf of Alaska populations. Thus, future research on temporal variation in productivity of Pacific salmon may benefit from considering indices of environmental processes at various spatial scales.

CCCC Paper Posters

Poster CCCC_P-4327

Climate-related variations in oceanographic condition and mesozooplankton in the southwestern East China Sea after the mid 1990s

Young-Shil **Kang**, In-Seong Han and Donghyun Lim

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Variations in oceanographic condition and mesozooplankton in the southwestern East China Sea (ECS) are examined to understand climate-related changes after the mid 1990s with emphasis on the 2002/03 El Niño. Data on temperature (SST), salinity (SSS), nutrients (NO_3, PO_4 and SiO_2), zooplankton biomass and abundance of four zooplankton groups during 1995–2005 were analyzed. SST showed increasing trend in February and November while August SST declined until the late 1990s. Subsequently, SST steadily decreased in February and increased in August except in 2002. February SSS increased until the late 1990s and then continuously decreased to 2004. SSS was particularly low in 2002 and 2003 compared to the other survey years. Nutrients (NO_3, PO_4 and SiO_2) clearly decreased after 2000 compared to before 2000. Contrasted to a general trend after 2000, nutrients in 2003 were higher than the other years. Zooplankton biomass showed steady decreasing trend with a high value in May 1997 and 1998. Conversely, abundances of copepods, amphipods, chaetognaths and euphausiids were very high in 2003, especially in May. It is concluded that SST and SSS showed a shifted phase in February after the late 1990s with the lowest value of salinity in 2002 and 2003. SST and SSS responded to the regime shift of 1997/98 and the El Niño

event in 2002/03. Zooplankton biomass also showed decreasing trend after the late 1990's, but abundance of four zooplankton groups didn't showed a typical trend. In 2003, nutrient concentrations were high and four zooplankton groups had high abundance, probably as a response to ocean conditions created by the 2002/03 El Niño.

Poster CCCC_P-4413

The salmon MALBEC project: A North Pacific scale study to support salmon conservation planning

Xan Augerot[1], Ray Hilborn[2], Nathan **Mantua**[2], Kate Myers[2], Randall Peterman[3], Dave Preikshot[4], Peter Rand[1], Greg Ruggerone[5], Daniel Schindler[2], Jack Stanford[6], Nathan Taylor[2], Trey Walker[2] and Carl Walters[4]

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A multi-investigator team has been synthesizing data and expert knowledge in order to develop a new simulation model – Salmon MALBEC (Model for Assessing Links Between ECosystems) – to support Pacific salmon conservation planning at the scale of the North Pacific basin at the scale of large ocean-draining river basins. MALBEC is designed to investigate threats to wild salmon ecosystems, with a special focus on integrating threats across the full life-cycle for major population groups. The model allows users to explore hypotheses about Pacific salmon at the North Pacific scale: the effects of competition among salmon stocks (and species) in the North Pacific, the response of salmon stocks and species to climate change, and the possible effects of large hatchery programs on natural and hatchery stocks from other regions. MALBEC is designed to conduct risk assessments based on different conservation, hatchery policy, and/or harvest management strategies. The model is supported by a data base including regionalized annual run-sizes, catches, spawning escapements, and hatchery releases for 135 major pink, chum, and sockeye population groups around the North Pacific for the period 1950–2006. The model is being run with observed salmon and environmental data from 1950–2006, and with environmental (climate and habitat change) and policy scenarios for the period 2007–2050.

FIS Paper Session

Convenor: Gordon H. Kruse (U.S.A.)

Papers addressing various topics in fishery science and fisheries oceanography in the North Pacific and its marginal seas (except S3, S4, S5, S7 and S11 topics) are invited.

Friday, November 2, 2007 09:00 – 17:20

09:00 **Rodrigo M. Montes, R. Ian Perry, E.A. Pakhomov and J.A. Boutillier**
Novel time series methods (fractals) applied to Eastern Pacific fisheries (FIS_P-4092)

09:20 **Inja Yeon, Myoung Ho Sohn, Mi Young Song, Hak Jin Hwang and Yang Jae Im**
Research program for stock rebuilding of blue crab, *Portunus trituberculatus*, in the western sea of Korea (FIS_P-4462)

09:40 **Alexander I. Glubokov**
Population structure of the Bering Sea pollock and functional structure of it range in recent decades (FIS_P-4036)

10:00 **Naoki Tojo, Akira Nishmura, Satoshi Honda, Tetsuichiro Funamoto, Seiji Katakura and Kazushi Miyashita**
Marine environment induced spatial dynamics of recruited walleye pollock juveniles (*Theragra chalcogramma*) and interactions with prey and predators along the Pacific coast of Hokkaido, Japan (FIS_P-4353)

10:20 **Toby D. Auth**
Distribution and community structure of ichthyoplankton from the northern and central California Current in May 2004–2006 (FIS_P-4041)

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

11:00 **Leonardo Huato-Soberanis and Martha J. Haro-Garay**
Spawning migrations in fish: A case study of the sockeye salmon from the Fraser river in British Columbia (FIS_P-4107)

11:20 **Marc Trudel, David L. Mackas and Asit Mazumder**
Assessing the effects of ocean conditions on the growth and survival of Pacific salmon in British Columbia and Alaska (FIS_P-4044)

11:40 **Oleg Bulatov, Boris Kotenev, Georgiy Moiseenko and Vladimir Borisov**
The GIS method application for the stock assessment of the walleye pollock and the Northeast Arctic cod (FIS_P-4069)

12:00 **Woo-Seok Gwak**
Genetic approach for the assessment of a stock enhancement of Pacific cod (*Gadus macrocephalus*) (FIS_P-4218)

12:20 **Jung Jin Kim, Suam Kim and Hwa Hyun Lee**
Summer occurrence and transport process of common squid (*Todarodes pacificus*) paralarvae in the East China Sea (FIS_P-4265)

12:40 ***Lunch***

14:00 **Nanami Kumagai, Hidetada Kiyofuji, Hideaki Kidokoro and Sei-Ichi Saitoh**
Prediction and of Japanese common squid (*Todarodes pacificus*) fishing grounds using generalized additive models in the Japan/East Sea (FIS_P-4322)

14:20 **Michael J. Schirripa**
Testing two methods of including environmental factors into stock assessments (FIS_P-4455)

14:40 **Edward J. Gregr, Rowenna Flinn, Mathew Bermann and Gaku Ishimura**
Predicting the relative abundance of pinniped prey in the Gulf of Alaska (FIS_P-4250)

15:00 **John R. Brandon, André E. Punt, Paul R. Wade, Wayne L. Perryman, Richard D. Methot, Mark N. Maunder and George M. Watters**
Integrating environmental data into marine mammal stock assessments: Application to the eastern North Pacific gray whale (FIS_P-4397)

15:20 **You Jung Kwon, D.H. An, C.I. Zhang and D.Y. Moon**
Standardization of CPUE for bigeye (*Thunnus obesus*) and yellowfin (*Thunnus albacares*) tunas of Korean longline fishery in the Indian Ocean (FIS_P-4275)

15:40 ***Coffee / tea break***

16:00 **Sayaka Nakatsuka, Akinori Takasuka, Hiroshi Kubota and Yoshioki Oozeki**
Estimating daily ration of skipjack tuna on larval and juvenile anchovy in the Kuroshio–Oyashio transition region in early summer (FIS_P-4076)

16:20 **Mikhail A. Stepanenko, Elena V. Gritsay and Svetlana Yu. Glebova**
Impact of environment and exploitation on the interannual variability eastern Bering Sea pollock: Abundance and distribution (FIS_P-4032)

16:40 **Franz J. Mueter, Cecilie Broms, Ken Drinkwater, Kevin Friedland, Jon Hare, George Hunt Jr., Webjørn Melle and Maureen Taylor**
Comparison of 4 Northern Hemisphere regions: Ecosystem responses to recent oceanographic variability (FIS_P-4239)

17:00 **Sarah Gaichas, Georg Skaret, Jannike Falk-Petersen, Jason S. Link, William Overholtz, Bernard A. Megrey, Harald Gjøsæter, William Stockhausen, Are Dommasnes and Kerim Aydin**
A comparison of community and trophic structure in four marine ecosystems based on energy budgets and system metrics (FIS_P-4249)

FIS Paper Posters

FIS_P-4056 **Nikolina Petkova Kovatcheva**
Maintenance of red king crab stocks in the North Pacific using mariculture methods

FIS_P-4089 **Dae Sun Son, Chae Woo Ma and Wongyu Park**
Survival rate and growth of larval swimming crab, *Portunus trituberculartus*, in the laboratory

FIS_P-4093 **Andrey Suntsov and Richard Brodeur**
Feeding ecology of three dominant lanternfish species (Myctophidae) off Oregon

FIS_P-4094 **Rodrigo M. Montes, R. Ian Perry, E.A. Pakhomov and J.A. Boutillier**
Long-term patterns in sea surface temperature (SST) and smooth pink shrimp (*Pandalus jordani*) catches off the west coast of Vancouver Island, Canada

FIS_P-4099 **Jie Zheng**
Temporal changes in size at maturity and their implications for fisheries management for eastern Bering Sea Tanner crab

FIS_P-4119 **Galina V. Belova**
Spawning and fecundity of highly abundant fishes of the family Bathylagidae in the Russian Far Eastern seas and adjacent waters of the northwestern Pacific Ocean

FIS_P-4130 **Yeonghye Kim, Dong Woo Lee, Seon Jae Hwang, Byung Kyu Hong, Soo Ha Choi**
Age and growth of Pacific cod, *Gadus macrocephalus* in the East/Japan Sea

FIS_P-4181 **Yuya Yokoyama, Hideaki Kudo and Masahide Kaeriyama**
Estimating escapement and spawning capacity of pink salmon (*Oncorhynchus gorbuscha*) at rivers in the Shiretoko World Natural Heritage area

FIS_P-4208 **Cindy A. Tribuzio and Gordon H. Kruse**
An alternative approach to estimating worn annuli for aging of spiny dogfish (*Squalus acanthias*) spines

FIS_P-4214 **Jun Yamamoto, Miyuki Hirose, Tetsuya Ohtani, Katashi Sugimoto, Kazue Hirase, Nobuo Shimamoto, Tsuyoshi Shimura, Natsumi Honda, Yasuzumi Fujimori and Tohru Mukai**
Transportation of organic matter to the sea floor by carrion falls of the giant jellyfish (*Nemopilema nomurai*) in the Japan/East Sea

FIS_P-4219 **Ryota Yokotani, Naotaka Imai, Hideaki Kudo and Masahide Kaeriyama**
Genetic differentiation between early-run and late-run populations of the Yurappu River chum salmon *Oncorhynchus keta* using the mitochondrial DNA analysis

FIS_P-4220 **A. Jason Phillips, Stephen Ralston, Richard D. Brodeur, Toby D. Auth, Robert L. Emmett, Carrie J. Johnson and Vidar G. Wespestad**
Recent pre-recruit Pacific hake (*Merluccius productus*) occurrences in the northern California Current suggest a northward expansion of their spawning area

FIS_P-4267 **Masakazu Shinto, Hideaki Kudo and Masahide Kaeriyama**
Development of the olfactory organ in chum salmon (*Oncorynchus keta*) during migration

FIS_P-4277 **Jong Hee Lee and Chang-Ik Zhang**
A study on the assessment of the large purse seine fishery off Korea based on principles of the Marine Stewardship Council

FIS_P-4285 **Marisa N.C. Litz, Robert L. Emmett, Selina S. Heppell and Richard D. Brodeur**
Ecological considerations for northern anchovy abundance and distribution in the northern California Current

FIS_P-4287 **Carrie J. Johnson, Robert L. Emmett and Gordon McFarlane**
Jack mackerel (*Trachurus symmetricus*) abundance, distribution, diet, and associated relationships to oceanographic conditions in the northern California Current

FIS_P-4298 **Dongwha Sohn, Lorenzo Ciannelli, Janet Duffy-Anderson, Ann Matarese and Kevin M. Bailey**
Distribution and drift pathways of Greenland halibut, *Reinhardtius hippoglossoides*, during early life stage in the eastern Bering Sea

FIS_P-4310 **Joo-il Kim, Young-il Seo and Sukgeun Jung**
Daily biomass and production of Pacific anchovy, *Engraulis japonicus*, in the southern coastal area of Korea

FIS_P-4311 **Sukgeun Jung**
Yield-per-recruitment of Pacific anchovy (*Engraulis japonicus*) in Korean coastal waters

FIS_P-4312 **Sukgeun Jung, Sun-do Hwang, Joo-il Kim, Young-il Seo and Jin-yeong Kim**
Fecundity and growth-dependent mortality of Pacific anchovy (*Engraulis japonicus*)

FIS_P-4330 **Kenji Minami, Kazushi Miyashita, Akira Hamano, Takeshi Nakamura, Yuta Maruoka and Hiroki Yasuma**
Acoustic measurement of *Sargassum* beds in coastal area of western Honshu, Japan

FIS_P-4388 **Bernard A. Megrey, Jon Hare, Are Dommasnes, Harald Gjøsæter, William Stockhausen, William Overholtz, Sarah Gaichas, Georg Skaret, Jannike Falk-Petersen, Jason S. Link and Kevin Friedland**
Recruitment variation in functionally equivalent fish stocks: A cross-ecosystem comparison

FIS_P-4396 **Richard D. Brodeur, E. Howell, J. Polovina, L. Ciannelli, W.G. Pearcy, R.M. Laurs and J. Childers**
Spatial and temporal variations in albacore habitat in the Northeast Pacific using remotely-sensed environmental data

FIS_P-4436 **Eugene V. Samko, Nafanail V. Bulatov and Alexander V. Kapshiter**
Anticyclonic eddies of various origin southeastward from Hokkaido and their influence on saury fishery

FIS Paper Oral Presentations

2 November, 09:00 (FIS_P-4092)

Novel time series methods (fractals) applied to Eastern Pacific fisheries

Rodrigo M. **Montes**[1], R. Ian Perry[2], E.A. Pakhomov[1] and J.A. Boutillier[2]

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Collapsing fisheries are significant global problems and what drives these collapses is hotly debated. Early-warning indicators of fish populations in trouble are urgently needed that could be used as indicators of change in, and reference points for, exploited marine populations. Marine ecosystems are characterized by complex non-linear patterns of variability, however these ecosystems often display remarkable quantitative regularities at different spatial and temporal scales. These regularities usually take the form of power law distributions that are well described through scaling patterns under the perspective of fractal theory. Scaling patterns represent self-similar processes – processes which have the same distributions at short and long time and/or spatial scales. In the present work, we applied fractal-based analyses to detect time-invariant scaling relationships in daily catch time series from the smooth pink shrimp (*Pandalus jordani*) fishery off the west coast of Vancouver Island, Canada. We also compared these with scaling patterns previously identified in daily catches of the southern hake (*Merluccius australis*) fishery of Chile. Scaling parameters, such as the Hurst coefficient (H) (self-similarity index) and the fractal dimension (D) (an index of complexity), were estimated. More complex scaling models (*e.g.*, a Universal Multifractal Model) were also used to detect and estimate multiple scaling patterns (multifractality) and their parameters. The possibility to use these parameters – and their variability as a function of time – to identify different stages of these fisheries was analyzed. Underlying processes as sources of the observed fractality/multifractality are proposed.

2 November, 09:20 (FIS_P-4462)

Research program for stock rebuilding of blue crab, *Portunus trituberculatus*, in the western sea of Korea

Inja **Yeon**, Myoung Ho Sohn, Mi Young Song, Hak Jin Hwang and Yang Jae Im

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Landings of blue crab, *Portunus trituberculatus,* in western Korean waters have declined from 18,000 t in 1988 to 4,500 t in 2006, with the rate of decrease recently increasing due to overfishing by Korean and Chinese fishers and habitat deterioration because of land reclamation, ghost fishing of lost gear, and waste discharges from the two countries. Therefore, additional stronger management measures are now necessary to conserve and rebuild the stocks. As a first step, we consider pertinent fisheries management aspects in the context of known species' biology. Relevant data come from tagging experiments, fishery statistics, biological studies, ichthyoplankton surveys and fishermen questionnaires. The adult crab wintering area is now known to be in the center of the Korean western sea, and spawning and nursery grounds are in nearshore waters along the Korean west coast. During winter, small crab usually hibernate in mud and sand substrates in Korean western tidal zones. Closed areas and size limits are being considered as fisheries management measures for the blue crab in Korean western sea.

2 November, 09:40 (FIS_P-4036)

Population structure of the Bering Sea pollock and functional structure of it range in recent decades

Alexander I. **Glubokov**

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The population structure of pollock is confounded by interannual variability in its seasonal and ontogenetic migrations. In order to ensure that the information obtained is comprehensive, studies should include the following types of at-sea work: bottom trawl, echointegration-trawl, zooplankton, ichthyoplankton surveys; juvenile survey; collection of genetic samples. The pattern of migrating pollock shoals can be understood only through repeated surveys during a year. Research material was collected in 28 cruises over 50 months, including 21 trawl surveys, 11 echointegration surveys, 8 juvenile surveys and 5 ichthyoplankton surveys. The population structure of pollock in the North Bering Sea and adjacent waters is reviewed using all the major approaches to study populations. Climate/ocean-specific regions in the Bering Sea are shown which are favourable for pollock at each stage of ontogenesis. Fish movements are linked to salient biological features: time and area of spawning; maturation age; extent and direction of ontogenesis, feeding, wintering and spawning migrations; location of feeding and wintering grounds. The analysis of genetic markers proves that North Bering Sea concentrations of pollock are isolated. The magnitude of Nei genetic distances between the Navarin and East Bering Sea pollock agrees with the population data. The author's own data and other published references were used to analyze changes in the structure of the range from the 1970's to the present time. In periods of low abundance, the migration routes of Navarin pollock are marked by being short; migrations become longer in periods of high abundance.

2 November, 10:00 (FIS_P-4353)

Marine environment induced spatial dynamics of recruited walleye pollock juveniles (*Theragra chalcogramma*) and interactions with prey and predators along the Pacific coast of Hokkaido, Japan

Naoki **Tojo**[1], Akira Nishmura[2], Satoshi Honda[2], Tetsuichiro Funamoto[2], Seiji Katakura[2] and Kazushi Miyashita[3]

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Walleye pollock (*Theragra chalcogramma*) is an important fishing target on the coastal shelf off northern Japan as well as elsewhere in the world. Along the Pacific coast of Hokkaido, Japan, recruited juvenile pollock are also an important ecological linkage among trophic levels. Many studies have been conducted to understand recruitment from a fisheries perspective, but not many studies have conducted on the seasonal and interannual spatial dynamics, as well as the causative ecological interactions. By using a time-series of acoustic data, we conducted retrospective analyses to understand the spatial and ecological dynamics of the juvenile pollock along the Pacific coast off Hokkaido. Data were obtained with echosounders (38kHz and 120kHz) along transects over 8nm intervals in winter (December–January), summer (June–July), and fall (August–September) from 1998 to 2005. Using backscattering strength, trawl samples, and environmental data from CTD castings, we classified the various size classes of walleye pollock and other fishes. Differences of backscattering strengths at two frequencies (ΔMVBS) were used to locate various-sized plankton in BONGO net samples. Juvenile pollock recruited to the eastern part of the study area in various patterns. Plankton distributions also showed seasonal and interannual variability, causing spatial differences of food availability for the recruiting young pollock. Juvenile pollock resided over a wide range of the sea temperatures (3 to >10°C), different from the larger sized pollock (<5°C). Cannibalism by adults was associated with the invasion of cold water. The spatial dynamics of pollock juveniles and their ecological interactions are induced by the spatial variability of these water masses.

2 November, 10:20 (FIS_P-4041)

Distribution and community structure of ichthyoplankton from the northern and central California Current in May 2004–2006

Toby D. **Auth**

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The distributions, concentrations, and community structure of pelagic larval fishes collected from the central and northern California Current in the northeast Pacific Ocean during May 2004, 2005, and 2006 were analyzed to investigate annual, latitudinal, cross-shelf, and depth-stratified variability. The 170 depth-stratified samples collected from 3 cruises yielded 14,819 fish larvae from 56 taxa representing 23 families. Dominant larval taxa were *Engraulis mordax*, *Citharichthys* spp., *Sebastes* spp., and *Stenobrachius leucopsarus*. Larval concentrations decreased significantly in 2006 from 2004 and 2005 levels following the anomalous oceanic conditions observed in 2005. Larvae were generally found in higher concentrations at northern (>43°N) vs. southern (<43°N) stations, with larval *E. mordax* and *Citharichthys* spp. found almost exclusively in the north during all sampled years. Interannual variability was observed in cross-shelf larval distributions, although concentrations of *S. leucopsarus* larvae consistently increased in an on-offshore direction, while larval *Sebastes* spp. were generally found in highest concentrations at intermediate stations along the shelf. *E. mordax*, *Citharichthys* spp., and total larvae were found in higher concentrations above the pycnocline (~20m) than below the pycnocline, while *Sebastes* spp. and *S. leucopsarus* larvae exhibited the opposite pattern. Several taxonomic and spatial assemblages were identified from cluster analyses in conjunction with multidimensional scaling. Multivariate analyses revealed that latitude, station depth, and sea-surface temperature were the most important factors explaining variability in larval concentrations. Larval concentrations were generally positively correlated with temperature and negatively correlated with salinity.

2 November, 11:00 (FIS_P-4107)

Spawning migrations in fish: A case study of the sockeye salmon from the Fraser River in British Columbia

Leonardo **Huato-Soberanis** and Martha J. Haro-Garay

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The reproductive migrations of long range migratory species, like sockeye salmon, are characterized by occurring within a short time span at a well determined time of the year, and with a high synchronization of initiation and cessation of the migration. These migrants are perceived to swim with a high degree of orientation, and in a bioenergetically efficient manner in order to maximize energy allocation into reproduction rather than into movement. Here we present a model based on the hypothesis that the migratory behavior of returning individuals arises as an adaptive response to minimize a measure of the total costs of migration, given an expectation of the state of the environment during the migration (defined in terms of currents, temperature, and risk of predation). The model predicts that the higher swimming speed observed when sockeye salmon reaches the coast, and the use of the Juan de Fuca as the primary route to reach the Fraser River, are likely a response to a higher risk of mortality in the coast. The model also indicates that given the short arrival time of individuals from the same race, they either start their migration from a short longitudinal range, or are distributed across a wider range and start their migration at different times, with individuals further away from the Fraser River starting earlier. Furthermore, the migratory behavior of sockeye salmon resulted very sensitive to the spatial distribution and value of predation risk.

2 November, 11:20 (FIS_P-4044)

Assessing the effects of ocean conditions on the growth and survival of Pacific salmon in British Columbia and Alaska

Marc **Trudel**[1, 2], David L. Mackas[3] and Asit Mazumder[2]

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The production of salmon has been shown to vary in relation to climate and ocean conditions at small and large spatial scales. Several hypotheses have been proposed to explain this variability. Although the specific mechanism affecting the marine survival of salmon differs among these hypotheses, they generally indicate that lower marine survival of Pacific salmon is associated with lower marine growth during their first year at sea. In this study, we examined the effects of ocean conditions on the growth and survival of Pacific salmon and develop forecasting models for the marine survival of Pacific salmon. Our work shows that, while plankton productivity and temperatures tend to be higher in southern British Columbia, salmon are generally smaller and leaner, and have lower growth and marine survival off the west coast of Vancouver Island than in southeast Alaska. The poorer growth and condition of salmon in southern British Columbia appears to be related to a calorie-deficient diet rather than to lower rates of food consumption or to higher metabolic rates. This indicates that ocean conditions affect salmon production through changes in prey community composition and quality, which in turn are induced by the effects of climate on ocean circulation.

2 November, 11:40 (FIS_P-4069)

The GIS method application for the stock assessment of the walleye pollock and the Northeast Arctic cod

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Abundances of the main commercial fish species, including walleye pollock *(Theragra chalcogramma)* and Northeast Arctic cod, are subject to annual variability. Reliable assessment of the exploitable biomass and forecasts of the TAC are an important goal of fishery research. The GIS method was developed in VNIRO based on catch statistics data. This method is essentially a synthesis of a traditional area method and modern information technology which incorporates Russian fishing vessel activity. Catch per unit effort (tons/hour) information from the daily catch reports provides the basis for stock assessment. For the stock assessment of the Northeast Arctic cod (*Gadus morhu*), 89,000 reports were used. Results show that for the 2000 – 2006 period, annual variability in exploitable biomass was between 1.9 and 2.8 million tons with a mean of 2.3 million tons. Twice the biomass was obtained by the GIS method when compared to the XSA. Similarly results were obtained for the pollock stock assessment for the North of the Okhotsk Sea. For the 2002 – 2007 period, the mean exploitable biomass obtained by the GIS method was 2.2 million tons and exceeded the XSA results by 57%. Since the GIS method has fewer sources of uncertainty and is easier to use, its application in fishery research may be more effective than that of XSA.

2 November, 12:00 (FIS_P-4218)

Genetic approach for the assessment of a stock enhancement of Pacific cod (*Gadus macrocephalus*)

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The purpose of this study is to document a genetic profiling approach to track a released hatchery strain of Pacific cod *Gadus macrocephalus*. To investigate the extent of genetic differentiation among populations and find a suitable genetic tool, genetic polymorphism in Pacific cod, collected from wild populations of two locations (southern and

western Korea), were examined using mitochondrial DNA (mtDNA) control region markers. Nucleotide sequence analysis of 584 bps in the variable portion of the 5′end of the mtDNA control region revealed 8 variable nucleotide sites among 63 individuals, which defined 3 and 7 haplotypes for southern and western populations, respectively. In addition, nucleotide diversity of those two wild populations was as low as 0.0004 ± 0.0006 and 0.0008 ± 0.0008. However, microsatellite DNA (msDNA) sequencing analysis showed a marked polymorphism in the wild populations with an observed (and expected) heterozygosity of 0.929 (0.933) and 0.941 (0.939) for southern and western populations in Korean waters. In contrast, a relatively low level of this value with 0.714 (0.752) in hatchery population was observed. As a genetic tag for the assessment of a stock enhancement of Pacific cod, microsatellite DNA sequencing analysis shows a higher availability than the sequences of the mtDNA control region.

2 November, 12:20 (FIS_P-4265)

Summer occurrence and transport process of common squid (*Todarodes pacificus*) paralarvae in the East China Sea

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The patterns of distribution and transport process of common squid (*Todarodes pacificus*) paralarvae are required to understand the year-class strength of the species, and summer occurrence of paralarvae collected using Bongo net and MOCNESS (20m interval down to 100m) in the northeastern East China Sea during 1999–2006 was re-examined. Common squid larvae were caught from 10 sampling cruises, and paralarvae occurred at 59 of 133 stations. A total of paralarvae 434 were collected. A high density of paralarvae was found in 20–80m. Over 90% pf common squid paralarvae were found southeast of Jeju Island and north of Kyushu Island where temperature ranges roughly 15–20°C and salinity 33–34psu. Mantle length (ML) of the paralarvae gradually decreased as water depth increased. Paralarvae averaged 4.47mm ML at the surface, but 3.68mm ML in 80–100m. Average MLs were similar through the year except a relatively large size in April. The spawning ground, located in the southern portion of study area, varies season by season, and paralarvae in Korean waters seem to be transported from the spawning ground for 10–20 days after hatching.

2 November, 14:00 (FIS_P-4322)

Prediction and of Japanese common squid (*Todarodes pacificus*) fishing grounds using Generalized additive models in the Japan/East Sea

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The Japanese common squid, *Todarodes pacificus,* is one of the most important commercial species in Japan. The objectives of this study are to clarify the relationship between squid fishing grounds and environmental factors using statistical models and to predict the potential fishing grounds using satellite remote sensing data and CPUE data. CPUE data from the squid jigging fishery and temperature data at 0m, 50m, 100m, and 200m were analyzed during 1973–2000. The generalized additive models (GAM) were applied to analyze the relative influence of various factors on squid CPUE. GAM results indicated that surface temperature is the most important variable ($p<0.001$) at temperatures of 0–200m. Average CPUEs were highest around 25°C (19–27.5°C) at 0 m. On the other hand, in the 50–100m layer, a positive effect on CPUE was associated with low temperature (2–9°C). These results suggested that it is possible to develop a prediction model of CPUE using environmental parameters derived from satellite data. Satellite data sets, NOAA/AVHRR sea surface temperature (SST), Orbview-2/SeaWiFS chlorophyll-*a* concentration (CHL) and AVISO sea surface height anomalies (SSHA) from 1997 to 2000 were used to understand spatial and temporal oceanographic characteristics of the fishing grounds. The potential fishing grounds were estimated from satellite data using these results of GAM. We suggest that these results contribute toward improving the accuracy of fishing grounds prediction.

2 November, 14:20 (FIS_P-4455)

Testing two methods of including environmental factors into stock assessments

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The PICES Working Group 16 report on the impacts of climate and climate change concluded that climate is a major factor affecting the productivity of virtually all key commercial species. However, almost none of the stock assessments conducted on these species explicitly include climate effects in the assessment model. The objective of this investigation is to evaluate two methods of including environmental variability directly into the assessment and its effect on the estimation of recruitment parameters, stock status, and the conservation benchmarks used to manage a stock. Two methods of incorporating environmental effects will be tested using a data simulator and the stock assessment model Stock Synthesis II. The first method models annual deviations in the stock-recruitment curve assuming no observation error in the environmental data by recalculating the expected value of recruitment according anomalies in the environmental time series for a given year. The second method allows for observation error in the environmental time series and uses this data as an index to tune the estimates of annual recruitment deviations. Both methods are tested against simulated data sets in an effort to determine which method produces the most accurate results and are suitable for future use. Response variables to the two methods include estimates of key benchmarks such as virgin biomass, maximum sustainable yield (MSY), and depletion.

2 November, 14:40 (FIS_P-4250)

Predicting the relative distribution of pinniped prey in the Gulf of Alaska

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Understanding how oceanographic conditions affect the spatial distribution of fish species is relevant to fisheries management, predator–prey relationships, critical habitat description, and to understanding the effects of a changing climate. Models of such species-habitat relationships are typically conducted with in-situ samples and remote sensing data. To investigate whether data on vertical structure would significantly improve the performance of such models, we combined remote sensing data and the output from an ocean circulation model to develop predictive models of walleye pollock (*Theragra chalcogramma*), Pacific cod (*Gadus macrocephalus*), rockfish (*Sebastes* spp.), and flatfish distributions for summer 2001. We related our independent data to unbiased catch-per-unit-effort (CPUE) data derived from a trawl survey in 2001. The inclusion of variables describing vertical structure resulted in models that explained more of the variance in the dependent (CPUE) data for each of the species groups considered. We compared the 2001 predictions to trawl survey data from other years using paired sample t-tests, thereby determining the generality of the 2001 predictions. Our analysis demonstrates the importance of using vertical structure within fisheries models and has implications for the use of such models to predict out of sample.

2 November, 15:00 (FIS_P-4397)

Integrating environmental data into marine mammal stock assessments: Application to the eastern North Pacific gray whale

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Management of marine mammal populations involves determining risk-adverse strategies that account for natural variability in the environment and impacts of climate change. However, such considerations have been largely

ignored during recent stock assessments. Therefore, an assessment framework was developed in order to take into account a hypothesized relationship between an environmental factor and a population process. A standard age-structured population dynamics model was extended to allow for stochastic birth rates which were potentially related to some aspect of the physical environment. The framework was applied to the eastern north Pacific stock of gray whales. Deviations from expected birth rates were estimated by fitting the model to available data on abundance and calf production, taking into account a hypothesized relationship between calf production and an index of sea-ice on the feeding grounds in the Bering and Chukchi Seas. The results were compared with those from a recent assessment, which did not explicitly consider environmental variability. Both approaches resulted in similar estimates of current stock status. However, the framework which incorporated environmental forcing resulted in a more realistic fit to the interannual variability observed in calf production and was able to confirm the hypothesized relationship between calf production and sea-ice. This study represents the first attempt to formally incorporate an environmental relationship into a population dynamics model for the eastern North Pacific stock of gray whales. Incorporating available sea-ice forecasts into this modeling framework could potentially improve the design of management strategies by providing more realistic projections of population dynamics.

2 November, 15:20 (FIS_P-4275)

Standardization of CPUE for bigeye (*Thunnus obesus*) and yellowfin (*Thunnus albacares*) tunas of Korean longline fishery in the Indian Ocean

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The commercial Korean tuna longline fishery has operated in the Indian Ocean since the mid 1960s and mainly targeted on bigeye, yellowfin and albacore tunas. Bigeye and yellowfin tuna catches have increased until the 1980s, and then decreased to around 5,000 tonnes in 1998. The catch-per-unit-effort (CPUE) of Korean longliners was used as abundance index for stock assessment. This study attempted to standardize CPUE of the Korean longline fishery for bigeye and yellowfin tuna in the Indian Ocean, based on fishery data from 1987 to 2006 using the Generalized Linear Model (GLM). Catch in numbers and effort data, which were used as response variables, were collected each month by 5×5 degrees of latitude and longitude. The explanatory variables were year, area, number of hooks between floats (HBF), SST and SOI. HBF, which was divided into four classes, was used in the model as fishing gear information and the area was divided eight sub-areas. SST and SOI were also used in the model as oceanographic factors. In most years since 1987, bigeye and yellowfin CPUEs declined, but they increased slightly for 2002–2004. CPUEs for bigeye have declined in most sub-areas except in the 6th sub-area where they increased from 2001 to 2005. Yellowfin CPUEs increased from 2002 to 2005 in most sub-areas.

2 November, 16:00 (FIS_P-4076)

Estimating daily ration of skipjack tuna on larval and juvenile anchovy in the Kuroshio–Oyashio transition region in early summer

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Daily ration of skipjack tuna (*Katsuwonus pelamis*) feeding on larval and juvenile anchovy (*Engraulis japonicus*) was estimated using the specimens captured in the Kuroshio–Oyashio transition region in May and June 2006. Skipjack tuna were captured in drift nets set over a six day period. When considered collectively, a total of 22 sampling trials during that period covered most of the 24 hours in a day. The contents of the stomach and the anterior portion of the intestine of skipjack tuna (n = 80, 409–573 mm in fork length) were examined and identified. The digestive tract was empty at midnight. The numbers of larval and juvenile anchovy ingested by skipjack tuna were estimated based on the anchovy otoliths in the anterior portion of the intestine. The daily ration of a skipjack tuna feeding on larval and juvenile anchovy was estimated from the number of otoliths and the wet body weight (BW) of anchovy based on an exponential model (Elliott and Persson 1978). The BW of anchovy ingested by the skipjack tuna was estimated from the otolith radius. An individual skipjack tuna was estimated to consume ca. 1000 individuals (79.7g) of larval and juvenile anchovy per day. This corresponds to approximately 3.6% of the BW of a skipjack and 45% of the total daily ration. From these estimates, we concluded that larval and juvenile anchovy constitute an important prey item for skipjack tuna.

2 November, 16:20 (FIS_P-4032)

Impact of environment and exploitation on the interannual variability of eastern Bering Sea pollock: Abundance and distribution

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Year class strength for eastern Bering Sea pollock fluctuates independently of juvenile abundance because of high variability in over winter survival. Food supply is identified as a major source of mortality. The winter diet is limited because few prey of the appropriate size are available, other than one or two species of zooplankton (small Copepods). Zooplankton abundance decreased in the eastern Bering Sea in 2002–2005, and at the southeastern shelf and off the eastern Aleutian Islands in 2006. Extremely low juvenile pollock survival was observed in winter 2002–2004, supporting the hypothesis. Pollock recruitment increased in 1998–2000 but declined again in 2001–2004. Most pollock year classes were weak over the 1964–2005 period, but strong year classes appeared in 1978, 1982, 1984, 1989, 1992, 1996, and 2000. There were 4 periods of strong year classes and 5 periods of weak year classes in the time series. The last weak period began in 2002 and is continuing. Periods of strong year classes correspond to maximums of solar activity, likely via climate and physical oceanographic factors linked to atmospheric circulation. Early survival of juvenile pollock obviously depends on currents and mesoscale water circulation. Recent data show that strong pollock year classes frequently appeared during the “cold type” winter, when the Aleutian Low was located over the Gulf of Alaska or central Bering Sea. The water circulation pattern influenced the local atmosphere in the eastern Bering Sea shelf and transported juvenile pollock inshore by northerly currents in spring where survival was higher.

2 November, 16:40 (FIS_P-4239)

Comparison of 4 Northern Hemisphere regions: Ecosystem responses to recent oceanographic variability

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Ecosystem responses to oceanographic variability resulting from recent climate changes are compared and contrasted for four high latitude regions of the Northern Hemisphere, two in the Pacific (Bering Sea and Gulf of Alaska) and two in the Atlantic (Georges Bank/Gulf of Maine and the Barents/Norwegian Seas). Changes in nutrient content and its effect on phytoplankton biomass and production are compared among systems and recent trends towards smaller zooplankton in the Bering Sea and in the Georges Bank region are evaluated. In each of the regions, several fish species show a general poleward movement in response to the warming, as well as more complex, non-linear responses resulting from internal community dynamics and fishing. Observed changes in the abundance, individual growth and species composition of the fish communities are assessed in terms of environmental and fishing effects. Changes in marine mammals and seabirds in the four regions are documented. Comparisons between the different regions are made to identify and distinguish general responses from regionally unique responses. This is a contribution from the PICES and ESSAS sponsored Comparison of Marine Ecosystems of Norway and the US (MENU) project.

2 November, 17:00 (FIS_P-4249)

A comparison of community and trophic structure in four marine ecosystems based on energy budgets and system metrics

Sarah **Gaichas**[1], Georg Skaret[2], Jannike Falk-Petersen[2], Jason S. Link[3], William Overholtz[3], Bernard A. Megrey[1], Harald Gjøsæter[2], William Stockhausen[1], Are Dommasnes[2] and Kerim Aydin[1]

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Comparing disparate groups of organisms across a wide range of marine ecosystems is challenging, but enlightening. Here, we demonstrate that standardized metrics both elucidate properties common to marine ecosystems and identify key distinctions for fishery management. Energy budget models were used to characterize trophic and community characteristics in five marine ecosystems: the Gulf of Maine and Georges Bank in the Northwest Atlantic Ocean, the combined Norwegian/Barents Seas in the Northeast Atlantic Ocean, and the eastern Bering Sea and the Gulf of Alaska in the Northeast Pacific Ocean. Comparable energy budgets were constructed by aggregating information for similar species into consistent functional groups across all five ecosystems. Several metrics (including functional group production, consumption, and biomass ratios, ABC curves, cumulative biomass, and network metrics) were examined across the ecosystems. The comparative approach clearly identified data gaps for each ecosystem, an important outcome of this work. Commonalities across the ecosystems included overall high primary production and energy flow at low trophic levels, high production and consumption by carnivorous zooplankton, and similar proportions of apex predator to lower trophic level biomass. Major differences included distinct biomass ratios of pelagic to demersal fish, ranging from highest in the Norwegian/Barents ecosystem to lowest in the Alaskan systems, and notable gradients in primary production per unit area, highest in the Alaskan and Georges Bank/Gulf of Maine ecosystems, and lowest in the Norwegian ecosystems. This is a contribution from the PICES and ESSAS sponsored Comparison of Marine Ecosystems of Norway and the US (MENU) project.

FIS Paper Posters

Poster FIS_P-4056

Maintenance of red king crab stocks in the North Pacific using mariculture methods

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The red king crab is the most important object of crab fishery both in the Far East and in the northern fishing area (Barents Sea). The main region for harvesting this species in the EEZ of the USSR, and Russia, was and remains to be the West Kamchatka shelf. The transoceanic introduction of the red king crab from the Pacific Ocean to the Barents Sea gave rise to the emergence of an abundant selfreproducing population of this high – value species in the North Atlantic. The interest to the red king crab as a potential species for mariculture became logical in recent years because of the invariably great demand for this product, and the emergent problem of the quality of harvestable males from the wild populations both in the Barents Sea and in the Far East. That is why in 2002 VNIRO scientists began research under the Program «Elaboration of normative and methodical bases for artificial reproduction of the red king crab in order to restore its natural populations» which was an integral part of the Federal Program "Scientific and technical support for fisheries science in Russia" financed by Federal Fisheries Agency of the Ministry of Agriculture of the Russian Federation. The knowledge of the biology of red king crab early life history stages has formed a basis for establishing basic culture methods and techniques: technical specifications and documentation for planning, designing, and building experimental crab rearing facilities aiming at further work on the technology of red king crab artificial reproduction and cultivation. The normative and methodological bases, as developed, have been applied from as early as 2006 to planning further reproduction of the red king crab, and to

designing new, and upgrading the existing crab-rearing integrated facilities. Intensive mariculture under controlled conditions will contribute to stock recruitment in this commercially harvested species of highest value.

Poster FIS_P-4089

Survival rate and growth of larval swimming crab, *Portunus trituberculartus*, in the laboratory

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Swimming crabs, *Portunus trituberculatus*, are commercially important off the coasts of Korea, Japan, and China. Fluctuations in the interannual harvest of swimming crabs may be correlated with the survival rate during the larval period. The survival rates, intermolt periods, and growth of larval swimming crabs were investigated in the laboratory. Larval swimming crabs are released and undergo development from April to August off the coast of western Korea in the Yellow Sea. Sea surface temperatures off the coast of western Korea during the larval season were used for the laboratory experiments, and ranged from 22 to 26°C. Larvae were individually cultured at four different temperatures, 22°C, 24°C, 26°C, and 28°C. Zoeae molted to megalopae at all temperatures and developed to the first crab stage at 24°C, 26°C, and 28°C. Survival rates from zoeae I to the first crab stage increased with increasing temperatures. Intermolt period and the growth rate of the mean carapace length were inversely correlated with temperature. Our research helps understand the changes in survival rate and growth of larval swimming crabs resulting from changing oceanic temperatures. Further, our study suggests that the fluctuations in fishery harvest of swimming crabs off the coast of Korea may be related to changes in larval survival affected by changing ocean conditions.

Poster FIS_P-4093

Feeding ecology of three dominant lanternfish species (Myctophidae) off Oregon

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Ubiquitous bioluminescent fishes of the family Myctophidae, commonly known as lanternfishes, are often the dominant components of pelagic communities in the North Pacific, achieving very high numbers and biomass and potentially competing with co-occurring commercial species. In order to better understand their role in functioning of pelagic ecosystems, we investigated food habits and general trophodynamics of three dominant lanternfish species in the northern California Current System – *Diaphus theta*, *Tarletonbeania crenularis* and *Stenobrachius leucopsaurus*. Based on an Index of Relative Importance, *Euphausia pacifica* was the most important prey for all three species. However, the three lanternfish species showed marked differences in utilization of other prey. Copepods were the only other major food category for *S. leucopsaurus*, whereas the diets of both *T. crenularis* and *D. theta* were more diverse and prey utilization more evenly distributed. *T. crenularis* consumed larvaceans, hyperiids and salps (in decreasing order of importance), while copepods, hyperiids and larvaceans were more important for *D. theta*. Of less common prey, *D. theta* consumed ostracods, larval bivalves and pteropod mollusks. The three myctophids examined in our study are known to belong to different ecological groups, the so-called “active” and “inactive” types, as reflected by their anatomy, chemical composition and behavior. We discuss how the observed divergence in feeding habits fits into existing ecological classification and how differential energy requirements, swimming capabilities and general lifestyles of closely related species underlie the finer resource partitioning in co-existing organisms.

Poster FIS_P-4094

Long-term patterns in sea surface temperature (SST) and smooth pink shrimp (*Pandalus jordani*) catches off the west coast of Vancouver Island, Canada

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Time series of exploited marine populations tend to exhibit reddened spectra, where fluctuations in density or abundance are a combination of high frequency variability (short term variation) on top of a dominant low frequency oscillation (long-term variation). Several factors contribute to redden the spectra, but there is general agreement that the major causes are environmental fluctuations, demographic processes (*e.g.*, density-dependence) and their interactions. Traditional analyses focus on the use of Box-Jenkins (BJ), univariate (ARIMA), and multivariate (*e.g.*, Transfer Function Noise) models to quantify the effect of these factors on the dynamics of fisheries time series. BJ models are inappropriate to detect and model the effect of low frequency oscillations of the environment on fisheries time series. In the present work, long-term memory patterns (*i.e.*, long-term correlations) were detected and quantified in: i) daily catch (DC) time series from the smooth pink shrimp (*Pandalus jordani*) fishery off the west coast of Vancouver Island, and ii) daily sea surface temperature (DSST) observations measured at Amphitrite Point lighthouse (approx. 48°55'N; 125°32'W), using fractal models. A time series with a fractal structure reveals the existence of long-term memory patterns (scaling dynamics). A single parameter (Hurst coefficient) was not able to quantify these scaling patterns in DC and DSST time series due to the existence of scaling relationships that vary through time (multi-scaling or multifractal dynamics). A multifractal model was used to quantify these multiple scaling patterns and to investigate the potential relationship between smooth pink shrimp catches and SST.

Poster FIS_P-4099

Temporal changes in size at maturity and their implications for fisheries management for eastern Bering Sea Tanner crab

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Tanner crabs *(Chionoecetes bairdi)* in the eastern Bering Sea are primarily distributed in 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 crabs from 1975 to 2006 and sizes at 50% morphometric maturity for male Tanner crabs from 1990 to 2006. Estimated mean sizes at maturity for females in both areas show a statistically significant downward trend during this period. Sizes at 50% morphometric maturity for males have declined significantly in Bristol Bay only. In Bristol Bay, the distribution centers of female Tanner crabs have shifted to the southwest over time and the decrease in female mean size at maturity is statistically significantly related to changes in longitude and bottom depths. Because of terminal molt at maturity, the decrease in size at maturity has important implications for fisheries management: a smaller proportion of males grow to legal size and therefore a higher proportion of large-growing males are removed by the fishery before they have a chance to participate in reproduction under the current size limit. The size limit for male Tanner crabs in these two areas needs to be re-evaluated with respect to biological conservation and economic objectives of the fishery management plan.

Poster FIS_P-4119

Spawning and fecundity of highly abundant fishes of the family Bathylagidae in the Russian Far Eastern seas and adjacent waters of the northwestern Pacific Ocean

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The reproductive biology of the Bathylagidae, typical mesobathypelagic inhabitants of the subarctic waters, is poorly studied. Fish were collected in the southwestern Bering Sea (region A), Okhotsk sea (region B), waters off eastern Kamchatka (region C) and in the Subarctic front in the western North Pacific (region D) during spring–summer–autumn. A total of 1616 specimens of *Bathylagus pacificus* (n = 96), *Leuroglossus schmidti* (n = 1095), *Lipolagus ochotensis* (n = 332) and *Pseudobathylagus milleri* (n = 93) were analyzed. Spawning of *B. pacificus* was observed in region A in September. Individual potential fecundity (IPF) of this species is low (10809 ± 4094 oocytes); but egg portion size (EP) is intermediate (2714 ± 1018 oocytes). Spawning females of *L. schmidti* were caught in the region «C» in July–September and in region D in July–November. This species presumably spawns in the region B during winter. IPF is intermediate (18249 ± 3429 oocytes), but EP is low (866 ± 256 oocytes). Prespawning females of *L. ochotensis* were observed in the region D in November, therefore they presumably spawn during winter. IPF is large (30145 ± 10013 oocytes), as well as EP (4035 ± 787 oocytes). Spawning of *P. milleri* was observed in the regions A and D during autumn. Both IPF (16089 oocytes) and EP (3329 oocytes) are intermediate. All investigated species are intermittent spawners, with uninterrupted type of vitellogenesis. *B. pacificus*, *L. ochotensis*, *P. milleri* are characterized oscillating development of oocytes and *L. schmidti* by stabilized development of oocytes. Spawning frequency in these species also differ: *L. schmidti* have higher, *L. ochotensis* intermediate and *B. pacificus* and *P. milleri* low spawning frequency.

Poster FIS_P-4130

Age and growth of Pacific cod, *Gadus macrocephalus* in the East/Japan Sea

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Pacific cod, *Gadus macrocephalus* is distributed in the East Sea/Japan Sea and the Yellow Sea. Stocks of this species have been decreasing due to overfishing and changes in their environments. Recently, the population sizes of this species were expected to keep increasing and rebuilding plans for the stocks are needed. The purpose of this study was to update information on age and growth to assess stock status using age-structured model and to suggest management strategies for this fisheries resources. Age and growth of *G. macrocephalus* were estimated from right-handed sagittal otoliths of 259 fish specimens from January to December 2003 in the East Sea/Japan Sea. The outer margins of the otolith were examined and showed that the opaque zone was formed once a year. The growths of fish were expressed by the von Bertalanffy growth equation, as follows: $L_t = 122.15\ (1- e^{-0.440\ (t\ +\ 0.09361)})$ for females and $L_t = 132.04\ (1- e^{-0.420\ (t\ +\ 0.0879)})$ for males, where L_t was total length in cm and t was age in year. The growth of males and females were significantly different ($P<0.05$). The age composition was ranged mostly ages 2–6, and the oldest were 8 years old in males and 11 years old in females.

Poster FIS_P-4181

Estimating escapement and spawning capacity of pink salmon (*Oncorhynchus gorbuscha*) at rivers in the Shiretoko World Natural Heritage area

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Pacific salmon (*Oncorhynchus* spp.) are a keystone species for biodiversity and sustainable production in the riparian ecosystem because they supply marine-derived material to the rivers at the time of spawning migration. The evaluation of accurate numbers of their escapement and spawning is of basic importance for quantifing the effect of salmons on the riparian ecosystems. In Japan, however, research on escapement dynamics of wild salmon has not

been fully studied because there are so few wild salmons. The objective of this paper is to evaluate the dynamics of escapement and spawning of Rusha River pink salmon (*O. gorbuscha*) population in the Shiretoko World Natural Heritage area. We counted and estimated escapement of pink salmon by the area under the curve method (AUC) and the evaluation model using maximum likelihood approach method (MLA), and total number of spawning redds in the Rusha River, 2006. They actively run up to the redds during the morning hours of a day. The number of their escapement was estimated at about 70 to 80 thousands of fish by the AUC and MLA methods. The total number of spawning redds (about 2,400) was extremely less than the adult escapement, because of dam constructions, hatchery program affects and spawning habitat in the river.

Poster FIS_P-4208

An alternative approach to estimating worn annuli for aging of spiny dogfish (*Squalus acanthias*) spines

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Aging of spiny dogfish (*Squalus acanthias*) spines is complicated by the tendency of the tips of the spines to wear off. Previous methods to estimate the number of worn-off bands are based on an exponential relationship between the spine diameter and number of annuli fitted to all members of the sampled population. This method assumes that the diameter of the spine is a proxy for growth and ignores a high degree of natural variability. An alternative quantitative method is proposed to address these two problems. Dogfish spines were read and measured consistent with previous methods. In addition, they were photographed and analyzed using image analysis software. Counts of annuli, distance between annuli, total distance between annuli and the base of spine enamel, and measurements of spine dimensions were taken. Spine dimensions were used to describe spine growth characteristics with animal size. The number of annuli with increasing length of the spine enamel was modeled using an exponential growth function with confidence intervals. Annual growth rates were also estimated using the distance between annuli and compared to environmental conditions, such as sea surface temperature. Results suggest that it may be possible to predict total annuli count for worn spines by accounting for at least some of the variance in earlier methods with a growth-based model and auxiliary data.

Poster FIS_P-4214

Transportation of organic matter to the sea floor by carrion falls of the giant jellyfish (*Nemopilema nomurai*) in the Japan/East Sea

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The fate of the large jellyfish *Nemopilema nomurai* after death was examined in the southwest Sea of Japan. The density of dead jellyfish was greater than that of live animals. The dead animals are heavier than the Japan Sea Proper Water which occurs deeper than 300m, suggesting that dead jellyfish sink to the sea floor. The sea floor survey, conducted with a towed Video Tape Recorder monitoring system between mid September and mid October, observed a total of 138 jellyfish during 28 of 29 operations. The density of carrion ranged between 0.2–5.1 individuals/1000m^2 (mean ± SE = 1.0 ± 0.2). Ophiuroids occurred abundantly at 23 jellyfish carcasses and a sea anemone was observed attached to five carcasses. The VTR surveys confirmed that carrion sinks to the sea floor not only during the winter, the normal end of life for medusae, but also during the fall. A trap survey baited with medusae was also employed, four different species were sampled with the traps: snow crab (*Chionoecetes opilio*), shrimp (*Pandalopsis japonica*), ivory shell (*Buccinum striatissimum*) and ophiuroids. Much of the trap bait

remained (49–68% weight-mean = 60.3%) during the 23 h soak-time, and the reduction in weight was greater than that observed by bacterial decomposition, suggesting benthic animals consume dead organisms. The present study indicates that dead *N. nomurai* sink to the sea floor continuously and were subsequently consumed by benthic scavengers.

Poster FIS_P-4219

Genetic differentiation between early-run and late-run populations of the Yurappu River chum salmon *Oncorhynchus keta* using the mitochondrial DNA analysis

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The Yurappu River, located in southern Hokkaido, has a wild chum salmon (*Oncorhynchus keta*) population, despite few wild-populations in Japan. Hatcheries in the Yurappu River released a huge amount of juvenile chum salmon transplanted around Hokkaido from 1952 to 1995. In the Yurappu River, therefore, the native population is considered to be genetically disturbed by transplanted populations. In general, the run-timing of Pacific salmon is heritable (Quinn, 2000). Southern populations have later run-timing than others in Hokkaido chum salmon (Nagata & Kaeriyama, 2003). We clarified the genetic differentiation between early-run and late-run populations in the Yurappu River chum salmon using the mtDNA analysis. Nucleotide sequence analysis of about 500bp in the variable portion of the 5′ end of the mtDNA control region revealed 8 variable sites, which defined 8 haplotypes. The Yurappu River chum salmon had smaller number of haplotype and haplotype diversity in the late-run than those in the early-run and other-river populations around Hokkaido. The F_{st} values over all populations suggested that the early-run population would be genetically disturbed by other-transplanted populations, while the late-run population should keep the original heritability in the Yurappu River chum salmon.

Poster FIS_P-4220

Recent pre-recruit Pacific hake (*Merluccius productus*) occurrences in the northern California Current suggest a northward expansion of their spawning area

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Coastal Pacific hake (*Merluccius productus*) are known to spawn in the southern California Bight from January to March, migrate north during late spring and summer to feed off Oregon/Washington and British Columbia, and then move back to southern California in the fall. Juvenile Pacific hake nursery areas have been found to occur along the coastal shelf and slope of California, and occasionally into southern Oregon during strong El Niño events. Several studies have captured larval and high abundances of young-of-the-year (YOY) Pacific hake in the northern California Current from 2003–2007. It appears that the 2006 year class of Pacific hake is successfully recruiting in the NCC based upon recent widespread occurrences in high densities not previously reported for this region. These preliminarily results suggest northern expansion in the spawning and recruitment of Pacific hake and will likely have major economic and ecological consequences in the northern California Current (NCC).

Poster FIS_P-4267

Development of the olfactory organ in chum salmon (*Oncorynchus keta*) during migration

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Olfaction plays a role in salmon behaviors such as homing, feeding, and intra- and inter-specific interactions. It is generally accepted that anadromous salmonids imprint some odorants of their natal streams during their seaward migration, and use their olfaction to identify those streams at the final riverine stage during their homeward migration. Despite the importance of the olfactory organ for the olfactory imprinting, developmental process of this organ is not well understood in Pacific salmon (genus *Oncorhynchus*). Olfactory cues from the environment are transmitted to the brain through the olfactory receptor cells in olfactory organ. We analyzed the morphology of olfactory organ (olfactory lamellae and receptor cells) in chum salmon (*O. keta*) during life history periods from fry to adult. The number of olfactory lamellae in one side of the olfactory organ indicated 4.5 ± 0.58 (mean ± S.E.) lamellae in fry, and reached a state of equilibrium at about 18 lamellae after high seas stage. The number of olfactory receptor cells on one side of this organ (OR) indicated 370,000 ± 44,000 and 21 ± 1.9 million cells in fry and mature salmon, respectively. The relationship between fork length (FL) and OR indicated allometry (lnOR = 1.49 × lnFL + 7.04, $R^2 = 0.98$, $p < 0.001$). Our results provide the first quantitative analysis of OR in Pacific salmon, and indicates that OR synchronizes with FL during salmon migration.

Poster FIS_P-4277

A study on the assessment of the large purse seine fishery off Korea based on principles of the Marine Stewardship Council

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The role of the Marine Stewardship Council (MSC) is to admit, via a certification programme, well-managed and sustainable fisheries and to harness consumer preference for seafood products bearing the MSC label of approval, or ecolabel. The MSC standard consists of three principles, and each principle is elaborated by a number of criteria. The three principles consider the status of target fish stock, impact of the fishery on ecosystem and performance, and effectiveness of fishery management system. The MSC assessment system includes detailed evaluation of biological characteristics such as size, sex, geographical range, and interaction with non-target and discarded species in the fishery. Also, it considers the fishery’s effects on the habitat and TEP species. In this study, MSC fisheries assessment system was applied to common mackerel, which is the main target species of the large purse seine fishery off Korea. The assessment consisted of examining eighty four performance indicators. It was determined that the fishery should meet a few more performance indicators to be consistent with the principles of MSC.

Poster FIS_P-4285

Ecological considerations for northern anchovy abundance and distribution in the northern California Current

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Northern anchovy, *Engraulis mordax*, is one of the dominant coastal pelagic species found in the northern California Current, and key prey for many piscivorous marine predators. However, little is known about their distribution with reference to the dynamic marine ecosystem of the northeastern Pacific. From 1977–2006, we captured northern anchovy in trawl surveys along the continental shelf off Oregon and Washington, and from 1998–2006, we recorded sea surface (3 m) temperature, salinity and density information at all sampling stations to test the hypothesis that anchovy abundance is linked to nearshore oceanography. We examined anchovy age structure and ran correlation analyses, multiple linear regression models, and multiple comparison tests to identify important physical and

biological factors related to anchovy habitat. We standardized anchovy density (number of fish/$10^6 m^3$), and included microhabitat (surface temperature, salinity, density, chlorophyll *a*, station distance from shore, and station depth) and macrohabitat variables (Pacific Decadal Oscillation, Multivariate El Niño Southern Oscillation, timing of the spring transition to upwelling conditions, and abundance of cold-water zooplankton) in our analyses. Anchovy densities increased significantly from 1998–2004, and appeared related to cooler sea surface temperatures. Density declines following 2004 corresponded to warmer ocean conditions and delayed coastal upwelling. We found that sea surface temperature and proximity to the shore were the most consistent environmental parameters explaining anchovy density and distribution. When lagged by one year, northern copepod biomass anomalies were highly correlated to year-one anchovy survival, suggesting that this factor may be determining year-class strength.

Poster FIS_P-4287

Jack mackerel (*Trachurus symmetricus*) abundance, distribution, diet, and associated relationships to oceanographic conditions in the northern California Current

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Jack mackerel (*Trachurus symmetricus*) is one of the most abundant pelagic predatory fishes found in the northern California Current. However, little has been published on its abundance, distribution, feeding habits, or ecology in this region since the 1980s. Jack mackerel data were collected from five different fish surveys conducted off Oregon, Washington, and British Columbia from 1981–1984 and 1992–2006. We gathered information on jack mackerel biology and ecology in the northern California Current, including spatial and temporal distribution and abundance, size and age composition, feeding habits, and relationships to oceanographic conditions such as temperature and salinity. Most jack mackerel in this region were large adults (from 300–600 mm FL), but juvenile jack mackerel (40–120 mm FL) were occasionally captured. Jack mackerel were most frequently captured when sea surface temperatures averaged 13°C and salinities averaged 31–32, but were present in hauls when sea surface temperatures ranged from 9.7–17.7°C and salinities ranged from 22.8–33.6. The primary prey of jack mackerel off Oregon and Washington was euphausiids (primarily *Thysanoessa spinifera* and *Euphausia pacifica*), other crustaceans, and small fishes. The large numbers of fish in stomach contents during some years (*i.e.* 2004) indicates jack mackerel may have some influence upon other fish populations. The distribution and abundance of jack mackerel in the northern California Current is most likely determined by a combination of factors, including food availability, temperature, salinity, turbidity, and water density. Further research is needed to identify jack mackerel population abundance and migration patterns.

Poster FIS_P-4298

Distribution and drift pathways of Greenland halibut, *Reinhardtius hippoglossoides,* during early life stage in the eastern Bering Sea

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To investigate the geographic distribution (horizontally and vertically) and drift pathways of Greenland halibut (GH) larvae and early juvenile in the eastern Bering Sea (EBS), we used historical ichthyoplankton data (1988 – 2005) which were collected by the Fisheries-Oceanography Coordinated Investigation (FOCI) of the Alaska Fisheries Science Center (ASFC). The data were collected using three different gear types, including 60cm Bongo nets (60BON), Modified Beam Trawl (MBT), and Multiple Opening/Closing Net Environmental Sampling System (MOCNESS). The distributions of GH larvae were analyzed separately with each gear type to eliminate difference in gear efficiency. Early GH larvae were found over 100 m isobaths and seem to drift northward in the EBS during spring. Late larvae and early juveniles of GH were found between 0 m and 100 m isobaths during summer. These distribution patterns indicate that GH larvae drift along the shelf edge and cross from offshore to onshore for settling. The distribution and drift pathways of larvae and early juveniles could be physically influenced by the Aleutian North Slope Current (ANSC) and the Bering Slope Current (BSC). There are also other potential physical mechanisms involved, such as eddies and shelf flows. In spring, the vertical distribution pattern suggests that adult GH spawn in very deep water (below 500 m), eggs and larvae slowly rise after hatching, and there is some degree of diel migration of larger individuals, probably to feed after absorbing their yolk-sac.

Poster FIS_P-4310

Daily biomass and production of Pacific anchovy, *Engraulis japonicus*, in the southern coastal area of Korea

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Based on size-based theory, we estimated daily standing stock biomass and production of Pacific anchovy, *Engraulis japonicus*, in the southern coastal areas off the Korean peninsula. To apply the daily egg production method, we conducted 15 ichthyoplankton surveys from May to July 2005 and deployed a KOB 80 net obliquely for 5 min from 10m water depth to the surface layer at speeds of 1–2 knots. Eggs were classified into the 9 developmental stages to estimate their mortality. The estimated daily egg production was 3,906 m^{-2} d^{-1} and mortality rate during the embryonic stages was 1.425 d^{-1}. The average batch fecundity per female weight was 431 eggs g^{-1}. Estimated female biomass of anchovy for the May–July period was 103×10^4 mt, but a cohort analysis indicated that the total anchovy biomass is seasonally-variable and could reach 980×10^4 mt in early November. Estimated potential production of age 0 anchovy was 40×10^6 mt yr^{-1}, which peaked in September. Estimated fishing mortality derived from the catch statistics was 0.067 yr^{-1}, which was marginal compared with the total mortality = production to mean-biomass ratio of age 0 anchovy, 11.3 yr^{-1}. We will validate our estimates of anchovy biomass by comparing them with outcomes of acoustic surveys.

Poster FIS_P-4311

Yield-per-recruitment of Pacific anchovy (*Engraulis japonicus*) in Korean coastal waters

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Commercial catch of Pacific anchovy (*Engraulis japonicus*) in Korean coastal waters has steadily increased since the 1950s. To evaluate consequences of fishing activities on anchovy production and economic yield, I undertook daily simulations for the yield-per-recruit (Y/R) analysis by applying the derived growth function and size-dependent natural mortality. I evaluated consequences of changes in fishing activity by varying: 1) fishing mortality, 2) the length at first capture (L_c), and 3) the range of target lengths of fishing nets (L_r). Results of Y/R analysis by varying L_c suggested that potential yield could be maximized when L_c ranges between 40–80mm fork length (FL), while contributions to predators and reproductive capacity were maximized when L_c > ca. 85mm. However, economic yield was relatively stable against varying L_c, because the price per weight of anchovy differs among the size classes in Korean markets. Although results suggested that reproductive capacity could be maximized when L_c and L_r > 95mm, annual fluctuations in anchovy catch have been relatively stable, suggesting that strong density-compensatory recruitment processes must occur to maintain the long-term equilibrium of stock size and that a larger spawning stock size would not necessarily guarantee higher yield of anchovy.

Poster FIS_P-4312

Fecundity and growth-dependent mortality of Pacific anchovy (*Engraulis japonicus*)

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We propose a method of estimating size-dependent natural mortality of marine pelagic fishes based on fecundity, especially for early-life stages. To estimate size-dependent fecundity, growth and mortality of Pacific anchovy (*Engraulis japonicus*), the most abundant fish species in coastal waters off the Korean peninsula, we undertook a synthesis of results from past studies. Assuming that the growth coefficient k varies with water temperature, we derived a modified von Bertalanffy growth equation covering all life stages. The fraction of mature females spawning per day ranged from 0 to 0.32 and estimated mean total batch-spawning per female during the spawning period from March to September was 35. A preliminary estimate of mean egg number spawned by a female, based on the relationship between batch fecundity and body weight, was 157×10^3 yr^{-1}. Accepting the "bigger-is-better" hypothesis, we derived a theoretical mortality curve that assumes instantaneous natural mortality as an inverse function of anchovy body length. Assuming equilibrium status of stock, estimated annual instantaneous mortality of age 0 anchovy was 11.3 yr^{-1} and estimated size-specific mortality was 1.22 d^{-1} mm^{-1}. Our theoretical mortality curve fit well the stage-specific mortalities, which were estimated based on ichthyoplankton surveys and catch data from commercial nets, but underestimated the egg mortality (0.89 and 0.82 d^{-1}).

Poster FIS_P-4330

Acoustic measurement of *Sargassum* beds in coastal area of western Honshu, Japan

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Sargassum beds have a large biomass and high productivity in coastal ecosystems. They play important ecological roles as nursery, feeding and refuge grounds for coastal fauna. In this study, we tried to detect *Sargassum* beds and their distribution using acoustic methods. For this purpose, a binary method and a geostatistical method were used. A field survey was conducted on 14 and 16 May 2007, in Kurumi riffle, Yamaguchi, Japan (1271 ha) using a quantitative echo sounder (frequency, 200kHz; vertical resolution, 4.8cm). The binary method provides an optimum threshold to separate the bottom and head of *Sargassum* beds. The bottom threshold was determined to separate the bottom of *Sargassum* beds and sea bottom, and the head threshold was determined to separate the head of *Sargassum* beds and sea water. The bottom threshold and the head threshold were -22.2dB, and -56.2dB, respectively. The height of *Sargassum* beds, given by bottom–head distance, was to be from 1.03 to 2.28 m with mean of 1.62 m (n = 95). The horizontal distribution of the detected *Sargassum* beds (n = 4739) was interpolated every 1 m^2 using kriging. The dimension of *Sargassum* beds in the study area was estimated to be 188 ha. The estimated height and distribution corresponded with direct observation by diving and underwater camera. It was suggested that acoustic measurement using the binary method is practical for estimating distribution of *Sargassum* beds.

Poster FIS_P-4388

Recruitment variation in functionally equivalent fish stocks: A cross-ecosystem comparison

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Temporal patterns of recruitment and spawning stock variability were compared among functionally analogous species from four marine ecosystems including the Gulf of Maine/Georges Bank, the Norwegian/Barents Seas, the eastern Bering Sea and the Gulf of Alaska. Variability was characterized by calculating coefficients of variation and anomalies for each time series. Patterns of synchrony and asynchrony in recruitment and spawning stock indices were examined among and between ecosystems and related to observed patterns in biophysical properties (*e.g.*, local trophodynamics, local hydrography and large scale climate indices) using a wide range of time series analyses, autocorrelation corrections, autoregressive processes, and multivariate cross-correlation analyses. Of all the commonalities, the relatively similar cross-ecosystem and within-species magnitude of variation was most notable. Of all the differences, the timing of high or low recruitment years across both species and ecosystems was most notable. However, many of the peaks in these indices of recruitment were synchronous across ecosystems for functionally analogous species. The relationships (or lack thereof) between recruitment anomalies and key biophysical properties demonstrated that no one factor consistently caused large recruitment events. Observations also suggested that there was no common set of factors that influence recruitment; often multiple factors were of similar relative prominence. This work demonstrates that commonalities and synchronies in recruitment fluctuations can be found across geographically distant ecosystems, but biophysical causes of the fluctuations are difficult to partition. This is a contribution from the PICES and ESSAS sponsored Comparison of Marine Ecosystems of Norway and the US (MENU) project.

Poster FIS_P-4396

Spatial and temporal variations in albacore habitat in the Northeast Pacific using remotely-sensed environmental data

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Albacore tuna (*Thunnus alalunga*) occurs through much of the temperate waters of the North Pacific and undergoes zonal feeding migrations across the entire basin. Oceanic habitat preferences and timing of immigration and emigration into the Eastern North Pacific have not been studied in detail. A hypothesis of interest is related to the role of the North Pacific Transition Zone frontal structure as an oceanographic mechanism determining the route and rate of albacore trans-Pacific migration. We used albacore logbook CPUE data for 1999 through 2004 stratified by month, latitude, and longitude (33,652 records) along with satellite-derived environmental variables (Reynolds SST, SeaWiFS SSChl, AVISO SSH, and ERS- or QSCAT-derived wind stress curl). CPUE was mapped for the main fishing season (May through October), overlaid on environmental maps, and pixel-by-pixel environmental records were extracted for each catch location where fishing occurred using both positive and zero sets. The optimum range (mean and variance) of each variable was estimated based on catch and CPUE was related to all environmental variables using GAM modeling by month and year or for the whole dataset combined and also east and west of 130°W. Finally, we plotted a binary prediction map of the distributional range of this species based on optimal habitat for each month and year. Catch varied significantly between years and all four environmental factors were related to the distribution of albacore in this region. The results may allow identification of gross factors that could be refined and possibly be used in further evaluations.

Poster FIS_P-4436

Anticyclonic eddies of various origin southeastward from Hokkaido and their influence on saury fishery

Eugine V. **Samko**, Nafanail V. Bulatov, Alexander V. Kapshiter

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On the basis of satellite data analysis, the Oyashio interaction with warm anticyclonic eddies is considered as the basic process conditioning the saury fishery. Large (100–120 miles in diameter) anticyclonic eddies are permanently observed in the area off the Pacific coast of Hokkaido Island. They have various origin, size, thermohaline and dynamic structure, so their influence on fish distribution is different. Parameters of anticyclonic eddies of various origin are described for 2004 and 2005, taking into account both infrared and altimetry data, and compared with the location of saury fishing grounds. In 2004, eddy A24 was traced; it was generated from the Kuroshio meander in 2002 and crossed the Subarctic front in early 2003. In October 2004, it had the size of 80 × 100 miles, with a homogeneous warm core with SST of 15–16°C, and rotation velocity about 47cm/s. The eddy was surrounded with cold waters of the 2nd branch of Oyashio. Saury shoals migrated eastward along northern border of the eddy. The eddy A28 was generated in the Subarctic frontal zone in 2005 as a result of impact of two eddies. It moved to the north with the speed 1.6 miles/day. In October 2005, the eddy had the size 80 × 90 miles, a SST in the core of about 16°C, and rotation velocity about 64cm/s. Warm and cold streamers had penetrated inside the eddy. Saury fishing grounds were formed in the center of the eddy and on the northern periphery of its warm-water area.

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 S2, S9 and S11 topics).

Wednesday, Oct. 31, 2007 09:00 – 15:40

09:00	**Phyllis J. Stabeno and James E. Overland** New climate states during the last decade in the North Pacific (POC_P-4403)
09:20	**Kenneth F. Drinkwater, Cecilie Broms, Kevin Friedland, Jon Hare, George Hunt Jr., Webjørn Melle, Franz J. Mueter and Maureen Taylor** Comparison of 4 Northern Hemisphere regions: Physical oceanographic responses to recent climate variability (POC_P-4402)
09:40	**Fangli Qiao, Yongzeng Yang, Zhenya Song, Guohong Fang and Yeli Yuan** The role of the ocean in East Asian climate change (POC_P-4483)
10:00	**Ichiro Yasuda** The 18.6-year nodal tidal cycle and bidecadal ENSO/PDO (POC_P-4347)
10:20	**Patrick Cummins and Howard Freeland** Variability of the North Pacific Current and its bifurcation (POC_P-4453)
10:40	***Coffee / tea break***
11:00	**Richard E. Thomson, Georgy V. Shevchenko and Alexander B. Rabinovich** Coastally trapped diurnal waves observed along the South Kuril Islands (POC_P-4078)
11:20	**Viacheslav G. Makarov, Valentina D. Budaeva and Oleg V. Zaitsev** Summer density distribution near the north-eastern coast of Sakhalin based on the parametric modeling of vertical structure (POC_P-4167)
11:40	**George V. Shevchenko and Alexander A. Romanov** Wave structure of tidal motions near the North Kuril Islands as revealed from the satellite altimetry measurements (POC_P-4101)
12:00	**Satoshi Osafune and Ichiro Yasuda** Bidecadal variation in the region south of Japan and relation between the large meander of the Kuroshio and the 18.6-year period nodal tidal cycle (POC_P-4351)
12:20	**Konstantin Rogachev** Zonal jet streams in the Pacific western subarctic (POC_P-4172)
12:40	***Lunch***
14:00	**Howard J. Freeland, P.G. Myers and M. Li** Mixed-layer depths along Line-P - The annual cycle and recent variability (POC_P-4299)
14:20	**Hiromichi Ueno, H.J. Freeland, W.R. Crawford, H. Onishi, E. Oka and T. Suga** Anticyclonic eddies in the Alaskan Stream (POC_P-4449)

14:40 **Carol Ladd, W.R. Crawford, W.K. Johnson, N.B. Kachel, P.J. Stabeno and F. Whitney**
Eddies in the eastern Gulf of Alaska (POC_P-4222)

15:00 **Maxim V. Krassovski and Richard E. Thomson**
The California Undercurrent off the west coast of Vancouver Island (POC_P-4186)

15:20 **Oleg Zaitsev, Carlos J. Robinson and Orzo Sanchez-Montante**
Seasonal variability of oceanographic conditions on the Pacific continental shelf of the southern Baja California peninsula (POC_P-4116)

Thursday, Nov. 1, 2007 09:00 – 17:20

09:00 **Ig-Chan Pang and Jae-Hong Moon**
Seasonal circulation in the Yellow Sea and the East China Sea (POC_P-4149)

09:20 **Xingang Lü, Fangli Qiao and Changshui Xia**
A fresh look at an old question: The mechanism of coastal upwelling in the East China Sea (POC_P-4243)

09:40 **Tsuyoshi Wakamatsu, Michael Foreman, Patrick Cummins and Josef Cherniawsky**
On the influence of random wind stress errors on the four-dimensional, mid-latitude, ocean inverse problem (POC_P-4496)

10:00 **Young-Gyu Park and Sang-Wook Yeh**
The effects of the Tsushima Warm Current on the East/Japan Sea (POC_P-4179)

10:20 **Victor I. Kuzin, Elena N. Golubeva and Gennady A. Platov**
Numerical simulation of the propagation of the Bering Sea and Siberian river waters to the Arctic – North Atlantic (POC_P-4439)

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

11:00 **Isaac D. Schroeder, Thomas C. Royer and Chester E. Grosch**
Ekman pumping along the Seward Line in the Northern Gulf of Alaska (POC_P-4378)

11:20 **Nadja Steiner, Svein Vagle, Ken Denman and Craig McNeil**
Gas exchange at Station Papa – Simulated and observed O_2, N_2 and CO_2 cycling (POC_P-4096)

11:40 **Masahiro Yagi and Ichiro Yasuda**
Variability of vertical diffusivity at the eastern gap of the Bussol' Strait (POC_P-4360)

12:00 **Hee-Dong Jeong, Yeong Gong, Yang Ho Choi and Chang Su Jeong**
Physical oceanographic features of HABs in the southern coast of Korea (POC_P-4333)

12:20 **Masatoshi Sato and Tokihiro Kono**
Baroclinic structure in the subarctic gyre of the North Pacific from the Argo float CTD data (POC_P-4339)

12:40 ***Lunch***

14:00 **Tokihiro Kono, Masatoshi Sato and Tsutomu Ikeda**
A mixing process of the Oyashio water as revealed by sequential observations off southeast Hokkaido, Japan (OECOS-WEST) (POC_P-4111)

14:20 **Olga Trusenkova, Vyacheslav Lobanov and Dmitry Kaplunenko**
SST anomalies related to wind stress curl patterns in the Japan/East Sea (POC_P-4064)

14:40 **Byung-Ho Lim, Kyung-Il Chang, Mark Wimbush, Jae-Hun Park, Magdalena Andres and JongJin Park**
Near 60-day variation of the Kuroshio observed in the East China Sea (POC_P-4424)

15:00 **Fei Yu**
Observational evidence of the Yellow Sea Warm Current (POC_P-4482)

15:20 **Natalia Rudykh**
Salinity variability in the Japan/East Sea (POC_P-4163)

15:40 ***Coffee / tea break***

16:00 **Gennady I. Yurasov and Natalia I. Rudykh**
Some features of Peter the Great Bay hydrological regime in the fall–winter period (POC_P-4320)

16:20 **Hitoshi Kaneko and Ichiro Yasuda**
Current and turbulent observations of North Pacific intermediate water in the Kuroshio-Oyashio confluence region (POC_P-4362)

16:40 **Dejun Dai, Fangli Qiao and Yeli Yuan**
Using the transform method to study the generation of internal tides (POC_P-4481)

17:00 **Vadim V. Navrotsky**
On the World Ocean as the primary natural cause of Global Climate Change (POC_P-4110)

POC Paper Posters

POC_P-4115 **Talgat R. Kilmatov and Vera A.Petrova**
Why and when is the jet of the Kuroshio Extension destroyed?

POC_P-4146 **Valentina V. Moroz and K.T. Bogdanov**
Water structure and circulation variability in the Komandor-Kamchatka area

POC_P-4164 **Sachiko Oguma, Tsuneo Ono and Akira Kusaka**
Interannual variation of the water mass mixing ratio in spring revealed by $\delta^{13}C$-$\delta^{18}O$ distribution in the coastal region off eastern Hokkaido

POC_P-4168 **Viacheslav G. Makarov and Sergei N. Bulgakov**
Modeling of barotropic eddy evolution near a chain of islands

POC_P-4171 **Konstantin A. Rogachev, Eddy C. Carmack and Michael G. Foreman**
Mechanisms of lateral circulation in Academy and other bays of the Shantar Archipelago, Sea of Okhotsk

POC_P-4194 **Galina A. Vlasova**
Influence of atmospheric processes on water circulation in the 200-m layer of the Sea of Okhotsk on the basis of modelling

POC_P-4205 **Nandita Sarkar, Thomas C. Royer and Chester E. Grosch**
Are deepening mixed layers responsible for transporting deep nutrients into surface waters in the northern Gulf of Alaska?

POC_P-4210 **Antonina M. Polyakova**
Extreme distribution of floating ice in the NW Pacific

POC_P-4233 **Vladimir Ponomarev, N.I. Savelieva and E.V. Dmitrieva**
Amur River discharge, ice cover of the Okhotsk Sea, Tatar Strait and the atmospheric indices of the Asia-Pacific region – The assessment of relationships

POC_P-4238 **Antonina M. Polyakova**
Atmospheric circulation over the Northern Pacific

POC_P-4321 **Alexander A. Nikitin and Genady I. Yurasov**
Surface thermal fronts in the Japan/East Sea

POC_P-4323 **Larisa S. Muktepavel**
Spatial-temporaral variability of shore polynias in the northern Sea of Okhotsk

POC_P-4337 **Hong Sik Min, Young Ho Kim and Cheol-Ho Kim**
Year-to-year variability of cold water in the southwestern region of the East/Japan Sea

POC_P-4348 **Ichiro Yasuda, Sachihiko Itoh, Masahiro Yagi, Satoshi Osafune, Hitoshi Kaneko, Hideo Nagae, Takeshi Nakatsuka and Jun Nishioka**
Turbulence observations around the Kuril Straits

POC_P-4350 **Sung-Tae Jang, Jae Hak Lee, Chang-Woong Shin and Chang-Su Hong**
Vertical mixing in the Ulleung Basin in the East/Japan Sea

POC_P-4497 **Tsuyoshi Wakamatsu and Michael Foreman**
Data assimilation studies at the Institute of Ocean Sciences for estimating the North Pacific Ocean circulation

POC Paper Oral Presentations

31 October, 09:00 (POC_P-4403)

New climate states during the last decade in the North Pacific

Phyllis J. **Stabeno** and James E. Overland

Pacific Marine Environmental Laboratory, 7600 Sand Point Way NE, Seattle, WA, 98115, USA. E-mail: phyllis.stabeno@noaa.gov

For the last decade both the Pacific Pattern and the Arctic Oscillation have varied around neutral. This has allowed room for other more regional climate patterns to develop and persist over the North Pacific, including the Bering Sea. During 2000 - 2005, the impact on the Bering Sea of these new climate patterns resulted in very warm atmospheric conditions due to major southerly wind anomalies. These wind anomalies contributed to a decrease in ice extent and earlier ice melt over the Bering Sea, and extremely warm ocean temperatures with anomalies of greater the 2°C. In 2006, the climate pattern shifted resulting in colder atmospheric conditions in the southern Bering Sea and Gulf of Alaska, and more moderate conditions in the western Bering Sea. These conditions continued in 2007. During both years, sea ice over the southeastern Bering Sea shelf was more extensive persisting into May. Ocean temperatures over the Bering Sea have cooled significantly from conditions in 2000 - 2005, but remain warmer than was observed in the 1990s. The climate pattern during 2000 - 2005 was so ideal for warm conditions that the warming that appeared in those years is an extreme. Any other pattern can not support such warming, and we suggest that the rate of warming in the Bering Sea will slow over the next decade when compared to the previous decade.

31 October, 09:20 (POC_P-4402)

Comparison of 4 Northern Hemisphere regions: Physical oceanographic responses to recent climate variability

Kenneth F. **Drinkwater**[1], Cecilie Broms[1], Kevin Friedland[2], Jon Hare[2], George Hunt Jr.[3], Webjørn Melle[1], Franz J. Mueter[4] and Maureen Taylor[5]

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Recent changes in climate conditions in several regions of the globe raise concerns about ecosystem resilience and sustainability of ecosystem services. We examine oceanographic responses to these climate changes in four high latitude regions of the Northern Hemisphere, two in the Pacific (Bering Sea and Gulf of Alaska) and two in the Atlantic (Georges Bank/Gulf of Maine and the Barents/Norwegian Seas). Air temperature, heat fluxes and wind forcing over the four regions are examined. The effects of these on the oceanography of the regions are then determined, compared and contrasted, including changes in ocean temperatures, salinities, stratification, and circulation patterns. In addition, changes in seasonal sea ice cover are compared between the two regions where it occurs (Bering and Barents seas). Changes in temperature and salinity are examined as a function of latitude and compared to expected changes (increasing temperature and decreasing salinities in the north). The importance of advection in the four regions to explain the observed responses is discussed. This is a contribution from the PICES and ESSAS sponsored Comparison of Marine Ecosystems of Norway and the US (MENU) project.

31 October, 09:40 (POC_P-4483)

The role of the ocean in East Asian climate change

Fangli **Qiao**, Yongzeng Yang, Zhenya Song, Guohong Fang and Yeli Yuan

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The ocean surface mixing layer (ML) determines the lower atmospheric boundary conditions, and controls mass, momentum and energy fluxes across the air–sea interface. Incorrect parameterizations of the 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 ML, so that we can better model the climate. As the mixing process is essentially an energy balance problem, waves, as the most energetic motions at the ocean surface, should play a controlling role. Unfortunately, in most ocean dynamics studies, wave motions have always been treated separately from the ocean circulation. Previously, most ocean circulation models have overlooked the role of the surface waves. As a result, these models have produced insufficient vertical mixing, with an under-prediction of the mixed layer depth and an over-prediction of the sea surface temperature, particularly during the summer season. As the ocean surface layer determines the lower boundary conditions of the atmosphere, this deficiency has severely limited the performance of the coupled ocean–atmospheric models and hence the climate studies. To overcome this shortcoming, we have established a new parameterization for the wave-induced vertical mixing that will correct this systematic error of insufficient mixing. The new scheme has enabled the mixing layer to deepen, the surface excessive heating to be corrected, and an excellent agreement with observed global climatologic data. Different circulation models such as the Princeton Ocean Model (POM), the Regional Ocean Model system (ROMS), and the Hallberg Isopycnal Model (HIM) show similar improvements, while an atmosphere–ocean circulation coupled model also shows amazing improvement. The prediction ability of the area of the tropical Pacific and Northern Indian Ocean is a weak point for all atmosphere–ocean coupled numerical models, thus limiting our ability to understand the role of the ocean in the East Asia climate change. Based on the wave-circulation coupled theory, the ocean thermal structure, wind field and precipitation are analyzed.

31 October, 10:00 (POC_P-4347)

The 18.6-year nodal tidal cycle and bidecadal ENSO/PDO

Ichiro **Yasuda**

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Bidecadal climate variability is examined with proxy time series of the El Niño-Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO) reconstructed from tree-ring records. Maximum entropy spectra show peaks around the 18.6-year period. Their band-passed time series indicate the tendency for a strong El Niño (La Niña) to occur a few to several years after the minimum (maximum) amplitude of diurnal tides in the 18.6-year period of the nodal tidal cycle, and that a positive (negative) PDO appears in the period of weak (strong) diurnal tides around the Kuril Islands. These results are consistent with previous analyses and model results, supporting the hypothesis that changes in tidal mixing around the Kuril Islands generate an upper layer thickness anomaly, which propagates as coastally trapped Kelvin waves along the western rim of the North Pacific, and then regulates 18.6-year periodicity in the equatorial sea surface temperature (SST), and eventually climate over the whole Pacific and surrounding regions via atmospheric tele-connection.

31 October, 10:20 (POC_P-4453)

Variability of the North Pacific Current and its bifurcation

Patrick **Cummins** and Howard Freeland

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The variability of the North Pacific Current (NPC) is discussed using sea surface height (SSH) data from altimetry, dynamic heights from Argo, and numerical results from a wind-driven, reduced-gravity model. Indices of the

strength of the subpolar and subtropical components of the NPC are examined based on output from multi-decadal simulations with the numerical model. This shows periods of both correlated and anti-correlated variability of the subpolar and subtropical gyres. A decomposition of the gyre transport time series indicates that the dominant mode of variability is a 'breathing' mode in which the subpolar and subtropical gyres co-vary in response to fluctuations in the strength of the NPC. This finding is consistent with an analysis of dynamic height data of limited duration from the array of Argo drifting floats. The leading mode of SSH variability over the northeast Pacific for the period 1993-2005 is also shown to be associated with in-phase variations in the transport of the subtropical and subpolar gyres.

31 October, 11:00 (POC_P-4078)

Coastally trapped diurnal waves observed along the South Kuril Islands

Richard E. **Thomson**[1], Georgy V. Shevchenko[2], and Alexander B. Rabinovich[1,3]

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Current meter measurements were obtained by the Sakhalin Research Institute of Fisheries and Oceanography from 2003 to 2005 in the vicinity of the South Kuril Islands. These measurements coincided with deployment of a SonTek Argonaut gauge on the northeastern shelf of Urup Island for a 9.5-month period from February–November 2003 and deployment of an acoustic Doppler current profiler (ADCP) on the Sea of Okhotsk side of Ekaterina Strait between Kunashir and Iturup Islands during the two periods of June-October 2003 and November 2004 - July 2005. Diurnal tidal currents were the dominant flow structure in both regions. Amplitudes of the K_1 and O_1 diurnal tidal currents were similar (~ 30 cm/s) and significantly stronger than the semidiurnal M_2 currents (10-15 cm/s). Both diurnal and semidiurnal currents undergo considerable seasonal variability, being amplified in summer and attenuated in winter. These seasonal variations are pronounced in the upper and mid layers but relatively weak in the near-bottom layer. The strong diurnal currents appear to be associated with diurnal coastally trapped waves (CTW), in good agreement with numerical modeling results by Rabinovich and Thomson (2001). The combination of complicated seafloor topography and the presence of numerous straits in this region are key factors promoting scattering of long tidal waves propagating along the chain of the Kuril Islands and leading to the generation of relatively short barotropic and baroclinic diurnal shelf waves.

31 October, 11:20 (POC_P-4167)

Summer density distribution near the north-eastern coast of Sakhalin based on the parametric modeling of vertical structure

Viacheslav G. **Makarov**[1], Valentina D. Budaeva[2] and Oleg V. Zaitsev[1]

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The study area is strongly influenced by runoff of the Amur River, which leads to a significant reduction in the salinity of near-surface waters and a sharpening of horizontal and vertical density gradients. Another important feature is coastal upwelling induced by the prevailing southerly winds during summer. A mean density field was constructed on a 1° grid using 130 CTD profiles obtained during four summer cruises of the R/V *Professor Khromov* (1998–2000 and 2006, FERHRI) and 120 quality-controlled profiles (1937–1993) from the North Pacific Hydrobase for the same season. A four-layer piecewise curvilinear parametric model of vertical density distribution consisted of a homogeneous surface layer, a seasonal pycnocline (represented as two layers) and a deep layer. Ten model coefficients (depth, density and maximum density gradient for each layer interface) were derived for each profile using the nonlinear least squares fitting to observed data. Then the coefficients were averaged within 1° squares, and a density field was reconstructed with the parametric model. Comparisons with the commonly used isobaric and isopicnal methods of averaging show that for strong stratification and high horizontal density variations, the parametric approach is preferable. The isobaric averaging can strongly deform the density structure in the layer 0–150 m. The step-like distribution with a sharp pycnocline, which was conspicuous on the individual profiles, was

diffused by averaging on *z*-levels. It could also lead to a change of inclination in the isopycnals, especially near the edge of the continental shelf. The isopycnal approach is of little use near the sea surface.

31 October, 11:40 (POC_P-4101)

Wave structure of tidal motions near the North Kuril Islands as revealed from the satellite altimetry measurements

Georgy V. **Shevchenko** and Alexander A. Romanov

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TOPEX/Poseidon altimetry data (1993-2003) were used to examine tidal motions near south Kamchatka and the North Kuril Islands. Five descending tracks (160, 84, 8, 186 and 110) crossed the islands almost normally to the coastline. At each track we selected 7 points with a spatial resolution of about 0.2°. Tidal amplitudes and phases for 18 main constituents were estimated using a high-resolution modification of the least squares method. A specific feature was found for tracks 84, 8 and 186: small-scale variations of amplitudes (for 3-4 cm) and phases (for 12-15°) of K_1 and O_1 harmonics which are dominant in tidal sea levels. The area of these spatial variations, which is adjacent to the Paramushir–Onekotan–Matua islands, corresponded well to the area of strong diurnal currents numerically simulated by Kowalik and Polykov (1998). Similar significant variations of diurnal tides, accompanied by strong currents on the eastern shelf of Sakhalin Island, are associated with subinertial quasigeostrophic shelf waves (Rabinovich and Zhukov, 1984), so we assumed that the same waves are responsible for the effect observed near the North Kuril Islands. Parameters of the shelf waves for this region were calculated and it was found that the frequencies of diurnal harmonics are close to the frequency of the zero group velocity of the first shelf mode, indicating a possible resonant generation mechanism of diurnal shelf waves. Consequently, tidal velocities and energy dissipation were estimated and found to be in reasonable agreement with those simulated by Kowalik and Polyakov (1998).

31 October, 12:00 (POC_P-4351)

Bidecadal variation in the region south of Japan and relation between the large meander of the Kuroshio and the 18.6-year period nodal tidal cycle

Satoshi **Osafune** and Ichiro Yasuda

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Bidecadal variation is known to be a prominent feature of the long-term variation of climate and ocean in the North Pacific. The modulation of the vertical mixing in the 18.6-year period nodal tidal cycle could cause the bidecadal variation of ocean observed in the subarctic region especially around the strong mixing regions such as around the Kuril Strait and the Bering Sea. This possibly affect climate through the change of heat transport by the Kuroshio. We investigated long-term variations in the Kuroshio region south of Japan, and found bidecadal variations of isopycnal depths and other water properties, which are synchronized with the bidecadal variations observed in the subarctic regions and thus with the 18.6-year period nodal tidal cycle. Isopycnal depth near the southern coast of Japan is shallow when the diurnal tide is strong. This bidecadal variations is in the same phase with the the variations observered in the subarctic region. This suggests that the 18.6-year period nodal tidal cycle may affect the Kuroshio region, possibly through a coastal wave. On the other hand, the bidecadal variations of isopycnal depths in the offshore region are rather in the opposite phase. Compared with the Kuroshio paths, the offshore isopycnal depth is shallow when the Kuroshio takes a large meander. This means that when the diurnal tide is weak and the isopycnal depth is deep near the coast, the Kuroshio tends to take a large meander path south of Japan. Thus, it is also suggested that the 18.6-year periods nodal tidal cycle possibly affect the large meander of the Kuroshio.

31 October, 12:20 (POC_P-4172)

Zonal jet streams in the Pacific western subarctic

Konstantin A. **Rogachev**

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Conductivity-temperature-depth (CTD) data, Argo buoys, World Ocean Circulation Experiment (WOCE) surface drifters, and satellite-derived sea-level observations to the east of Kamchatka show the presence of zonal jet streams and mesoscale eddies. A major fraction of the water in this region is derived directly from the Alaskan Stream. The Alaskan Stream sheds 1-2 eddies per year, most where the Stream abruptly turns clockwise to flow into the Bering Sea through Near Strait. Large mesoscale anticyclonic eddies, averaging approximately 300 km in diameter, have a significant volume transport in comparison with that of the Kamchatka Current itself. The Aleutian eddies play a substantial role in the transport of warm Alaskan Stream water westward. The system of Aleutian eddies and Kamchatka eddies divides the western subarctic gyre into two parts with substantial change of potential vorticity and stratification. Significant variability was observed off Kamchatka and in the upstream Oyashio in 1959-2007. This variability is due, in part, to a variation of the Alaskan Stream flow. The absence of Alaskan Stream inflow to the east of Kamchatka results in essential cooling (0.5°C) of subsurface waters. The cause of this subsurface cooling is both due to the lack of advection of warm water and enhanced convection from the surface because of reduced high salinity and weak stratification. Enhanced transport of warm and saline water westward by zonal jets and eddies leads to observed warming and increase in stratification in the upstream Oyashio and Kamchatka Currents.

31 October, 14:00 (POC_P-4299)

Mixed-layer depths along Line-P – The annual cycle and recent variability

Howard J. **Freeland**[1], P.G. Myers[2] and M. Li[2]

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The Argo array has been capable of mapping variations in ocean properties in the Gulf of Alaska since early 2002. This time series is short by most oceanographic standards but offers reliable mapping at a high resolution horizontally, vertically and in time. This paper will outline the view, so far, of the variability in the depth of the seasonal mixed layer computed by an objective method. Though only 6 years of data are available, we nevertheless will show the average seasonal cycle in mixed-layer depth along Line-P and examine the variability about that cycle between 2002 and the present time. Finally, hypotheses will be made about the possible causes of the variability.

31 October, 14:20 (POC_P-4449)

Anticyclonic eddies in the Alaskan Stream

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Anticyclonic eddies in the Alaskan Stream (AS) were investigated through analysis of altimetry data from satellite observations during 1992–2006 and hydrographic data from profiling float observations during 2001–2006. Fifteen long-lived eddies were identified: three eddies appeared from the beginning of the satellite observations, another three were first observed in the eastern Gulf of Alaska off Sitka, and another four were first detected at the head of the Gulf of Alaska near Yakutat. The other five eddies formed along the AS between 157º–169ºW and we call these AS eddies. Four of the fifteen long-lived eddies crossed the date line and reached the western subarctic gyre; all four were AS eddies. A Sitka eddy and a Yakutat eddy were observed by profiling floats along the AS around 160º–170ºW; warm cores were not detected in either eddy. An AS eddy was observed by profiling floats after it detached

from the AS in the western subarctic gyre, although profiles were not obtained within 50 km of the eddy center. Intermediate water 50–100 km off the eddy center had low potential vorticity compared with that in the western subarctic gyre, probably providing the western subarctic gyre with low-potential-vorticity intermediate water in the AS region.

31 October, 14:40 (POC_P-4222)

Eddies in the eastern Gulf of Alaska

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Eddies in the Gulf of Alaska are important sources of coastal water and associated nutrients, iron, and biota to the high nutrient, low chlorophyll central Gulf of Alaska. Three primary eddy formation regions along the eastern boundary have been identified, (from south to north, Haida, Sitka, and Yakutat). In the spring of 2005, three eddies (one of each type) were sampled soon after their formation. The subsurface eddy core water in all three eddies was defined by high iron concentrations and low dissolved oxygen compared with surrounding basin water. The Sitka and Yakutat core waters also exhibited a subsurface temperature maximum (mesothermal water) coincident in depth with the iron maximum, suggesting that eddies may play a role in the formation of temperature inversions observed throughout the Gulf of Alaska. The data suggest different formation regions, with the Yakutat eddy forming in shallow shelf water with riverine input while the Sitka and Haida eddies appear to form in deeper water.

31 October, 15:00 (POC_P-4186)

The California undercurrent off the west coast of Vancouver Island

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Shipboard survey data and current meter records from a long-term (20 year) mooring site on the continental slope off the west coast of Vancouver Island, British Columbia are used to investigate the spatial and temporal variability of the California Undercurrent and its relation to possible regional and large-scale driving mechanisms. Extending from Baja California to Vancouver Island, the California Undercurrent is part of the California Current System, a typical basin-scale eastern boundary circulation system. Of the four current meters at nominal depths of 35, 100, 175, and 400 m, the upper two show seasonally reversing flow whereas the instrument at 175 m depth registers a year-round core poleward flow of roughly 3-5 cm/s. The deepest current meter, located approximately 100 m above the bottom, reflects the influence of the nearby Barkley submarine canyon. The residual (non tidal) flow at 100 and 175 m depths, and the water properties obtained from conductivity-temperature-depth (CTD) casts during the shipboard surveys, indicate the California Undercurrent over the continental slope off central and southern Vancouver Island. Seasonally averaged geostrophic velocity relative to a 1000-dbar level suggests that the flow extends to the northern tip of Vancouver Island. Correlation of the 175-m flow with local wind stress forcing in the low-frequency band (periods of months) is higher than with ocean-wide climatic indices, suggesting that regional processes play a key role in the dynamics of the undercurrent.

31 October, 15:20 (POC_P-4116)

Seasonal variability of oceanographic conditions on the Pacific continental shelf of the southern Baja California peninsula

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Seasonal variability of oceanographic conditions along the Pacific continental shelf of the southern part of the Baja California peninsula was analyzed using both historical data and field observations. Averaged monthly sea surface temperature (SST), obtained from the Advanced Very High Resolution Radiometer satellite images (AVHRR), showed the evolution of a thermal front between tropical and subtropical waters recorded during the transition period from winter-spring to summer-autumn. This evolution was characterized by a change in the direction of the SST horizontal gradient. The seasonal patterns of geostrophic currents calculated using hydrographic-altimeter data indicated that the SST seasonal variability was modulated by a poleward coastal flow during autumn that transported subtropical waters along the west coast of the peninsula. This intrusion was more intense during the El Niño years. Geostrophic balance in the study area presented meanders and eddies along the peninsula coast. In spring relatively weak meanders were located close to the coast. In summer the generation of geostrophic eddies was intensified, and in autumn eddies moved offshore. Another key feature observed in the mean seasonal values of the SST was a coastal upwelling activity that was more intense during the spring-summer period. The thermohaline structure, observed from the data obtained *in-situ* at the area, showed that the negative anomalies of SST (–2.5 °C) contrasted strongly with conditions recorded offshore. The combination of both the upwelling events and the tidal horizontal transport could be considered an important nutrient flux mechanism for coastal lagoons.

1 November, 09:00 (POC_P-4149)

Seasonal circulation in the Yellow Sea and the East China Sea

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Data analysis shows that the distribution of the Tsushima Warm Current Water (TWCW) expands northward to the Yellow Sea (YS) in winter and retreats southward in summer, and that the thermal front is linked to the YS in winter and to the Korea/Tsushima Straits (KTS) in summer from the central region of the East China Sea (ECS). These features reflect the wind-driven seasonal circulation revealed from model calculations. The northerly winter monsoon causes water to drift from the China coast southward out of the YS with decreasing transport in the Taiwan Strait (TS) which, in turn, pulls some of the TWCW into the YS. Since transport in the TS is much smaller than that in the KTS, the major part of the TWC needs to be supplied from the Kuroshio. On the other hand, the southerly summer monsoon causes the surface water to drift northeastward with increasing transport in the TS. The inflow into the YS along the China coast pushes the water in the YS to the south along the YS trough. Since the increased transport in the TS is sufficient to supply the transport in the KTS, the Tsushima Warm Current (TWC) flows from the TS to the KTS. Consequently, in the Y/ECS there is a large-scale seasonal circulation driven by the monsoon wind, which is comprised of seasonal phenomena prominently found in the Y/ECS.

1 November, 09:20 (POC_P-4243)

A fresh look at an old question: The mechanism of coastal upwelling in the East China Sea

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The mechanism responsible for coastal upwelling in the East China Sea (ECS) was a hot topic in the 1980s-1990s in China. However, this issue was seldom discussed in the past decade. In this study, we employ the newly developed MASNUM wave-tide-circulation coupled numerical model to probe into the dynamics of upwelling off ECS coasts, and propose a mechanism which is different from the traditional viewpoints. It has been found that the coastal upwelling off ECS is mainly a result of density-frontal forcing. Located topographically on a slope, the density front agrees well with the upwelling area. In summer, the density front results from a temperature gradient between the two sides: in the shallow side, the water is vertically homogeneous and heated due to tidal mixing and solar radiation, while deep water on the other side remains cold. In winter, the salinity gradient becomes the primary contributor to the density front: the Yangtze River Diluted Water (YRDW) flows southward clinging to the coast, and its salinity is much lower than that of the offshore Taiwan Warm Current (TWC). Owing to the sharp density gradient, the baroclinic pressure gradient force (PGF) is so large that it dominates the bottom dynamic balance in the cross-frontal direction near the frontal zone. This PGF stimulates a secondary circulation across the front, and upwelling appears as a branch. Other dynamic factors, including wind and the TWC, only exert subsidiary influences on the formation of upwelling.

1 November, 09:40 (POC_P-4496)

On the influence of random wind stress errors on the four-dimensional, mid-latitude, ocean inverse problem

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In a weakly constrained four-dimensional variational (W4DVAR) data assimilation system, the prior error covariance of model state variables (*i.e.*, the background error covariance) is a function of the model error covariance. In this study, we examine sensitivities of the background error covariance of an ocean general circulation model (OGCM) to spatial and temporal decorrelation scales in the wind stress error covariance. These sensitivities are diagnosed by computing the prior sea surface height (SSH) error variance and representers for the SSH measurements, which are subspaces of the background error covariance. The SSH error variance due to the wind stress error shows strong sensitivity to both the length and temporal decorrelation scales. The sensitivity patterns in the subpolar and subtropical gyres are shown to differ due to different contributions from barotropic and baroclinic responses in each gyre. The SSH variance and representer structure in the subtropical domain is mainly explained by baroclinic responses while both barotropic and baroclinic responses are important for the subpolar gyre. The spatial structure of the SSH variance indicates that the background error covariance is determined not directly by the wind stress error, but indirectly by the wind stress curl error, which in turn consists of two independent random components. Analyses of the SSH variance and representer vectors suggest that the dominant dynamical balance determining the structure of the prior model state error covariance matrix is quasi geostrophic. The impact of the sensitivity on the inverse solution is inferred.

1 November, 10:00 (POC_P-4179)

The effects of the Tsushima Warm Current on the East/Japan Sea

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Through an idealized modeling experiment, in which the East Sea is simplified as a small rectangular basin with a through flow placed at the upper left corner of a larger basin, the effect of the Tsushima Warm Current on the East

Sea has been investigated. The NOAA/GFDL Modular Ocean Model (MOM) V.3 is used in this experiment. The horizontal resolution is 0.25° both in the zonal and meridional directions. The basin is 4000 m deep, and there are 36 depth levels in the vertical. The effects of surface wind stress are also considered by comparing results with and without a zonal wind stress. As is well known, the Tsushima Warm Current supplies heat to the East Sea and when the inflow is considered, the model ocean becomes warmer. The water flowing from the small basin into the larger basin is cooler than the western boundary current and colder water is found near the outlet in the cases with the through flow. The inflow also brings variability from the larger basin into the smaller basin, and the cases with the through flow show greater variability. The model is idealized and we may not be able to apply model results to the East Sea directly, but the model results show that through the Tsushima Warm Current the variability in the Northwestern Pacific could be transferred to the East Sea.

1 November, 10:20 (POC_P-4439)

Numerical simulation of the propagation of the Bering Sea and Siberian river waters to the Arctic–North Atlantic

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Model experiments in the region covering the Arctic Ocean coupled with the North Atlantic are carried out using the NCEP/NCAR reanalysis data and are aimed at reproducing a general system of circulation, ice formation and drift. This paper focuses on the propagation of Bering Sea water beyond the Arctic basin and its involvement in the generation of waters in the Atlantic. A comparison of the differences with Siberian river freshwater propagation is also discussed.

1 November, 11:00 (POC_P-4378)

Ekman pumping along the Seward Line in the northern Gulf of Alaska

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The Northeast Pacific GLOBEC (GLOBal ocean ECosystems dynamics) program (October 1997 to December 2004) collected hydrographic data along the Seward Line that stretches from the inner shelf (GAK1 59.8°N, 149.5°W) and extends over 200 km beyond the continental slope. The complexity of the interannual hydrographic variability in this area stems from the interacting influences of local forcing such as winds, coastal freshwater discharge, eddies, and fronts with remote forcing like El Niño-Southern Oscillation. Until now, the influence of winds on the system has been calculated using coarse resolution upwelling index data or spatially very sparse buoy data. The coarse resolution wind measurements cannot describe the cross shelf spatial variations of the winds, which are expected to be significant due to the influence of the high coastal mountain chain on atmospheric motion. Satellite scatterometer wind data, with its high spatial resolution (25 km), are used to calculate wind velocity shears across the shelf. On average the wind shears produce positive wind stress curls that cause upwelling as a result of Ekman pumping. Calculations show that the transport due to this upwelling is 25% - 50% of the transport due to Ekman transport. The effect of the upwelling due to Ekman pumping is seen in the mid-shelf area (40 - 80 km from the coast) at depths between 100 - 200 m. Here the anomalies of salinity are positively correlated with the anomalies of vertical velocities. The upwelling could be an important mechanism in supplying nutrients to the surface layer on this shelf.

1 November, 11:20 (POC_P-4096)

Gas exchange at Station Papa – Simulated and observed O_2, N_2 and CO_2 cycling

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A 1-D coupled atmosphere-ocean-biogeochemical model has been developed to study gas exchange at the atmosphere–ocean interface. The coupled model consists of an atmospheric Single Column Model (SCM), based on the CCCma AGCM (Canadian Centre for Climate Modelling and Analysis-Atmospheric General Circulation Model), the General Ocean Turbulence Model (GOTM) and a 7-component ecosystem model embedded in GOTM. The ecosystem model also includes oxygen, nitrogen, carbon, silica and dimethyl sulphide (DMS) cycling. The study focuses on simulated and observed N_2 and O_2 variability. The comparison of these gases allows for separation of physical and biological processes. Including CO_2, the model also tests different parameterizations for gas exchange, including a formulation for gas injection via bubbles, which affects gas concentrations within the whole mixed layer. Observations are derived from a long-term air-sea exchange mooring which has been maintained in the North Pacific near Ocean Station Papa (OSP, 145°W, 50°N) since September 2002 as part of the Canadian Surface Ocean Lower Atmosphere Study (C-SOLAS). The mooring provides a new long-term data set for gas measurements. In addition to Conductivity, Temperature and Depth (CTD) recorders at two depths, the mooring is equipped with ProOceanus Gas Tension Devices (GTDs) measuring the total gas pressure at four different depths, two oxygen sensors, two fluorometers for chlorophyll estimates, and an upward-looking 200-kHz echo-sounder for bubble measurements. Data collected from June 2003 to June 2005 are compared with the simulations. For most of the time the model shows good agreement with observations. However, in summer 2003 the observations revealed a strong oxygen and chlorophyll event, which is not reproduced in the standard model run. OSP is a High Nutrient Low Chlorophyll (HNLC) region, limited by macro-nutrient iron. Increases in usually low chlorophyll values occur occasionally due to natural iron enrichment (dust deposition, eddy transport, below surface layer transport). Although limitations of 1-D modelling become apparent here, an assumed input of iron in the model is able to explain the differences between simulated and observed oxygen and chlorophyll maxima.

1 November, 11:40 (POC_P-4360)

Variability of vertical diffusivity at the eastern gap of the Bussol' Strait

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The Bussol' Strait is a major site of water exchange between the Okhotsk Sea and the North Pacific. It is suggested that there is strong vertical turbulent mixing because of strong tide and that resulting diapycnal upwelling plays an important role in Oyashio southward intrusion and bidecadal variability in northwestern subarctic Pacific. However, it has not been clear how strong vertical turbulent mixing is and how much it temporally changes. We measured vertical mixing directly by vertical microstructure profiler (VMP2000) in the Okhotsk cruise in August 2006 and observed strong vertical diffusivity up to $10^3 cm^2/s$. At the eastern gap of the Bussol' Strait, where the mean component of flow had two-layered structure and the amplitude of diurnal tide was about 1.5m/s even for the depth deeper than 1000m depth, we performed repeat of VMP2000, conductivity-temperature-depth (CTD) and lowered acoustic Doppler current profiler (LADCP) observations for 24 hours. To cover the depth where VMP2000 could not measure vertical mixing, vertical eddy diffusivity is estimated indirectly using density inversions in CTD profile data. To establish the validity and calibration of the indirect method, we used the directly measured VMP data and CTD data obtained concurrently. This shows that the depth of strong mixing corresponded to the depth of large amplitude of diurnal tide and that simply averaged diffusivity in the water column (0-1500m) at this station amounted to ~300cm^2/s.

1 November, 12:00 (POC_P-4333)

Physical oceanographic features of HABs in the southern coast of Korea

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Harmful algal blooms (HABs) represent a significant and expanding threat to fisheries resources and human health in Korea. Based on our regular monitoring since 1981, we proved that the nature of dinoflagellate blooms have changed over the last two decades. Their outbreaks were rare during the 1980s, but they became frequent and persistent during the 1990s. In light of their spatial distribution, they occurred mainly in the South Sea of Korea during the 1980s, then became widespread, encompassing the entire southern coast and some part of eastern and western coasts of the Korean peninsula during the 1990s. In recent years they have occurred again on the southern coast of Korea. HABs occurred mostly in mid-summer and lasted more or less one week during the 1980s, but have become more persistent, lasting more than two weeks since the 1990s. In particular, one bloom of Cochlodinium polykrikoides persisted for nearly two months in 1995. In this study, the relationship between HAB development and physical environment parameters collected at our regular monitoring stations along the southern coast of Korea are examined to understand the physical processes which are playing vital roles in the coastal environments where HABs develop.

1 November, 12:20 (POC_P-4339)

Baroclinic structure in the subarctic gyre of the North Pacific from the Argo float CTD data

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We analyzed conductivity-temperature-depth (CTD) data obtained from Argo floats drifting during October 2005-September 2006 in the subarctic North Pacific north of 30°N. A geopotential anomaly of 1000db was calculated and interpolated using an objective analysis method to make a map every two months. The geopotential maps at 20db showed that the east-northeastward current flowed at about 45°N in the central Pacific throughout the 1-year observational period. The northward transport in the upper 1000m also did not change during this period. In addition, the southern limits of the subarctic gyre, taken from the Argo data, continued to be located around 40°N and 50°N in the western and eastern waters of the central Pacific, respectively. These locations were slightly similar to the southern limit of the positive curl-tau which was a mean of 37 years from 1970 to 2006. It is suggested that the baroclinic structure in the upper 1000m is stable in the interior of the subarctic gyre and it may depend on the mean wind field. The barotropic response of the subarctic gyre to wind stress was suggested in the North Pacific (Isoguchi *et al.*, 1997; Qiu, 2002), although the Sverdrup balance may not be assumed in this gyre (Tatebe and Yasuda, 2004). On the other hand, a 5- to 6- year variation was suggested to dominate this gyre and to be generated by the baroclinic structure (Qiu, 2002). These variations may not strongly affect the density structure of the upper 1000m.

1 November, 14:00 (POC_P-4111)

A mixing process of the Oyashio water as revealed by sequential observations off southeast Hokkaido, Japan (OECOS-WEST)

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As part of the Ocean Ecodynamics COmparison in the Subarctic Pacific (OECOS)-WEST field program whose goal was to reveal processes associated with phytoplankton blooms, sequential conductivity-temperature-depth (CTD) observations were made in the southeast off Hokkaido, where the Oyashio flows. In total, we obtained 14 and 71

temperature and salinity profiles from the sea surface to the 1000m from 8 - 15 March and 5 April - 1 May 2007, respectively. During these periods, temperature fields (Meteorological Agency, 2007) at the 100m depth showed that a warm eddy did not exist and warm water extended north from the Oyashio Front. In March, both temperature and salinity of the water column were higher than those of the Oyashio water, especially from the sea surface to 200m depth. In April, these high temperatures and salinities persisted at the top and bottom of the water column, with exceptions at 200–600m depths where the properties became identical to those of the Oyashio. The water characterized by the higher temperature and salinity is the ‘modified’ Oyashio water which was formed in the southeast off Hokkaido or carried from the Oyashio Front. It is believed that the Oyashio water is modified by mixing with the subtropic waters originating from the Kuroshio, warm eddies and the Tsugaru Warm Current, and is mostly carried south of the Oyashio Front. Our results suggest another scenario in which a large amount of the Oyashio water is modified north of the Front and carried east as a part of the subarctic gyre.

1 November, 14:20 (POC_P-4064)

SST anomalies related to wind stress curl patterns in the Japan/East Sea

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Local and non-local forcings are recognized for sea surface temperature (SST) variability. Studies for the Japan/East Sea (JES) have been focused on interannual to interdecadal timescales and links of SST anomalies to large-scale atmosphere processes affecting local air–sea heat exchange (Minobe *et al.*, 2004; Park and Chu, 2006). Non-local heat fluxes are induced by large-scale oceanic currents and mesoscale features. The mesoscale dynamics is highly intense in the JES. Here, we study the variability of the JES SST by Complex Empirical Orthogonal Function (EOF) analysis; links to wind stress curl are revealed and implications to circulation features are discussed. Daily New Generation SST from July 1, 2002 to July 7, 2006 (Guan and Kawamura, 2004) is analyzed. Typical patterns of wind stress and curl obtained from NCEP/NCAR 6h 1° × 1° gridded data for 1998-2005 (Trusenkova *et al.*, 2006) and occurrences of cyclonic and anticyclonic curl are used. SST anomalies are obtained by removing an average annual cycle represented by the leading mode of the initial data decomposition. The first mode of the residual anomalies represents an adjustment to the average annual cycle, greatest in December, with the increased (decreased) SST in the southern (northwestern) JES. The maximum adjustment is linked to the inflow in the Korea Strait and to areas of cyclonic wind stress curl over the northwestern JES. The second, semiannual mode accounts for the SST increase around the western subarctic front, greatest in May-June/November-December and lagging 2 months behind the increased occurrence of anticyclonic wind stress curl.

1 November, 14:40 (POC_P-4424)

Near 60-day variation of the Kuroshio observed in the East China Sea

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From the direct observation of the Kuroshio in the East China Sea (ECS), the Kuroshio volume transport for 13 months in 2003-2004 was calculated. The mean net (absolute) transport is 18.5±0.8 Sv with standard deviation of 4.0 Sv, and the mean velocity structure is characterized by a deep countercurrent over the continental slope beneath the Kuroshio and a recirculation offshore (Andres *et al.,* 2007, submitted). Observed bottom temperature near the shelf break (water depth: 290m) shows a dominant near 60-day variation. Decrease (increase) in the temperature at this period is closely related to the strengthening (weakening) of the vertical shear in along-shelf velocity, consistent with the thermal-wind relationship. The near 60-day variation was also found in both acoustic travel-time data and the net Kuroshio volume transport. The observed 60-day variation of the Kuroshio in the ECS has not been previously documented. Focusing on the 60-day variation, the relationship between the observed Kuroshio in the ECS and the wind northeast of Taiwan will be discussed as a possible forcing mechanism.

1 November, 15:00 (POC_P-4482)

Observational evidence of the Yellow Sea Warm Current

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The Yellow Sea Warm Current (YSWC) is the main current in the southern region of the Yellow Sea in winter. This paper uses data from 3 moorings in the path of the YSWC and a conductivity-temperature-depth (CTD) station in the same area to study the 3-dimensional structure of the YSWC. The results show that: (1) In a monthly averaged timescale, the YSCW is stable northward from the sea surface to the bottom; (2) the upper layer of the YSWC is strongly influenced by the winter cold front, with the direction of the YSWC often changing when the strong cold front arrives; (3) the bottom layer of YSWC is also influenced by meteorology but is stable northwestward where the currents are between 4cm/s to 10 cm/s; (4) warm water in the bottom layer also indicates that the YSWC is stable near the bottom.

1 November, 15:20 (POC_P-4163)

Salinity variability in the Japan/East Sea

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A variety of climatic conditions in separate parts of the Japan/East Sea creates a number of distinct factors which influence water salinity. This leads to river run-off, ice formation and ice thaw prevailing in the north and northwest of the sea. Evaporation, atmospheric precipitation and circulation play the main role in the south and southeast of the sea. In Tatar Strait fresh water is connected to Amur River run-off. In the present work multiscale variability of Japan/East Sea salinity is examined using an oceanographic database for 1920-2006 which includes about 185,000 salinity profiles. Statistical research of salinity is carried out. Accuracy of salinity tool measurements for the different time periods is determined. The Japan/East Sea is divided into 6 areas using annual curves salinity cluster analysis. In each of the divided areas, the interannual salinity variability in different layers is investigated. The periods of salinity variation are determined approximately. It is found that the salinity of the Japan/East Sea is reduced. Cluster analysis of t-s curves shows a non-uniformity in interannual variability of water masses characteristic at the north and south areas of the Japan/East Sea.

1 November, 16:00 (POC_P-4320)

Some features of Peter the Great Bay hydrological regime in the fall–winter period

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The regime of Peter the Great Bay (northwestern Japan/East Sea) waters is considered, based on the data of two complex surveys conducted in November-December 1999 and in March 2000, and more frequent conductivity-temperature-depth (CTD) observations along 132ºE. Three main factors controlled the distribution of temperature and salinity: convection, upwelling of intermediate water, and advection of freshened water by the Primorye Current. Autumnal stratification changed to a winter quasi-homogenous structure within several days in late November. In winter, a bottom layer with high density formed due to brine rejection, and subsequent convection. This water spread from the Amur Bay to the southern part of the Ussury Bay, then to the shelf edge and along the continental slope to the deep basin. The winter season ended in late March when both temperature rise and salinity decrease, that was caused by heat influx growth, winter monsoon weakening, and strengthening of the Primorye Current advection into the Bay opened part of the Bay.

1 November, 16:20 (POC_P-4362)

Current and turbulent observations of North Pacific intermediate water in the Kuroshio-Oyashio confluence region

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North Pacific Intermediate Water (NPIW), characterized by a vertical salinity minimum, is renewed in the Kuroshio Extension (KE) region where the eastward KE and the southward alongshore Oyashio form a confluence. Current and turbulence observations were performed using a vertical microstructure profiler (VMP), conductivity-temperature-depth (CTD) and acoustic Doppler current profiler (ADCP) in order to investigate contributions of turbulence and baroclinic instability to watermass transformation and NPIW formation. We found large vertical diffusivity ($10\sim100 cm^2 s^{-1}$) around a salinity minimum at the station just before the confluence near the Boso peninsula. The strong turbulence possibly reduces the salinity minimum. Just after the KE separated from the Japan coast, Oyashio water was observed to intrude into the intermediate depths (300~600m) of the KE where a remarkable salinity minimum was formed. Around these prominent salinity minima, vertical diffusivity was relatively large ($\sim1 cm^2 s^{-1}$). The low-salinity water intrusion had an eddy-like structure in the intermediate layer, which is consistent with a baroclinic instability wave. The directly measured velocity from ADCP and CTD data show these intrusions transported 2.0~2.5Sv of Oyashio water in the density layer between 26.6-27.4σ_θ.

1 November, 16:40 (POC_P-4481)

Using the transform method to study the generation of internal tides

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The generation of internal tides draws a lot of interest because of its important role in diapycnal mixing. Difficulty in obtaining eigensolutions of internal tides over curved topography is a limitation for further theoretical study on the generation problem. There have been two assumptions: the weak-topography assumption and the unlimited water depth assumption, that were usually used in previous studies. This study suggests a kind of transform method that can convert the subcritical curved topography in physical space to a flat bottom in transform space while the governing equation of internal waves is still hyperbolic in transform space. Thus, one can obtain eigensolutions of internal tides generated over subcritical topographies when the assumptions of weak topography and unlimited water depth are both withdrawn. The energy flux of internal tides is calculated and the results for Gaussian topography show that: (1) when the topographic slope is much smaller than the slope of internal tide rays, the energy flux reduces to the results of Llewellyn Smith and Young (2002), who investigated the energy flux of internal tides generated over weak topography under the frame of limited water depth; (2) this energy flux deviates more obviously from the result of Llewellyn Smith and Young (2002) when the ratio of the topographic slope to the slope of internal tidal rays becomes larger; (3) the energy flux in this study is reduced to Bell's result, which is obtained under both assumptions, when the water depth approaches infinity no matter whether the topographic slope is larger or smaller.

1 November, 17:00 (POC_P-4110)

On the World Ocean as the primary natural cause of Global Climate Change

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The main effects of Global Climate Change (GCC) are due to changes of climatic parameters in space-time distributions. So, GCC may be represented by changes in the space–time spectra of temperature dispersions. The main source of climate fluctuations is the Sun's energy, but we have to look for changes that are not so common with the energy, as in its absorption and accumulation in different parts of the Earth. These processes change considerably over the land due to human activity, but energy accumulation is negligible there. The World Ocean,

occupying 72 % of the Earth surface, is the main accumulator of solar energy in the 100-200 m layer. The process is highly dependent on the ocean water optical properties, which depend crucially on primary production and plankton concentration. Fluctuations in ocean production can be caused by large fluctuations in the non-energetic, but biologically active part of solar radiation. By analyzing mechanisms of solar activity influences on the ocean biota, estimating corresponding changes of the ocean water properties and fluctuations of solar energy accumulation, as well as mechanisms of the energy redistribution over the Globe by dynamical processes in the ocean and atmosphere, we come to the conclusion that the lowest trophic layers of ocean ecosystems can be looked at as the most important cause of Global Climate Change on a decadal scale.

POC Paper Posters

Poster POC_P-4115

Why and when is the jet of the Kuroshio Extension destroyed?

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A model of an eastern zonal jet has been developed and applied to the Kuroshio Extension and Gulf Stream Currents after their separation from the coast. The model equations are based on a variational approach to the minimum entropy production (Glansdorff P., Prigogine I.). Approximate analytical solutions are developed in which Stommel's model is a special case without dissipation. It is shown, that 1) a condition of jet existence is an asymmetric current shape with sharp northern borders and eroded southern borders; 2) the current dynamical axis is located to the south of the convergence axis. This provides a condition for the sinking of cold northern water and the formation of intermediate subtropical water; 3) there is a critical parameter range out of which the current is not a jet current anymore. This can affect climate change in western Europe and Northern America. The distribution of temperature and salinity across the Subarctic Front and the Kuroshio in the western and central North Pacific is presented. We will discuss the performance of critical model parameters based on climatic trends.

Poster POC_P-4146

Water structure and circulation variability in the Komandor-Kamchatka area

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The given studies were based on the resources of the Pacific Oceanological Institute Far Eastern Branch, Russian Academy of Science (POI FEB RAS) data bank including, archived materials of the national research cruises in the Komandor-Aleutian Islands area, the data of the modern field observations carried out by POI, FEB RAS, as well as the global array of the average long-term hydrological data of the more than a semi-centennial period covering the whole area of the NW Pacific. The role of the Komandor-Aleutian Island Straits in the formation of water characteristics of the Kuril-Kamchatka Current zone was analysed. The dependence of water structure formation in the current zone on the variability of water exchange through the straits was revealed. New information about the variability of hydrological water characteristics was obtained. It was shown that in winter, the Bering Sea waters inflow through the straits is the most intensive. Kamchatka Strait is the main supplier of the cold transformed Bering Sea waters. In the sub-strait zone of the Komandor-Kamchatka area, the current is replenished both by the warm and high-salinity waters of the Aleut Current. As a result of the variability in water discharge to the ocean through the Kamchatka Strait and of Aleut Current zone distribution, water circulation varies in the Komandor-Kamchatka area, corresponding with the thermohaline characteristics of the Kuril-Kamchatka Current zone. Such variability has both a seasonal and interannual character.

Poster POC_P-4164

Interannual variation of the water mass mixing ratio in spring revealed by $\delta^{13}C$-$\delta^{18}O$ distribution in the coastal region off eastern Hokkaido

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The coastal region off eastern Hokkaido, the most western of the Kuril Islands, is one of the pathways of water masses between the southern Okhotsk Sea and the western North Pacific. In the southern Okhotsk Sea, the Soya Warm Current water (SWCW) flows along the northeastern coast of Hokkaido, and the East Sakhalin Current water (ESCW) moves southward along west side of Sakhalin Island. Former studies suggested that cold fresh water mixed with sea ice melt-water flows out of the Okhotsk Sea via the Nemuro Strait and affects water properties of the coastal part of the Oyashio water (OYW). However, it was not clear how much volume of SWCW and/or ESCW was coming from the Okhotsk Sea to the area off southeastern Hokkaido, as well as sea ice melt-water. We used stable isotopes, $\delta^{13}C$ of dissolved inorganic carbon (DIC) and $\delta^{18}O$ of seawater, as chemical tracers of SWCW, ESCW, and OYW. $\delta^{13}C$-$\delta^{18}O$ plots of coastal water off southeastern Hokkaido obtained in January, March and May in 2005 and 2006 suggest that the mixing ratios of SWCW and ESCW change year-by-year, while temperature and salinity have small differences. We were able to detect sea ice melt-water once in January 2005 when it moved out with the mixed waters of SWCW and ESCW. However, we could not detect it during other cruises.

Poster POC_P-4168

Modeling of barotropic eddy evolution near a chain of islands

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Eddy evolution near a chain of islands was investigated by means of theoretical modeling. There are two well-known examples of this phenomenon: anticyclonic Kuril eddies originating from the Kuroshio rings in the North Pacific, and the North Brazil Current rings moving to the Lesser Antilles in the near-equatorial North Atlantic. In this study, an island lying between two headlands has been considered as the principal element in a chain of islands. A coastal irrotational background current was induced by a balanced source–sink system located in the straits. Barotropic quasi-geostrophic approximation and the constant Coriolis parameter were used. Eddy evolution in the vicinity of the straits was studied both analytically, using a point-vortex approach, and numerically with the contour dynamics method. Three different regimens of eddy evolution were detected: (i) a free passage along the coast, (ii) a complete penetration through the strait, and (iii) a capture of the eddy in the entrainment zone between the straits. These regimens and their combinations (*e.g.*, partial capture or partial penetration) were controlled by the ratio of the eddy and island sizes, the proximity of the vortex trajectory to the coast, and the ratio of the coastal current and eddy intensities. As has been seen, large eddies cannot be captured, even partially. On the contrary, for relatively small eddies, a family of stable steady states has been found.

Poster POC_P-4171

Mechanisms of lateral circulation in Academy and other bays of the Shantar Archipelago, Sea of Okhotsk

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Academy Bay is an important summertime feeding ground for pelagic-feeding bowhead whales (*Balaena mysticetus*). Tidally-driven circulation in the Shantar archipelago has been studied using satellite observations, physical (CTD, currents, tides) and biological (zooplankton sampling) measurements. It is shown that dense

populations of large zooplankton species (such the copepod *Calanus glacialis*, and pteropod *Limacina helicina*) are concentrated five-fold by physical mechanisms within this critically important ecosystem. The lateral gradients of salinity are asymmetrical, with higher salinity at the deepest location. The combination of flood tidal currents and strong landward estuarine circulation near the bottom leads to a maximum in currents in the western or central part of the Bay. The lateral cells are strongly asymmetric. Tidally averaged lateral circulation with convergent surface flow and divergent bottom flow persists due to flood-ebb and east-west asymmetries. The surface convergence, associated with lateral circulation, accumulates the arctic mollusc *Limacina helicina*, while divergent bottom flow is associated with western accumulation of arctic calanoids (such as *Calanus glacialis*). Within the headlands tidal currents (with amplitude of ~ 80 cm/s) further act to aggregate zooplankton. Tidally driven lateral circulation acts to concentrate zooplankton and provides the necessary densities of planktonic prey for bowhead whales.

Poster POC_P-4194

Influence of atmospheric processes on water circulation in the 200-m layer of the Sea of Okhotsk on the basis of modelling

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On the basis of numerical experiments, using a quasi-stationary baroclinic model and the "north-western" type of the atmospheric processes (classification of Polyakova), water circulation in 200-m layer of the Sea of Okhotsk and the mechanism of behaviour of the hydrodynamical structures in it are studied. In brief, model predictions were made using the principles of self-similarity or vertical similarity, based on the function of their stratification. Input information for the model is a global array of monthly averaged climatic data on surface temperature and salinity in nodes of a regular grid $10' \times 10'$ from the Generalized Digital Environmental Model (GDEM) archive, and average monthly fields of the atmospheric pressure, corresponding to a given type of baric system. Bottom topography, coastline framework, water exchange on the margins, β-effect, and coefficients of the vertical and horizontal turbulent exchange were used in the parameterization. The "north-western" type of atmospheric circulation, based on the dislocation of the main trajectories of cyclones over Far Eastern Seas and North Pacific, was chosen because it is expressed throughout the year. Analyses of charts for transport streamfunctions have shown that the study area is characterized by quasi-stationary hydrodynamic characteristics not dependent on the atmospheric circulation and specific hydrodynamic features stemming from atmospheric baric systems originating over the ocean surface. The common feature for all charts in the 200-m layer is a mosaic of anticyclonic eddies, which are a result of turbulent mixing. The distribution of hydrodynamical structures has a strongly pronounced seasonal nature that is influenced by "north-western" type of atmospheric processes. For example, anticyclonic eddies are most active and are more strongly advanced in a studied layer during the autumn period (October, November). It fully complies with the activity of the considered synoptic situations because during this time of the year, it is most intensive.

Poster POC_P-4205

Are deepening mixed layers responsible for transporting deep nutrients into surface waters in the northern Gulf of Alaska?

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The northern Gulf of Alaska is a region with a "nutrient paradox". Whereas most productive marine ecosystems are located in upwelling zones, the northern (coastal) Gulf of Alaska is a region of predominantly downwelling inducing winds. Other mechanism(s) are required to explain how nutrients are made available in the euphotic zone. This study uses Spearman's correlation techniques to correlate hydrographic data and mixed layers with nutrient concentrations along the Seward Line in the northern Gulf of Alaska. Hydrographic and nutrient (nitrate, phosphate, silicate) data used here are from January 1998 to December 2001, from the GLOBEC (GLOBal ocean ECosystem dynamics) NEP (Northeast Pacific) program. Highly significant positive correlations between nutrients at depths of 150-300 m with salinity and negative correlations with low-temperature waters on the continental shelf strongly suggest that the

source of nutrients to the shelf is the deep waters of the Gulf of Alaska. The nutrients are likely transported horizontally inwards along the bottom rather than within the surface Ekman layer. A secondary source of nutrients might be the Alaska Coastal Current during the late summer/early fall peak of freshwater discharge. MLDs (mixed layer depths) are negatively correlated with deep nutrients (75-300 m) on the inner shelf, but it is significant that the correlations decrease rapidly at the shelf-break and offshore. This indicates that additional mechanisms might be involved in bringing nutrients to the euphotic zone, especially in the outer shelf region of the northern Gulf of Alaska.

Poster POC_P-4210

Extreme distribution of floating ice in the NW Pacific

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From January to April floating tongues of ice move from the Sea of Okhotsk to the NW Pacific through the Kuril Straits. At the same time, along the eastern coast of Kamchatka Peninsula, a solid sheet of floating ice descends. In January and February, during extremely hard years, the individual floating ice tongues move from the Bering Sea along Kamchatka Peninsula to the Fourth Kuril Strait which is 30-50 miles in width. In March, the width of the ice block along the eastern coast of the Kamchatka Peninsula may increase up to 100 miles and propagate towards Onekotan Island. During cold years, floating ice from the Bering Sea reaches its largest propagation along the Kamchatka Peninsula in April, while stretching to the south and south-east from the coast for 200 miles. In the area of the Northern Kuril Straits, except for the First Kuril Strait, there were no sightings of the floating ice by aircraft. Along the Malaya Kuril Ridge the ice lessens, as compared to March. The floating ice blocks can still come through any strait of the Kuril Ridge to the ocean (from Kruzenshtern Strait and far to the south) but they no longer possess such length, and the ice tongue width does not exceed 30 miles. In April, along Hokkaido Island, the floating ice was not fixed during the whole period of observations.

Poster POC_P-4233

Amur River discharge, ice cover of the Okhotsk Sea, Tatar Strait and the atmospheric indices of the Asia-Pacific region – The assessment of relationships

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Here, we investigate the relationship between atmospheric indices (pressure difference anomalies between the Siberian High, Hawaii High and Aleutian Low – SH-HH, SH-AL, HH-AL) and anomalies of Amur River discharge (ARD) and ice cover of the adjacent Amur River Basin (Tatar Strait – Ice_Tat, Okhotsk Sea – Ice_Okh) for the period 1930-2001. Our study shows that simultaneous feedback of ARD, Ice_Okh and Ice_Tat on external periodic forcing of the atmosphere has changed during last century. Interannual variability of these parameters, smoothed with an 11–year running average, shows oscillations with different periods and amplitudes. In the 1940s, 1970s and 1990s, the atmospheric indices changed their sign. The most pronounced climate shift occurred in the 1970s and was accompanied by a change in the relationships between SH-HH, SH-Al, HH-AL and regional hydrometeorological parameters. The SH-AL oscillation period lessened by twice after the 1970s. Cluster and correlation analyses of 3-year running data for two periods (before and after the 1970s) suggest changes in the climate system. A Cluster Tree has been subdivided in two large clusters, including the aforementioned indices and sea surface temperature (SST) in Okhotsk Sea and Tatar Strait, precipitation in Amur River Basin, ice cover, ARD. The remarkable change in correlation has obtained between atmospheric indices, AO, SST, and ARD. We found very high correlations between the range of SST and AO (0.88-0.90) while the ranges of other hydrospheric parameters have a robust correlation with regional atmospheric indices (0.79-0.94). The correlation between the AO range and the atmospheric indices ranges are less than 0.45. A high correlation between Ice_Okh and ARD ranges (0.74) is associated with the simultaneous influence of atmosphere forcing on these components.

Poster POC_P-4238

Atmospheric circulation over the Northern Pacific

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The classification of atmospheric circulation is carried out on the basis of a 50-year period of observations. It is distinguished by six types: North-Western (NW), Okhotsk-Aleutian (OA), Latitudinal-Aleutian (LA), Southern-Latitudinal, Okhotsk-Hawaiian (OH), and Cyclones over the Ocean (Co). All six types of atmospheric processes are characterized by a distinctly expressed seasonal motion: they are the most intensive in winter, somewhat weaker in autumn, even weaker in spring, and have minimum intensity in summer. All six types of atmospheric processes occur in 3-5, 5-6, 6-7, 11-12-year periods. The NW, OA, LA, and Co types are characterized by a pronounced 30-year cycle possessing an anisochronous character for all four types of seasonal situations.

Poster POC_P-4321

Surface thermal fronts in the Japan/East Sea

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The historical study of ocean frontal zones, sections, and fronts is short. Only in the first 40 years of the twentieth century was the first evidence provided of special areas connected to thermal phenomena in the study of fronts. Pioneers in the study of ocean fronts were the Japanese scientists (Uda, 1934; Suda, 1936). The necessity of studying ocean fronts was dictated to them first by the interests of the coastal fishery that would ensure enough protein for the Japanese population. Today, the fishing industry interests remain an important stimulus for research in fronts. The study period of ocean fronts is divided into two stages: Stage 1 (1934–1975) - ship research using standard or special technology developed for deep-water sounding of the ocean and stage 2 (1975–present) - remote research, which is especially effective in the study of thermal fronts on the ocean surface. In the present work, we analyse remote IR and TV NOAA images for 1976-2003. Using information from published references, the classification of fronts is executed within the limits of the Japan/East Sea. The scheme of superficial thermal fronts differs from traditional representations. The basic elements of the hydrological structure in the Japan/East Sea are consistently shown for all seasons. In this area the basic Subarctic Front (SAF) is divided into 2 western branches: Northwest (NW) and Southwest (SW) and 2 northern branches: Northeast (NE) and Northern Central (NC). The bifurcation points of the Subarctic front are in the west – 40.5°N, 134.5°E, and in the east at coordinates 41°N, 139°E. The division of the SAF on warm and cold sectors is most appreciable as it is marked in the central part of the sea, between bifurcation points, and already behind each of these points SAF is divided into two branches that are connected to features of circulation in this area. Geographically, SAF is focused in the central and western part of the sea mainly on breadth, and in the northern part on a longitude. Three fronts are allocated in the Tsushima Current zone. In coastal areas the fronts of seaside, West-Sahalinskoe, North-Korean currents are located. The Subarctic front and its branches are found on IR and TV images in all seasons. It is most clearly shown at the end of winter, when it is precisely traced as two fronts. In the spring the basic attributes of the two branches of fronts of the Subarctic front are maintained, but gradually in the beginning of the summer they weaken. In the summer the presence of the SAF on the surface is only seen via some its characteristic attributes, while at depths below the seasonal thermocline the front seen from ship data is expressed clearly. In the autumn the fronts are clearly found. The greatest gradients of temperature on the Northwest branch of the Subarctic front are marked in November, while on the Southwest branch they are marked in February, March and May. SAF represents an extensive zone in the Japan/East Sea, therefore, its influence on all local fronts is considerable and is defined by its site and capacity. The elements of spatial distribution, seasonal and interannual variability can be planned within the limits of the appropriate frontal zones and allow classification of thermal conditions in warm and cold years. It is possible with enough confidence to assert that last year's intensive advection of waters of subtropical structure in the northwest part of the Japan/East Sea will be kept on a rather high level for the near future.

Poster POC_P-4323

Spatial-temporaral variability of shore polynias in the northern Sea of Okhotsk

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The character of seasonal ice-extent variability can cause either favourable or adverse conditions for spawning grounds, migration routes and the formation of commercial targets stocks. Herring are one of the most important species inhabiting the waters of the northern Sea of Okhotsk. The features of migration connected with the change of generation abundance and success in spawning (Ayushin B.N. 1947, Tyurnin B.G. 1975, etc.) depend on oceanographic conditions, and practically all herring strong year classes occur only under favourable ice conditions within the spawning area (Melnikov I.V., 2001). The aim of this paper is to study features such as the shore polynias of the ice regime in the Sea of Okhotsk. Satellite surveys of ice cover erosion were used in the analysis. The occurrence and steady development of shore polynias were determined and their areas were calculated according to these data. Since ice and atmospheric processes develop in relation to each other, indices of atmospheric circulation by Kats, calculated for the period from November till June, were used to analyse the reasons for polynia formation. Occurrence and understanding of the polynias, set against a background of intraseasonal anomalies of Kats indices, are determined. The process of steady expansion of open water zones is related to seasons with positive anomalies of meridional index prevalence, *i.e.*, under intensive northern transport. Such regularities are not revealed for anomalies of a zonal index.

Poster POC_P-4337

Year-to-year variability of cold water in the southwestern region of the East/Japan Sea

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Year-to-year variability of cold water in the Ulleung Basin of the East/Japan Sea is investigated based on historical hydrographic data. Three different types of cold water are distinguishable: northern and southern cold water along the east coast of Korea and one offshore in the southern Ulleung Basin. In summer their distributions show three characteristic patterns. In general, northern cold water that has been noticed in the northwestern region of the Ulleung Basin near the east coast of Korea extends offshore and southward along the coast in summer. However, its offshore, as well as southward, expansion varies largely from year to year. Southern cold water near the east coast of Korea around 36°N also varies from year to year. Southern cold water combines with the northern cold water into a large mass in some years but is isolated from the northern cold water due to the warm water mass associated with the Ulleung warm eddy. The relationships of the bottom cold water around the Korea Strait with these other cold water features are examined. The bottom cold water in the western region of the Korea Strait is probably related to the expansion of the cold water appearing along the east coast of Korea, while that in the central region of the Korea Strait is related to the southward expansion of offshore cold water.

Poster POC_P-4348

Turbulence observations around the Kuril Straits

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Direct turbulence measurements were performed by using a vertical microstructure profiler (VMP2000: Rockland Scientific Inc.) in the joint Japan/Russia August–September 2006 cruise of the R/V *Prof. Khromov* (Far Eastern Hydrometeorological Research Institute) around the Kuril Straits where vertical mixing is expected to be large due to strong diurnal tidal currents. A total of 41 casts were performed, mostly down to 600m depth or near the bottom. At three stations, 6–7casts were repeated over 24hours around the Kuril Islands, 15 one-time stations around the Bussol' Strait, and one shallow station of 6casts/12hours in the northwestern Okhotsk Sea. Data with falling speeds

less than 0.45m/s were excluded; vertical mixing coefficients were estimated with Osborn's (1980) formula. One-day mean vertical mixing coefficients averaged in the water column were 0.8cm^2/s at the station west of Urup Island, 7.6cm^2/s at the station east of Urup Island and 33cm^2/s at the station of the eastern gap of the Bussol' Strait. At the easternmost station of the Bussol' Strait, 1260cm^2/s was observed as a column average while a simple average across the Bussol' Strait was estimated to be 130 cm^2/s.

Poster POC_P-4350

Vertical mixing in the Ulleung Basin in the East/Japan Sea

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In order to investigate mixing in the Ulleung Basin in the East Sea, the Korea Ocean Research and Development Institute conducted a hydrographic survey which included turbulence measurements using the R/V *Eardo* in September 2006 and March 2007. In 2006, a small warm eddy characterized by homogeneous 10° water appeared at 100 - 200 m depth in the region southwest of Ulleungdo. Sea surface temperature was lower near the coast of Dok Island (Dokdo) compared to the outer area, indicating mixing near the island in March 2007. Microstructure profiling measurements were carried out at 26 stations in the Ulleung Basin and at 10 stations between Ulleungdo and Dokdo, respectively. The dissipation rate of turbulent kinetic energy (ε) is used to estimate the diapycnal eddy diffusivity. The largest value of ε, 1×10^{-5} Wkg^{-1}, appears in the surface layer. The stability in the thermocline is very strong, even though it takes much more energy to displace a particle of water. It is characterized by a high value of the Brunt-Väisälä frequency, 1×10^{-4} s^{-1}, and high ε in the thermocline is measured. This high ε in the thermocline seems to be caused by internal waves. Higher eddy diffusivity of 5×10^{-3} m^2 s^{-1} is calculated at a station near Dokdo which probably results from the island effect of Dokdo.

Poster POC_P-4497

Data assimilation studies at the Institute of Ocean Sciences for estimating the North Pacific Ocean circulation

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Data assimilation is the general term referring to techniques used to blend observed data and model-produced state vectors for optimal estimation. In the next three years, several data assimilation studies for estimating the North Pacific Ocean circulation will be conducted under the support of COMDA/DFO and GOAPP/CFCAS projects at the Institute of Ocean Sciences. In this presentation, we will summarise plans for data assimilation studies and their potential impact on hindcast and forecast studies of the physical and biological environment.

Posters from International Organizations / Programs

Poster Observer_P-4144

The Bering Sea Ecosystem Study (BEST): A new program for the eastern Bering Sea

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The Bering Ecosystem Study Program (BEST), sponsored by the U.S. National Science Foundation Office of Polar Programs, seeks to develop a fundamental understanding of how climate change, with a focus on diminishing seasonal sea ice cover, will affect the marine ecosystems of the eastern Bering Sea, the continued use of its resources, and the economic, social and cultural sustainability of the people who depend on them. Fieldwork will span four years (2007–2010) with a final synthesis year (2011). In the first competition, five proposals were funded. A second competition has been completed for field work starting in 2008. The first cruise, 10 April–12 May 2007, was a cooperative effort between BEST and NOAA researchers onboard the US Coast Guard ice-breaker *Healy*. Future cruises are planned yearly in early spring (March–April), with a second yearly cruise most likely in summer (late June–July). A social science component has been developed in collaboration with Alaskan Native Communities. The Planning Office has been facilitating outreach and educational activities for the program and the coordination of BEST research with the investigations of other U.S. and foreign programs working in the Bering and other sub-arctic seas. Through close cooperation and integration of effort, we expect the emergence of a much stronger program than could have been sustained by any one agency or country alone.

Poster Observer_P-4300

Argo – An ocean observing system for the 21st century

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

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This poster updates readers on the progress of the international Argo array. Argo is an international venture designed to install a global array of profiling floats in all oceans of the world, with deployments starting in 2001 and continuing to the present day. The poster will summarize progress towards full implementation of a globally homogeneous array of devices. By the time the poster is displayed at the PICES meeting we will be very close to having 3000 floats reporting data every 10 days from every ocean basin on the planet. This was the original plan advertised in the Argo prospectus written in 1999. The prospectus also voiced the objective of making all data freely available in near-real time and we are almost achieving this objective. Currently 90% of all profiles are available for download from the Global Argo Data Centres within 24 hours of their acquisition. So far 25 nations have deployed floats in support of Argo and this is likely to grow in the near future. Argo now permits mapping of the physical oceanography of the top 2000 decibars of the ocean in real-time. This should be of particular interest to scientists attempting an ecosystem approach to the management of ocean resources. To date Argo has focused on its primary mission of describing the distribution of heat and fresh water in the oceans and the advection of those properties. However, in rapidly increasing numbers, floats are being deployed with sensors designed to observe dissolved oxygen. This opens the way to a wide area of new applications.

Poster Observer_P-4375

North Pacific Research Board and National Science Foundation partner in comprehensive study of eastern Bering Sea ecosystem

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The North Pacific Research Board (NPRB) and National Science Foundation (NSF) are partnering to study the eastern Bering Sea shelf ecosystem and how it may respond to climate change and loss of sea ice. It will include three field seasons in 2008–2010 and two years for analysis and reporting. It is based on the NSF 2005 Bering Ecosystem Study and NPRB Bering Sea Integrated Ecosystem Research Program. Nearly $50 million will support this program: $14 million from NPRB, $21 million from NSF, and the remainder in matching funds from NOAA, U.S. Fish and Wildlife Service, and U.S. Geological Survey. Over 70 federal, state, and university scientists will be involved, hailing mainly from Alaska, Washington, Oregon, and British Columbia. NSF will study atmosphere and ocean physics and lower trophic levels, including physical and biological sampling around sea ice and on the ocean floor, primary production near sea ice, nutrients and stratification, and energy transfer through zooplankton. NPRB will emphasize forage fish, commercial fish species such as pollock, Pacific cod, and arrowtooth flounder; northern fur seals, walrus and whales; and common murres and blacklegged kittiwakes. Foraging patterns of marine mammals and seabirds will be studied within large prey aggregations near the Pribilof, Bogoslof, and St. Lawrence Islands. NPRB also will support local and traditional knowledge research. Federal matching funds from NOAA, USGS, and USFWS will support trawl surveys; seabird telemetry; and studies of fur seal pups and persistence of foraging hotspots. An innovative ecosystem modeling activity will tie the program components together.

Poster Observer_P-4498

Ecosystem Studies of Sub-Arctic Seas (ESSAS)

Kenneth F. **Drinkwater**[1] and George L. Hunt, Jr.[2]

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Ecosystem Studies of Sub-Arctic Seas (ESSAS) is a regional programme of GLOBEC whose principal object is to compare, quantify and predict the impact of climate variability on the productivity and sustainability of Sub-Arctic marine ecosystems. ESSAS includes the Bering Sea, Sea of Okhotsk and the Oyashio Shelf Region in the Pacific and the Barents Sea, Iceland region, Greenland shelves, Newfoundland/Labrador shelves, Gulf of St. Lawrence and Hudson Bay in the Atlantic. Recently, changes in species abundance or distribution have been observed within several Sub-Arctic marine ecosystems, which appear to correlate with fluctuations in the physical environment. Sub-Arctic comparisons are expected to help determine the fundamental processes controlling the structure and function of their marine ecosystems. In June 2007, ESSAS held workshops in Hakodate, Japan that addressed the role of seasonal sea ice in marine ecosystems, the evaluation of IPCC models for predicting future climate scenarios in the Sub-Arctic seas and approaches to using models to compare the Sub-Arctic seas and to predict their responses to climate change. National ESSAS programs have been established in Iceland, Japan, Norway, and the USA, and other countries such as Canada, Russia, and Korea have participated in ESSAS activities. In addition, comparative ecosystem studies have been initiated within ESSAS between Norway and Canada (NORCAN) and Norway and the US (MENU). ESSAS is heading an International Polar Year (IPY) consortium, ESSAR (Ecosystem Studies of Sub-arctic and Arctic Regions), containing 13 projects lead by 9 different countries. Extensive fieldwork to back ESSAS objectives will take place within ESSAR.

W1 BIO Workshop Lessons learned during MIE-1 and MIE-2: Reconciling acoustics and trawl data

Co-Convenors: Evgeny A. Pakhomov (Canada) and Orio Yamamura (Japan)

Micronekton is one of the important but largely understudied components of marine ecosystems functionally linking small zooplankton and higher trophic levels. Recent advances in acoustic devices and efforts to standardize sampling gears undertaken by both PICES and ICES communities have made the sampling of micronekton more precise. Nevertheless, the issue of inter-calibrating the growing number of micronektonic gears is still unresolved. The PICES Advisory Panel on *Micronekton Sampling Inter-calibration Experiment* (MIE-AP) has organized two field experiments (off Hawaii in 2004 and off Japan in 2005) to collect comparative data for several micronekton sampling gears and a wealth of acoustic information. The main objective of this workshop will be: (1) to finalize the analysis and to compare MIE-1 and MIE-2 data sets; (2) to present and discuss acoustic data sets from both cruises; (3) to compare ICES and PICES inter-calibration experiments; and finally (4) to discuss new developments in the field of micronekton quantitative techniques.

Sunday, October 28, 2007 18:00 – 21:30

18:00 ***Introduction by convenors***

18:10 **Hiroya Sugisaki and Koichi Sawada (Invited)**
Introduction to J-QUEST research project: Quantification of micronekton using an integrated system of echosounder and stereo TV cameras (W1-4113)

18:40 **Réka Domokos, Evgeny A. Pakhomov, Michael P. Seki and Jeffrey J. Polovina (Invited)**
Acoustic characterization of the mesopelagic community off the Leeward coast of Oahu, Hawaii (W1-4229)

19:10 **Hiroki Yasuma, Kazushi Miyashita and Orio Yamamura**
Acoustic monitoring of a lanternfish *Diaphus theta* in the northwestern Pacific (W1-4331)

19:30 **Evgeny A. Pakhomov, M.P. Seki, A.V. Suntov, R.D. Brodeur and K.R. Owen**
Inter-comparison of three sampling gears during the first Micronekton Intercalibration Experiment (MIE-1): Size composition approach (W1-4086)

19:50 **Orio Yamamura**
Preliminary results of the 2007 MIE-3

20:10 ***Discussion on:***

- New developments in the field of micronekton quantification: could acoustics be the way forward?
- Is it possible to undertake a comparison between ICES and PICES inter-calibration experiments?
- How far are we in the acoustic data set analyses?
- Compatibility of acoustic and trawl data: Caveats, problems and solutions
- Lessons from the MIE-3 cruise
- An inter-sessional workshop to look at the data from 3 inter-calibration experiments and discuss drafting of the MIE-AP report (schedule, contents and allotment of writers)

W1 Oral Presentations

28 October, 18:10 (W1-4113) Invited

Introduction to J-QUEST research project: Quantification of micronekton using an integrated system of echosounder and stereo TV cameras

Hiroya **Sugisaki**[1] and Koichi Sawada[2]

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Using newly designed sampling gears, such as MOCNESS or MOHT, horizontal and vertical distribution as well as species composition of mesopelagic micronekton have become better understood. Net biomass values generally considered as underestimates when compared to acoustic estimates. It is not unusual that echosounder estimates of the mesopelagic fish biomass are 10 times higher than net sampling values. However, the species of mesopelagic micronekton cannot be identified precisely using echosounder. Since the ecology (migration pattern, feeding habit, *etc.*) of micronekton is different between individual species, their discrimination is important. Recently, an integrated system of echosounder and stereo TV cameras (J-QUEST) was developed. The system allows to collect acoustic and visual data on target species simultaneously. Presently, it is still difficult to identify micronekton species from the video image. Furthermore, the light system drives some micronekton away. To improve J-QUEST system quantification abilities we collect the information on individual species characteristics (*e.g.* distribution, body size, position of luminous organ *etc.*). In addition, there are efforts to improve the light isystem based on the visual characteristics of micronekton. Estimation of precise biomass of mesopelagic micronekton is very important for research on vertical transportation of organic matters in the ocean ecosystems. J-QUEST has potential to become a helpful gear for quantification of micronekton. The results obtained will contribute to the research of not only micronekton biology but carbon cycle in the ocean.

28 October, 18:40 (W1-4229) Invited

Acoustic characterization of the mesopelagic community off the leeward coast of Oahu, Hawaii

Réka **Domokos**[1], Evgeny A. Pakhomov[2], Michael P. Seki[1] and Jeffrey J. Polovina[1]

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Acoustic backscatter collected with a split-beam dual frequency echosounder system was used to describe the mesopelagic community off the west coast of Oahu, Hawaii. Surveys were conducted at the 38 kHz and 120 kHz frequencies, in waters typically 800 – 1300 m deep. The shallow scattering layer (SSL) was generally observed in the upper 200 m, while the deep scattering layer (DSL) was observed between 450 m and 750 m. Both layers exhibited dynamic and complex features, each composed of several thin layers with structures that varied both in space and time. While the SSL was considerably denser during nighttime than daytime due to the diel vertical movements of migratory micronekton, the DSL was a permanent feature likely reflecting the presence of non-migratory organisms and/or organisms that migrate from deeper waters during the night. Daytime the water column was devoid of organisms between ~200 m and ~400 m, while organisms were more dispersed vertically during night. Areas of shallower than ~800 m topography were associated with denser and deeper DSL. Differences in the strength of backscatter at the two frequencies in the upper 200 m indicate higher percentages of fish with swimbladder and possibly other gas-bubble-containing organisms in the SSL during nighttime than daytime, suggesting that these organisms make up the majority of micronekton that migrate to the surface during the night. Generally, the characteristics of acoustic backscatter are more consistent with trawl sample compositions from nets with larger mouth openings and mesh sizes relative to those of smaller nets.

28 October, 19:10 (W1-4331)

Acoustic monitoring of a lanternfish *Diaphus theta* in the northwestern Pacific

Hiroki **Yasuma**[1], Kazushi Miyashita[1] and Orio Yamamura[2]

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Diaphus theta is the most abundant mesopelagic fish in the northwestern Pacific. The purpose of this study was to quantitatively characterize the distribution of *D. theta*, and to investigate its relationship with other dominant species in the mesopelagic layer. Field acoustic data and biological samples were obtained both day and night in summer of 2005 (MIE-II) and 2006 off Hokkaido, Japan, using various trawls. These data were used to estimate the fish density and diel changes of its vertical distribution. Differences of acoustical target strength (TS) between 38 kHz and 120 kHz were applied to identify the echo of *D. theta* or other dominant species, such as krill. Temperature and salinity data obtained at multiple sampling stations were interpolated over the transect to compare with the calculated net densities of *D. theta* at specific locations. Day and night distribution structures of *D. theta* were characterized after the identification using semivariograms. Relatively dense schools were observed around 300-m depth during daytime. During nighttime, the schools of *D. theta* widely scattered and mixed with other dominant species above 100-m depth. Acoustic results appear to match the pattern obtained using net sampling. In the surface layer (above 100-m), estimated fish densities were about ten-fold higher at nighttime than in daytime. These distribution patterns seemed to be regulated by some environmental factors (*e.g.* thermocline) above 100-m depth and related to the position of the Oyashio current branch.

28 October, 19:30 (W1-4086)

Inter-comparison of three sampling gears during the first Micronekton Intercalibration Experiment (MIE-1): Size composition approach

Evgeny A. **Pakhomov**[1,2], M.P. Seki[3], A.V. Suntov[4], R.D. Brodeur[5] and K.R. Owen[6]

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Further analysis of the data set collected during the first Micronekton Intercalibration Experiment (MIE-I) conducted during October 6-12, 2004 on the leeward side of Oahu Island, Hawaii is presented. Three sampling gears, including a 140 m^2 pelagic Cobb trawl (CT), a 4 m^2 Hokkaido University rectangular frame trawl (HT) and a 2-m Isaacs-Kidd Midwater Trawl (IKMT) were deployed in a random sequence either in the upper 150 m during the darkness or at 550 m during the daytime from the NOAA research vessel *Oscar Elton Sette*. The deployment of the three types of gear resulted in a collection of more than 100 species of macroplankton and micronekton with no visible dominant species. In the diverse micronekton community, it appeared to be impossible to obtain species specific correction coefficients. As a consequence, the size composition approach for main taxonomic groups has been used to inter-compare different gears. For the three gears, the most comparable densities were obtained within a size interval ranging from 30 to 60 mm. This was due to individual gears sampled effectively the different size groups of plankton/micronekton. Despite variable mesh sizes, mouth areas and operation characteristics of the individual gears it appeared to be possible to establish size-dependent relationships between size spectrums of sampled organisms collected using different gears.

W2 FIS Workshop Methods for standardizing trawl surveys to ensure constant catchability

Co-Convenors: David A. Somerton (U.S.A.), Jin-Yeong Kim (Korea) and Greg Workman (Canada)

Standardization in the gear and methodology used to conduct pelagic and bottom trawl surveys is essential for a correct interpretation of catch per unit effort as a measure of relative abundance. In the United States, standardization problems stemming from inaccurate measurement of the towing warps on a NOAA survey vessel resulted in a thorough review of standardization methodology and the development of the National Bottom Trawl Survey Protocols (http://spo.nmfs.noaa.gov/tm/tm65.pdf) governing the operation of all NOAA-sponsored surveys. Subsequently, ICES formed the Study Group on *Trawl Survey Standardization* to examine the same issue for ICES-sponsored multinational surveys, and to formulate a similar set of standardized operating protocols expected to be published in the fall of 2007. The proposed workshop will review the various pelagic and bottom trawl surveys conducted by PICES member countries, with a focus on the operational protocols used to ensure that survey catchability remains constant over time. Topics to be discussed likely would include a consideration of various instruments to monitor trawl performance, such as acoustic trawl measurement systems, bottom contact sensors and speed through water sensors, as well as trawl design and operation procedures that allow trawl catchability to be robust to environmental variation.

Sunday, October 28, 2007 09:00 – 18:00

09:00 ***Introduction by convenors***

09:10 **Dave Reid (Invited)**
Survey trawl standardization (W2-4473)

09:40 **David A. Somerton**
Development of the NOAA national bottom trawl survey protocols (W2-4230)

10:00 **Keneth L. Weinberg**
Protocols for conducting Alaska Fisheries Science Center bottom trawl surveys (W2-4284)

10:20 **Aimee Keller, Victor Simon and Beth Horness**
Methods for standardizing the U.S. west coast groundfish trawl survey (W2-4295)

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

11:00 **Dan Urban, Nicholas Sagalkin and Kally Spalinger**
Alaska Department of Fish and Game trawl surveys in the Gulf of Alaska and eastern Aleutian Islands (W2-4463)

11:20 **Greg Workman, Norm Olsen and Rick Stanley**
Development of a standardized Fisheries Independent bottom trawl Survey program (FIS) off the west coast of Canada (W2-4491)

11:40 **Jung Hwa Choi, Hui Chun An and Bong Jin Cha**
Introduction of Korean survey bottom-trawl and catchability method (W2-4232)

12:00 **M.A. Mizyurkin, A.I. Shevchenko and S.E. Astafyev**
Approach of research trawl surveys certification (W2-4512)

12:20 ***Discussion of survey standardization methodology***

12:40 ***Lunch***

14:00 **Stan Kotwicki and Michael H. Martin**
The effects of improving accuracy and precision of area swept estimates on relative biomass estimation and stock assessment (W2-4231)

14:20 **Yasuzumi Fujimori, Kazushi Miyashita and Satoshi Honda**
Consideration of bottom contact effect on the catch of demersal species in a trawl survey in Japan (W2-4307)

14:40 **Orio Yamamura**
Catch efficiency of a small-sized Danish seine (W2-4282)

15:00 ***Discussion of research on standardization issues***

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

15:50 **David A. Somerton, Peter T. Munro and Kenneth L. Weinberg**
Whole-gear efficiency of a benthic survey trawl for flatfish (W2-4493)

16:10 **D.G. Reid, R.J. Kynoch, I. Penny and K. Peach**
Estimation of catch efficiency in a new angler fish survey trawl (W2-4494)

16:30 ***Discussion on estimating absolute catchability***

16:50 ***Discussion of standardization issues related to potential international surveys***

17:50 ***Concluding remarks***

W2 Oral Presentations

28 October, 09:10 (W2-4473) Invited

Survey trawl standardization

Dave **Reid**

FRS Marine Laboratory, Aberdeen, Scotland. E-mail: D.Reid@marlab.ac.uk

The presentation will provide an overview of the work of the ICES Study Group on survey Trawl standardization. In particular: Specification for survey gears: procurement and construction, preparation for sea; shakedown and calibration; and maintenance of gear at sea; Trawling Performance Monitoring; Training & Personnel; Gear changes and Intercalibration; The ideal survey trawl – State of the art. The talk will draw on experience in Europe and N. America and provide examples using the following survey trawls: Campelen – as used in Norway and Canada; Poly Nor Eastern - as used by NOAA in the NW USA; GOV – as used in most European bottom trawl surveys.

28 October, 09:40 (W2-4230)

Development of the NOAA national bottom trawl survey protocols

David A. **Somerton**

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In 2002, the towing warps aboard a NOAA research vessel were incorrectly measured so that one was progressively shorter than the other when trawling at increasing depths. This error was perceived by the groundfish industry as sufficiently substantial to lead to underestimated stock size and reduced harvest quotas. The subsequent furor over this, known to the press as “trawlgate”, led the director of NOAA to require a thorough review of the standardization protocols used by the 10 NOAA bottom trawl surveys to ensure that catchability of these surveys did not vary over time. A 3 day workshop was then held to both evaluate the protocols in current use and to define those that are crucial for ensuring standardization. Such protocols were classed into three groups: 1) procedures for measuring warp length and the operation of autotrawl systems, 2) procedures for setting, towing and retrieving the trawl and 3) procedures for building and repairing trawls. These protocols were then developed for each survey and collectively published as the NOAA national protocols for conducting bottom trawl surveys. Each survey must now demonstrate conformity with the NOAA protocols to certify its data for used in stock assessments.

28 October, 10:00 (W2-4284)

Protocols for conducting Alaska Fisheries Science Center bottom trawl surveys

Kenneth L. **Weinberg**

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The U.S. national trawl survey standardization protocols are designed to minimize the risk of unintended changes in trawl efficiency or catchability between stations and from year to year. The details for carrying out these protocols are survey-specific. The Alaska Fisheries Science Center (AFSC) currently conducts 4 geographically distinct bottom trawl surveys using chartered commercial stern trawlers. The focus of this presentation emphasizes the standardization efforts for two of the AFSC surveys, the annual Eastern Bering Sea survey and the biennial Gulf of Alaska survey. The responsibility for implementing standardized procedures fall into three categories: those belonging to the vessel; those belonging to the Center, but conveyed to the vessel; and those belonging to the Center and carried out by the Center. It is the vessel’s responsibility to provide skilled fishermen and 1-inch diameter towing cable, accurately measure and mark towing cables under scientist supervision, and ensure the autotrawl winch system is certified to be in proper working order. Standardized survey procedures determined by the Center and conveyed to the vessel include: whether or not to use autotrawl; tow location, duration, speed, and direction; procedures for gear deployment and retrieval; scope ratio determination; standardization of at-sea gear repair, catch

handling, and criteria for tow acceptance. Protocols for which the Center is wholly responsible include the construction and certification of trawls and rigging, post-survey repairs, and the purchase and maintenance of the otter doors. Methods used by each survey will be discussed in greater detail.

28 October, 10:20 (W2-4295)

Methods for standardizing the U.S. west coast groundfish trawl survey

Aimee **Keller**, Victor Simon and Beth Horness

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The Northwest Fisheries Science Center conducts an annual groundfish bottom trawl survey along the West Coast upper continental slope and shelf from May to October. The survey targets commercial groundfish resources inhabiting depths of 55-1280 m from the U.S.-Canadian to the U.S.-Mexican border. Since 1998, four chartered West Coast bottom trawlers have participated in the survey each year, two during pass 1 (May-July) and two during pass 2 (August-October). All vessels progress south along the coast, finishing the survey south of San Diego, CA. The history, design, and trawl standardization protocols for the West Coast Groundfish Trawl Survey are described. Operation protocols include: net diagrams, construction, repair methodology and certification procedures; warp standardization and measurement; tow duration, distance-fished and speed over ground; and use of trawl mensuration instrumentation. On each haul wingspread, headrope height, trawl depth, temperature and bottom contact are measured using trawl-mounted sensors. Trawl operations are mediated and reviewed by field staff via two custom-built software applications. The first displays real-time sensor data and includes trawl annotations and environmental conditions. The second provides a graphical display of all sensor time series for evaluation and review, and requires entry of a tow quality judgment at the conclusion of each trawl operation. Both software applications promote data quality by guiding field staff workflow, minimizing data entry errors and providing for as much immediacy in operation evaluation and corrective action as possible during and following trawling. Variation in net mensuration data for acceptable tows are described and discussed.

28 October, 11:00 (W2-4463)

Alaska Department of Fish and Game trawl surveys in the Gulf of Alaska and eastern Aleutian Islands

Dan **Urban**, Nicholas Sagalkin and Kally Spalinger

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The Alaska Department of Fish and Game (ADF&G) has conducted large mesh bottom trawl surveys for crab and groundfish on a regular basis since 1988 and a small mesh bottom trawl survey for shrimp since 1970. A station grid has been established around Kodiak Island, the south side of the Alaska Peninsula, and the eastern Aleutian Islands as far west as Umnak Island. A single haul is conducted at each station with typically around 380 hauls for the large mesh survey and 100 hauls per shrimp survey. Past mensuration work has established the net openings but ADF&G does not place sensors on the net on a regular basis. Over the period of these surveys, most work has been accomplished with the same vessel, the 27.4 m R/V *Resolution*, using the same net and door design. The placement of the trawl within the station is largely consistent from year to year but trawling speed of has varied from 3.7 to 4.6 km/hour. For the last three years, ADF&G has been assessing the variability of Tanner crab catches within a station by conducting multiple hauls within the same station. Results vary widely by sex and size class, although the CPUE of legal (large male) Tanner crab remains consistent.

28 October, 11:20 (W2-4491)

Development of a standardized Fisheries Independent bottom trawl Survey program (FIS) off the west coast of Canada

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In 2003 the Pacific Biological Station initiated a series of bottom trawl surveys designed to index the abundance of all demersal groundfish species available to bottom trawl gear on the west coast of Canada. At the outset we acknowledged that for a time series to be meaningful we would have to develop a fixed set of survey protocols, software tools, gear mensuration requirements and a standardized survey trawl. To date nine surveys in four distinct areas covering approximately 80 % of the coastal waters of British Columbia have been carried out. Each year one survey is conducted using a government research vessel and one using a charted commercial fishing vessel. In an effort to reduce biases amongst vessels, areas, and years we use the same surveys design, optimization scheme, survey trawl, and gear configuration for every survey. As well we use the same rules to determine what constitutes a valid survey tow across all surveys. I will describe the efforts undertaken to date to ensure constant catchability across surveys, where we appear to be succeeding and where we have encountered technical difficulties.

28 October, 11:40 (W2-4232)

Introduction of Korean survey bottom-trawl and catchability method

Jung Hwa **Choi**[1], Hui Chun An[2] and Bong Jin Cha[2]

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Bottom trawl surveys of Korea are primarily conducted by the National Fisheries Research and Development Institute (NFRDI). NFRDI has been developing methods to standardize trawl survey catchability for several years. Several projects are focused on survey standardization using the NFRDI research vessel. The Fisheries Research Team (FRT) constructed a new scientific vessel to further develop methods to control change bridle length, head rope length and otter board design. Recently, five research vessels have been operated in 4 separate areas for 75 sea-blocks. The stock assessments of commercial species (Snow crab, Japanese eel, Yellow goose fish *etc.* are estimated by using area swept methods with estimates of trawl efficiency. I summarize here the progress of FRT survey bottom-trawl methods for stock assessment.

28 October, 12:00 (W2-4512)

Approach of research trawl surveys certification

M.A. **Mizyurkin**, A.I. Shevchenko and S.E. Astafyev (Presenter: Mikhail Stepanenko)

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The TINRO-center had finalized and published results of long term (1979-2004) research program for study nekton species quantitative distribution in the Bering, Okhotsk and Japan Seas and adjacent northwest Pacific Ocean. Abundance and biomass of nekton species estimated on base of midwater trawl surveys. The midwater trawl surveys operations conducted onboard research vessels (800-6000 hp) and used 21 kinds of trawl gears. Catch ability coefficient established depends of specimen size basically for 3 size groups and varied from 0.01 to 0.5. It is obvious that catch ability varied depends of type of trawl gear and it had influence on accuracy of research data. In 2002 Russia, United States and Japan conducted limited intercalibration of trawl gears used for study of salmon quantitative distribution. The TINRO-center suggests establish international technique of research trawl surveys on base of experience all North Pacific nations. Certification of the technique must include research vessel type, fishing gears, acoustic equipment and net control systems.

28 October, 14:00 (W2-4231)

The effects of improving accuracy and precision of area swept estimates on relative biomass estimation and stock assessment

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The technologies used in the estimation of area swept have changed enormously over the past 30 years, enabling much more accurate estimates of area swept. In addition, the ability to interpret collected data has improved over time as data analyses continually improve and mature. These changes often occur incrementally over time resulting in a "technology creep" that may gradually change the perception of area swept over time. While more accurate estimates are certainly desirable, these improvements can also lead to problems in inter-annual comparison of results as sources of bias are reduced or eliminated. We examined the effect of four analytical changes that could have a direct effect on the estimation of area swept and relative biomass calculations for three surveys in Alaska. The effects examined were: changes in the methodologies of estimating distance fished and net spread, the effect of better estimates of sound speed at depth on estimation of net spread, and the effect of the added distance traveled by the net during wire retrieval after haulback. The effects of each individual change and the cumulative change on area swept estimation and the resulting biomass estimates were estimated. The potential effect of these changes on the stock assessments of a few key species in Alaska was also examined.

28 October, 14:20 (W2-4307)

Consideration of bottom contact effect on the catch of demersal species in a trawl survey in Japan

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It is well known that the trawl geometry and bottom contact affect catchability, especially for typical demersal species like a flatfishes. Nevertheless, such an influence was mostly disregarded in Japanese bottom trawl surveys because its evaluation needs considerable effort and time. We present results of a trawl experiment to investigate the influence of bottom contact on the catch of walleye pollock and flatfishes. The experiment, which examined the effects produced by different scope ratios (the ratio of warp length to fishing depth: 2.5, 3.0, 3.5), was conducted with the bottom trawl net used by Fisheries Research Agency in Japan to survey walleye pollock. For the 2.5 scope ratio, the net mouth shape and bottom contact fluctuated because the trawl doors did not contact the bottom. The bottom contact was increased when the scope ratio was increased to 3.0 or more. Walleye pollock, flatfishes, and sculpins were caught in most tows, but the catch of flatfishes and sculpins increased remarkably with scope ratio. For walleye pollock using the 3.5 scope ratio, the fish length frequency (n = 300) was dissimilar from that those of obtained with the other scope ratios, although there was no difference between the 2.5 and 3.0 scope ratios. These results indicate that the scope ratio should be set as 3.0 in the actual survey for walleye pollock within the depth ranged from 100 to 300 m.

28 October, 14:40 (W2-4282)

Catch efficiency of a small-sized Danish seine

Orio **Yamamura**

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In the coastal area (<150 m depths) of Hokkaido Island, surveys using otter trawls are precluded due to densely deployed fishing gears (bottom gillnets, baskets and longlines), as well as for ecological reasons. Therefore, a small-sized fishing boat (7.3t) equipped with a Danish seine (19.2 × 2.4m wing size) is currently used for the sampling of predators of juvenile walleye pollock. Since the fishing efficiency of the net is still unknown, a series of comparative

tows were made using the fishing boat and a large-sized fishing research vessel (*Hokko-maru*, 902t), equipped with a bottom trawl spread with a pair of otter boards. During October and November 2006, nearby tracks were towed by these vessels. The area swept by the Danish seine was estimated by the GPS track of the fishing boat, which was approximated to triangles or quadrangles. The area swept by the otter trawling net was measured by monitoring the distance between the otter boards using a SCANMAR sensor. In the area sampled, horned and plain sculpin (*Enophrys diceraus* and *Myoxocephalus jaok*) and Kamchatka and witch flounder (*Atheresthes evermanni* and *Glyptocephalus stelleri*) were dominant, and were apparently distributed non-patchily. So these species were used to estimate the area swept by the Danish seine. Density estimate was made for different gears, depths (60m and 90m) and fish types (sculpins and flounder). According to the results of this experiment, the catch efficiency rate of the otter trawl was about 40 and 60 times as large as that of the Danish seine for sculpins and flounders.

28 October, 15:50 (W2-4493)

Whole-gear efficiency of a benthic survey trawl for flatfish

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The proportion of fish passing between the otter doors of a bottom trawl that are subsequently captured (*i.e.*, whole-gear efficiency) was estimated from data collected on experiments to measure the herding efficiency of the bridles and doors, the capture efficiency of the net, and the length of the bridles sufficiently close to the bottom to elicit a herding response. The experiments were conducted with the Poly Nor'eastern trawl, used by the Alaska Fisheries Science Center on bottom trawl surveys, and focused on four species of flatfish: flathead sole (*Hippoglossoides elassodon*), rex sole (*Glyptocephalus zachirus*), Dover sole (*Microstomus pacificus*) and arrowtooth flounder (*Atheresthes stomias*). Efficiency estimates were based on a revised mathematical model of the trawl capture process; variances of these estimates were obtained with a newly developed estimator. Herding efficiency, or the percentage of fish passing between the wings and doors that are herded into the net path, ranged from 17% for arrowtooth flounder to 24% for flathead and Dover sole. Net efficiency for flathead sole, rex sole and arrowtooth flounder increased with fish length and reached maximum values between 85-98%. Net efficiency for Dover sole decreased monotonically with body length both because only relatively large individuals were sampled and because this species appears to be especially adept at escaping under the footrope. Whole-gear efficiency varied with length similarly to net efficiency and reached maximum values between 40% and 50% for flathead sole, rex sole and arrowtooth flounder. Maximum whole-gear efficiency for Dover sole was approximately 33%.

28 October, 16:10 (W2-4494)

Estimation of catch efficiency in a new angler fish survey trawl

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A new series of targeted angler fish (*Lophius* spp.) bottom trawl surveys were launched by FRS in 2005. The surveys used a new survey net based on a commercial trawl and adapted for survey purposes in collaboration with the fishing industry. The aim of the surveys was to use swept area abundance estimates to provide an absolute abundance estimate for these species in waters around Scotland. Before this was possible it was necessary to determine the capture efficiency of the net using the efficiency equations developed by Somerton *et al.* (1999). Two components were examined: herding by the sweeps, and losses under the footrope. Herding was reported in a previous paper. The present papery presents the results of a series of trials using bags below the fishing line to quantify the proportion of fish at length that escaped below the gear. The results show clear length dependency with smaller fish more likely to be lost under the gear. Below 30cm, approximately 75% of the angler fish were found in the ground gear bags, while for the larger fish the proportion was 25%. The paper presents the catching efficiency of the net using both the sweep herding and losses under the ground gear. In brief, the combination of the two components indicated that the net efficiency was approximately 0.7. That is, that the net would be expected to catch approximately 70% of the fish that were originally in the path of the net between the wings.

W3 FIS/MEQ Workshop
Comparative analysis of frameworks to develop an ecosystem-based approach to management and research needed for implementation

Co-Convenors: Glen Jamieson (Canada), Patricia Livingston (U.S.A.) and Chang-Ik Zhang (Korea)

An ecosystem-based approach to management (EBM) is an integrated approach to management of land, water, and living resources that promotes conservation and sustainable use over a broad range of human activities in an ecosystem. Implementation of an EBM for marine ecosystems in the North Pacific Ocean requires a number of steps and activities. An explicit framework that outlines the objectives, legal mandates, and institutional roles and responsibilities is essential. Data requirements and analytical tools need to be developed. This workshop invites papers to: 1) highlight existing national and international frameworks for implementation of an ecosystem approach to management; 2) outline the data requirements for such an approach; 3) describe the analytical tools being developed; 4) show the progress in communicating results of EBM activities; and 5) discuss outstanding research gaps for making progress. The workshop will be organized to allow time for keynote summaries of PICES Working Group 19 results, invited contributions from other PICES groups, insights by other organizations involved in providing integrated ecosystem advice, talks on governance issues and difficulties, socioeconomic issues, *etc*. During a discussion period, participants are welcome to advise the convenors on the desirability of publishing the results of the workshop in a leading primary scientific journal.

Friday, October 26, 2007 09:00 – 18:00

09:00 ***Introduction by convenors***

09:10 **Keith Sainsbury (Invited)**
Sustainable use of marine ecosystems – The search for practical ways to support and implement ecosystem-based fisheries management and regional development (W3-4429)

10:00 **Jake Rice**
Ecosystem approaches to management – Where to start? (W3-4252)

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

10:50 **David L. Fluharty**
Realizing ecosystem based management through integrated ecosystem assessment and regional collaboration in the United States (W3-4387)

11:15 **Glen S. Jamieson**
Integrated management in Canada's Pacific North Coast: Challenges in determining ecological objectives (W3-4040)

11:40 **R. Ian Perry, William R. Crawford and Alan F. Sinclair**
Comparative analysis of Canadian Pacific North Coast and Strait of Georgia marine ecosystems (W3-4202)

12:05 **Chang Ik Zhang, Suam Kim, Donald Gunderson, Jae Bong Lee, Inja Yeon, Hee Won Park and Jong Hee Lee**
Progress in the development of an ecosystem-based approach to assess and manage fisheries resources in Korea (W3-4425)

12:30 ***Lunch***

14:00 **Mitsutaku Makino and Tatsu Kishida**
Ecosystem-based management in Japan: Its status and challenges (W3-4507)

14:25 **Vladimir I. Radchenko**
Ecosystem-based principles in the contemporary fisheries management on the Russian Far East (W3-4495)

14:50 **Jake Rice**
ICES frameworks and processes for science advice in an ecosystem approach (W3-4509)

15:15 **Xianshi Jin**
Implementation of ecosystem-based management in China

15:40 **Inja Yeon, H.J. Whang, M.H. Shon, Y.J. Im, J.G. Myoung and WWF YSEPP project partners**
Yellow Sea marine ecoregion for implementation of ecosystem-based management in marine capture fisheries (W3-4475)

16:00 ***Coffee / tea break***

16:20 **John Stein**
Science plan for FISP

16:40 **Phil R. Mundy**
Data requirements for implementing an ecosystem approach to management from a PICES perspective (W3-4486)

17:00 **Bernard A. Megrey, Michio J. Kishi, Shin-ichi Ito, Kenneth A. Rose, Francisco E. Werner and members of the MODEL Task Team and the NEMURO Mafia**
Modeling multi-trophic level marine ecosystems using the NEMURO family of models: Climate change applications in the boreal North Pacific and scientific potential for ecosystem-based management (W3-4510)

17:20 ***Discussion and summary***

W3 Oral Presentations

26 October, 09:10 (W3-4429) Invited

Sustainable use of marine ecosystems – The search for practical ways to support and implement ecosystem-based fisheries management and regional development

Keith **Sainsbury**

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In the last 50-100y there has been a dramatic increase in the intensity and range of human uses, including fishing, of the world's marine ecosystems. This has brought significant benefits to human societies and economies. But many of the ecosystems providing these benefits are showing serious degradation and reduced capacity to sustain this intensity and pattern of human use. There is a growing consensus to address these issues through development and application of Ecosystem Based approaches to management. These approaches apply to management of individual uses, for example through Ecosystem Based Fishery Management of fisheries, as well as to integrated management of all uses of a marine ecosystem through regional Ecosystem Based Management. Ecosystem Based approaches to management represent a fundamental change from the singe species or single impact approaches of the past, and raise major challenges to both science and management. We are all grappling to find frameworks and methods that deliver practical interpretation, support and implementation of these Ecosystem Based approaches. Like many countries Australia is challenged to find practical and cost-effective ways to bring an ecosystem-based approach into its management of marine ecosystems and resources. So here I will outline some of the approaches being developed and applied in Australia, with an emphasis on what is being applied in practice. For Ecosystem Based Fishery Management this includes qualitative and quantitative ecological risk assessment methods, simulation testing of management strategies, reexamination and extension of the use of reference points, adoption of formal catch control rules, increased use of spatial management, and a Government sponsored program to reduce fishing capacity. Scientific and management methods to support integrated regional Ecosystem Based Management are less well developed but examples will be outlined, including the implementation of a system of marine protected areas and early attempts to scientifically evaluate regional management strategies.

26 October, 10:00 (W3-4252)

Ecosystem approaches to management – Where to start?

Jake **Rice**

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With all that has been written about the ecosystem approach, it is getting hard to see how to make it operational. Everyone agrees an Ecosystem Approach is superior to alternative approaches to management, but the literature abounds with confusing explanations of what an ecosystem approach is, how it should be undertaken, and how it improves on single-factor, single consideration management. This paper lays other three levels of choices that need to be made, to take EAM from a vague, all-encompassing platitude to practical improvements in management, and in science supporting management. First, and most general, is it is necessary to stop confusing integrated management, ecosystem approaches to management, and inclusive management. All three are improvements over their respective alternatives, each complements the other two, but they are different concepts. They require different changes in governance, management, and science, and can occur at different rates, depending on the circumstances of a particular case. The paper will outline these differences. Second, there are different science requirements to support three different parts of EAM, and it is important to design science programs to make progress on all three. One is to take account of the effects of environmental forcing on the ecosystem properties being used, a second is to take account of the footprint of the activity being managed on the ecosystem, and the third is to deal with social science dimension of the options to address the first two. Failing to make synchronized progress on those three research fronts will diminish the value of progress on the others. The paper will develop these interrelationships. Third, once both integrated management and an ecosystem approach are adopted, management has to choose whether to start with existing management approaches and structures and work towards a common centre, or start from the determinants of the ecosystem's structure and function and work outwards towards the human activities being managed. There are benefits and costs to both approaches. The paper will explain the costs and benefits, and conclude with a discussion of the options for moving forward.

26 October, 10:50 (W3-4387)

Realizing ecosystem based management through integrated ecosystem assessment and regional collaboration in the United States

David L. **Fluharty**

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Efforts to implement ecosystem based management of marine regions are taking place in the United States in large part led by the National Oceanic and Atmospheric Administration [NOAA] but in collaboration with federal and state agencies, tribal governments, as well as industry and environmental interests. While definitely a work in progress, this initiative builds on previous work over several decades to move toward ecosystem-based fishery management, place-based ecosystem management, and improved monitoring and analysis capabilities. Increasingly, governments are called-upon meet expanding goals and changing values with respect to managing marine ecosystems. This is seen in existing and evolving legislative and administrative mandates as well as in the prioritization of natural and social science research in support of those mandates. While in the United States there is not a formal mandate for ecosystem based management, the challenges of ocean management create conditions where developing such an approach is necessary. NOAA is currently defining and experimenting with Integrated Ecosystem Assessments [IEAs] performed across the full agency that serve as scientific inputs around which regional collaboration can develop. Here we examine the context from which this initiative began, we describe the approach being developed and we assess progress to date and future steps.

26 October, 11:15 (W3-4040)

Integrated management in Canada's Pacific North Coast: Challenges in determining ecological objectives

Glen S. **Jamieson**

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Canada has been developing a process to determine appropriate relevant ecological objectives since 2001, when under the overarching objective of conservation of species and habitat, conceptual objectives relating to biodiversity, productivity and the physical and chemical properties of ecosystems were defined. Under each of these, further nested components were recognized as existing, and an "unpacking" process was developed to link conceptual objectives to operational objectives for management. However, a main challenge in unpacking is that because there are thousands of potential parameters to monitor, a definable process is needed to determine ecological objectives that are both most scientifically justifiable and socio-economically relevant to use in management. To identify some of the most relevant ecosystem parameters to monitor, Canada undertook a delphic process to identify both high priority locations (Ecologically and Biologically Significant Areas (EBSAs), and Degraded Areas) and species (Ecologically Significant Species and Community Properties (ESSCPs), and Depleted and Rare Species). Conservation objectives, defined as science-based objectives one "unpacking" level above operational objectives, were then to be determined from priority items from these four combined lists. In practice, the science identification of conservation objectives is proving challenging, and the planned complementary determination of "desirable objectives" to incorporate socio-economic values has yet to start. Finally, both processes are now stalled because of funding cuts, which raises concern about the will in Canada to move as rapidly as possible from single-species management to ecosystem-based management. Achievements to date and lessons learnt are described.

26 October, 11:40 (W3-4202)

Comparative analysis of Canadian Pacific North Coast and Strait of Georgia marine ecosystems

R. Ian **Perry**[1], William R. Crawford[2] and Alan F. Sinclair[1]

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We compare and contrast the structure, function, and ecosystem-based management issues for two of the major marine ecosystems of the Pacific coast of Canada: the North Coast of British Columbia; and the Strait of Georgia. We structure our analysis around four key questions: 1) what processes determine hydrographic properties; 2) what processes control the supply of nutrients; 3) who eats whom, and how are food-web interactions facilitated; and 4) what are the critical factors causing changes in these ecosystems? The North Coast is larger, but both are strongly influenced by adjacent mountains that affect climate, rainfall, and circulation features. Both areas are strongly influenced by freshwater, but this is more important in the southern Strait of Georgia. Nutrient supply and food-web interactions in both regions are facilitated by “Bakun’s Triad”: enrichment, retention, and concentration. The overall trophic structure of the North Coast appears to be robust to reduction or elimination of single components of the food web; it does not display a wasp-waist structure with a single constricting species. The North Coast ecosystem is more strongly connected to the adjacent deep ocean, including extensive migrations by fish, marine mammals, and seabirds. The Strait of Georgia and the deep ocean are less closely connected: deep-water properties in the Strait display a 1-year lag from the offshore, and the major biological connections are by salmon and herring. Analyses of productivity and fisheries yields suggest different time trends exist between these two regions. We conclude with an analysis of the critical factors driving changes, and the resilience or vulnerability of these ecosystems to these changes.

26 October, 12:05 (W3-4425)

Progress in the development of an ecosystem-based approach to assess and manage fisheries resources in Korea

Chang-Ik **Zhang**[1], Suam Kim[1], Donald Gunderson[1], Jae Bong Lee[2], Inja Yeon[2], Hee Won Park[1] and Jong Hee Lee[1]

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A practical method is proposed for assessing fishery resources at the ecosystem level. It makes use of objectives, indicators, and reference points. A two-tier system is used to accommodate the quantity and quality of the available data. We identified three objectives, namely sustainability, biodiversity and habitat protection. For three objectives essential indicators were selected, and target and limit reference points were assigned for each indicator to carry out the ecosystem-based assessment. It is hoped that assessment and management at this elevated level will prevent significant and potentially irreversible changes in marine ecosystems caused by fishing, and that the plan is to use the procedure by as early as 2009 in Korea. This method is demonstrated by applying it to some Korean fisheries.

26 October, 14:00 (W3-4507)

Ecosystem-based management in Japan: Its status and challenges

Mitsutaku **Makino** and Tatsu Kishida

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Under the Japanese institutional framework, organizations of local fishers have the authority to decide who, where, and how to use coastal ecosystems, including fishery resources. At the same time, local fishers have voluntarily implemented a wide range of management measures to address specific local conditions. These measures include not only conventional resource management measures such as input, gear, or seasonal limits, but also include such activities as upstream reforestation, promotion of environment-friendly detergent usage in local households, maintaining seaweed plantations as nursery grounds, and protection of essential habitats by establishing no-take zones. However, these activities focus mainly upon the conservation/promotion of ecosystem services which are

supposed to increase fisheries harvests, and relatively little consideration of the general public's interests is presently taken in decision-making processes. In offshore areas, Fisheries Research Agency and prefectural fisheries research organizations have jointly conducted biophysical monitoring of the marine environment, and assess stock sizes of marine resources. Also, catch statistics are reported by fishers' organizations, and these have been compiled by the Ministry of Agriculture Forestry and Fisheries for over 50 years. Based on this information, ecosystem status indices such as relative biomass or size changes of keystone species, and stock fluctuations, can be calculated. The central government has set total allowable catches (TACs) for seven species, but the TAC setting procedure is presently from a single-species perspective. The most serious impediment for integrated management of marine ecosystems in Japan is the vertically-segmented administrative system amongst eight marine-related ministries. Therefore, a new law, Marine Basic Law of 2007, has just been legislated which will integrate/coordinate the policies of these eight ministries.

26 October, 14:25 (W3-4495)

Ecosystem-based principles in the contemporary fisheries management on the Russian Far East

Vladimir I. **Radchenko**

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Russian Far East fisheries possess all preconditions for successful application of basic ecosystem-based principles in the contemporary management. On the Far East, Russian fishery is managed by 11 fishery zones. All fishery objects are involved in the total allowable catch (TAC) establishment procedure and fishery statistics. All fishery vessels are under the federal monitoring and equipped by the satellite positioning system sensors. The legal norm code of Russian fisheries developed in the last years. Federal low "On Fisheries and Water Biological Resources Conservation" was signed in 20 December of 2004, "Fisheries rules for the Far-eastern basin" – in 1 March, 2007. Ecosystem studies of marine biological resources in the Russian far-eastern seas were begun in the early 1980s. Data are summarized and analyzed by 44 biostatistical areas. Despite the listed preconditions, sole formal approach (regulation by TAC establishment) prevailed in the fishery management. Since 2004, even the coastal fishery on Pacific salmon is also regulated by the TAC limits. There are several other approaches to the fishery regulation applied: area and season closures, prohibition of endangered species catch, prohibited gear and methods of catching. "Fisheries rules…" foresees specific requirements to the fishing ventures, vessels, documentation, establishes a minimal mesh size, allowed fishery gear size and constructions, fishery size for the most fish/invertebrates species and groups. Permitted bycatch of non-target species is limited by 2% in weight (beside the marine mammals, crabs, and shrimp), for fishery objects under the permitted size – by 8% in number for all specialized fishery types. For future development, the fishery science suggests gradual withdrawal from the total TAC limitation for the every last fishery objects, to optimize management approaches for different types of fishery objects (common pelagic fishes, coastal groundfish, *etc.*), transition from the one-species to the one-fishery regulation.

26 October, 14:50 (W3-4509)

ICES frameworks and processes for science advice in an ecosystem approach

Jake **Rice**

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ICES has long been a provider of formal science advice to policy and management clients, and to ensure advice is scientifically sound and represents the views of the full ICES community, structured processes with clear rules for membership and conduct of activities at the advisory level are utilized. As the clients of ICES advice diversified, so did the advisory processes and by 2002, ICES had three advisory committees, one each on Fisheries Management, the Marine Environment, and Ecosystems, with each supported by its own set of working groups and functioning within its own culture. However, the division of advisory tasks among different committees was inefficient and resulted in overlapping advice across client requests, which was difficult to reconcile across committees. In response, ICES initiated a major overhaul of its advisory processes into a single advisory committee that is supported by a different layering of Expert Groups below it. The latter will consolidate disciplinary knowledge, integrate related

information across disciplines, conduct peer review and draft advice, and ensure consistency and relevance of advisory products. Secondly, it has clarified what "ecosystem advice" clients need for their business, and has built internal frameworks to structure the advice in ways that meet these needs. What the content of "integrated ecosystem advice" should look like, and the standards to be met by tools used to develop this content, is being coordinated by the Advisory Committee on Ecosystems (ACE).

26 October, 15:40 (W3-4475)

Yellow Sea marine ecoregion for implementation of ecosystem-based management in marine capture fisheries

Inja **Yeon**[1], H.J. Whang[1], M.H. Shon[1], Y.J. Im[1], J.G. Myoung[2] and WWF[3] YSEPP project partners

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The Yellow Sea is a semi-enclosed body of water bordering China to the west and South Korea and North Korea to the east. With marked seasonal variations, the Yellow Sea Marine Ecoregion supports both cold temperature species as well as warm water species. Approximately 400 fish species have been reported from marine and coastal habitats in the sea. The region is one of the most heavily exploited in the world with fishing mainly by Chinese, Korean and some Japanese vessels. Around 100 species are fished commercially in the sea. Landings of commercially important species have declined by about 30% over the past twenty years, and fishing of many of the larger or higher value species has been replaced by fisheries for smaller or less value species. Overfishing is thought to be the main driver affecting structural changes of fish communities, although land and sea-based pollution, as well as extensive coastal development around the sea, are also major threats to natural resources and habitats in the Yellow Sea. Twenty-five species have been chosen as priority indicator species based on five criteria: 1) representative species/habitat types, 2) isolated stock or species, endemism and unique species assemblages, 3) depleted species, 4) commercial importance; and 5) change in biological characteristics in response to fishing pressure. Collectively, 16 areas, spawning or main distribution areas, were determined as ecologically important habitats in the Yellow Sea. Fishing in these areas may be more closely regulated to achieve longer-term benefits from fisheries and for ecosystem-based management.

26 October, 16:40 (W3-4486)

Data requirements for implementing an ecosystem approach to management from a PICES perspective.

Phil R. **Mundy**

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The data requirements for implementing an ecosystem approach to management in the North Pacific can only be met through an international network of physical, chemical and biological observations that span the region's oceans, atmosphere and food webs. PICES is uniquely situated and constituted to be the catalyst for realizing this network, as the North Pacific Marine Science Organization was engaged in fostering the international cooperation in the interdisciplinary sciences necessary to meet the data requirements of the ecosystem approach to management, EAM, well before the term EAM had been established in literature and common usage. Through its standing committees and programs, PICES brings together under one roof the broad expertise in oceanography; physical, chemical and biological and in fisheries management, that are essential to successfully implementing EAM. As envisioned by the ocean observing community (*i.e.* GOOS) and allied efforts (*i.e.* GLOBEC), the data network for implementing EAM, has three key components which define its requirements; observations, communications, and analysis. The types of essential observations have been defined and refined by national and international efforts (*i.e.* CGOOS, IOOS) however the challenge for the community with which PICES may help is to reconcile the time and space scales necessary to couple biological and physical models. Data communications requirements have also been addressed in principle (*i.e.* IOOS DMAC), and PICES, again, has an advantage in the constitution and members of TCODE and MONITOR, who address issues of "interoperability" for data sets and observations on international scales. Finally,

PICES abilities to foster international cooperation in analysis have been repeatedly demonstrated in programs and products such as CCCC, NEMURO and NPESR.

26 October, 17:00 (W3-4510)

Modeling multi-trophic level marine ecosystems using the NEMURO family of models: Climate change applications in the boreal North Pacific and scientific potential for ecosystem-based management

Bernard A. **Megrey**[1], Michio J. Kishi[2], Shin-ichi Ito[3], Kenneth A. Rose[4], Francisco E. Werner[5] and members of the MODEL Task Team and the NEMURO Mafia

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4 Department of Oceanography and Coastal Sciences, Coastal Fisheries Institute, Louisiana State University, Baton Rouge, LA, 70803, USA
5 Department of Marine Sciences, University of North Carolina, Chapel Hill, NC, 27599-3300, USA

In this presentation, we describe the NEMURO family of models and include several examples of using numerical simulation models to explore the consequences of climate change and global climate warming on the productivity of marine ecosystems. We depict techniques to characterize the nutrient dynamics and biological productivity of the lower trophic levels, methods of dynamically coupling the lower trophic level model to a fish bioenergetics and population dynamics model, and examples of how the various models have been used to explore basin-scale and species-specific responses to climate forcing and examine local and regional response of the same species to multi-decadal climate signals. We conclude with a description of a new initiative where we extend NEMURO to spatially explicit simulations of upwelling systems containing anchovies and sardines and offer perspectives on the scientific potential of applying these new tools to ecosystem-based management.

W4 MEQ Workshop and laboratory demonstration Review of selected harmful algae in the PICES region: III. *Heterosigma akashiwo* and other harmful raphidophytes

Co-Convenors: Charles G. Trick (Canada) and Ichiro Imai (Japan)

This workshop is the third of an annual series in which harmful algal bloom (HAB) species that impact all or most countries in the North Pacific are discussed in detail. In 2007, we will focus on one species of raphidophytes, in particular, *Heterosigma akashiwo*. This species is distributed throughout the PICES region and has caused serious damage to finfish aquaculture, resulting in severe economic losses in PICES member countries. The integration of information from each country will advance our understanding of this organism. Topics will include modes of toxicity, distribution, impact (differences between toxic and nontoxic strains), as well as physiology and ecology in each of the member countries. In particular, we would like to identify additional studies needed specifically to define *H. akashiwo*'s mode of toxicity. Comparison with similar raphidophytes, namely *Chattonella* and *Fibrocapsa*, will also be included. The workshop will be preceded by a half-day laboratory demonstration on *Heterosigma* cell and toxin detection.

Friday, October 26, 2007 13:00 – 18:00

Laboratory demonstrations on detection techniques for algal toxins

13:00 **Carmelo R. Tomas**
Microscopic observations and detailed analysis of raphidophyte taxonomy (W4-4506)

13:30 **Roman Marin III, Nilo Alvarado and Christopher A. Scholin**
Rapid detection of *Heterosigma akashiwo* in natural samples using DNA probe based assay (W4-4505)

Saturday, October 27, 2007 09:00 – 18:00

MEQ workshop

09:00 ***Introduction by convenors***

09:10 **Carmelo R. Tomas (Invited)**
The Raphidophyceae: Enigmas in taxonomy, identification and morphology (W4-4288)

09:50 **Hakgyoon Kim, Samgeun Lee, Changkyu Lee, Kyongho An, Wolae Lim, Sookyang Kim, Youngtae Park and Yoon Lee**
Two decadal changes of *Heterosigma akashiwo* blooms in Korean coastal waters (W4-4080)

10:10 **Jack E. Rensel and K. Bright**
Bloom dynamics of *Heterosigma akashiwo* in Puget Sound and the Strait of Juan de Fuca (W4-4471)

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

10:50 **Ichiro Imai, Shigeru Itakura and Mineo Yamaguchi (Invited)**
Life cycle strategies and occurrences of red tides of *Heterosigma akashiwo* and *Chattonella* spp. in

temperate coastal sea (W4-4336)

11:30 **Jinhui Wang and Yutao Qin**
Blooms of *Heterosigma akashiwo* and *Chattonella marina* in Chinese coastal waters (W4-4175)

11:50 **Takashi Kamiyama**
Effects of *Heterosigma akashiwo* blooms on planktonic food webs: Responses of microbial loop components (W4-4162)

12:20 ***Lunch***

14:00 **Tatsuya Oda (Invited)**
Generation of ROS (reactive oxygen species) by *Chattonella marina* as a possible factor responsible for the fish-killing mechanism (W4-4038)

14:40 **Roman Marin III, Scott Jensen, Brent Roman, Eugene Massion, Christina Preston, Dianne Greenfield, William Jones, Gregory Doucette, Tina Mikulski, Kristen King, Mike Parker, Mark Brown and Chris Scholin**
Routine rapid detection of *Heterosigma* in natural samples using DNA probes (W4-4357)

15:00 **Charles G. Trick, M. Klein and C. Ling**
Environmental parameters regulate exoenzyme and haemolysin production in *Heterosigma akashiwo* (W4-4290)

15:20 **Desmond J. Johns and Patricia Glibert**
Characterization of nitrogen uptake by *Heterosigma akashiwo* grown in turbidostat culture under two light intensities (W4-4161)

15:40 ***Coffee / tea break***

16:00 **Julian Herndon and William P. Cochlan**
Nitrogen utilization by the raphidophyte *Heterosigma akashiwo*: Growth and uptake kinetics in unialgal cultures and natural assemblages of San Francisco Bay (W4-4415)

16:20 **William Bjornsson and Charles G. Trick**
Regulation of environmental metabolites in *Heterosigma akashiwo*: Nutrient-limited chemostat studies (W4-4373)

16:40 ***Summary and wrap up***

W4 Poster

W4-4484 **Li Zheng, Xiaotian Han, Xiuchun Guo, Ping Han, Zhiming Yu and Xiaoru Wang**
Study on algicidal activity of marine bacteria to two HAB species *Heterosigma akashiwo* and *Prorocentrum micans*

W4 Laboratory Demonstration Oral Presentations

26 October, 13:00 (W4-4506)

Microscopic observations and detailed analysis of raphidophyte taxonomy

Carmelo R. **Tomas**

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The workshop will give hands on experience with living cultures of the members of the brown and green raphidophytes. This will include direct brightfield microscopic observations, a presentation of the latest pigment compositional measurements, and pertinent EM features. Diagnostic features for identification, collection and preservation and will be discussed as will techniques in cultivation.

26 October, 13:30 (W4-4505)

Rapid detection of *Heterosigma akashiwo* in natural samples using DNA probe based assay

Roman **Marin III**, Nilo Alvarado and Christopher A. Scholin

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We demonstrate the use of a commercially available, DNA probe based assay that detects and provides an estimate of the abundance of *Heterosigma akashiwo* in cultured and natural samples in approximately 1 hour. The test employs species-specific, ribosomal RNA (rRNA) targeted DNA probes in a sandwich hybridization assay (SHA) format that are applied using a robotic processor. Sample handing is minimal and no nucleic acid purification or PCR is required. The assay system is an improved version of that described previously by Tyrell *et al.* (Tyrrell, J.V., L.B. Connell and C.A. Scholin, 2002. Monitoring for *Heterosigma akashiwo* using a sandwich hybridization assay. *Harmful Algae* 1:205–214; Tyrrell, J.V., C.A. Scholin, P.R. Berguist and P.L. Berguist, 2001. Detection and enumeration of *Heterosigma akashiwo* and *Fibrocapsa japonica* (Raphidophyceae) using rRNA-targeted oligonucleotide probes. *Phycologia* 40: 457–467.)

W4 Workshop Oral Presentations

27 October, 09:10 (W4-4288) Invited

The Raphidophyceae: Enigmas in taxonomy, identification and morphology

Carmelo R. **Tomas**

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Within recent years, the Raphidophyceae have assumed a more important role in the formation of blooms including those involving fish mortalities. *Heterosigma akashiwo*, presently recorded from nearly all coastal waters of the American continent, Japan and Europe, displays a wide variation in morphology, pigmentation and motion. Confusion in identification of this species has plagued researchers studying blooms for decades. Within the genus *Chattonella*, morphotypes for *C. antiqua, C. ovata* and *C. marina* are markedly distinct but molecular analysis of the SSU, LSU, and ITS spacers fail to show these as separate entities. Cells of *C. marina* and *C. subsalsa* are often confused in reporting blooms. What criteria should be used to classify these organisms? *Fibrocapsa japonica*, with a more conservative morphology of the raphidophytes has diagnostic mucocysts in addition to cell shape and distinct pigments to distinguish it from other species. Recently, *F. japonica* without mucocysts was reported from the North

Sea. *Haramonas dimorpha* contains an unusual pigment found in no other raphidophyte but in toxic prymnesiophytes. *Chattonella verruculosa* (Japan) and *Chattonella* aff. *verrucuosa* (North Sea) are no longer considered raphidophytes but members of a distinctly different class. The species *Olisthodiscus luteus*, previously confused with *Heterosigma akashiwo*, does not share pigment composition, morphology or patterns of motility with the other raphidophytes. Does it still belong in the Raphidophyceae? These aspects as well as characteristics of the “green raphidophytes” will be incorporated into the discussion on what it means to be a raphidophyte.

27 October, 09:50 (W4-4080)

Two decadal changes of *Heterosigma akashiwo* blooms in Korean coastal waters

Hakgyoon **Kim**[1], Samgeun Lee[2], Changkyu Lee[2], Kyongho An[2], Wolae Lim[2], Sookyang Kim[2], Youngtae Park[2] and Yoon Lee[2]

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For the last two decadal observations since 1980, *Heterosigma akashiwo* had caused the first bloom in 1983 in Masan Bay, Korea. Even though blooms have been observed from March to November, most of the monospecific reddish blooms have occurred from late spring to early summer. Until 1994, they occurred mostly in the South Sea extending from Yeosu coast to Busan port, and sporadically in the coast of the East Sea from Kijang to Onsan Bay. On the viewpoint of annual geographic distribution, they were localized in the western part of the Jinhae Bay until 1984, but extended to Onsan Bay in 1985, and to Yeosu coast in 1989. It was shown that Masan Bay was the most frequent bloom area of this species over the last two decades. Recently, this species was responsible for haunting blooms in inshore waters, while *Cochlodinium polykrkoides* for offshore water. The bloom density was generally less than 5,000cells/L until 1984, but it developed into the blooms of high density more than 10,000 cells/L with the highest density of 110,000 cells/mL in 1985. The monospecific blooms have been prevailed in late spring May to June, and then multispecific bloom with concurrent species such as *Prorocentrum* spp. and *Skeletonema costatum* in summer. Such monospecific blooms are consistent with warming season in which river runoff enrich the coastal waters. The optimal temperature and salinity range for the initiation and subsequent development of the bloom is 20–26°C and 22–28 psu respectively.

27 October, 10:10 (W4-4471)

Bloom dynamics of *Heterosigma akashiwo* in Puget Sound and the Strait of Juan de Fuca

J.E. **Rensel**[1] and K. Bright[2]

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Heterosigma akashiwo may under some conditions kill farmed and wild fish in the coastal waters of the Northeast Pacific and elsewhere in the world. Evidence indicates that fish farms in Washington State do not cause blooms of *Heterosigma akashiwo* for several reasons. These blooms in Puget Sound have been recorded prior to fish farming. Additionally, seventeen years of wide spread aerial and vessel-based surveys prior to and during blooms indicate that blooms are large scale events that originate from specific areas remote from the fish farms. Tides, winds and estuarine circulation transports the blooms into other areas. Washington State’s fish farms are located in areas of naturally high dissolved inorganic nitrogen levels that results from Pacific Ocean upwelling. Rather than nutrients, it is a combination of sunlight, transport of cells, water temperature and grazing that limit microalgal productivity in these areas. Surface concentrations of dissolved nitrogen at any location in Puget Sound may decline for short periods during blooms to lower-than-normal levels in the late spring or early summer but this is more pronounced in backwater bays and inlets where fish farms are not located. A conceptual model is used to predict these blooms with some success and is revised when possible. The summer of 2006 provided an opportunity to verify the model, with separate blooms in North Puget Sound (associated with the massive river discharge and brackish plume of the Fraser River) and in Central Puget Sound (related to exceptionally warm weather). These separate bloom had different initiation areas and forcing factors that recurred similar to several prior blooms, raising our confidence in model validity.

27 October, 10:50 (W4-4336) Invited

Life cycle strategies and occurrences of red tides of *Heterosigma akashiwo* and *Chattonella* spp. in temperate coastal sea

Ichiro **Imai**[1], Shigeru Itakura[2] and Mineo Yamaguchi[3]

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The harmful raphidophytes *Heterosigma akashiwo* and *Chattonella* spp. (*C. antiqua*, *C. marina* and *C. ovata*) have a cyst stage in their life cycle. The cysts settle to the sea bottom to overwinter and thereby ensure the persistent existence in the same area, and the germination of cysts provides the inoculum for blooms to overlying waters. Vegetative cells of *C. antiqua* and *C. marina* originate from the germination of cysts in the bottom sediments in early summer when the bottom temperature reaches an adequate level of ca. 20°C. The cells multiply asexually during the summer and produce cysts at unfavourable conditions such as nutrient depletion. The cysts spend a period of spontaneous dormancy at sea bottom until the following spring. In spring, most cysts complete the period of spontaneous dormancy and acquire the ability to germinate. However, they must undergo a post dormancy period (enforced dormancy) because the temperature is too low for germination. In *H. akashiwo*, vegetative cells can overwinter in the water column, but *H. akashiwo* also has benthic cysts. The germination of cysts was not observed at 5°C, low at 10°C, and optimal at ≥15°C. Temperature is a crucial factor for excystment and initial growth just after germination. The spring bloom of *H. akashiwo* shows great regularity in temperate coastal waters. This suggests that the seed population are cells after excystment that are greatly affected by bottom temperature, and that population growth is affected by surface temperature (favourable at ≥18°C). It is empirically known that raphidophyte blooms have been observed when diatoms are scarce in water columns. Diatoms form resting stage cells under nutrient-deficient conditions, and rapidly sink to bottom and disappear from the water columns. Raphidophyte cysts can germinate in the dark, whereas diatom resting stage cells require light for germination. Thus the predominance of raphidophytes might be attributed to the disappearance of diatoms and subsequent failure of germination of their resting stage cells under low light conditions. The selective germination of cysts at the sea bottom is presumably a significant factor for the initiation and success in raphidophyte red tides.

27 October, 11:30 (W4-4175)

Blooms of *Heterosigma akashiwo* and *Chattonella marina* in Chinese coastal waters

Jinhui **Wang**[1,2] and Yutao Qin[1]

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Blooms of *Heterosigma akashiwo* and *Chattonella marina* are not frequently recorded in Chinese coastal waters. First records are in 1985 (Dalian, Bohai Sea) and in 1991 (Dapeng Bay, South China Sea). Blooms of harmful raphidophytes are not recorded in East China Sea, where most of harmful algal bloom and red tide in Chinese coast were recorded. Whereas Bohai Sea, South China Sea and Yellow Sea have the records of raphidophytes blooms. The basic biological characteristics, physiological and bio-chemical regularity on the growth of *H .akashiwo* are described. Nitrogen source, phosphorus source, Fe^{3+}, EDTA and Zn^{2+} are the limiting factors in the growth of *H. akashiwo*. *H. akashiwo* could divide at high rate and is more likely to bloom under high temperature and high illumination in summer, and this species is able to distribute widely in the ocean and estuaries due to its adaptation to wide salinities. Some developments on *H. akashiwo* such as ELISA and its application for quantifications, inhibition effects of macroalgae and bacteria, toxicity assay are summarized.

27 October, 11:50 (W4-4162)

Effects of *Heterosigma akashiwo* blooms on planktonic food webs: Responses of microbial loop components

Takashi **Kamiyama**

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Blooms of *Heterosigma akashiwo* occur in coastal waters of subtropical, temperate and subarctic areas in the world. The blooms not only cause damage to fish aquacultures but also influence planktonic food webs. Previous studies on the relationships between *H. akashiwo* and zooplankton have indicated that *H. akashiwo* is rejected as food sources by zooplankton such as copepods and tintinnids, and this rejection is probably due to chemical substances originated from *H. akashiwo* cells. Results from intensive field investigation during the course of *H. akashiwo* blooms revealed that the abundance of tintinnid ciliates decrease when the density of *H. akashiwo* exceeded 10^4 cells ml^{-1} and indicate the negative correlation between *H. akashiwo* concentration and the species diversity of tintinnid ciliates. Also, the abundance and the species diversity of tintinnid ciliates recovered after several days of the bloom decay. In contrast to the tintinnid ciliates, each assemblage of bacteria, heterotrophic nanoflagellates (HNFs) and aloricate ciliates sensitively responded to the development and the decay of the blooms: bacterial abundance rapidly increased at the end of the bloom, the peak of which was followed by increases of HNFs and aloricate ciliates with lag period of a few days. The increase of each microbial loop components during the course of the *H. akashiwo* bloom suggests that the dissolved organic matter produced from *H. akashiwo* cells temporarily enhanced the energy flow from bacteria through HNFs to bacterivorous aloricate ciliates.

27 October, 14:00 (W4-4038) Invited

Generation of ROS (reactive oxygen species) by *Chattonella marina* as a possible factor responsible for the fish-killing mechanism

Tatsuya **Oda**

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Chattonella marina, a raphidophycean flagellate, is highly toxic to fish, especially to yellowtail, *Seriola quinqueradiata*. Blooming of *C. marina* has repeatedly caused severe damage to fish farming in Japan. One of the characteristic features of this flagellate is the production of reactive oxygen species (ROS) such as superoxide anion and hydrogen peroxide under normal growth conditions. Since *Heterosigma akashiwo* and other raphidophytes also produce ROS, ROS generation seems to be a common biological feature of raphidophytes. Since harmful effects of ROS have been well documented in various biological systems, ROS may be a responsible factor for fish mortalities by raphidophytes. Interestingly, it was found that ROS level in *C. marina* increased by the addition of mucus substances from gill lamellae of yellowtail. Our previous studies suggested that *C. marina* has NADPH oxidase like enzyme as a ROS generation system on the cell surface that can recognize exogenous stimuli and increase the enzyme activity. We also found that cell surface structure called glycocalyx is easily discharged form *C. marina* cells and attached to gill surface, and glycocalyx has NADPH oxidase activity. It has been reported that a decrease in oxygen partial pressure of arterial blood is the earliest physiological disturbance observed in fish after *C. marina* exposure. Histological studies of fish exposed to *C. marina* suggested that excessive mucus on gill surface interferes with oxygen transfer, resulting in asphyxia. ROS are known to induce mucus secretion in mammalian system. Thus, it is possible that ROS produced by *C. marina* induce mucus secretion on gill surface that may lead to dysfunction of gill. In addition to ROS, resent our studies have demonstrated that *C. marina* is producing relatively high level of nitric oxide (NO) which has various bioactivities including toxicity.

27 October, 14:40 (W4-4357)

Routine rapid detection of *Heterosigma* in natural samples using DNA probes

Roman **Marin III**[1], Scott Jensen[1], Brent Roman[1], Eugene Massion[1], Christina Preston[1], Dianne Greenfield[1], William Jones[1], Gregory Doucette[2], Tina Mikulski[2], Kristen King[2], Mike Parker[1], Mark Brown[1] and Chris Scholin[1]

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Studies of the distribution, abundance, ecology and impacts of *Heterosigma* blooms require identification and enumeration of cells collected from a variety of locations over a sustained period of time. However, do to the delicate nature of the cells, fixing samples can distort their morphology or destroys them altogether. Counting live cells requires a skilled microscopist with experience in picking out the cells from complex natural sample matrix, something that can be problematic at low cell densities. To overcome these challenges and to expedite sample processing we have developed a DNA probe based assay using a Sandwich Hybridization Assay (SHA) format that detects and provides an estimate of *Heterosigma* densities in natural samples in approximately 1 hour. The assay can also be deployed using the Environmental Sampling Processor (ESP), an autonomous robotic device that utilizes molecular probe technology to identify and quantify a wide range of HAB species, invertebrates and bacteria. The ESP makes it possible to maintain a monitoring presence when access to the sampling site is not convenient or returning samples to the laboratory for analysis can invoke an unacceptable time lag. The ESP can also accept inputs from external contextual sensors such as a CTD, optical sensors and nutrient analyzers (*etc.*) making it possible for the ESP to sample adaptively. In this presentation we examine in detail the SHA system and its implementation on the bench top and *in situ* systems, including recent deployments of both in Monterey Bay, California.

27 October, 15:00 (W4-4290)

Environmental parameters regulate exoenzyme and haemolysin production in *Heterosigma akashiwo*

Charles G. **Trick**[1, 2], M. Klein[1] and C. Ling[1]

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[2] Schulich School of Medicine and Dentistry, University of Western Ontario, London, ON, N6A 5B7, Canada

The fish-killing flagellate species, *Heterosigma akashiwo*, is a significant harmful algal bloom taxon in many areas of the North Pacific rim countries. Efforts to predict the blooms and subsequent fate of *Heterosigma akashiwo* cells require understanding the factors that contribute to the toxicity and maintenance of this species. The supply and speciation of different forms of nitrogen and iron are important nutritional parameters influencing the growth, production, and composition of protist communities. While most cells access macronutrients in the inorganic form, some cells are successful in competing for the dissolved organic forms of these elements by producing extracellular enzymes, enabling them to access nutrients. The EnzCheck protease assay was used to assay if marine phytoplankton produced extracellular proteases in response to two environmental conditions: the supply of nitrogen and the supply of iron in the inorganic or organically-complexed form. Haemolytic activity was measured using the erythrocyte lysis assay, which involves the incubation of an algal sample with erythrocytes and subsequent photometric measurements of released hemoglobin. A broad survey of phytoplankton illustrated the diversity in the ability of marine phytoplankton to produce these proteases. While the levels of these extracellular enzymes were not significantly stimulated by altering the nitrogen source, several of the isolates grown under low iron conditions produced significantly more exoenzymes that when iron was replete. Similar environmental conditions led to the release of a light-activated haemolysin. Implications on the models of iron acquisition will be discussed.

27 October, 15:20 (W4-4161)

Characterization of nitrogen uptake by *Heterosigma akashiwo* grown in turbidostat culture under two light intensities

Desmond J. **Johns** and Patricia Glibert

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Raphidophytes were recently identified to contribute significantly to algal blooms and have been implicated in fish kills in the coastal bays of Delaware and Maryland. Ecosystem dynamics facilitating raphidophyte blooms in this system are poorly understood. Nutrient loading, particularly nitrogen in the form of NH_4 and urea, has been increasing for the past decade in these poorly-flushed bays, often reaching levels >5 µM-N. To assess the contribution of these forms of nitrogen to raphidophyte growth, specific uptake rates of NH_4, urea, and NO_3 were determined for the raphidophyte *Heterosigma akashiwo* (CCMP 2393) grown in NO_3-based media in turbidostat culture at 200 and 100 µmol photons m^{-2} s^{-1}. Growth rates were 1.13 d^{-1}. Rates of uptake were determined using ^{15}N-labeled substrates in concentrations bracketing the range observed in Maryland coastal bays. For cells grown at 200 µmol photons m^{-2} s^{-1}, specific uptake rates were highest for NH_4, followed by NO_3, then urea at V_{max}. Rates of V_{max} of NH_4 at 100 and 200 µmol photons m^{-2} s^{-1} were not significantly different and exceeded growth rates by a factor of ~5, suggesting enhanced uptake capability. At 200 µmol photons m^{-2} s^{-1}, the half saturation constant, K_s, was < 1.0 µM-N for urea and NH_4 and was 1.21 µM-N for NO_3. *H akashiwo* often forms blooms in coastal bays during the late summer after ambient nitrogen concentrations have been depleted. *H. akashiwo* thus displays a higher affinity for NH_4 and urea than NO_3 at ambient concentrations typical of late summer in these bays.

27 October, 16:00 (W4-4415)

Nitrogen utilization by the raphidophyte *Heterosigma akashiwo*: Growth and uptake kinetics in unialgal cultures and natural assemblages of San Francisco Bay

Julian **Herndon** and William P. Cochlan

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The nitrogen uptake and growth capabilities of the potentially harmful, raphidophycean flagellate *Heterosigma akashiwo* were examined in unialgal batch cultures (isolated from the Pacific Northwest), and *in situ* within San Francisco Bay, California. Culture growth rates as a function of three nitrogen substrates (ammonium, nitrate and urea) were determined at saturating and sub-saturating photosynthetic photon flux densities (PPFDs). At saturating PPFD (110 $\mu E \cdot m^{-2} \cdot s^{-1}$), the growth rate of *H. akashiwo* was slightly greater for cells maintained on NH_4^+ (0.89 d^{-1}) compared to cells grown on NO3- or urea, which had identical growth rates (0.82 d^{-1}). At sub-saturating PPFD (40 $\mu E \cdot m^{-2} \cdot s^{-1}$), both urea- and NH_4^+-grown cells grew faster than NO_3-grown cells (0.61, 0.57 and 0.46 d^{-1}, respectively). The N uptake kinetic parameters were investigated using exponentially growing batch cultures of *H. akashiwo* and the ^{15}N-tracer technique. Maximum specific uptake rates (V_{max}) were 28.0, 18.0 and $2.89 \cdot 10^{-3} \cdot h^{-1}$ for NH_4^+, NO_3^- and urea, respectively. V_{max}/K_s, a robust indicator for substrate affinity when substrate concentrations are low, were 19.4, 12.2 and $6.88 \cdot 10^{-3} \cdot h^{-1}/(\mu g\text{-at } N \cdot L^{-1})$ for NH_4^+, NO_3^- and urea, respectively. These laboratory results demonstrate that at both saturating and sub-saturating N concentrations, N uptake preference follows the order: $NH_4^+ > NO_3^- >$ urea. These are compared with the N uptake preferences of natural blooms of *H. akashiwo* in San Francisco Bay, where elevated concentrations of both inorganic and organic N substrates are commonly observed, and where concentrations of *H. akashiwo* have been observed as great as $3 \cdot 10^8$ $cells \cdot L^{-1}$.

27 October, 16:20 (W4-4373)

Regulation of environmental metabolites in *Heterosigma akashiwo*: Nutrient-limited chemostat studies

William **Bjornsson**[1] and Charles G. Trick[1, 2]

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The raphidophyte *Heterosigma akashiwo* has been implicated in fish-kills and economic losses to aquaculture operations worldwide. Much research has been conducted to characterize the compounds responsible for the icthyotoxicity caused by *H. akashiwo.* The putative toxic compounds produced by *H. akashiwo* include reactive oxygen species (ROS), haemolytic compounds, and an organic brevetoxin-like compound, none of which can be definitively linked to the toxicity of *H. akashiwo.* In batch culture multiple factors may act in concert or antagonistically: an accumulation of extracellular organic material, cell death without subsequent removal, an increase in "toxic" substances within the vessel, *etc.*, all may influence the physiology of the experimental culture. Nutrient limitation is perhaps the more difficult factor to control in batch culture. As cells reach stationary growth, levels of the limiting nutrient in the media can be highly variable. By incorporating continuous culturing techniques, the concentrations of limiting nutrient are rigorously controlled, allowing a more precise examination of the role that nutrient limitation has in toxin production and toxicity. Using nutrient limited chemostats, the role of limitation of the macronutrients nitrate (N) and phosphate (P) and of the micronutrient iron (Fe) in *H. akashiwo* toxicity have been examined. Cultures of two strains of *H. akashiwo* were grown under varying N:P regimes and iron concentrations and the production of H_2O_2 and haemolysins were assessed. Cells were assayed for their allelopathic properties against a model algal competitor *Rhodomonas salina.* The anti-grazer properties of *H. akashiwo* were examined using *Artemia salina* bioassays. Varying N:P ratios showed no significant differences in toxin production or allelochemical/toxicological properties.

W4 Poster

Poster W4-4484

Study on algicidal activity of marine bacteria to two HAB species *Heterosigma akashiwo* and *Prorocentrum micans*

Li **Zheng**[1], Xiaotian Han[2], Xiuchun Guo[1], Ping Han[1], Zhiming Yu[2] and Xiaoru Wang[1]

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Harmful algal blooms (HABs) have become a severe ecological issue within the last three decades. They cause economic losses to aquaculture, fisheries operations and bring major environmental and human health impacts. With the aim of eliminating HABs, several approaches using physical and chemical methods have been tried. While biological methods such as antagonistic microorganisms have been tried. Various microorganisms, such as bacteria, actinomycetes, fungi, phages and amoebae, have been reported to kill the HAB species. Among these, antagonistic bacteria have the potential to become useful agents for microalgal control. In this study, two microalgae species *Heterosigma akashiwo* and *Prorocentrum micans* with high red tied frequency in China seas were chose as our target HAB species. A rapid detection method of microalgae based on viable cell fluorescence was established. The algicidal activity of 15 marine bacteria associated with marine macroorganisms to the two HAB species was investigated. These bacteria were identified through biomolecular method and their phylogenetic relationship was analyzed. The results showed that seven strains could inhibit the growth of the two HAB species with different IR (inhibition rate) value from 17.8% to 88.7% and the inhibition exhibited certain selectivity. Three strains *Bacillus* sp. NJ6-3-2 (AY621379), *Pseudoalteromonas* sp. QD1-2 (AY626830) and *Bacillus* sp. ATCI 02-4 (AY626834) had the

ability to inhibit the growth of both two species. The other three strains *Pseudoalteromonas* sp. NJ6-3-1 (AY626863), *Bacillus* sp. NJ5-7-1 (AY626828) and *Alteromonas* sp. SSN-6 (AY626837) had the ability to inhibit the growth of *Prorocentrum micans*. One strain *Pseudoalteromonas* sp. SS6-4 (AY626838) only inhibited the species *Heterosigma akashiwo*. The phylogenetic analysis demonstrated that, among seven strains with algicidal activity, four strains NJ6-3-1, QD1-2, SSN-6, SS6-4 belonged to γ-proteobacteria subdivision and the other three strains NJ5-7-1, NJ6-3-2, ATCI 02-4 belonged to Gram+ subdivision. Our results implied that marine bacteria of *Bacillus* sp. and *Pseudoalteromonas* sp. were the potential biocontrol species to eliminate HABs.

W5 MONITOR/BIO Workshop Measuring and monitoring primary productivity in the North Pacific

Co-Convenors: Paul J. Harrison (Canada/Hong-Kong) and Sei-ichi Saitoh (Japan)

Marine net primary productivity is a key metric of ecosystem health and carbon cycling and is commonly a function of plant biomass, incident solar flux, and a scaling parameter that accounts for variations in algal physiology. Net primary productivity is defined as the amount of photosynthetically fixed carbon available to the first heterotrophic level, and is the relevant metric for addressing environmental questions ranging from trophic energy transfer to the influence of biological processes of carbon cycling. Long-term monitoring of primary productivity is a high priority for PICES nations because it is one of the essential parameters for the understanding of marine ecosystems and biogeochemistry. Recently, measurement technology of primary production has become extremely advanced through the application of fast repetition rate fluorometers, satellites, buoys, *etc*. However, inconsistencies between *in situ* measurements and satellites still exist, and there are some differences between the values obtained with C^{13} and C^{14} isotopic methodology. This workshop will discuss the state-of-the-art primary productivity measurement technology and its application to understanding primary productivity in the North Pacific. Presentations at this workshop should: address techniques for measuring primary productivity, compare *in situ* and satellite measurements of primary productivity, demonstrate the utility of long time series measurements in understanding ecosystem variability, and describe the application of primary productivity studies to marine ecosystems and biogeochemistry.

Saturday, October 27, 2007 09:00 – 12:30

09:00 ***Introduction by convenors***

09:10 **Michael Behrenfeld (Invited)**
A satellite view of North Pacific primary production (W5-4467)

09:50 **Toshiro Saino (Invited)**
Satellite monitoring and *in situ* validation of ocean primary productivity (W5-4433)

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

10:50 **Sinjae Yoo and Jisoo Park**
Primary productivity of the Yellow Sea (W5-4314)

11:10 **Eko Siswanto, Joji Ishizaka, Mitsuhiro Toratani, Toru Hirawake and Sei-Ichi Saitoh**
The effect of tropical cyclones on primary production enhancement – Some results from the W-PASS (Western Pacific Air-Sea interaction Study) project (W5-4500)

11:30 **Akihiro Shiomoto**
Comparison of daily primary production between east and west in the subarctic North Pacific: A review from a new angle (W5-4469)

11:50 **Paul J. Harrison, Michael Lipsen and Adrian Marchetti**
Phytoplankton biomass and primary productivity at Stn P and along Line P: Long-term variability over decades and during episodic events (W5-4479)

12:10 ***Discussion***

W5 Posters

W5-4332 **Jeong-Min Shim, Suk-Hyun Yun, Jae-Dong Hwang, Hyun-Gook Jin, Yong-Hwa Lee, Young-Suk Kim and Un-Gi Hwang**
Seasonal variability of picoplankton in the middle part of East/Japan Sea

W5 Oral Presentations

27 October, 9:10 (W5-4467) Invited

A satellite view of north Pacific primary production

Michael **Behrenfeld**

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The North Pacific has historically been the site of intensive field studies on marine ecosystem dynamics and its dependence on seasonal cycles in phytoplankton net primary production. However, such investigations, while providing key process-level information, are difficult to extrapolate to the more synoptic scale of basin-level fluctuations occurring at seasonal and interannual periods. Satellite remote sensing measurements provide a path for characterizing broad spatial and temporal changes in the North Pacific, but require the interpretation of optical properties in terms of the ecosystem parameters of interest. This presentation will discuss developments in remote sensing estimates of net primary production, how these estimates are changing our view of plankton dynamics in the North Pacific, and directions for future improvements.

27 October, 9:50 (W5-4433) Invited

Satellite monitoring and *in situ* validation of ocean primary productivity

Toshiro **Saino**[1,2]

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An *in situ* ocean primary productivity profiling system was developed to measure oceanic primary productivity in a real-time fashion, for the purpose of near-real time validation of satellite derived estimate of primary productivity. It is comprised of a fast repetition rate fluorometer installed on a profiling buoy tethered to an underwater winch. The system has capabilities of acoustic communication between the profiling buoy and the winch, iridium phone communication between the profiling buoy and the shore based laboratory. A custom made FRRF (Diving Flash) processes the measured fluorescence signal in real-time and transmits a depth profile of temporal value of primary productivity per unit biomass. By comparing the FRRF profiling measurements with depth profiles of oxygen-17 anomaly in dissolved oxygen, both with 2 hours intervals from 0400 to 2000, it was shown that the FRRF measures instantaneous gross primary productivity *in situ*. Daily depth integrated gross primary productivity is estimated based on empirical relationship between *in situ* PAR and physiological parameters (Fv/Fm and σ_{PSII}) of phytoplankton assemblage. The gross primary productivity measurement by the frrf is non-destructive, rapid, objective, easy to obtain, and hence is superior for validation purpose of satellite data. It will be discussed that the gross primary productivity data could be used in place of net primary productivity to discuss biogeochemical cycle provided with data on oxygen/nitrogen or oxygen/argon ratio.

27 October, 10:50 (W5-4314)

Primary productivity of the Yellow Sea

Sinjae **Yoo** and Jisoo Park

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The Yellow Sea is a small shallow marginal sea with rather a simplistic circulation pattern. However, high turbidity caused by strong tidal mixing in the coastal waters makes its light environment very complicated. Diffuse attenuation coefficient easily surpasses 2.0 m^{-1} in the turbid zone, while it is less than 0.14 m^{-1} in the central region when the water column is stratified. In winter, the water column gets totally mixed vertically even in the deepest

central region, while in summer, the depth of thermocline can be as shallow as some 10 m. Photosynthetic parameters also show a wide range: For example, from our four-year surveys, I_k ranged 74.1 ~ 606.4 (median: 217.2) μE m^{-2} s^{-1} and P_m^B ranged 0.48 ~ 18.71 (median: 4.24) mg C (mg chl-*a*)$^{-1}$ hr^{-1}. Extremely low I_k values as low as 11.2 μE m^{-2} s^{-1} were also reported. As a consequence, existing estimates on the primary productivity based on *in situ* measurements in the Yellow Sea show a wide range of values from 11.78 to 2,694 mg C m^{-2} d^{-1}. The high variability in environmental characteristics calls for using satellite data for better estimation of the primary productivity of the Yellow Sea. To achieve the goal with reasonable accuracy using satellite data, there are many problems to resolve such as the retrieval of chlorophyll and diffuse attenuation coefficient of PAR, and the estimation of physiological parameters and vertical structure of chlorophyll in water column. Here we attempt to overcome some of these problems by dividing the Yellow Sea into two different regions in terms of light environments. The results and problems in such an approach are discussed.

27 October, 11:10 (W5-4500)

The effect of tropical cyclones on primary production enhancement – Some results from the W-PASS (Western Pacific Air-Sea interaction Study) project

Eko Siswanto[1,2], Joji Ishizaka[3], Mitsuhiro Toratani[4], Toru Hirawake[5] and Sei-Ichi **Saitoh**[5]

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Understanding the effect of tropical cyclone (typhoon) passages on the ocean primary production (PP) enhancement is an essential issue in assessing the effect of global climate change on ocean biogeochemical processes. Investigating the influence of long-term global warming on typhoon-forced PP enhancement is more problematic because it deals with a period without satellite ocean color data. The objectives of this study are: (1) to describe the evidence for the effect of a typhoon on PP enhancement in the outer shelf of the East China Sea (ECS) (coastal region) and the western North Pacific (offshore region), (2) to construct an empirical relationship to estimate PP enhancement induced by a typhoon, and (3) to extrapolate the constructed relationship to elucidate the interannual and interdecadal variations of typhoon-forced PP enhancement from 2004 back to 1980. In this study, we investigated the distribution of phytoplankton biomass and primary production in study regions during 1998–2004, before and after typhoon passages using satellite multi-sensor remote sensing. We employed ocean color (Chlorophyll-*a* (Chl-*a*), SeaWiFS), photosynthesis active solar radiation (PAR, SeaWiFS), sea surface temperature (SST, AVHRR and AMI) datasets. Primary production was calculated using the vertically generalized production model (VGPM). In the ECS, we used the local photosynthetic parameter of VGPM. We will introduce some typical evidence of typhoon-forced PP enhancement and discuss the empirical relationship and the results of extrapolation during the 1980–2004 period.

27 October, 11:30 (W5-4469)

Comparison of daily primary production between east and west in the subarctic North Pacific: A review from a new angle

Akihiro **Shiomoto**

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Daily primary production in the subarctic North Pacific has a low-west and high-east pattern in winter. Chl-*a*-specific primary productivity measured at each depth within the euphotic zone was plotted against light intensity (PAR) at those depths, using the previous data at station KNOT (western station) and station P (eastern station) in winter. The primary productivity increased linearly with the increase in PAR until 18 Ein m^{-2} d^{-1}, which is nearly equal to the maximum PAR in winter, at station KNOT. At station P, the primary productivity was saturated at around 3 Ein m^{-2} d^{-1}, suggesting that relatively high primary productivity occurred even in the deeper layer. The saturated values were almost equal to the value at 18 Ein m^{-2} d^{-1} at station KNOT. The photosynthetic characteristic adapting to the more widespread PAR of the phytoplankton can produce the higher daily primary production at station P than at station KNOT. In contrast, a substantial difference was not observed for daily primary production in

summer between east and west. PAR is higher in summer than in winter and it is thus possible that the relatively high primary productivity, which is nearly equal to that at station P, occurs even in the deeper layer at station KNOT. The high PAR is considered to be one of factors causing the non-substantial difference in daily primary production in summer. It is necessary to consider the differences in the response of phytoplankton to PAR between east and west in the discussion of the differences in daily primary production.

27 October, 11:50 (W5-4479)

Phytoplankton biomass and primary productivity at Stn P and along Line P: Long-term variability over decades and during episodic events

Paul J. **Harrison**[1], Michael Lipsen[2] and Adrian Marchetti[3]

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[3] Dept Oceanography, University of Washington, Seattle, WA, USA

Stn P is located in iron-limited HNLC waters and it has one of the longest open ocean time series in the world. Measurements of phytoplankton biomass and primary productivity over the last four decades indicate that these two parameters are more variable than one might expect in these HNLC waters. Long term decadal variability may be due to regime shifts that occurred in the mid 1970s. Interannual variability appears to be linked to factors such as El Niño/La Niña years. Dust events, the offshore movement of coastal eddies, and natural seasonal cycles, contribute to intra-annual variability. The recent mesoscale Fe enrichment simulated a natural elevation in iron concentrations and this experiment followed the response of the primary producers for 30 days. Line P is a transect from the BC coast to Stn P and measurements at stations along this transect have been valuable in determining the interaction between the coastal waters and the open ocean. The continuation the long term measurements along Line P and at Stn P provide an exceptional ground-truthing data record for comparing estimates of chlorophyll and primary productivity by remote sensing methodologies. These extensive data sets have highlighted the complexity of understanding the factors and time scales that influence primary productivity in the NE Pacific.

W5 Poster

Poster W5-4332

Seasonal variability of picoplankton in the middle part of the East/Japan Sea

Jeong-Min **Shim**, Suk-Hyun Yun, Jae-Dong Hwang, Hyun-Gook Jin, Yong-Hwa Lee, Young-Suk Kim and Un-Gi Hwang

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The seasonal and vertical distributions of small-sized phytoplankton: *Synecococcus*, *Prochlorococcus* and picoeukaryotes were investigated in the middle part of the East/Japan Sea during three different seasons, spring, summer and autumn in 2006. All groups of picoplankton showed clear seasonal patterns in population abundance. Among the group, *Synecococcus* showed the most prominent seasonal variation during the study period. The maximal abundance of *Synecococcus* occurred in summer and the lowest in autumn, and vertically, high abundance was found in the upper 20 m of water column. The seasonal distribution of *Prochlorococcus* displayed the reverse tendency with that of *Synecococcus*. The abundance of *Prochlorococcus* ranged from 2.9×10^3 cells ml^{-1} in summer to 311×10^3 cells ml^{-1} in autumn. However, the seasonal distribution of picoeukaryotes was shown to be relatively constant, and the maximal abundance was 81.5×10^3 cells ml^{-1} in summer. The highest abundance of picoeukaryotes occurred in summer and the lowest in autumn and the seasonal distribution in abundance of picoeukaryotes showed a similar trend with that of *Synecococcus*.

W6 POC/CCCC Workshop Climate scenarios for ecosystem modeling

Co-Convenors: Jacquelynne R. King (Canada) and Michael G. Foreman (Canada)

This workshop will include invited papers from members of the Climate Forcing and Marine Ecosystem Task Team (CFAME) and the POC Committee Working Group on *Evaluations of Climate Change Projections* (WG 20) on research activities related to applying output from WG 20 regional climate models, or IPCC (Inter-governmental Panel for Climate Change) global models, to CFAME ecosystem models. CFAME is developing conceptual and empirical models of the mechanisms relating climate forcing to the population dynamics of species and to ecosystem processes. CFAME has focused on four North Pacific ecosystems that represent different dominant physical processes: (1) California Current System (boundary current with upwelling); (2) Kuroshio/Oyashio Current System (boundary currents); (3) Sea of Okhotsk (sea ice cover); and (4) Yellow Sea/East China Sea Region (freshwater input). WG 20 is developing higher resolution regional coupled atmosphere-ocean models forced by IPCC global or regional models. These regional models could provide forecasts of regional parameters (such as SST, sea ice cover, and river discharge) relevant to ecosystem processes. This workshop will facilitate discussion between CFAME and WG 20 members for future collaborative research on forecasting the impacts of climate change (as represented by IPCC projection scenarios) on regional ecosystems and species of the North Pacific.

Friday, Oct. 26, 2007 09:00 – 17:00

09:00 **Jacquelynne King (CFAME member)**
- Introductions
- Review workshop objectives

09:15 **Kerim Aydin (CFAME Co-Chairman, Invited)**
- Overview of CFAME terms of reference
- CFAME workshops and work completed to date

09:30 **Michael Foreman (WG 20 Co-Chairman, Invited)**
- Overview of WG 20 terms of reference
- Work completed to date

California Current System

09:45 **Vera Agostini (CFAME member, Invited)**
Overview of the California Current System

10:00 **Gordon McFarlane (CFAME member, Invited)**
Conceptual mechanisms linking physical and biological oceanography to population dynamics of key species in the California Current System

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

10:50 **Emanuele Di Lorenzo (WG 20 member, Invited) and Niklas Schneider**
A North Pacific gyre-scale oscillation: Mechanisms of ocean's physical-biological response to climate forcing (W6-4176)

11:10 **Enrique Curchitser (WG 20 member, Invited)**
Embedding a high-resolution California Current climate model into the NCAR global climate model

11:25 **Michael Foreman (WG20 member, Invited)**
Future winds off the BC coast

Kuroshio/Oyashio Current System

11:40 **Akihiko Yatsu (CFAME member, Invited), Tsuneo Ono, Kazuaki Tadokoro (CFAME member, Presenter), Akira Nishimura, Shin-ichi Ito, Sanae Chiba and Yasunori Sakurai**
Overview of the Kuroshio/Oyahsio Current System (W6-4139)

11:55 **Akihiko Yatsu, Yoshiro Watanabe (CFAME members, Invited), M. Kaeriyama, Y. Sakurai and A. Nishimura (Presented by Jacquelynne King)**
Conceptual mechanisms linking physical and biological oceanography to population dynamics of key species in the Kuroshio/Oyashio Current System

12:25 ***Lunch***

14:00 **Taketo Hashioka, Yasuhiro Yamanaka, Takashi T. Sakamoto and Maki N. Aita**
Future projection with a 3-D high-resolution ecosystem model (W6-4324)

Yellow Sea / East China Sea

14:20 **Young Shil Kang (CFAME Co-Chairman, Invited)**
Overview of the Yellow Sea/East China Sea

14:35 **Yeong Hye Kim (Invited)**
Conceptual mechanisms linking physical and biological oceanography to population dynamics of key species in the Yellow Sea/East China Sea

15:05 **Jinhee Yoon, K.-I. Chang, Takashi T. Sakamoto, Hiroyasu Hasumi and Young Ho Kim**
Effects of global warming on the East/Japan Sea heat balance using a global climate model (MIROC3.2-hires) (W6-4315)

15:25 ***Coffee / tea break***

15:50 **James Overland (CFAME member, Invited)**
Synthesis and summary of key climate and oceanographic factors identified by CFAME and required for ecosystem projections given climate change

16:20 **Muyin Wang (WG 20 member, Invited)**
Uncertainties in climate model ensemble projections

16:30 ***Workshop discussion***
- Outstanding issues and discussion from presentations
- Next steps for collaboration between CFAME and WG20

Saturday, Oct. 27, 2007 09:00 – 12:00

09:00 ***Workshop discussion***
Continued discussion from previous day, if required

Breakout discussions - CFAME and WG20 to convene separately
CFAME:
- Finalize species' scenarios by ecosystem
- Discussion of communication of results
- Review and of draft PICES Scientific Report
- Assignment of tasks

WG20:
- Provision parameters for the CFAME shopping lists
- Future meetings and research plans

W6 Oral Presentations

26 October, 10:50 (W6-4176)

A North Pacific gyre-scale oscillation: Mechanisms of ocean's physical-biological response to climate forcing

Emanuele **Di Lorenzo**[1] and Niklas Schneider[2]

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2 International Pacific Research Center, University of Hawaii at Manoa, 1680 East West Road, Honolulu, HI, 96822, USA

Understanding past climate fluctuations in the North Pacific is critical to predicting the ocean's physical-biological response to 21st century climate change. We find that previously unexplained decadal variations of salinity and nutrients in the Southern California Current reflect an oscillation in the North Pacific gyre-scale circulation (NPGO), which is independent of the Pacific Decadal Oscillation (PDO). Along the California coast, changes in alongshore wind stresses associated with the NPGO, rather than PDO, cause low-frequency variations in nutrient upwelling and surface chlorophyll-*a*. The NPGO and PDO both exhibit sharp transitions associated with major North Pacific ecosystem shifts, suggesting that both modes contribute to decadal variations in zooplankton and fish populations. Therefore observed amplifications of the NPGO decadal variance during global warming may be critical to accurate ecosystem forecasts.

26 October, 11:40 (W6-4139) Invited

Overview of the Kuroshio/Oyashio Current System

Akihiko Yatsu[1], Tsuneo Ono[1], Kazuaki **Tadokoro**[2], Akira Nishimura[1], Shin-ichi Ito[2], Sanae Chiba[3] and Yasunori Sakurai[4]

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The Kuroshio and Oyashio currents are western boundary currents that transport heart, nutrient, and planktonic animals. The Kuroshio/Oyashio ecosystem also provides important fishing grounds of pelagic and demersal fishes and invertebrates. The Transition Zone formed between these currents is downstream off the Honshu Island and is an oceanographically complex area that is known as a key area of recruitment of some commercial pelagic fishes. We overview ecosystem characteristics of Kuroshio, Oyashio and Transition Zone, ranging from climatic forcings, local physics, primary and secondary productions, and population dynamics of major fishes and squids.

26 October, 14:00 (W6-4324) Invited

Future projection with a 3-D high-resolution ecosystem model

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To clarify the effect of global warming on marine ecosystems, we have been developing and improving a 3-D ecosystem model, the COCO-NEMURO, which consists of the PICES NEMURO (North Pacific Ecosystem Model for Understanding Regional Oceanography) coupled with the COCO (CCSR Ocean Component Model). Hashioka and Yamanaka (2007) conducted a global warming experiment using a medium resolution version (1 x 1 degrees) of

COCO-NEMURO in the western North Pacific. In that experiment, predicted changes in the lower tropic level ecosystem for the subarctic-subtropical transition region associated with global warming were significantly larger than those of other regions. However, medium resolution models generally cannot reproduce some key features of the Kuroshio Current (*e.g.*, separation latitude and current speed) which strongly affect the physical environment in the western North Pacific. It was also difficult to use high-resolution models for studies of ecosystem changes associated with climate change (especially for future projection) because they are computationally intensive. We have developed a new high-resolution version (1/4 x 1/6 degrees) of the COCO-NEMURO as an offline model in collaboration with climate modelers. We are currently conducting a 20th century experiment and a global warming experiment using physical forcing from a high-resolution climate model (the CCSR/NIES/FRCGC coupled Ocean-Atmosphere GCM: K-1 model, which contributed to the IPCC-AR4). Our model accurately reproduced the seasonal and regional variations of Chl-*a* concentration associated with meso-scale features in the present-day simulation. We will present preliminary results of our global warming experiment.

26 October, 15:05 (W6-4315) Invited

Effects of global warming on the East/Japan Sea heat balance using a global climate model (MIROC3.2-hires)

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Observations show that the East/Japan Sea (EJS) has undergone drastic changes in past few decades such as a warming of upper and deep waters, and a decrease in dissolved oxygen content in deep waters. No postulation, however, has been attempted concerning the future oceanographic states of the EJS as the climate continues to change. Motivated by this gap, we analyzed results from a high-resolution global coupled climate model (MIROC3.2-hires, T106L56AGCM + 0.28×0.16 L48 OGCM) to examine climate change projections over the EJS. In this study, results from the present climate simulation (20C-run) are compared with those from a future projection (IPCC A1B scenario) to investigate the response of the EJS to global warming. The final 30-year mean sea surface temperature averaged over the entire EJS in the scenario run increases by 4° as compared to that in the 20C-run. The surface warming is more pronounced in the northern EJS than in the southern part. This warming is mainly caused by the reduced sensible heat loss from the EJS to the atmosphere. Weakening winter monsoons result in a decrease in the sensible heat loss by about 20% in winter over the EJS. Model results suggest that warming in the EJS is mainly related to changes in atmospheric conditions over the sea, rather than changes in the horizontal heat transport through the straits.

WG 21 Meeting

Meeting of WG 21 on Non-indigenous Aquatic Species Science topic presentations

Co-Convenors: Darlene Smith (Canada) and Vasily I. Radashevsky (Russia)

Friday, October 26, 2007, 14:00-15:00

WG21-4514

Studies on invasive species in the far-eastern part of Russia

Vasily I. **Radashevsky**

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A working group has been established in May 2007 to coordinate studies on the invasive species in the far-eastern part of Russia. The group includes members of the Institute of Marine Biology, Russian Academy of Sciences, and the Sea Protection Institute, both located in Vladivostok, Primorsky Region. In cooperation with the Sea Ports of Vladivostok and Nakhodka, major vectors of ship transportations in the Sea of Japan have been determined and a strategy of complex investigations has been developed. Samples of fouling and ballast water have been regularly collected since June 2007. Sampling protocols and first results of this investigation are summarized and presented.

WG21-4513

Biogeography and trans-ocean introductions of the green algae *Ulva* spp. from/to Japan deduced from the identifications based on molecular markers

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To assess introductions of *Ulva* species to Japanese coasts, we investigated the genetic diversities of populations of *Ulva/Enteromorpha* using molecular markers (nuclear rDNA ITS and spacer between chloroplast *atpH* and *atpI* genes), for specimens collected in Japan, Korea, China, Australia, New Zealand and Europe, as well as collections from the hulls and ballast water of intercontinental cargo carriers. In Mikawa Bay and Osaka Bay, Japan, these species dominated: *Ulva pertusa*, *U. ohnoi*, *U. arasakii*, *U. fasciata*, *U. linza* (=*Enteromorpha linza*), *U. compressa* (=*E. compressa*), *U. flexuosa* (=*E. flexuosa*), *U. tanneri*, *U. californica*, *U. scandinavica*, and *U. armoricana*. *Ulva pertusa* and *U. ohnoi* were most dominant from spring to early summer and from autumn to early winter, respectively. *Ulva flexuosa*, *U. armoricana*, *U. californica*, and *U. scandinavica* appear to be recently introduced to Japanese coasts, with the last two first recorded in the present study. Based on the chloroplast *atpH-atpI* sequence data, 15 haplotypes were recognized in NE Asian populations (native range) of *Ulva pertusa*, but only one (Oceania) or two (Europe) haplotype(s) corresponding to those found on the Pacific and Sea of Japan coasts of Japan were found. Therefore, the *U. pertusa* populations in Oceania and Europe appear to be derived from introductions from NE Asia. This study was supported by the Global Environment Research Fund (D-4 & D-072; Ministry of Environment, Japan).

WG21-4148

Assessment of the genetic impact of introduced *Strongylocentratus intermedius* on native sea urchin populations in northern China

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Strongylocentratus intermedius is native to north Japan, north Korea, and the Pacific coast of Russia. This species was introduced to north China for marine aquaculture by the Dalian Fishery College in 1989, and is now in large-scale culture in the Liaoning and Shandong provinces in northern China. .However, several native sea urchin species, such as *Strongylocentrolus nudus and Hemicentrolus pulcherrimus,* have strong phylogenetic relationships with *S. intermedius*. These high-quality native species are very important sea urchin fishery resources in north China. However, there exists a risk of “genetic pollution” due to the introduction of *S. intermedius*. In order to assess this possible genetic impact, several experiments were conducted to test whether the native sea urchin species and the introduced species can mate successfully. Experiments included the crosses and reciprocal crosses between *S. nudus and S. intermedius*, *H. pulcherrimus and S. intermedius*. When the eggs of *S. intermedius* were fertilized with sperm of *S. nudus*, the average fertilization rate was about 47.1%. While the average fertilization rate of *S. nudus* eggs with *S. intermedius* sperms reached only 1.9%, when the eggs of *H. pulcherrimus* were fertilized with sperms of *S. intermedius*, the average fertilization rate was about 25.1%. The average fertilization rate of *S. intermedius* eggs with *H. pulcherrimus* sperms reached 36.4%. These results of hybridization between native sea urchin species and the introduced species show that the introduction of *S. intermedius* possibly can have great impacts on the genetic integrity of native sea urchin species.

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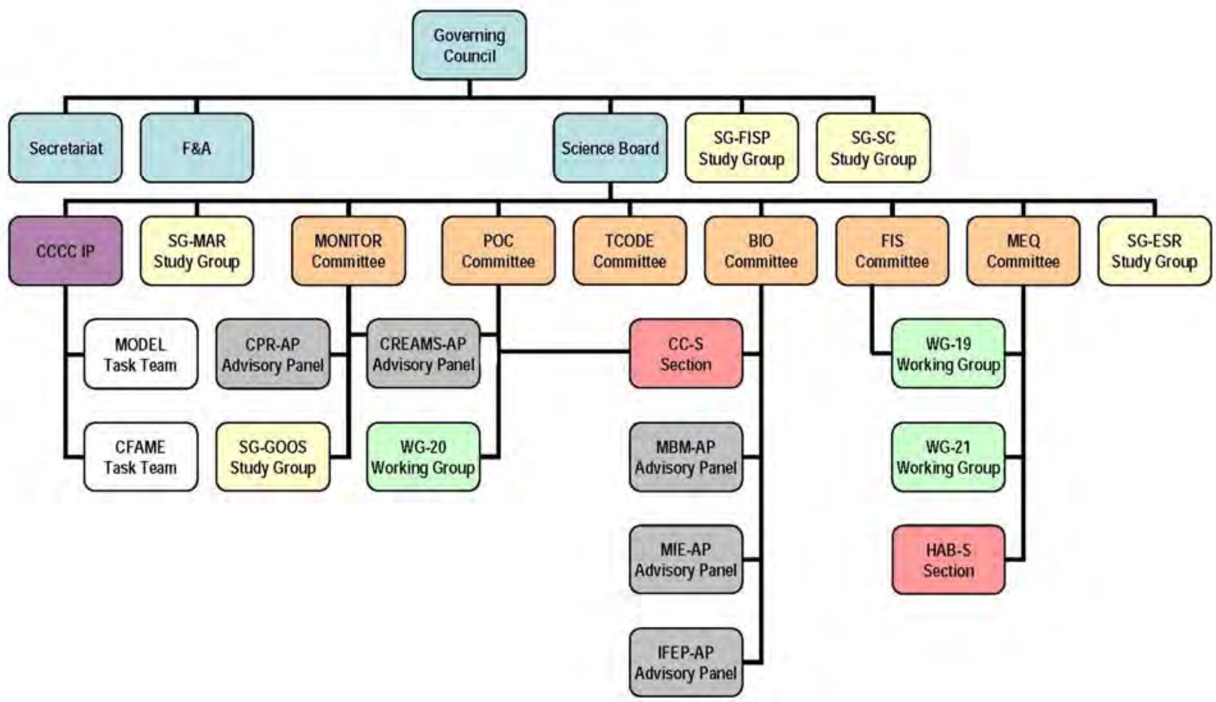
PICES Structure



PICES STRUCTURE ACRONYMS

GC	Governing Council

Executive Committees

SB	Science Board
F&A	Financial and Administration Committee

Scientific and Technical Committees (ongoing groups)

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

Expert Groups (*ad hoc* groups)

HAB-S	Section on *Harmful Algal Blooms*
CC-S	Section on *Carbon and Climate*
WG-19	Working Group on *Ecosystem-based Management Science and its Application to the North Pacific*
WG-20	Working Group on *Evaluations of Climate Change Projections*
WG-21	Working Group on *Non-indigenous Aquatic Species*
SG-ESR	Study Group on *Ecosystem Status Reporting*
SG-FISP	Study Group on *Future Integrative Scientific Program(s)*
SG-GOOS	Study Group to develop a strategy for GOOS
SG-MAR	Study Group on *Marine Aquaculture and Ranching in the PICES region*
SG-SC	Study Group on *Scientific Cooperation between PICES and non-member countries*
CPR-AP	Advisory Panel on *Continuous Plankton Recorder Survey in the North Pacific*
CREAMS-AP	Advisory Panel on *CREAMS/PICES Program in East Asian Marginal Seas*
IFEP-AP	Advisory Panel on *Iron Fertilization Experiment in the Subarctic Pacific*
MBM-AP	Advisory Panel on *Marine Birds and Mammals*
MIE-AP	Advisory Panel on *Micronekton Sampling Inter-calibration Experiment*

Scientific Program

CCCC-IP	PICES-GLOBEC Climate Change and Carrying Capacity (CCCC) Program Implementation Panel
CFAME	Climate Forcing and Marine Ecosystem Response Task Team
MODEL	Conceptual/Theoretical and Modeling Studies Task Team