PICES-2013

Communicating forecasts, uncertainty and consequences of ecosystem change

North Pacific Marine Science Organization

October 11-20, 2013
Nanaimo, BC, Canada

Table of Contents

Notes for Guidance vi

VICC Centre Floor Plan vii

Meeting Timetable viii

Keynote Lecture 1

Schedules and Abstracts

S1: Science Board Symposium
Communicating forecasts, uncertainty and consequences of ecosystem change 5

S2: BIO/FIS/POC Topic Session
Are marine ecosystems of the North Pacific becoming more variable? 15

S3: MEQ/FUTURE Topic Session
Status, trends and effects of pollutants in coastal ecosystems:
Implications for wildlife and humans 21

S4: POC Topic Session
The changing carbon cycle of North Pacific continental shelves and marginal seas . . . 35

S5: BIO/FIS Topic Session
Marine ecosystem services and the contribution from marine ecosystems to the
economy and human well-being 49

S6: BIO/POC/TCODE/MONITOR/FUTURE Topic Session
Recent trends and future projections of North Pacific climate and ecosystems 59

S8: BIO/FIS/MEQ/TCODE/FUTURE Topic Session
Ecosystem indicators to characterize ecosystem responses to multiple
stressors in North Pacific marine ecosystems 77

S9: MONITOR Topic Session
Cost-effective, cooperative ocean monitoring 97

S10: FIS/TCODE Topic Session
Banking on recruitment curves; returns on intellectual investment 105

BIO Contributed Paper Session 113

FIS Contributed Paper Session 131

MEQ Contributed Paper Session 153

POC Contributed Paper Session 161

General Poster Session 171

W1: Workshop
Comparison of size-based and species based ecosystem models 179

W2: POC/BIO/MONITOR/FUTURE Workshop
Identifying mechanisms linking physical climate and ecosystem change:
Observed indices, hypothesized processes, and "data dreams" for the future 185

W3: BIO Workshop
Marine bird and mammal spatial ecology. 195

W4: TCODE Workshop
Tools, approaches and challenges for accessing and
integrating distributed datasets 205

W6: MEQ Workshop
Economic impacts of harmful algal blooms on fisheries and aquaculture 209

HAB-S Meeting 215

W7: MEQ Workshop
Traditional seafoods of coastal aboriginal communities in the North Pacific:
Insight into food, social and ceremonial uses at Snuneymux'w
First Nation in Nanaimo, British Columbia 221

Registrants 223

Observers 248

Author Index 253

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

Notes for Guidance

The North Pacific Marine Science Organization (PICES) announces its 2013 Annual Meeting to be held October 11–20, 2013, at the Vancouver Island Conference Centre (VICC), Nanaimo, British Columbia, Canada. The meeting is hosted by the Government of Canada, Department of Fisheries and Oceans in coordination with the PICES Secretariat. Local arrangements are made by the Department of Fisheries and Oceans, Science Branch, Pacific Region.

Presentations

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

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

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

Posters

Posters on general interest to the PICES Scientific Committees, including those not necessarily matching the themes of the Topic Sessions, are welcome. Posters will be on display from October 15 (a.m.) until the end of the wine and cheese Poster Session on the evening of October 17, when poster presenters are expected to be available to answer questions.

Internet access

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

Social activities

Monday, October 14 (18:15-20:30)

Welcome Reception

The Welcome Reception for all participants (and registered guests) will be held at the Vancouver Island Conference Centre in the Mount Benson Ballroom.

Tuesday, October 15 (18:00-21:00)

Sport Event

The event this year is Flag Rugby Football at Pioneer Park in Nanaimo. This is a non-contact two team sport on a lighted field with enough room for 80 participants and some additional space on the bus if attendees just want to come to cheer their colleagues on. There is a Rugby clubhouse on site for refreshments and pizza. Bus transportation will be arranged. Please sign up for the Bottom-Up Team (climatologists, physical oceanographers and lower-trophic level biologists) and the Top-Down Team (higher-trophic level biologists, social scientists and fisheries managers) at the Registration Desk.

Wednesday, October 16 (18:30-21:00)

Extravaganza Dinner

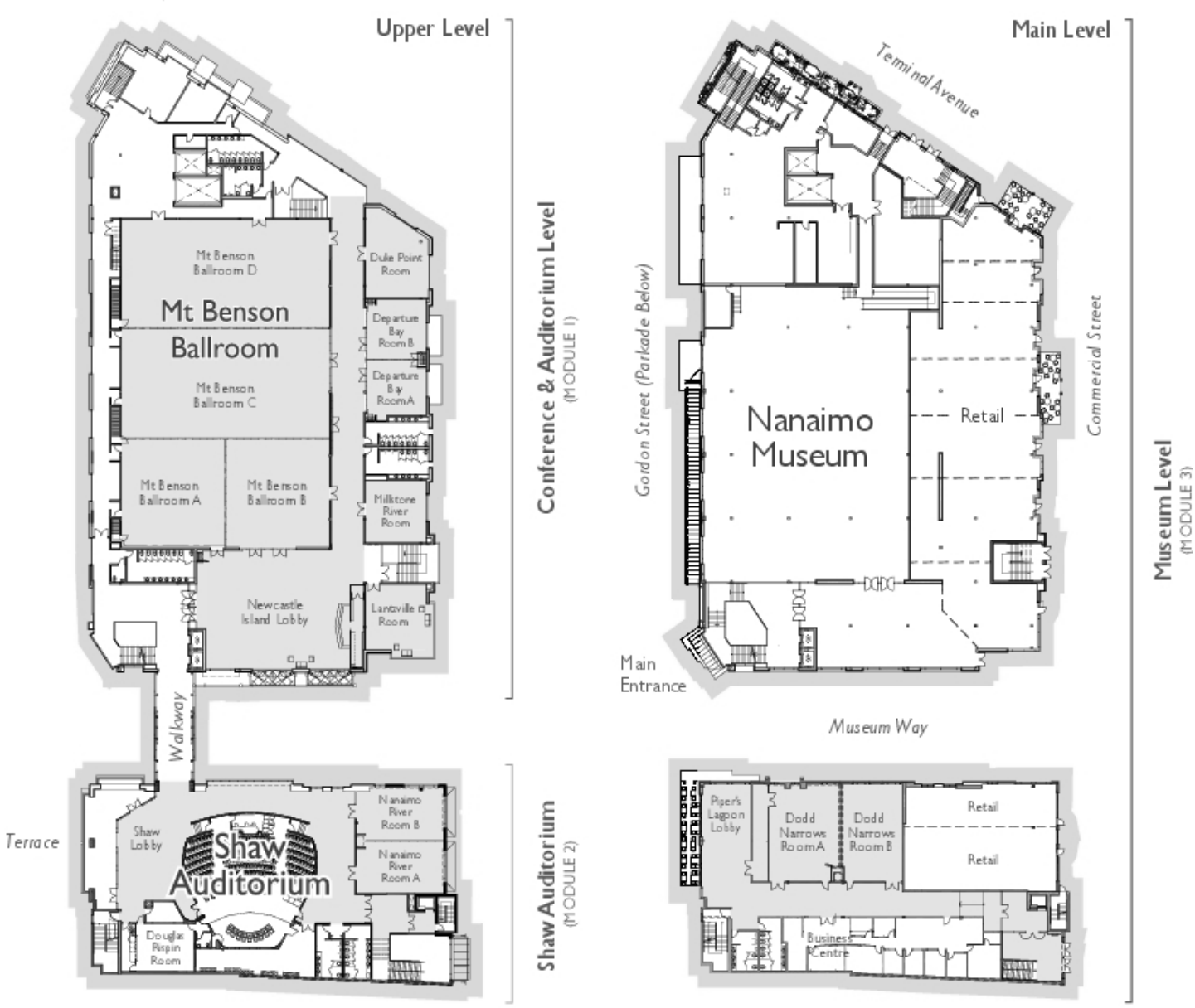
The Extravaganza Dinner will be held at the Bistro at Westwood Lake. The ticket price of the dinner is CAD$110. Drinks will be included with the courses, and bus transportation will be arranged. The capacity of the event is limited to ~45. Please contact Christina Chiu at the Registration Desk for tickets.

Thursday , October 17 (18:15-20:30)

Wine & Cheese Poster Session Reception

The wine & cheese Poster Session at the meeting venue will allow participants to roam around the poster displays and chat with presenters while sipping beer or wine and nibbling on hot and cold hor d'oevres.

VICC Floor Plan



Meeting Timetable

Thursday, October 10						
09:00 12:30	**PICES/MAFF** Project Team Meeting* (*Departure A*)					
14:00 18:00				**WG-27** Meeting (*Millstone*)		
Friday, October 11						
09:00 12:30	POC/BIO/MONITOR/ FUTURE **W2** (*Departure A&B*)	BIO **W3** (*Duke Point*)	TCODE **W4** (CANCELLED)	**W6** (*Nanaimo A*)	MEQ **W7** (*Offsite*)	
14:00 18:00				**S-HAB** Meeting (*Nanaimo A*)		
Saturday, October 12						
09:00 12:30	**W1** (*Ballroom B*)	**AP-MBM** Meeting (*Duke Point*)	**WG-21** Meeting (*Departure A*)	**WG-26** Meeting (CANCELLED)	**S-HAB** Meeting (*Nanaimo A*)	**WG-28** Meeting (*Nanaimo B*)
14:00 18:00					**AP-CPR** Meeting (*Nanaimo A*)		**SG-MP** Meeting (*Millstone*)
18:00 21:00	**WG-29** Meeting (*Departure B*)						
Sunday, October 13						
09:00	**FUTURE** Meeting (*Ballroom B*)					
12:30	**Science Board** Meeting (*Nanaimo A*)					
14:00	**AP-AICE** Meeting (*Departure A*)	**AP-COVE** Meeting (*Millstone*)	**AP-SOFE** Meeting (*Departure B*)	**S-CC** Meeting (*Dodd Narrows A*)	**S-CCME** Meeting (*Dodd Narrows B*)	**AP-CREAMS** Meeting (*Nanaimo A*)	**WG-30** Meeting (*Nanaimo B*)
18:00 19:30	**BIO** Meeting Day 1 (*Nanaimo A*)	**FIS** Meeting Day 1 (*Nanaimo B*)	**MEQ** Meeting Day 1 (*Dodd Narrows A*)	**MONITOR** Meeting Day 1 (*Departure B*)	**POC** Meeting Day 1 (*Millstone*)	**TCODE** Meeting Day 1 (*Departure A*)	**S-HD** Meeting Day 1 (*Dodd Narrows B*)
Monday, October 14						
09:00 10:00	**Opening Session** (*Ballroom C&D*)					
10:30 17:30	**Science Board Symposium (S1)** (*Ballroom C&D*)					
18:00 21:00	**Welcome Reception** for all participants and registered guests (*Ballroom A&B*)					
Tuesday, October 15						
09:00 12:30	BIO/FIS **S5** (*Ballroom A*)	BIO/POC/TCODE/ MONITOR/FUTURE **S6 (Day 1)** (*Ballroom B*)	MONITOR **S9** (*Departure A&B*)	**FIS** Paper Session (*Duke Point*)		
14:00 17:30			**MEQ** Paper Session (*Departure A&B*)			
18:00 21:00	**Sport Event**					

Meeting Timetable (continued)

Wednesday, October 16							
09:00 12:30	BIO/POC/TCODE/ MONITOR/FUTURE **S6 (Day 2)** (*Ballroom B*)		POC **S4 (Day 1)** (*Ballroom A*)	MEQ/FUTURE **S3** (*Duke Point*)		**F&A Meeting*** (*Nanaimo B*)	
12:30 14:00	**SG-SC-NP** Meeting (*Nanaimo A*)						
14:00 18:00	**BIO** Meeting Day 2 (*Nanaimo A*)	**FIS** Meeting Day 2 (*Nanaimo B*)	**MEQ** Meeting Day 2 (*Dodd Narrows A*)	**MONITOR** Meeting Day 2 (*Departure B*)	**POC** Meeting Day 2 (*Millstone*)	**TCODE** Meeting Day 2 (*Departure A*)	**S-HD** Meeting Day 2 (*Dodd Narrows B*)
18:30 21:30	**Extravaganza Dinner**						
Thursday, October 17							
09:00 12:30	POC **S4 (Day 2)** (*Ballroom A*)		BIO/FIS/MEQ/TCODE/ FUTURE **S8 (Day 1)** (*Ballroom B*)	FIS/TCODE **S10** (*Departure A&B*)		**BIO** Paper Session (*Duke Point*)	
14:00 17:30							
18:00 20:30	**"Wine and Cheese" Poster Session**** (*Ballroom C&D*)						
Friday, October 18							
09:00	BIO/FIS/MEQ/TCODE/ FUTURE **S8 (Day 2)** (*Ballroom B*)		BIO/FIS/POC **S2** (*Ballroom A*)		**POC** Paper Session (*Departure A&B*)		
12:30 14:00	**Closing Session***** (*Ballroom B*)						
15:00 18:00	**Science Board Meeting*** (*Nanaimo A*)						
18:30 21:00	**Chairman's Reception*** [by invitation only]						
Saturday, October 19							
09:00 18:00	**Science Board Meeting*** (*Nanaimo A*)			**Governing Council Meeting*** (*Nanaimo B*)			
Sunday, October 20							
13:00 18:00	**Governing Council Meeting*** (*Nanaimo B*)						

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

Sessions/Workshops

S1	Communicating forecasts, uncertainty and consequences of ecosystem change
S2	Are marine ecosystems of the North Pacific becoming more variable?
S3	Status, trends and effects of pollutants in coastal ecosystems: Implications for wildlife and humans
S4	The changing carbon cycle of North Pacific continental shelves and marginal seas
S5	Marine ecosystem services and the contribution from marine ecosystems to the economy and human well-being
S6	Recent trends and future projections of North Pacific climate and ecosystems
S8	Ecosystem indicators to characterize ecosystem responses to multiple stressors in North Pacific marine ecosystems
S9	Cost-effective, cooperative ocean monitoring
S10	Banking on recruitment curves; returns on intellectual investment
BIO-P	BIO Contributed Paper Session
FIS-P	FIS Contributed Paper Session
MEQ-P	MEQ Contributed Paper Session
POC-P	POC Contributed Paper Session
W1	Comparison of size-based and species based ecosystem models
W2	Identifying mechanisms linking physical climate and ecosystem change: Observed indices, hypothesized processes, and "data dreams" for the future
W3	Marine bird and mammal spatial ecology
W4	Tools, approaches and challenges for accessing and integrating distributed datasets
W6	Economic impacts of harmful algal blooms on fisheries and aquaculture
W7	Traditional seafoods of coastal aboriginal communities in the North Pacific: Insight into food, social and ceremonial uses at Snuneymux'w First Nation in Nanaimo, British Columbia
GP	General Poster Session

Meetings

Committees

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

Advisory Panels

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

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

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

FUTURE Science Program Advisory Panels

AP-AICE Advisory Panel on Anthropogenic Influences on Coastal Ecosystems

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

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

Sections

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

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

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

S-HD Section on Human Dimensions of Marine Systems
(*reports to Science Board*)

Study Group

SG-MP Study Group on Marine Pollutants
(*reports to MEQ Committee*)

SG-SC-NP Study Group on Scientific Cooperation in the North Pacific Ocean
(*reports to Science Board*)

Working Groups

WG-21 Working Group on Non-indigenous Aquatic Species
(*reports to MEQ Committee*)

WG-26 Working Group on Jellyfish Blooms around the North Pacific Rim: Causes and Consequences
(*reports to BIO Committee*)

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

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

WG-29 Working Group on Regional Climate Modeling
(*reports to POC Committee*)

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

Keynote Lecture

Canada's changing Pacific marine ecosystems: Forecasts, uncertainties, potential consequences, and communication

R. Ian **Perry**

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The theme for this 2013 PICES Annual Meeting is "communicating forecasts, uncertainty and consequences of ecosystem change". This theme was chosen to feature the PICES integrating program Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems (FUTURE), and in particular to highlight its central question of "What is the future of the North Pacific given current and expected pressures?" The goal of this presentation is to propose how PICES may move forward with this theme and these issues, using examples largely (but not exclusively) from Canada and the NE Pacific.

Canadian marine waters provide good examples of these issues, since its marine ecosystems are different now than they were 50, even 25, years ago. This presentation illustrates how Canadian marine systems have changed, and discusses potential drivers for these changes including climate and human influences. Linking drivers and pressures to specific changes can be difficult, although approaches such as the Driver-Pressure-State-Impact-Response, pathways of effects, and Bayesian Network models show promise including, for some approaches, the explicit consideration of uncertainties. These approaches, along with statistical and simulation models and constructing alternative scenarios, can be used to project the drivers, pressures and ecosystem states into the future, from which the human and ecosystem consequences and implications can be evaluated and different management actions explored. Ultimately, these findings need to be communicated to inform scientific, policy, and public discussions of the decisions and trade-offs that will be required to attain desirable, or avoid undesirable, potential futures.

Communicating scientific findings is a core element of this meeting theme and of the FUTURE program. PICES has been very effective at communicating scientific knowledge and advances to other scientists, but perhaps less effective at communicating these advances to decision-makers and the public. Much has been learned recently about the psychology of communicating science, in particular from the issue of climate change. Key questions include communicating what, why, how, and to whom. But the first requirement is to 'know your message'. Knowing your message includes understanding current conditions, how these may change in the future (forecasts), their uncertainties, and the potential consequences of current and future conditions. The Canadian Science Advisory process provides one example of how Canada develops scientific knowledge on marine issues and then integrates that knowledge into public discussions and decision-making. The ultimate goal of these Canadian activities, and of the PICES FUTURE program, is to ensure a North Pacific that is productive and resilient to the pressures and uncertainties of a changing world.

Schedules and Abstracts

S1 Science Board Symposium
Communicating forecasts, uncertainty and consequences of ecosystem change

Co-Convenors: Sinjae Yoo (SB), Atsushi Tsuda (BIO), Elizabeth Logerwell (FIS), Chuanlin Huo (MEQ), Hiroya Sugisaki (MONITOR), Kyung-Il Chang (POC), Toru Suzuki (TCODE), Thomas Therriault (AICE), Hiroaki Saito (COVE), Phillip Mundy (SOFE) and Igor Shevchenko (Russia)

Invited Speakers:
Richard Beamish (Fisheries and Oceans Canada, retired)
Alida Bundy (Bedford Institute of Oceanography, DFO, Canada)
Brian Helmuth (Northeastern University, USA)
Mitsutaku Makino (Fisheries Research Agency, Japan)
Muyin Wang (University of Washington, Seattle, WA, USA)

One goal of the PICES FUTURE program is to improve our capability to convey in a clear and effective manner how North Pacific marine environments may change due to natural and anthropogenic stressors, including climate change, and ultimately how societies will be affected by these changes. This new goal requires advancement in scientific communication which has largely been uncharted territory for PICES. To facilitate advancement in this new area, the Symposium will focus on four major issues pertaining to scientific communication: Products, Communicating Uncertainty, Decision Support Tools, and Human Dimensions. Products will include integration of outputs from field observations and models to provide comprehensive overviews of ecosystem status, trends and change for different audiences that include international experts, resource managers and the general public. Communicating Uncertainty will include the qualification or quantification of uncertainty associated with status, outlooks and forecasts of ecosystem changes. Decision Support Tools will include processing scientific outputs for management advice in an open and transparent way that will allow scientists to provide results that quantify the benefits and risks associated with different management strategies. Lastly, Human Dimensions will include the integration of social sciences in decision-making with respect to marine policy or management to capture the economic, cultural or societal values associated with sustainable ecosystems – this integration is the first step to communicating the social significance of predicted impacts from climate or ecosystem changes. In addition to these four focal issues, the Symposium will also discuss the scientific basis of FUTURE products such as the regional nature of marine ecosystem change, the causes of change, the challenges of attribution, and the future of change.

Monday, October 14 (10:30-18:10)

10:30 **Ian Perry (Keynote)**
Canada's changing Pacific marine ecosystems: Forecasts, uncertainties, potential consequences, and communication

11:15 **Richard J. Beamish (Invited)**
Sustaining Marine Science (S1-8921)

11:40 **Brian Helmuth (Invited)**
Communicating uncertainty in the era of climate change: When do 'the details' matter? (S1-9056)

12:05 **Harold (Hal) P. Batchelder, Isabel Torres de Noronha, Oran Young, Suzanne Lawrence, Peter Fox, J. Luis Valdes, David Vousden, Ruben Zondervan, Robin Mahon, Leopoldo C. Gerhardinger, Heidi Schuttenberg and Marion Glaser**
Future Ocean Alliance (FOA): Enhancing ocean sustainability challenges through knowledge-based governance and decision-making (S1-9149)

12:25 ***Lunch***

13:55 **Mitsutaku Makino and Keith R. Criddle (Invited)**
Why do we need Human Dimensions for the FUTURE Program? (S1-9217)

14:20 **Alida Bundy (Invited)**
Communication is a two-way process: Bringing science to the people and people to the science (S1-9195)

14:45 **Edward J. Gregr, Kai M.A. Chan and Villy Christensen**
When are models good enough? Assumptions and uncertainty in forecasts of ecosystem state and service supply (S1-9172)

15:05 **Carrie A. Holt**
Evaluating benchmarks of biological status for data-limited populations of Pacific salmon: Impacts of climate-driven changes in productivity (S1-8985)

15:25 **William J. Sydeman, Marisol García-Reyes, David S. Schoeman, Ryan R. Rykaczewski, Bryan A. Black, Sarah Ann Thompson and Steven J. Bograd**
Meta-analysis: A tool for communicating complexity to informed general audiences (S1-9094)

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

16:05 **Muyin Wang and James E. Overland (Invited)**
Arctic sea ice projections and uncertainties – An update from CMIP5 models (S1-9175)

16:30 **Hans-O. Pörtner**
An integrated view of climate sensitivity in marine organisms: The need for proxies indicating molecular to ecosystem-level changes (S1/W2-9216)

16:50 **Phillip R. Mundy, Will Koeppen, Stephanie N. Schmidt, Ellen Tyler, Eric J. Newland, Bryce Mecum, Kathrine Howard, Darcy Dugan and Brian Stone**
Operational outlook and forecast in support of the management of a climate-driven fishery (S1-9064)

17:10 **Sue C.H. Grant and Bronwyn L. MacDonald**
Fraser River Sockeye pre-season run size forecasts: Methods, indicators, and uncertainty (S1-8888)

17:30 **Shin-ichi Ito, Masaki Seito, Tooru Yoshida, Kazuhiro Takeuchi, Shigeho Kakehi, Taku Wagawa, Yutaka Isoda and Hiroshi Kawamura**
Water temperature forecasts to decrease megadeath of aquacultured scallops in Mutsu Bay, Japan (S1-9120)

17:50 **Marc Trudel**
Using ocean conditions to forecast salmon runs: Lessons learned from a decade of sampling juvenile salmon at sea (S1-8903)

18:10 *Session Ends*

S1 Posters

S1-P1 **Gakushi Ishimura, Keita Abe, Kento Ito, Hiroki Nakano and Bolorchimeg Byamba**
Post-Tsunami Recovery Strategies: Issues and challenges for group operations by Kesennuma off-shore longline fisheries in Kesennuma, Japan

S1-P2 **Tuula E. Hollmén and Suresh A. Sethi**
Development of conceptual ecological models to support the Gulf Watch Alaska long-term monitoring program

S1 Oral Presentations

October 14, 11:15 (S1-8921)

Sustaining Marine Science

Richard J. **Beamish**

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It is likely that the best way to sustain marine science will be to have an informed public. An effective partnership tells the public what we know, do not know and need to know for them to make intelligent decisions. The recent dynamics of the coho salmon fishery in the Strait of Georgia is a good example of why this partnership is needed. In the late 1980s, the sport and commercial fishery had an average annual catch of about 1.2 million fish with an expectation that the new hatchery program might substantially increase this catch before about 2000. By the mid-1990s the fishery was virtually over because of a major decline in marine survival and a new migration pattern that emptied the strait of coho salmon. It was not until this year that sport fishing opportunities for coho salmon returned to the Strait of Georgia. The explanations mostly remain a mystery, but we know that the changes occurred in the ocean. It is now a perfect time to discover what is going on. Recreational fishermen are eager to help. Hatchery managers are ready for change. Scientists can make award-winning discoveries. All that is needed is a focus, a team and a person to lead the parade.

October 14, 11:40 (S1-9056)

Communicating uncertainty in the era of climate change: When do 'the details' matter?

Brian **Helmuth**

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Generalizations of the impacts of climate change such as poleward migrations of species range boundaries have served as a useful heuristic framework. However, recent evidence suggests that these simplifications may be violated in nature more often than has previously been appreciated, and that the 'details' of how organisms interact with their environment can have dramatic influences on how environmental change affects ecosystems. Ecological forecasting approaches that build on a mechanistic understanding of how coastal organisms interact with their environment can provide spatially explicit estimates of where, when and with what magnitude climate-influenced impacts are likely to occur. Specifically, coupled biophysical-energetic models estimate spatial and temporal patterns of growth, reproduction, and maximum body size in coastal invertebrates, and can serve as a potentially effective means of providing decision makers with relevant, useful indicators. However, these approaches also show that because of nonlinearities in how the environment affects organismal physiology, and in how such individual impacts scale to ecosystem-level processes, these methods must be embedded within a probabilistic framework. As scientists we thus face the quandary of communicating complex processes in "sound bites" while recognizing that we can never truly predict the exact, detailed impacts of climate change with a high degree of certainty. Borrowing from approaches adopted by the insurance industry, communicating how various adaptation and mitigation strategies can affect the likelihood of 'surprises' such as ecological thresholds (tipping points) - *i.e.*, a focus on weather rather than climate- may serve as a more effective means of communication than focusing on generalizations.

October 14, 12:05 (S1-9149)

Future Ocean Alliance (FOA): Enhancing ocean sustainability challenges through knowledge-based governance and decision-making

Harold (Hal) P. **Batchelder**[1], Isabel Torres de Noronha[2], Oran Young[3], Suzanne Lawrence[4], Peter Fox[5], J. Luis Valdes[6], David Vousden[7], Ruben Zondervan[8], Robin Mahon[9], Leopoldo C. Gerhardinger[10], Heidi Schuttenberg[11] and Marion Glaser[12]

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4 942 Amiford Dr., San Diego, CA, 92107, USA
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6 Ocean Sciences, IOC/UNESCO, 7 place de Fontenoy, 75352, Paris 07 SP, France
7 UNDP GEF Agulhas and Somali Current Large Marine Ecosystems Project, PBag 1015, 18 Somerset St., Grahamstown, 6140, Republic of South Africa
8 Earth System Governance Project, Lund University, P.O. Box 170, SE-221 00, Lund, Sweden
9 CERMES, Cave Hill Campus, University of the West Indies, Barbados
10 Centre for Environmental Studies, University of Campinas, Rua dos Flamboyants, 155 – Cidade Universitaria Zeferino Vaz, Campina – CEP 13083-867, Sao Paulo, Brazil
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Global ocean governance needs to address the sustainability challenges of the 21st century. The Future Ocean Alliance (FOA) vision and objectives of promoting and delivering more sustainable oceans are needed now. Everyday new threats to ocean sustainability emerge, or known threats are found to expand to new regions of the global oceans. FOA proposes a knowledge network for sharing learned experiences across disciplines and geographical constraints—the "one world ocean community". Decision-making that effectively incorporates research results is a goal also of the PICES FUTURE program. FOA intends to promote enhanced collaboration between the research and decision-making communities from both public and private spheres. A dialogue across disciplines (natural, social and economic), across sectors, across stakeholders and across scales of management needs to be promoted to support the production, communication and use of knowledge towards actionable solutions for good ocean governance and sustainable ocean management. For several years, members of these communities have been meeting at international venues to consider responses to this challenge. The FOA aims to promote and facilitate such communication, and to build upon and leverage the knowledge and investments of existing communities of knowledge, and to share, connect, and translate knowledge for decision makers on ocean issues. Advancements in sustainability-science, knowledge networks, regional ocean governance, and understanding of the dynamics of coupled human and natural systems are essential to guiding meaningful policy solutions. FOA intends to integrate existing knowledge networks to examine and improve practices in ocean governance, integrated ecosystem assessment, resource management and discipline-based informatics.

October 14, 13:55 (S1-9217)

Why do we need Human Dimensions for the FUTURE Program?

Mitsutaku **Makino**[1] and Keith R. Criddle[2]

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Good scientific (biophysical or ecological) arguments for management actions are sometimes not accepted or implemented because of the perceived socio-economic or cultural costs. Similarly, management actions undertaken without careful consideration of human dimensions are unlikely to achieve expected outcomes. Therefore, an integrated understanding of how ecosystem changes affect human social systems, and vice versa, is necessary to improve the stewardship of marine ecosystems. To this end, increased attention must be paid to human dimensions and the integration of social science into marine ecosystem research, that is, to recognition that marine systems are social-ecological systems (SES). In other words, recognition that ecological (or 'natural') systems and human (cultural, social, economic, *etc.*) systems are simply dimensions of a greater whole.

The key questions that motivate FUTURE reflect recognition of the North Pacific as a SES. For example, FUTURE Research Theme 3 addresses anthropogenic pressures on marine ecosystems, the impacts of ecosystem change on dependent human populations, and the development of social strategies to cope with those changes. FUTURE Objective 2 reflects a commitment to convey research findings to society and to foster the engagement. To support these goals, the Study Group on Human Dimensions (SG-HD) was established in 2009 (and completed in 2011), and the Section on Human Dimensions of Marine Systems (S-HD) was formed in 2012. This presentation briefly discusses two important factors which motivate the integration of human dimensions into FUTURE (governance effectiveness and the value system at the objective setting process) and, based on the results of SG-HD and the ongoing works of S-HD, describes the present status of North Pacific ecosystem-focused social science research in PICES member countries.

October 14, 14:20 (S1-9195)

Communication is a two-way process: Bringing science to the people and people to the science

Alida **Bundy**

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We live in the so-called Anthropocene, signifying an era in which humans have, and are, significantly impacting the planet, witnessed by global warming and loss of biodiversity. Concern for our future has precipitated the need to place humans firmly at the centre of global change, to seek better ways to communicate science to non-scientists and to hasten calls for interdisciplinary approaches to resource management. The IndiSeas program, Indicators for the Seas, is one such attempt to communicate the effects of change to international experts, resource managers and the general public. IndiSeas uses a suite of empirical indicators to provide interdisciplinary assessments of the status of exploited ecosystems. The IndiSeas website allows users to explore the results for individual ecosystems, or to compare results across ecosystems. But communication is a two-way process. We must recognise that humans are both driver and recipients of change and that we need to understand how humans respond to change in the marine environment. The IMBER Human Dimensions working group is developing a decision support tool, IMBER-ADApT (Assessment based on Description, Responses and Appraisal for a Typology) that builds on knowledge learned from past experience of response to global change, to enable decision makers to: triage and improve their response to change; make decisions efficiently for transitions towards coastal sustainability; and evaluate where to most effectively allocate resources to "reduce" vulnerability and enhance resilience of coastal peoples to global change. I will discuss both these initiatives and make links to the PICES FUTURE program.

October 14, 14:45 (S1-9172)

When are models good enough? Assumptions and uncertainty in forecasts of ecosystem state and service supply

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Predictive models are the primary means of examining and communicating the consequences of ecosystem change. However, such models are overly optimistic, as evidenced by the development of coupled models several levels deep, that often produce point estimates with little treatment of uncertainty. We show that many ecosystem models leave uncertainty entirely implicit, leading to a multi-faceted problem. First, the use of such model outputs -particularly in coupled models - requires assumptions about model confidence. However, since model design assumptions are also typically implicit, such assumptions are generally optimistic, and questions of model confidence can be difficult to answer. As a result, stakeholder uptake of model outputs may be uneven. To demonstrate the benefits of more explicit model assumptions we developed a set of trophic models for the sea otter-urchin ecosystem in British Columbia, Canada using the EcoPath mass balance tool. We forecast a suite of ecosystem state and service supply indicators using increasingly complex models, and showed how changes in model assumptions and complexity influenced model forecasts. We propose that if model objectives are clear and assumptions explicit, measures of such change can be used to assess model sufficiency. More explicit assumptions

and uncertainty would also allow inter-disciplinary model coupling to begin dealing with questions of confidence, while aligning model objectives and assumptions with human well-being allows a richer description of model performance, and a more complete picture of how we understand ecosystem change.

October 14, 15:05 (S1-8985)

Evaluating benchmarks of biological status for data-limited populations of Pacific salmon: Impacts of climate-driven changes in productivity

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In marine fisheries, spawner abundance and recruitment data are commonly used to identify reference points for assessment and management purposes. For Pacific salmon, spawner-recruitment relationships are used to derive lower and upper benchmarks that delineate three zones of biological status: green, amber, and red, representing increasing conservation concern and possible management intervention. When time-series of recruitment are not available, benchmarks relative to historical levels may be derived from spawner time-series alone. However, performances of benchmarks for data-limited populations have not been rigorously evaluated against their data-rich counterparts. Although previous studies on data-rich populations have identified benchmarks that are robust to climate-driven changes in productivity, the effects of climate change on the performance of data-limited benchmarks is unknown and presents a considerable risk for populations experiencing persistent changes in productivity. A Monte Carlo simulation model was developed to compare the performance of benchmarks derived from spawner-recruitment models with those derived for data-limited populations that use only spawner abundances. The model included stochastic variability in population dynamics, observation errors, and implementation uncertainty for multiple sub-populations within a population aggregate. Results suggest that probabilities of extirpation were low for all benchmarks when productivity was high or moderate (~4 recruits/spawner at low abundances), but when productivity was low (~1.5 recruits/spawner at low abundances) or declining, probability of extirpation was as much as 24% higher for benchmarks based on spawner abundances compared with those derived from spawner-recruitment models. These results suggest caution when applying benchmarks to data-limited populations where declines in productivity are a concern.

October 14, 15:25 (S1-9094)

Meta-analysis: A tool for communicating complexity to informed general audiences

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Communicating complex scientific concepts and information to informed non-academics, such as managers and policy-makers, is difficult. This problem is exacerbated by recent exponential growth of the literature. How are informed general audiences to make sense of this information, especially when study results are contradictory and rich in unfamiliar statistics? Meta-analysis (*i.e.*, analysis of analyses) is a powerful scientific approach used to synthesize the literature and offers promise as a tool for communicating complexity to informed lay-audiences. As an example, we conducted a meta-analysis of the literature on potential effects of global warming on upwelling marine ecosystems (Bakun's 1990 upwelling intensification hypotheses (hereafter BH). The BH is complex, involving atmospheric science and physical and biological oceanography, yet is critical to society as upwelling ecosystems contribute disproportionately to the world's wild capture fisheries; moreover, ocean acidification and de-oxygenation in these systems are dependent on upwelling. While the BH provides a step-by-step mechanism for how anthropogenic global warming could influence upwelling (see Rykaczewski S6), our meta-analysis

focused on the result of the hypothesized mechanism, *i.e.*, increasing wind fields. We synthesized results from 22 studies published between 1990 and 2012, representing analyses of 198 time series of observed and estimated wind. Using this meta-database, we investigated whether results were consistent or inconsistent with BH and whether results varied by season, data type (observed or modeled wind fields), study duration, or latitude. This meta-analysis suggests recent upwelling-favorable wind intensification in 3 of 5 of the world's eastern boundary current regions over the past half century.

October 14, 16:05 (S1-9175)

Arctic sea ice projections and uncertainties – An update from CMIP5 models

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With much improvement over the past decades there is considerable confidence that the latest coupled climate models provide credible, quantitative projections of the future climate at continental scales and above. Our task was to develop guidelines for the use of these climate models, particularly, those that are part of the Coupled Model Intercomparison Project, phase 5 (CMIP5) for regional ecosystem studies. Uncertainty in climate predictions arises from three distinct sources: internal variability, model and scenario uncertainty. The relative importance of the three uncertainty sources varies with prediction lead time and with spatial and temporal averaging scale. As a result, the uncertainty reaches minimum when the lead time is between 30-50 years. Comparing with CMIP3 models, the spread among the model simulated sea ice extents are still large. By using observational constraints to eliminate outlier models we are able to reduce the uncertainties in future projections. For example, among 37 models which have projections under at least two proposed emissions scenarios (RCP4.5 and RCP8.5), less than half of them (12) made satisfactory performance as their simulated sea ice extent agree reasonable well with observations. Yet the models as a whole still underestimate the sea ice decline trend in recent decade. These models projected that Arctic will be nearly 2-3 month ice free in the middle of 21st century, and 5- month ice free by the end of 21st century. This will have large impact not only on the climate system, but also the social, economic and ecological aspects.

October 14, 16:30 (S1/W2-9216)

An integrated view of climate sensitivity in marine organisms: The need for proxies indicating molecular to ecosystem-level changes

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Climate change effects on marine ecosystems predominantly involve effects of temperature, hypoxia and CO_2. All life forms respond to these drivers, potentially following common, insufficiently understood principles. In animals the concept of oxygen and capacity dependent thermal tolerance (OCLTT) appears as a suitable integrator of various effects, across levels of biological organisation. Recent studies confirm OCLTT involvement in changing species abundance, biogeographical ranges, phenology and species predominance. Performance capacity set by aerobic scope and energy budget, building on baseline energy turnover, link fitness (within thermal window) and functioning at ecosystem level. In variable environments like the intertidal zone, animals also exploit their capacity for passive tolerance. The complexity of molecular adjustments involved in long-term adjustments to climate requires further analysis. While presently the temperature signal appears predominant in the field, observations may well include emerging effects of other stressors, acting synergistically by narrowing the aerobic OCLTT window. OCLTT may link apparently disjunct effects of ocean warming, acidification and hypoxia. In brief, warming induced CO_2 accumulation in body fluids links to the effects of ocean acidification mediated by the weak acid distribution of CO_2. Temperature induced hypoxemia links to the hypoxia sensitivity of thermal tolerance. The present paper discusses the suitability of various proxies indicating the temperature dependent effects of climate related stressors. Mechanism-based modelling efforts are then needed to develop reliable, organism to ecosystem projections of future change.

October 14, 16:50 (S1-9064)

Operational outlook and forecast in support of the management of a climate-driven fishery

Phillip R. **Mundy**[1], Will Koeppen[2], Stephanie N. Schmidt[3], Ellen Tyler[4], Eric J. Newland[3], Bryce Mecum[5], Kathrine Howard[3], Darcy Dugan[4] and Brian Stone[2]

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Communicating the impacts of climate variables on fisheries to natural resource managers and their constituents is accomplished by an annual outlook and forecast of the timing (phenology) of the spawning migration of salmon at entry to the mouth of the natal river. The outlook and forecast for timing of Chinook salmon in the Yukon River has been conducted for four years, 2010-2013, providing key dates and information 2-3 weeks in advance of the run. The outlook provides a qualitative appraisal (early, average, late) of the timing of the migration and has been consistent with the observed timing of the migrations in all years. The forecast is composed of quantitative estimates of the dates on which the 15th, 25th and 50th percentiles of the migration occur, as linear functions of spring weather and ice conditions. Deviations of the forecast percentile dates from the measured dates ranged from 0-7 days over the four years, which included the latest migration in history, 2012. Starting in research mode to advise only the managers of the fishery (2010 and 2011), the outlook and forecast went operational in 2012 and 2013 with web pages designed for harvesters, managers and the general public. The web pages provided a short narrative explaining the migration model; plots of the forecast, historical data, and a time-series of the current season's data that were updated daily; and graphs of real-time data from climate variables that influence the Chinook salmon migration including sea ice cover, air and sea surface temperatures and wind velocity and direction.

October 14, 17:10 (S1-8888)

Fraser River Sockeye pre-season run size forecasts: Methods, indicators, and uncertainty

Sue C.H. **Grant** and Bronwyn L. MacDonald

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Indicators of survival explored to date have not reduced uncertainty in Fraser Sockeye return forecasts and remain an active area of research. The uncertainty in survival mechanisms for Fraser Sockeye stocks is attributed to the broad range of environments (freshwater & marine) these stocks occupy throughout their life-history. In the absence of leading survival indicators, Fraser Sockeye forecasts have been particularly uncertain in recent years, due to the systematic declines in survival exhibited by many stocks, which culminated in the lowest survival on record in the 2005 brood year. To capture inter-annual random (stochastic) uncertainty in Fraser Sockeye forecasts (largely attributed to differences in survival), forecasts are presented as standardized cumulative probabilities (10%, 25%, 50%, 75%, and 90%), using Bayesian statistics, rather than as single deterministic point estimates. At the 25% probability level, for example, there is a one in four chance the actual return will fall at or below the specified predicted return, given historical data. Fisheries managers use these forecast probability distributions to frame out the range of fishing opportunities that stakeholders may expect in the upcoming year. These return forecasts are also used, in concert with run timing forecasts, as Bayesian priors for in-season run size models, which are used to manage the fisheries early in the fishing season before test fishery and hydroacoustic data become available. As work proceeds on the exploration of survival indicators for salmon stocks, uncertainty should be considered in the presentation of environmental-recruitment correlations.

October 14, 17:30 (S1-9120)

Water temperature forecasts to decrease megadeath of aquacultured scallops in Mutsu Bay, Japan

Shin-ichi **Ito**[1], Masaki Seito[2], Tooru Yoshida[2], Kazuhiro Takeuchi[3], Shigeho Kakehi[1], Taku Wagawa[1], Yutaka Isoda[4] and Hiroshi Kawamura[5]

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Mutsu Bay located in the northern tip of the Japanese main island. It is one of the most active aquaculture spots of scallops in Japan and the production had been between 70,000 and 100,000 t since 1990. The yield had been 10-14 billion yens. However, in 2010, an extreme hot summer caused megadeath of scallops (66.7% mortality) and the production and yield decreased to 33,000 t and 6 billion yens, respectively. The water temperature in 15 m depth reached 26.8 degC on 7th September and the record (25.1 degC in 1994) was renewed. We investigated the salinity budget in the bay and found that anti-estuary circulation was kept in 2010 summer and the circulation transported outside warm water into the bay. There are three buoys monitoring the temperature in the bay. A statistical method to forecast the water temperature was established and was used for making advises to the aquaculture fishermen. In 2012, another extreme hot water condition was happened. However, the mortality was much less than that in 2010. When the water temperature forecasts showed higher temperature, cautions not to force other stresses than temperature were announced to the fishermen. This precautionary advice resulted in the lower mortality in 2012. Water temperature buoys have been increased to monitor the inside of the aquaculture farm. Improvement of the water temperature prediction skill is needed for more decrease of mortality in the extreme temperature conditions.

October 14, 17:50 (S1-8903)

Using ocean conditions to forecast salmon runs: Lessons learned from a decade of sampling juvenile salmon at sea

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Stock assessment models currently used to manage salmon fisheries often fail to accurately predict run-size for adult salmon. Differences between predicted and actual returns are often attributed to biophysical processes related to changing ocean conditions, indicating the need to integrate information on climatic and biological drivers into the annual stock assessment process for Pacific salmon. For the last decade, we have been collecting physical, chemical, and biological oceanographic data as well as juvenile salmon and associated pelagic fish community in the Northern California Current System, Transition Domain, and Alaska Coastal Current to understand how changes in climate and ocean conditions affect the distribution, migration, growth, and survival of salmon. This research has also been used to develop simple models to forecast salmon returns. In this presentation, I discuss some of the challenges and limitations of using ocean conditions for forecasting salmon returns. In particular, I will consider issues related to: 1) the predictive power of forecasting models, 2) shifting baselines, and 3) regime shifts. Understanding the consequences of these limitations is necessary to effectively communicate forecasting uncertainties to mangers and society and to be better prepared for unexpected surprises when these models fail.

S1 POSTERS

S1-P1

Post-Tsunami Recovery Strategies: Issues and challenges for group operations by Kesennuma off-shore longline fisheries in Kesennuma, Japan

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Fishing communities in the northern Tohoku, Japan were severely affected by March 11, 2011 tsunami by the Great Tohoku Earthquake. Off-shore longline fishery in Kesennuma, which mainly target swordfish and blue shark, was one of the few survived fishing vessel groups in this area. The local processing industries heavily depend on their blue shark landings, and therefore, this fishery group has a significant role on the recovery of local economy. From April 2012, their operations have shifted to group operations ('Syudan Sougyou') from individual operations ('Kojin Sougyou') to optimize the production and the cost sharing. This study address issues and challenges of the off-shore longline fisheries in their recovery by analyzing the integrated data set of log-book (*i.e.*, catch location, fuel consumption, operational costs) and detailed daily market data of their landings (*i.e.*, price of each swordfish landed, average class price of blue shark) from January 2009 to March 2011 (Pre Tsunami) and from January 2012 to May 2013 (Post Tsunami). Our analysis suggests that 1) current group operations are quasi-optimum for the production, 2) the risk sharing structure between vessel owners and crews should be reconsider to motivate crews to improve their operations. This study ends with implications for future strategies for the recovery of Off-shore longline fishery in Kesennuma.

S1-P2

Development of conceptual ecological models to support the Gulf Watch Alaska long-term monitoring program

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An integrated long-term monitoring program was initiated in 2012 to collect and synthesize data about the condition of the ecosystem and resources impacted by the 1989 oil spill in Prince William Sound, Alaska, and to further guide restoration and resource monitoring activities. The goal of the long-term monitoring program is to provide scientific data and products to inform management agencies and the public of changes in the environment and the impacts of these changes on injured resources and services. To assist the synthesis effort, conceptual ecological models are developed to demonstrate current state of knowledge about the Gulf ecosystem, to support development of quantitative models, to link scientific objectives to resource management, and to provide outreach tools. Elements of these conceptual models include an ecological site description, links to scientific and management questions, model assumptions, visual diagrams, interactive exploration tools, and supporting research data documentation. A general system model is linked to submodels of specific scientific or management interest, and re-assessed throughout the program to demonstrate progress of understanding about ecosystem structure and function. Linkages among model components are assessed using ratings elicited from principal investigators of ecosystem components. Decision analysis tools are used to link scientific objectives with resource management priorities to support long-term monitoring plans.

S2 BIO/FIS/POC Topic Session
Are marine ecosystems of the North Pacific becoming more variable?

Co-Convenors: Steven Bograd (USA), Elizabeth Logerwell (USA), William Sydeman (USA) and Yutaka Watanuki (Japan)

Invited Speakers:
Emanuele Di Lorenzo (Georgia Institute of Technology, USA)
Michael Litzow (University of Tasmania, Australia)

A primary forecast from Global Climate Models (GCMs) is increasing variability in the physical and biological attributes of marine ecosystems (IPCC 2007). It is also well known from oceanography, marine ecology, and fisheries biology that variability is a key attribute of population stability/instability. Increasing spatial and temporal variance has also been hypothesized to be a precursor to long-term marine ecosystem change or "regime shifts". In this session, we invite papers that test hypotheses of increasing marine ecosystem variability relative to global climate change, be they of natural or anthropogenic origins. In particular, we invite studies that (1) address the theoretical basis for variance changes in North Pacific marine ecosystems using GCMs, paleo-ecological data, or experimental evidence, (2) directly test an hypothesis of "increasing ecosystem variability" using observational physical and/or biological data, and (3) consider how human social and economic systems and structures may be affected by increasing ecosystem variability, including the possible need for modifications in conservation and management strategies to deal with greater unpredictability and extremes in ecological conditions. A special volume for the primary literature will be investigated pending sufficient subscription to this session, or alternatively, a meta-analysis/review paper may be developed.

Friday, October 18 (09:00-12:30)

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

09:05 **Emanuele Di Lorenzo (Invited)**
Changes in character of North Pacific variability and ecosystem implications (S2-9057)

09:30 **Michael Litzow, William J. Sydeman, David S. Schoeman, Sanae Chiba, Marisol García-Reyes, Michael Malick, Hiroya Sugisaki and Sarah Ann Thompson (Invited)**
Nonlinear change in the variability of North Pacific climate – Are biological systems responding? (S2-9200)

09:55 (cancelled) **Bryan A. Black, William J. Sydeman, David C. Frank, Daniel Griffin, David W. Stahle, Marisol García-Reyes, Ryan R. Rykaczewski, Steven J. Bograd and William T. Peterson**
Six centuries of variability and extremes in a coupled marine-terrestrial ecosystem (S2-9148)

10:15 **Marisol García-Reyes, William J. Sydeman, Ryan R. Rykaczewski, Allison R. Wiener, Isaac D. Schroeder and Steven J. Bograd**
What do Global Climate Models say about increasing variance in the California Current upwelling ecosystem? (S2-9069)

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

11:00 **Jay O. Peterson, William T. Peterson and Jennifer L. Fisher**
Assessing ecosystem variability from an array of indicators relevant to the northern California Current (S2-9151)

11:20 (cancelled) **Jennifer L. Fisher and William T. Peterson**
Increased variability in the copepod community structure and biomass in the northeast Pacific (Newport, Oregon, USA) over the last 16 years (S2-9159)

11:40 **Seokjin Yoon, Eiji Watanabe, Hiromichi Ueno and Michio J. Kishi**
Estimating potential habitat for chum salmon (*Oncorhynchusketa*) in the Western Arctic using a bioenergetics model coupled with a three-dimensional lower trophic ecosystem model (S2-9000)

12:00 **Sen Tok Kim**
Spatial distribution and long-term dynamics of demersal fish biomass within East Sakhalin Current area, Sea of Okhotsk (S2-8885)

12:20 *Comments and Discussion*

12:30 *Session Ends*

S2 Oral Presentations

October 18, 09:05 (S2-9057)

Changes in character of North Pacific variability and ecosystem implications

Emanuele **Di Lorenzo**

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The spatial and temporal character of decadal variability in the North Pacific is changing. While the Pacific Decadal Oscillation (PDO) explains most of the ocean's physical variability before the 1976-77 climate transition, the North Pacific Gyre Oscillation (NPGO) now explains the largest fraction of North Pacific decadal variability. This shift in the character of North Pacific variability is recorded in a variety of ecological indicators across the Pacific both in the lower-trophic (*e.g.* phytoplankton, zooplankton) and higher trophic levels (*e.g.* rock fish, salmon).

The shift towards a more energetic NPGO in the 1980-2013 is connected to a shift in the dominant flavor of El Niños in the tropical Pacific, where Central Pacific El Niños have become more frequent than the traditional eastern Pacific El Niño. During central Pacific El Niño the westward displacement of the peak SST anomalies towards the dateline favors atmospheric "teleconnections" that project the tropical decadal variance onto the NPGO rather than PDO. We show that these changes towards more frequent Central Pacific El Niños and more energetic NPGO are linked to a common atmospheric forcing pattern of variability, the North Pacific Oscillation (NPO). The NPO is a stochastic pattern of atmospheric variability that is isolated statistically as the second dominant Empirical Orthogonal function of sea level pressure over the North Pacific. After examining the dynamics that control the spectrum of variability of the NPO in the observational record, we discuss how changes in variance in different frequency bands of the NPO translate into an ocean and marine ecosystem response. We also examine future projections of NPO variability in the IPCC AR5 climate model, and the implications for physical and biological variability.

October 18, 09:30 (S2-9200)

Nonlinear change in the variability of North Pacific climate – Are biological systems responding?

Michael **Litzow**[1,2], William J. Sydeman[2], David S. Schoeman[3], Sanae Chiba[4], Marisol García-Reyes[2], Michael Malick[5], Hiroya Sugisaki[6] and Sarah Ann Thompson[2]

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Anthropogenic forcing is predicted to increase climate variability. As many biological processes, such as recruitment to fish populations, are sensitive to variability in environmental conditions, such an increase in climate variability has the potential for ecological effects. In this study, we evaluate the evidence for ecologically-important increases in climate variability across the North Pacific (20°-66°N) over recent decades (1951-2010). Our climate data are SST values on a 1°x1° grid from the HADISST data set, which we standardized by the mean and SD of the 1951-1980 climatology. Analysis of basin-wide SD over sliding windows at three temporal scales (month, year, decade) shows similar, nonlinear trends in variability at all three scales. Variability increased during a period of warming in the 1970s-1990s, then decreased during the 2000s and 2010s, when mean temperatures were generally stable. To test the hypothesis that biological variability has tracked these changes in climatic variability, we collected a set of long-term data sets from a diverse set of populations (zooplankton, ichthyoplankton, groundfish, salmon, seabirds, pinnipeds) from a variety of ecosystems (Oyashio Current and Transition; Bering Sea; Gulf of Alaska; California Current). Analysis of variability trends across these time series allows us to test for community-level

changes in variability, across multiple taxa and trophic levels, over large spatial scales. Further analysis of trends in SST variability at the scale of individual large marine ecosystems also allows us to assess the coherence of the basin-scale patterns at ecologically-relevant spatial scales.

October 18, 09:55 (S2-9148)

Six centuries of variability and extremes in a coupled marine-terrestrial ecosystem

Bryan A. Black[1], William J. **Sydeman**[2], David C. Frank[3], Daniel Griffin[4], David W. Stahle[5], Marisol García-Reyes[2], Ryan R. Rykaczewski[6], Steven J. Bograd[7] and William T. Peterson[8]

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In coastal upwelling zones, alongshore equatorward winds lift deep, cold, nutrient-rich waters into the photic zone, fueling some of the Earth's most diverse and economically valuable marine ecosystems. Off the west coast of North America, in the California Current (CC) upwelling zone, physical and biological indicators measured in the past decades show increasing ecosystem variability, a warning sign that a critical transition in ecosystem functioning could be approaching. Here, we show coherent responses in seabird breeding success, fish growth, and radial tree enlargement to wintertime climate variability, thereby coupling the coastal marine and terrestrial environments. By combining this suite of datasets, we provide a 576-year (1428-2003), annually resolved proxy of a winter climate pattern associated with upwelling intensity and related ecosystem productivity. We find that interannual variability has increased by ~60% over the 61-year instrumental record, yet remains within reconstructed pre-industrial boundaries. Nonetheless, the modern rise in variance is unique in that it is driven by an unprecedented succession of downwelling-favorable winters that severely reduce CC productivity and negatively impact top-level predators of commercial value and conservation concern.

October 18, 10:15 (S2-9069)

What do Global Climate Models say about increasing variance in the California Current upwelling ecosystem?

Marisol **García-Reyes**[1], William J. Sydeman, Ryan R. Rykaczewski, Allison R. Wiener, Isaac D. Schroeder and Steven J. Bograd

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Increased variability in coastal upwelling has been observed in the California Current System during the last decades (Macias *et al.* 2012 PLOS one). In addition, increased variability in North Pacific climate has been observed, with important ecosystem and fisheries impacts (Sydeman *et al.* 2013 GCB). The cause(s) of such increases in variance is unknown but may be due to low-frequency climate variability or anthropogenic climate change. Here, we use an ensemble approach of state-of-the-art global climate models included in the 5th assessment report from the IPCC (Taylor *et al.* 2012 BAMS) to study future changes in variance in North Pacific climate and California Current upwelling under increasing atmospheric CO_2 concentrations. Specifically, we investigate the hypothesis that increasing variability in the phenology (timing) and amplitude of upwelling in the California Current may be attributed to anthropogenic shifts in the positioning and strength of the North Pacific High. Increasing variability in the phenology of upwelling is apparent, and related to earlier and increasing wintertime (January-March) winds, likely caused by a poleward shift of the NPH. Comparison of current observations and projected changes in upwelling variance enhances our understanding of the causes of recent changes in upwelling (anthropogenic driven trend or natural climate oscillation). Moreover, focus on variance in upwelling will facilitate better forecasts of California Current ecosystem variability in the future.

October 18, 11:00 (S2-9151)

Assessing ecosystem variability from an array of indicators relevant to the northern California Current

Jay O. **Peterson**[1], William T. Peterson[2] and Jennifer L. Fisher[1]

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We have assembled an 18 year dataset of ocean ecosystem indicators that characterize the marine habitat in the northern California Current. The array of indicators range from basin-scale climate processes [*i.e.* PDO, ONI] to regional and local-scale physical and biological processes [*e.g.* temp, spring transition, zooplankton community composition]. The indicators have proven useful for ecosystem-based assessments of salmon marine survival. However, estimates of uncertainty and quantification of variability have been lacking, but are of utmost importance to those interested in applying ecosystem-based metrics to stock assessments and management decisions. Here, we present results from our efforts to quantify inter-annual variability across a diverse array of ecosystem indicators.

October 18, 11:20 (S2-9159)

Increased variability in the copepod community structure and biomass in the northeast Pacific (Newport, Oregon, USA) over the last 16 years

Jennifer L. **Fisher**[1] and William T. Peterson[2]

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Hydrographic and zooplankton data have been collected every two weeks for the past 16 years at a nearshore station off Newport, OR in the northeast Pacific. This effort has shown that copepod species composition exhibits a strong seasonal cycle and that inter-annual variations in specific copepod communities are driven largely by basin-scale processes opposed to processes associated with local upwelling. Over this time period, the PDO is no longer decadal, rather it changes sign more rapidly. Likewise, ENSO is now recognized to have two flavors–eastern Pacific and central Pacific. Sea surface temperature generally tracks both PDO and ENSO, but salinity does not and appears to be out of synch. Similarly, copepod species richness, total copepod biomass, and the biomass of different copepod groups are fluctuating.

October 18, 11:40 (S2-9000)

Estimating potential habitat for chum salmon (*Oncorhynchusketa*) in the Western Arctic using a bioenergetics model coupled with a three-dimensional lower trophic ecosystem model

Seokjin **Yoon**[1], Eiji Watanabe[2], Hiromichi Ueno[1,3] and Michio J. Kishi[1,2,3]

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Japanese and Russian chum salmon stocks are predominant in the Bering Sea during summer and fall. However, recently, several studies reported different tendency. Higher densities of chum salmon were observed within the vicinity of the Bering Strait and the Chukchi Sea than the eastern Bering Sea on September 2007 and alike Japanese chum salmon migrated to northern areas in the Bering Sea on August 2009.SST in the Arctic marginal seas has increased since the mid-1960s, especially since 2000. We speculated that SST increase affect to salmon northing directly. Therefore, we focused on chum salmon migrating northward to the Western Arctic. We estimated the potential habitat for chum salmon in the Western Arctic using a bioenergetics model coupled with a three-dimensional lower trophic ecosystem model (3D-NEMURO). 'Potential habitat' was defined as 'an area where chum salmon can grow up (*i.e.*, the growth rate is positive)'. In the bioenergetics model, the growth rate

of an individual chum salmon was calculated as a function of water temperature, salinity, and prey density, which were obtained from the 3-D NEMURO model results. For global warming scenario, we used the modeled monthly water temperature anomaly between 2005 and 2095 under the IPCC SRES-A1B scenario. Under the global warming scenario, the potential habitat for chum salmon increased during early summer and autumn due to the water temperature increase, whereas during summer the potential habitat for smaller chum salmon increased but that for larger chum salmon decreased because the water temperature exceeded the optimal condition.

October 18, 12:00 (S2-8885)

Spatial distribution and long-term dynamics of demersal fish biomass within East Sakhalin Current area, Sea of Okhotsk

Sen Tok **Kim**

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Modern dynamic processes observed in the sub-Arctic sea ecosystems affect, among other things, the demersal fish community. Its structure in the Sea of Okhotsk changes significantly due to climatic and oceanological features of the past decades. In a zone of the cold East Sakhalin Current, off the northeast coast of Sakhalin Island, patterns of fish spatial distribution, their biomass ratios within the shelf and slope areas, structure of multispecies communities, species and total fish resource dynamics are studied insufficiently. The long-term counting trawl surveys reveal some general aspects of fish biology and dynamics of their stocks that are important for a study of the main trends in the environment changes and response of marine ecosystems. A shelf zone is essential for the formation of fish aggregations in the study area. Its location and size largely determines the spawning and feeding areas for many species that inhabit the area. The total fish biomass, along with the group and species components, is formed mainly by the abundant species of Gadidae, Pleuronectidae, and Cottidae families. The main trends of the long-term fish dynamics in the east Sakhalin waters are similar to those in the northwestern waters (Kamchatka Peninsula) and south-west (South Kuril Islands) of the Sea of Okhotsk. The multi-year data indicate an increasing trend in the total fish biomass during the periods of warming of the Sea, which are favorable for the appearance of the abundant fish generations.

S3 MEQ/FUTURE Topic Session
Status, trends and effects of pollutants in coastal ecosystems: Implications for wildlife and humans

Co-Convenors: Olga Lukyanova (Russia) and Won Joon Shim (Korea)

Invited Speakers:
Sandra O'Neill (NWFSC, NOAA, USA)
Lorrie Rea (University of Alaska Fairbanks, USA)

Marine pollutants can impact the quality and/or abundance of invertebrates, fish, and wildlife. In addition, the contamination of seafood can diminish the viability of commercial species and/or deliver potentially harmful contaminants to human consumers. While pollutant topics vary geographically, a number of priority pollutants are common throughout the northern hemisphere. This session will highlight a number of practical approaches to assessing the status, trends and effects of emerging and/or priority pollutants in the PICES region, as well as examples from other parts of the world. Some of these approaches are presently being used as indicators of marine environmental quality in some jurisdictions. Examples include the 'Mussel Watch' program for monitoring metals and persistent organic pollutants (POPs), spatial and temporal trends in POPs in seabird eggs, and effects of POPs and hydrocarbons on the health of marine biota. Some of these efforts have proven very useful in revealing improvements to marine ecosystem health subsequent to the implementation of regulations, including the dramatic declines in PCB, DDT, dioxin and organotin levels and associated effects. Nevertheless, a number of pollutant concerns are emerging, such as replacement flame retardants, pharmaceuticals, and current use pesticides. Characterizing the status, trends and effects of marine pollutants in coastal ecosystem components can provide cost-effective means to guide regulations, source control and/or remediation strategies that will ultimately protect ecosystem health and services.

Wednesday, October 16 (09:00-12:30)

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

09:05 **Sandra O'Neill, Gina Ylitalo, David Herman and James West (Invited)**
Persistent organic pollutant fingerprints in five Pacific salmon species (*Oncorhynchus* spp.): Evidence of distinct contaminant sources associated with their marine distribution and feeding (S3-8941)

09:30 **Lorrie D. Rea, J. Margaret Castellini, Lucero Correa, Brian S. Fadely, Vladimir N. Burkanov and Todd M. O'Hara (Invited)**
Some maternal Steller sea lion diets elevate fetal mercury concentrations in the western Aleutian Island area of population decline (S3-8881)

09:55 **Yutaka Watanuki, Ai Yamashita, Mayumi Ishizuka, Yoshinori Ikenaka, Shouta M.M. Nakayama, Chihiro Ishii, Takashi Yamamoto, Motohiro Ito, Tomohiro Kuwae and Philip N. Trathan**
Feathers of tracked seabirds reveal a spatial pattern of marine pollution (S3-8868)

10:15 **Mikhail V. Simokon, Lidia T. Kovekovdova and Denis P. Kiku**
Arsenic in the coastal ecosystems of Far Eastern Seas (S3-9109)

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

11:00 **Won Joon Shim, Nam Sook Kim, Sang Hee Hong, Gi Myung Han and Sung Yong Ha**
An almost successful story of TBT regulation to protect the coastal environments of Korea (S3-8910)

11:20 **Hideaki Maki, Gen Kanaya, Shin-Ichi Fukuchi,Kazuki Miura, Hisao Sasaki, Nobuyuki Tanaka, Nobuo Chiba and Osamu Nishimura**
Petrogenic and pyrogenic PAHs contamination in the sediments in Tohoku coastal seas, Japan by the great tsunami on 3.11.2011 (S3-8927)

11:40 **Jean-Pierre Desforges, Moira Galbraith, Neil Dangerfield and Peter Ross**
Microplastics in the marine environment in coastal British Columbia (S3-8916)

12:00 **Jingfeng Fan and Hongxia Ming**
The contamination and risk assessment of infective human enteric viruses in surface seawater from Bohai Bay, China (S3-9048)

12:20 *Comments and Discussion*

12:30 *Session Ends*

S3 POSTERS

S3-P1 (*cancelled*) **Md. Khurshid Alam Bhuiyan, Abu Hena Mustafa Kamal, Ismail Johan and Mohd Hanafi Idris**
Accumulation of trace metals in a mangrove ecosystem, Miri River, Sarawak, Malaysia

S3-P2 (*cancelled*) **K.K. Satpathy, S.N. Panigrahi, A. Mohanthy, Nisha Keshav, H. Achyuthan and S.K. Sarkar**
Recent emergence of shallow water hypoxia in the inner shelf region of the Bay of Bengal

S3-P3 (*cancelled*) **Dmitriy A. Butorin and Andrey P. Chernyaev**
Levels of 4-NP and 4-OP in bottom sediments of the Peter the Great Bay (Japan/East Sea)

S3-P4 **Sangjin Lee**
NOWPAP activities addressing marine litter

S3-P5 **Young Kyoung Song, Won Joon Shim, Mi Jang, Sang Hee Hong and Gi Myung Han**
Ship paint as a new input source of floating microplastics in surface microlayer

S3-P6 **Chunjiang Guan, Fengao Lin and Jingfeng Fan**
A public questionnaire survey of oil spill in 7.16 Dalian New Port

S3-P7 **Dong-Woon Hwang, Pyoung-Joong Kim, Minkyu Choi, In-Seok Lee, Sook-Yang Kim and Hee-Gu Choi**
Temporal trend and spatial distribution of trace metals in coastal sediment of Korean peninsula

S3-P8 **Jung-Hoon Kang, Oh-Youn Kwon, Kyun-Woo Lee and Won Joon Shim**
Marine floating microplastics around Geoje Bay in the Southern Sea of Korea

S3-P9 **Kyun-Woo Lee, Jung-Hoon Kang and Won Joon Shim**
Toxicity of micro polystyrene particle for marine copepod *Tigriopusjaponicus*

S3-P10 **Yanin Limpanont, Kwang-Sik Choi, Hyun-Ki Hong and Chang-Keun Kang**
Histopathology of Manila clams *Ruditapes philippinarum* surveyed in Korean waters

S3-P11 (*cancelled*) **Vasiliy Yu. Tsygankov, Margarita D. Boyarova, Peter A. Tyupeleev, Ilya A. Shcherbakov, Olga N. Lukyanova and Nadezhda K. Khristoforova**
Chlorinated hydrocarbons in organs of marine mammals, seabirds and salmon from the North-West Pacific

S3-P12 (*cancelled*) **Nadezhda K. Khristoforova, Vasiliy Yu. Tsygankov, Olga N. Lukyanova and Margarita D. Boyarova**
Pollutants in Pacific and Atlantic salmon

S3-P13 (*cancelled*) **Galina S. Borisenko and Yuriy G. Blinov**
Findings of radioecological monitoring of salmon in the North West of the Pacific Ocean

S3-P14 **Guangshui Na, Zihao Lu, Wanru Zhang, Hui Gao, Jinqiu Du, Zhen Wang, Yaqi Cai, Ziwei Yao and Chuanlin Huo**
Occurrence and distribution of five types of antibiotics and antibiotic-resistant *Escherichia Coli* in Liao River estuary, China

S3-P15 **Jianguo Du, Zhao Jiayi and Chen Bin**
Assessing ecological risks of heavy metals to marine organisms by species sensitivity distributions

S3 Oral Presentations

October 16, 09:05 (S3-8941)

Persistent organic pollutant fingerprints in five Pacific salmon species (*Oncorhynchus* spp.): Evidence of distinct contaminant sources associated with their marine distribution and feeding

Sandra **O'Neill**[1], Gina Ylitalo[2], David Herman[2] and James West[1]

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Levels of persistent organic pollutants (POPs) in Pacific salmon (*Oncorhynchus* spp.) depend on where they live and what they eat. Salmon may be exposed to contaminants in freshwater and estuarine habitats, however, the majority of the adult body burden of POPs are accumulated in marine habitats where most of their feeding and growth occurs. We measured whole body concentrations of POPs in salmon originating from streams along the west coast of North America, ranging from northern British Columbia to northern California. POPs levels in pink, chum and sockeye were lower than Chinook and coho salmon, which have more coastal marine distributions. Species with more coastal distributions places them nearer to land-based contaminant sources that are readily transported to coastal marine waters. In particular, Chinook salmon populations feeding and residing along more developed coastlines are exposed to higher POPs concentrations, potentially high enough to affect their health as well as the health of their predators, including humans and killer whales. Moreover, regional patterns in POPs among Chinook salmon populations provide distinct contaminant fingerprints associated with in their marine distribution through more contaminated coastal environments. These contaminant fingerprints may be used as a comparative tool to help elucidate marine distribution or migration patterns of other Chinook populations and variation in marine distribution among individuals within populations. Comparisons of chemical fingerprints in Chinook salmon and resident killer whales, which feed primarily on Chinook salmon, may be used to identify populations of Chinook salmon most important to the diet of whales.

October 16, 09:30 (S3-8881)

Some maternal Steller sea lion diets elevate fetal mercury concentrations in the western Aleutian Island area of population decline

Lorrie D. **Rea**[1,3], J. Margaret Castellini[2], Lucero Correa[3], Brian S. Fadely[4], Vladimir N. Burkanov[4,5] and Todd M. O'Hara[6]

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One hypothesis for the lack of recovery of endangered Steller sea lions (SSLs, *Eumetopias jubatus*) in Alaska is low natality. Mercury exposure can be neurotoxic to piscivorous mammals and impact reproduction. Young pups have higher total mercury concentrations ([THg]) in hair than older juvenile SSLs reflecting exposure of pups to mercury *in utero* when lanugo (natal pelage) is grown. We utilized patterns of $\delta^{13}C$ and $\delta^{15}N$ isotope ratios in the vibrissae (whiskers) of young pups to understand how diet variations between gestating females might impact mercury exposure during this critical period of fetal development. Hair was collected from 416SSL pups (newborn to 6 weeks old) captured on their natal rookeries in Alaska (USA; n=342) and Russia (n=74) and analyzed on a direct mercury analyzer (Milestone DMA-80). Hair [THg] was variable among pups, ranging from 1.4 to 73.7 µg/g dwt. The highest [THg] concentrations were above the risk thresholds for other mammals and were found in geographic regions showing continued population decline. In the western Aleutian Islands approximately 20% of pups had [THg] above the risk thresholds. In this area, pups born with the highest [THg] in

their hair (above 40 μg/g) showed a significantly higher $\delta^{15}N$ in vibrissa sections grown during the late gestation ($F_{2,25}$=8.61, p=0.0019) suggesting that their mothers may have incorporated higher trophic level fish into their diet. These data along with new investigations of organochlorine contaminants in Aleutian Steller sea lions are designed to assist wildlife management decisions for this species, particularly in the Aleutian Islands.

October 16, 09:55 (S3-8868)

Feathers of tracked seabirds reveal a spatial pattern of marine pollution

Yutaka **Watanuki**[1], Ai Yamashita[1], Mayumi Ishizuka[2], Yoshinori Ikenaka[2], Shouta M.M. Nakayama[2], Chihiro Ishii[2], Takashi Yamamoto[1,3], Motohiro Ito[3], Tomohiro Kuwae[4] and Philip N. Trathan[5]

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Marine birds accumulate chemical markers in their body and come back to the colony every year where their tissues can be sampled easily. Therefore, they are believed to be reliable indicators of environmental variability in their year-round ranges. However, because they arrange widely (>1000km), the spatial scale associated with chemical markers is generally too coarse to be useful in regional management. Here, by analyzing feathers for mercury (Hg) content and nitrogen stable isotope ratio as a proxy of trophic level, we propose a technique to monitor the spatial pattern of marine pollution. Our model is derived from the year-round tracking movements of a pelagic migrant, the streaked shearwater (*Calonectris leucomelas*). The Hg contents in the outermost tail-feathers which are replaced during the non-breeding period showed a 4 times difference amongst birds spending their non-breeding period in the different regions. The Hg was highest for birds staying in South China Sea (3.1ppm), especially for birds spending in coastal regions, moderate for birds in the Arafura Sea (1.5ppm) and lowest for birds in the sea north of New Guinea (0.8ppm) and north west of Australia (0.8ppm). δ^{15} did not strongly relate to Hg contents. Chemical markers in the tissues of pelagic top predators together with the information of their year-round movement afford to give spatial pattern of pollution that can be useful for practical marine planning.

October 16, 10:15 (S3-9109)

Arsenic in the coastal ecosystems of Far Eastern Seas

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Arsenic is a metalloid that is considered as nonessential for living beings. Due to its chemical properties arsenic demonstrates rather complicated behavior in the marine environment and can exist in aquatic systems in variety of inorganic and organic forms. It is known, that inorganic arsenic is one of the most toxic elements and produces acute or chronic effect, while inhaling or ingesting by humans. So the monitoring of arsenic in the environment is a necessary framework worldwide.

Determination of total arsenic was carried out in the seawater, surface bottom sediments and commercial fish, invertebrate and seaweed species of Peter the Great Bay (Japan/East Sea) for last decade. Spatial distribution of arsenic depended on hydrological conditions and point sources of pollution. Concentrations of arsenic in the bottom sediments ranged from 0.83 to 25.5 mg/kg dry wt and were highest near local sources of pollution, demonstrating probable adverse effect on benthic organisms. Although the arsenic concentrations in the most species of marine bioresources from different fishing sites of Far Eastern Seas were relatively low, crustacean and kelp species showed elevated levels of arsenic, significantly higher than maximum allowable level of 5 mg/kg, established in Russian Federation for marine fishes, invertibrates and seaweeds. It is known that arsenic accumulates in marine biota predominantly in the organic, nontoxic forms. So the necessary step in future researches is to establish statements for regulation of inorganic arsenic in marine bioresources of Far Eastern Seas.

October 16, 11:00 (S3-8910)

An almost successful story of TBT regulation to protect the coastal environments of Korea

Won Joon **Shim**, Nam Sook Kim, Sang Hee Hong, Gi Myung Han and Sung Yong Ha

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Tributyltin (TBT) has been actively applied to antifouling paints as a biocide additive to prevent the adherence of sedentary organisms to ship hull and other structural surfaces immersed in water. TBT's excellent antifouling performance for both, the soft and hard fouling, made itself as a dream antifouling agent from the 1960s. However, since its deleterious effects on non-target marine organisms were revealed at well below ppb level in the early 1980's, it has been known as one of the most notorious toxicants man ever introduced to marine environments. Korea is a world leading in ship building industries; and shipping activities are relatively high as a peninsula. The occurrence of TBT in multi-media and its adverse biological effects has been reported in Korean waters since middle of the 1990s. The Korean government banned the use of TBT based antifouling paint on ships less than 400 tonnage from 2000 and whole ships from 2003 based on evidence of its contamination and biological effects. Regulatory process taken to ban on use of TBT containing paints in Korea is one of good examples which controls the hazardous chemicals in Korean marine environment. Effectiveness of the regulation was monitored for 10 years after the total ban on use of TBT based antifouling paints in Korea. An apparent reduction of TBT concentration was found in seawater and biota, and in a less extent in sediments. Frequency and degree of imposex in gastropod species, as a TBT specific biomarker, obviously decreased after the regulation. However, other alternative antifouling agents used to replace TBT were currently of the emerging concern.

October 16, 11:20 (S3-8927)

Petrogenic and pyrogenic PAHs contamination in the sediments in Tohoku coastal seas, Japan by the great tsunami on 3.11.2011

Hideaki **Maki**[1], Gen Kanaya[1], Shin-Ichi Fukuchi[2], Kazuki Miura[2], Hisao Sasaki[3], Nobuyuki Tanaka[3], Nobuo Chiba[3] and Osamu Nishimura[3]

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On 3.11.2011, the devastating tsunami generated the Great East Japan Earthquake destroyed and washed away fuel tanks at some ports in the Tohoku coastal area, which resulted in oil spill and fire on the sea surface. The spilled oil and ashes were adsorbed onto the fine sediment particles which were suspended by tremendous tsunami energy. Subsequently, the sediment containing vast amount of fuel and soot sank and precipitate onto the bay bottom. It was found that some sediment samples taken within a coupe of months after 3.11.2011 produced enormously oily odor and contained high concentration of both aliphatic and aromatic hydrocarbons (occasionally, higher than 70,000 ng-ΣUSEPA 16PAHs/g-dry weight of sediment). We have sampled some sediments from the coastal seas of the Tohoku district facing the Pacific ocean and analyze hydrocarbons in them, which reveals that n-alkanes originated from diesel fuel for fishing vessels were very rapidly depleted and petrogenic PAHs such as naphthalene, fluorene, dibenzothiophene, phenanthrene and their alkylated derivatives have degraded gradually, however, pyrogenic PAHs such as benzofluoranthenes, benzanthracenes and benzopyrenes have been likely to increase rather than decline. Interestingly, both horizontal and vertical profiles of petrogenic and pyrogenic PAHs in sediments were not homogenous, which implies that the tsumani-suspended sediments contaminated with spilled fuel behaved differently from those with soot formed by fire on the sea surface. Moreover, benthic fauna were likely to diminish due to the increment of PAHs concentrations in sediment.

October 16, 11:40 (S3-8916)

Microplastics in the marine environment in coastal British Columbia

Jean-Pierre **Desforges**[1], Moira Galbraith[2], Neil Dangerfield[2] and Peter Ross[1]

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Large plastic debris has long been recognized as a threat to marine biota while microplastics (<5mm) are currently receiving an increased attention due to their ubiquity, persistence, risk of ingestion and transport of contaminants. Here, we document the abundance of microplastics in the marine environment in coastal British Columbia. Seawater was collected and sieved (250, 125 and 62.5µm) using the saltwater intake system of the CCGS John Tully during the August 2012 Line P and September 2012 La Perouse monitoring programs. Samples were acid digested and examined using light microscopy. One hundred percent of sites contained microplastics, ranging from 8.5 to 9179 particles/m^3. Microplastic concentrations were at least four times higher in coastal waters (west Vancouver Island) than Pacific offshore waters (Line P) (316.5 *vs* 1426.8 particles/m^3; p=0.012). Similarly, plastic concentrations were three times higher in inland waters of eastern Vancouver than coastal waters off the west coast of Vancouver Island (5021.0 *vs* 1721.9, p=0.004). Plastic particles were assigned to two product types: fibres/filaments and plastic fragments; and divided into four size categories: <100, 100-500, 500-100 and >1000 µm. Fibres/filaments accounted for the majority of plastics for La Perouse (84±12%) and Line P samples (65±23%) and most fell in the 100-500µm size class. Further work is needed to understand the sources of microplastics in British Columbian waters in light of the on-coming debris from the Tohoku Tsunami, as well as the risk and implications for biota.

October 16, 12:00 (S3-9048)

The contamination and risk assessment of infective human enteric viruses in surface seawater from Bohai Bay, China

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The contamination of six kinds of human enteric viruses was investigated in the seawater across a large geographical region along the Chinese coasts which is highly polluted with human rotavirus and poliovirus. Therefore, these two kinds of viruses were chosen to present the pollution of human enteric viruses and enable the risk assessment of infective rotavirus and poliovirus in Bohai Bay, China. From December 2010 to September 2011, an integrated cell culture and real-time PCR (ICC-qPCR) method was established, Beta-Poisson and exponential models were employed respectively. Thirty-two percent of the samples were positive for rotavirus and fifty-seven percent for poliovirus. The estimated concentration of infectious human rotavirus and poliovirus were 1~279 PFU/L and 0.2~196 PFU/L. Our preliminary risk assessment indicated the annual risk of illness (10-day exposure) caused by rotavirus at almost all the contaminated sites, while 68.75% for poliovirus exceeded an acceptable threshold of marine recreational water quality (19 illnesses per 1,000 swimmers). The results demonstrated that the contamination of enteric viruses in this coastal area were severe, which may constitute a potential public health risk. The detection method and dose-response model in the current work appear useful for evaluating pathogenic risks of seawater to vacationers and can inform management actions.

S3 POSTERS

S3-P1 (*cancelled*)

Accumulation of trace metals in a mangrove ecosystem, Miri River, Sarawak, Malaysia

Md. Khurshid Alam **Bhuiyan**, Abu Hena Mustafa Kamal, Ismail Johan and Mohd Hanafi Idris

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An investigation was carried out to determine the concentration of trace metals in the surface water, porewater, surface sediments, the hooded oyster *Saccostrea cucullata* and the red macroalgae *Bostrychia radicans* from three locations of the Miri river mangrove forest. The concentration of nutrients in water was also analyzed. Trace metal concentrations in water in the present study exceeded the background levels in marine waters. The concentrations of metals in water were ordered as Fe>Zn>Mn>Cu for surface water and Zn>Fe>Mn>Cu for porewater. The metal concentrations in sediments were ordered as follows: Fe>Zn>Cu>M where the concentration in bioavailable levels fall between the Threshold Effects Level and Probable Effects Level. Distribution patterns for metals in macroalgae were ordered as Fe>Zn>Mn>Cu. For the oyster, the metals were ordered as Fe>Mn>Zn>Cu for soft tissue and Fe>Zn>Cu>Mn for hard shell. Results indicated higher concentration of $NO_3^{--}N$ (59.4±0.4mg/l) in porewater compared to surface water (20.7±0.3mg/l), probably, due to the decomposition of plant materials and biological disposal from urban users into these mangrove ecosystems. Similarly, mean concentrations of $NH_3^{-}N$ and $PO_4^{3--}N$ were higher in porewater than river water. The concentration of nutrients in water of the present study exceeded the recommended maximum level. The findings of this study can help to improve river water quality and its management in this mangrove forest for future management.

S3-P2

Recent emergence of shallow water hypoxia in the inner shelf region of the Bay of Bengal

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Oxygen minimum zones (OMZs) might restrict animal life, affecting geochemical reactions, community structure of marine life and fishery. The number and intensity of OMZs are likely to increase as global warming and nutrient enrichment rob the ocean of oxygen. There are six major OMZs places in the world oceans, amongst the Bay of Bengal (BOB) comes at the fifth level.

We encountered hypoxic and anoxic conditions in the continental shelf and slope region along the BOB in a relatively shallow depth during the coastal monitoring programme (2009-2010). To the best of our knowledge, this forms the first report of its kind from BOB. In water spread of 320x50 km of the shelf region hypoxia was observed at a depth of 24m and a reasonably anoxic zone at a depth of 60m during the year of 2009. During 2010, hypoxia was observed at a depth of 59m and anoxia at a depth of 82m. Earlier studies have indicated an OMZ (0.7 mg/L O_2) at a depth of ~100m during 2004 which has been expanded upwards in the current investigation. BOB is one of the most open systems receiving high nutrient inputs, with no physical barriers separating its coastal zone from the open ocean. We observed a sharp increase in nutrients (phosphate, silicate, nitrate) at hypoxic depths and a water column stratification at shallower depths (<50m) compared to earlier reported isopycnals (70m). The heavy input of inorganic nutrients and organic carbon in the northern BOB and physical forcing due to the wind driven upwelling could contribute to the present state of intensification of hypoxia.

S3-P3

Levels of 4-NP and 4-OP in bottom sediments of the Peter the Great Bay (Japan/East Sea)

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Xenoestrogens are anthropogenic substances having a negative effect on endocrine system, the development of vertebrate and invertebrate animals and hormonal regulation processes. Alkylphenols (APs) - 4-nonylphenol (4-NP) and 4-octylphenol (4-OP) are generally concerned with them. APs are able to accumulate in the bottom sediments of industrialized centers water area becoming the source of secondary pollution. In 2011, the level of alkylphenols in Amur and Ussuri Bay was from below detection limits up to 157.38 mg/kg dry weight. The 4-NP highest concentrations were found in the bottom sediments of the Amur Bay and the 4-OP highest concentrations – in the sediments of Ussuri Bay. The content of phenols is at the sub-critical level and is able to cause the changes in the structure of marine organisms community, such as the slow maturation of reproductive organs, the changes in sex and age structure of populations. Thus, the situation determines the necessity of full-value monitoring activities, the identification and classification of pollution sources substances exhibiting the xenoestrogens effect.

S3-P4

NOWPAP activities addressing marine litter

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Marine litter originates from many sources and causes a wide spectrum of environmental, economic, safety, health and cultural impacts. Given the diversity and abundance of sources, marine litter is a global concern and is likely to remain a major problem in near future. Solving the marine litter problem requires global, regional and national programs and their effective implementation. In order to enhance the awareness, capacity and actions of the member countries for effective management of marine litter in the northwest Pacific, the Action Plan for the Protection, Management and Development of the Marine and Coastal Environment of the Northwest Pacific Region (NOWPAP) had initiated marine litter activities in 2005 with a project called Marine Litter Activity (MALITA). Later on, NOWPAP Regional Action Plan on Marine Litter (RAP MALI) was developed in 2008 in order to encourage NOWPAP member states to implement actions to deal with marine litter at a national and local level. RAP MALI consists of three key elements: 1) prevention of marine litter input to the marine and coastal environment; 2) monitoring of marine litter quantities and distribution, and 3) removal of existing marine litter and its disposal. As RAP MALI implementation has been proven successful during the past several years, it will serve as a roadmap continually for the countries to tackle the issue in cooperation with the UNEP Regional Seas Programme and other UN agencies and programmes (*e.g.*, FAO, IMO and GPA). In the poster, some experiences in addressing marine litter problems in the NOWPAP region are illustrated.

S3-P5

Ship paint as a new input source of floating microplastics in surface microlayer

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Small sized and low specific gravity microplastics are expected to be accumulated within the surface microlayer (SML) of water due to SML's high surficial tension. In this study, plastic-like particles were identified by FT-IR microscope in SML from ten stations of southern coast of South Korea in May and July of 2012. Abundances of microplastics are in the range of 68-473 particles/L in May and 60-253 particles/L in July. Results from FT-IR identification showed that microplastics in the SML contains at least two types of polymers in fragment; 1) polyester (soybean oil modified phthalic alkyd) and 2) poly (acrylate:styrene) copolymer. These co-polymer

types accounted for over 90% of total microplastics abundances and are known to be used in ship paint, coating, pharmaceutical, oil industry, textile finishing, etc. Ship paint was suspected as an origin of the co-polymer fragments, considering their distinct green or blue color as well as thousands of fishing boats registered in the study area. The FT-IR spectrums of the major microplastic co-polymer fragments in the SML and the ship paint chips collected from several boat hulls in the study area matched identically. It indicates that two co-polymer particles are mainly originated from ship paints applied to ship hulls. However, it is unclear, yet that the co-polymer fragments were introduced to surface water directly from during ship moving and (or) ship repairing in shipyards and ports. Further study is required to investigate environmental and ecotoxicological consequences of co-polymer fragments and their associated toxic chemicals in SML.

S3-P6

A public questionnaire survey of oil spill in 7.16 Dalian New Port

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An accidental explosion of storage tanks pipeline in Dalian Dagushan New Port pier of China National Petroleum Corporation occurred in July 16, 2010, resulting in oil spill into the sea. We carried out a public questionnaire survey in July 30, 2010. The survey results showed that more than 95% of the public? cared about sea, 96% of respondents are aware of the oil spill, 57% believed that the oil spill causes 'serious impact on the ecological environment' and 64% of the respondents were of the opinion that greatest concern after oil spill is 'ecological restoration' Respondents who believed that the oil spill could cause most serious impact in aquaculture industry and the tourism industry accounted for 54% and 45%, respectively. Respondents who opined of serious impact to aquaculture in Golden Pebble Beach, Development Zone Town, and Dalian Bay survey area accounted for more than 80%. In Golden Pebble Beach, and the Dalian Bay area, the respondents who opined the tourism industry to be 'seriously affected' accounted for more than 70%. The multiple results of questionnaire in Lushun Dragon King Tong showed that it was not affected of the oil spill. The public satisfaction of the emergency measures taken by the Government reached 82%.

S3-P7

Temporal trend and spatial distribution of trace metals in coastal sediment of Korean peninsula

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We measured the concentrations of trace metal (Cu, Pb, Zn, Cd, Cr, As and Hg) at 71 stations in coastal sediment around Korean peninsula from 2004 to 2010 to understand the temporal variation and spatial distribution of metal concentrations in sediment. The highest concentrations of all metals except Cr were found in the southeastern coast of Korean peninsula where many big cities, industrial complexes, and large-scale fish and shellfish farms are located, indicating that the metal concentrations in sediment are influenced by anthropogenic source associated with human activities in the coastal zone. The average concentrations of trace metals in the southern coast did not show marked temporal variation, owing to sustainable coastal management by the designation of special management area and marine environment conservation area, whereas the average concentrations of Cu and Cr in the eastern coast and Cu, Zn, Cd and Cr in the western coast gradually increased during the study periods. These trends may be related to coastal development, such as the construction of hotel, resort, golf course, and expressway along the coastline, and the continuous input of pollutant through river runoff and atmospheric deposition from China and Korea. Based on the results of sediment quality guidelines (SQGs) and geo accumulation index (Igeo), the coastal sediments around Korean peninsula were a little polluted for Cr and were moderately polluted for As.

S3-P8

Marine floating microplastics around Geoje Bay in the Southern Sea of Korea

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Floating microplastics are determined in terms of abundance, distribution and characteristics around Nakdong River mouth in the Southern Sea of Korea. Surveys were carried out in 29th-30th May during dry period and 23rd-24th July after rainy season using Manta-trawl net with 330 μm mesh and hand net with 50 μm mesh. Particles were classified into expanded polystyrene (EPS), fragment of hard plastic (Fragment), fibrous particles (Fiber) and other forms based on physical form, size classes were selected as <2mm, 2-10mm, 10-25mm, and >25mm. Particles quantity varied with in ranges of 0.62-56.91 particles/m^3 (May) and 0.64-860.86 particles/m^3 (July) by trawls and in ranges of 260-1,410 particles/m^3 (May) and 210-15,850 particles/m^3 (July) by hand net. The maximum abundance from particles by trawls occurred at size class of 2-10 mm dominated by EPS of which relative abundance increased from 54.28% (May) to 87.29% (July). From particles by handnet, EPS at sizes of 2-10 mm increased from 140 to 7,820 particles/m^3 which relative abundance was less than 30% during surveys. Sizes of <2 mm from particles by handnet accounted for 97.53% (May) and 68.52% (July) consisting of fragments and fibers. From sizes <2mm showed wide range of occurrence, mean abundances of fiber, hard plastics and EPS from trawl samples were higher after rainy season than those during dry season, whereas those of fiber and EPS from handnet samples increased in July compared to in May. These results indicated that abundances and size class of floating microplastic was likely affected by runoff during rainy season in the survey area.

S3-P9

Toxicity of micro polystyrene particle for marine copepod *Tigriopusjaponicus*

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We investigated the influence of three polystyrene (PS) micro-beads (0.05, 0.5 and 6 μm diameter) which were selected to measure the sized effect of microplastic for survival, development and fecundity of the copepod *Tigriopus japonicus* using acute and chronic toxicity test. *T. japonicus* ingested and excreted all PS beads used in the study even at the condition with livefeed without food selection. The copepods (nauplius and adult female) could survive at all sized-beads and various concentrations tested in the acute toxicity test for 96 h. In the two-generation chronic toxicity test, 0.05 μm PS beads with over 12.5 μg/mL concentration caused mortality of nauplius or copepodite in the F_0 generation even at 1.25 μg/mL concentration in the next generation. In 0.5 μm PS beads treatment, although there was no significant effect in the F_0 generation, the highest concentration (25 μg/mL) induced significant decrease in the survival compared with the control in the F_1 generation. 6 μm PS beads did not affect survival of *T. japonicus* over two generations. The length of nauplius phase and generation time of the copepod were similar with the result of survival. Sex ratio showed no significant difference at all treatments over two generations. The smallest sized-beads (0.05 μm) did not affect the fecundity of the copepod. However, 0.5 and 6 μm PS beads caused a significant decrease of the fecundity at all concentrations. These results suggest that the microplastic such as micro sized-PS bead may lead to negative effect tomarine filter feeder.

S3-P10

Histopathology of Manila clams *Ruditapes philippinarum* surveyed in Korean waters

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Manila clam *Ruditapes philippinarum* is one of the most important shellfish resources on the west coast of Korea. In the present study, we used histology to survey the pathologic condition of the clams in Korean waters. To date, few studies have investigated the pathologic condition of clams in Korean waters. For the survey, 40 adult clams were collected from 23 sampling sites in April and November 2007. The protozoan parasite *Perkinsusolseni* and trematodes were found to be the two most common parasites infecting Manila clams in Korean waters. Prevalence and infection intensity of *P. olseni* were higher among clams from commercial clam beds in the west, which were characterized with sandy- or silty-mud tidal flats. *P. olseni* infection intensity was also higher during the post-spawning period and the high infection intensity coincided with the mass mortalities of clams in some clam beds. Gonad castration was commonly observed in female clams severely infected with the trematodcercaria. The histology revealed that some clams were also infected with Turbellaria, copepod, rickettsia-like organisms, *Martelioides*sp., the ovarian parasite commonly found in Pacific oyster, and larval cestodes. The total parasite burden was found to be higher at commercial clam culture grounds on the west coast, where the Manila clams have been cultivated intensively for the decades.

S3-P11

Chlorinated hydrocarbons in organs of marine mammals, seabirds and salmon from the North-West Pacific

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Chlorinated hydrocarbons are harmful and toxic substances affecting biota. HCHs and DDTs are used as pesticides in southern Hemisphere and may occur in polar regions due to atmospheric transfer. Isomers of HCH and DDT and its metabolites were detected in organs of marine mammals (*Eschrichtius robustus, Odobenus rosmarus divergens*) from the Bering Sea. Maximum concentration was obtained in walrus liver (90263 ng/g lipid). Seabirds (*Larus schistisagus, Aethia cristatella, Aethia pusilla, Fulmarus glacialis, Oceanodroma furcata*) were collected in the Okhotsk Sea. Total maximal pesticide concentration was determined in pen with skin of the Crested Auklet (16095 ng/g lipid), minimal concentration– in pen of the Northern Fulmar (29 hg/g lipid). Pacific salmon (*Oncorhynchus gorbusha, Oncorhynchus keta*) are the most abundant on epipelagial o North Pacific. In Pink salmon, total pesticides concentration in body burden was about 20 ng/g, in Chum salmon – 15 ng/g. High pesticide concentration was detected in Sockey liver (225 ng/g wet weight) and gonads (390 ng/g). Salmon are considered to be an important vector in the transport of pollutants in the North Pacific.

S3-P12

Pollutants in Pacific and Atlantic salmon

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Atlantic and Pacific salmons are the most common, numerous and high valued fishery in the salmon family. *Salmo salor* (an Atlantic salmon) is the most popular among all the Atlantic species of salmon. And species of genus Oncorhynchus: pink salmon, chum, red salmon, coho salmon, chinook salmon and cherry salmon are the most popular among the Pacific ones. As long as the catch of an Atlantic salmon has significantly decreased, over 99% of them are grown in hatcheries, while 50% of Pacific salmons are still reproducing in natural spawning. In Russian waters the most valuable species in fishing are the chum and fast-growing pink (*Oncorhynchus gorbusha, Oncorhynchus keta*). Analysis of trunks of this fish, caught in July 2012 near the Kurile Islands has shown that pink had very low concentration of all measured elements - Hg, Pb, Cd, As, Zn, Cu, and chum had a little more. Another chum which was caught in October 2012 near the shores of Primorsky Region (Russia) was larger and contained 2-3 times more elements. However, the concentrations of toxic elements in fish in both cases were much lower than the acceptable levels. According to published data, an Atlantic salmon grown in hatchery near the shores of Norway comparing to chum had higher concentrations of elements: Zn - in about 100 times, Cd - in about 10 times, Hg - in 5 times, Cu - in 2 times.

S3-P13

Findings of radioecological monitoring of salmon in the North West of the Pacific Ocean

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Under a hygienic assessment test of the quality of the flesh of a fish one usually estimates its safety with regard to the content of artificial radionuclides Cs-137 and Sr-90.

In 2012, we continued monitoring the radioactive pollution of pacific salmon, procured from the Sea of Okhotsk and in coastal waters of Kuril Islands of the Pacific Ocean. In March and in April of 2011, juvenile pink salmon contained Cs-137 radionuclides four times as many as in the year before the leakage.

The same samples contained Cs-134 radionuclides that prove the fact of anthropogenic radioactive contamination as a result of release of nuclear activity in the “Fukushima I” Nuclear Power Plant in March 2011. Canned pink salmon had an elevated concentration of Cs-137/134 radionuclides. The examined samples of pink salmon belonged to a school of Okhotsk salmon. In October-November, 2010 pink salmon fingerlings migrated to the Ocean wintered and fattened in Pacific waters.

At the same time, the radioactivity of pink salmon that was caught this year in the Sea of Okhotsk next to Kuril Islands and the East coast of Sakhalin remained on the background pollution level, which is typical for Far Eastern fish. The radiological researches of fish flesh, conducted along the seacoast of Kuril Island before salmon enters the Sea of Okhotsk in June and at the beginning of July in the year of 2012, have shown that fishing grounds meet the standards of safety imposed by the sanitary rules.

Monitoring the radioactive situation in the fishery grounds of the Far Eastern basin is being continued.

S3-P14

Occurrence and distribution of five types of antibiotics and antibiotic-resistant *Escherichia Coli* in Liao River estuary, China

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Massive antibiotics and their metabolites are released into different compartments of the environment accompanied by the emergence of bacterial resistance which is regarded as a major concern of health by the officials world-wide. In order to investigate the occurrence and distribution of some antibiotics and antibiotic-resistant *Escherichia Coli* in Liao River estuary, China, 12 water and 10 sediment samples were sampled. Five types and sixteen antibiotics were simultaneously analyzed with solid phase extraction coupled with liquid chromatography tandem mass spectrometry. Assessment of antibiotic resistance in *Escherichia Coli* isolates is carried out by using MI-R method using relevant antibiotics in their lowest inhibitory concentrations.

The results showed that Chloroamphenicol, Sulfonamides, Tetracyclines, Fluoroquinolones, Macrolides concentrations in water were 2.03 ngL^{-1}~30.09 ngL^{-1}, ND~102.37 ngL^{-1}, 0.27 ngL^{-1}~29.37 ngL^{-1}, ND~42.95 ngL^{-1} and ND~58.42 ngL^{-1} respectively. The residue concentrations in sediments were ND~19.47 μgkg^{-1}, ND~3.61 μgkg^{-1}, ND~3.95 μgkg^{-1}, ND~2.82 μgkg^{-1} and ND~0.18μgkg^{-1}. High prevalence of antibiotic resistance was found in the Liao River estuary. The levels of resistance to antibiotics investigated were from 18.18% to 58.06%. For further analysis, occurrence and phenotypic analyses of antibiotic-resistant strains in *Escherichia Coli* population were compared with salinity and the different antibiotic compounds detected in the Liao River estuary. The results indicated that the correlations between salinity and the percent resistance were stronger than those between antibiotic residues and the percent resistance. Fortunately, we found that some antibiotics such as sulfamethoxazole have closer relation with the occurrence of antibiotic-resistant *Escherichia Coli.*

S3-P15

Assessing ecological risks of heavy metals to marine organisms by species sensitivity distributions

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Species sensitivity distributions (SSD) method was used to assess the ecological risk of eight heavy metals (As, Cd, Cr, Cu, Hg, Mn, Pb, Zn) to marine organisms. The acute toxicity data (LC_{50} or EC_{50}) were collected from ECOTOX database and SSD curves were fitted based on BurrIII function. The acute ecological risks of the heavy metals and the sensitivity of different marine species (vertebrate and invertebrate) to these heavy metals were compared by the hazardous concentrations for 5% of the species (HC5) and the potential affected fractions (PAF). Then the HC5 values of the seven heavy metals were in the order: Pb>Mn>Zn>Cr>Cu>Hg>Cd>As. When exposure concentration was lower than $10\mu g \cdot L^{-1}$, no significant differences in the ecological risks of Cr, Cu and Hg was observed. However, As, Cd, Cu and Hg exceeded the threshold of 10% (PAF) at the exposure level of $10\mu g \cdot L^{-1}$. The ecological risks of the heavy metals increased rapidly as the exposure concentration increased. When came up to $1000\mu g \cdot L^{-1}$, 82.49 %, 87.31% and 85.90% of marine species would be affected by As, Cu and Hg, respectively. The order of sensitivity to marine species varied with different concentration of heavy metals. The ecological risk of all heavy metals to crustaceans was higher than fishes.

S4 POC Topic Session
The changing carbon cycle of North Pacific continental shelves and marginal seas

Co-sponsored by SOLAS

Co-Convenors: Minhan Dai (China), Sophia Johannessen (Canada) and Dong-Jin Kang (Korea)

Invited Speakers:
Miguel Goni (Oregon State University, USA)
Kon-kee Liu (Institute of Hydrological and Oceanic Sciences, National Central University, Chinese-Taipei)

Coastal waters link the atmosphere, the land and the open ocean, both dynamically and biogeochemically. Consequently, the carbon cycle of the continental shelves and marginal seas that ring the North Pacific is particularly complex and prone to rapid changes induced by global climatic and regional anthropogenic forcing. Among others, these drivers include increasing temperature, ocean acidification, eutrophication, and deoxygenation of seawater. Such changes represent a potential for great harm to the ecosystems and fisheries that rely on these highly productive waters. This session invites presentations on ocean acidification, hypoxia, eutrophication and other topics related to the biogeochemistry of organic and inorganic carbon in Pacific continental shelves and marginal seas.

Day 1, Wednesday, October 16 (09:00-12:50)

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

09:05 **Miguel A. Goñi (Invited)**
Land-ocean conductivity in the carbon cycle of the Pacific Northwest margin (S4-8930)

09:30 **Vadim Navrotsky, Valeriy Liapidevskii, Vyacheslav Lobanov and Elena Pavlova**
On small- and meso-scale dynamic processes responsible for long-term fluctuations of biological parameters of continental shelves and marginal seas (S4-8887)

09:50 **Dong-Jin Kang, Jae-Yeon Kim, Tongsup Lee, Pavel Tischchenko and Kyung-Ryul Kim**
An application of TrOCA to the East/Japan Sea (S4-8970)

10:10 **Minhan Dai, Jinwen Liu, Wenping Jing, Hongjie Wang, Xianghui Guo and Guizhi Wang**
Multiple stressors in the coastal ocean ecosystem (S4-9011)

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

10:50 (*cancelled*) **Wiley Evans and Jeremy T. Mathis**
Calcium carbonate corrosivity in an Alaskan inland sea (S4-8953)

11:10 **Zhong-yong Gao, Heng Sun and Liqi Chen**
Distributions of pCO_2 and their decadal changes in the Bering Sea (S4-9050)

11:30 **Jerome Fiechter, Enrique Curchitser, Christopher Edwards, Fei Chai, Nicole Goebel and Francisco Chavez**
Spatiotemporal variability of air-sea CO_2 exchange in the California Current (S4-8876)

11:50 **Liyang Zhan, Liqi Chen, Jiexia Zhang and Yuhong Li**
Implication of different Nitrous oxide distribution patterns between Canadian and Greenland Basin on Global Deep Ocean water nitrous oxide Production (S4-9053)

12:10 **Guimei Liu, Xuanliang Ji, Shan Gao and Hui Wang**
Temporal and spatial variability of carbon cycle in the Northwestern Pacific: A 3D physical-biogeochemical modeling study (S4-9214)

12:30 *Comments and Discussion*

12:50 *Session Ends*

Day 2, Thursday, October 17 (09:00-12:30)

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

09:05 **Kon-Kee Liu (Invited)**
Anthropogenic impacts on the carbon cycle and related biogeochemical processes of western North Pacific continental margins (S4-9165)

09:30 **John A. Barth, Oscar Pizarro, Kate Adams and Nadin Ramirez**
Comparing hypoxia over the continental shelves off central Oregon, USA, and Concepción, Chile (S4-8982)

09:50 **Sophia Johannessen, Diane Masson and Robie Macdonald**
Why the Strait of Georgia is not a dead zone (S4-9173)

10:10 (*cancelled*) **Christopher Krembs, Maggie Dutch, Julia Bos, Skip Albertson, Brandon Sackmann, Mya Keyzers, Laura Friedenberg and Carol Maloy**
Increasing nutrients, changing algal biomass, Noctiluca blooms and a declining benthic foodweb. Is eutrophication fueling the microbial food web and reducing the benthic-pelagic coupling in Puget Sound? (S4-9147)

10:10 **Sonia Batten, Abigail McQuatters-Gollop and Dionysios Raitsos Exarchopoulos**
Variability in lower trophic levels on the Alaskan Shelf (S4-8906)

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

10:50 **Julie E. Keister, Anna McLaskey, Lisa Raatikainen, Amanda Winans and Bethellee Herrmann**
Species diversity in zooplankton responses to hypoxia and elevated pCO_2 (S4-9162)

11:10 **Rui Yin and Atsushi Ishimatsu**
Effects of ocean acidification on the physiological profile of the Japanese pearl oyster *Pinctada fucata* (S4-9041)

11:30 **Andrew M. Edwards, Holly E. Neate, Rowan Haigh, Carrie A. Holt and Debby Ianson**
Vulnerability of Canadian Pacific fisheries to ocean acidification (S4-8989)

11:50 **Burke Hales, Katherine Harris, Wiley Evans and George Waldbusser**
Winter conditions in Oregon coastal waters as refugia from ocean acidification (S4-9212)

12:10 *Comments and Discussion*

12:30 *Session Ends*

S4 POSTERS

S4-P1 **Yusuke Takatani, Atsushi Kojima, Kazutaka Enyo, Yosuke Iida, Toshiya Nakano, Masao Ishii, Daisuke Sasano, Naohiro Kosugi, Takashi Midorikawa and Toru Suzuki**
New empirical equations for total alkalinity in surface waters over the Pacific Ocean from the PACIFICA database

S4-P2 **Boram Sim, Dong-Jin Kang, Cho-Rong Moon, Young Gyu Park and Kyung-Ryul Kim**
Basin-to-basin comparison of radiocarbon in the East/Japan Sea

S4-P3 **Masao Ishii, Toru Suzuki, Daisuke Sasano, Naohiro Kosugi, Yusuke Takatani, Masahide Wakita, Akihiko Murata, Lisa Miller and Robert M. Key**
PACIFICA carbon data 2nd-level quality control

S4-P4 **Jae-Yeon Kim, Dong-Jin Kang, Tonsup Lee, Kyung-Ryul Kim, JeongHee Shim and Hee-Dong Jeong**
fCO_2 characteristics in the surface of marginal seas around Korea (East/Japan Sea and East China Sea)

S4 Oral presentations, Day 1

October 16, 09:05 (S4-8930)

Land-ocean conductivity in the carbon cycle of the Pacific Northwest margin

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The Pacific Northwest margin of North America is characterized by intense seasonal contrasts in forcings controlling carbon transfers between the marine and terrestrial regions. Upwelling-favorable winds and low precipitation typical of late spring and summer give way to downwelling-favorable winds and moisture-laden storm systems during winter. High rainfall results from the interaction of these 'atmospheric rivers' of moisture with the steep coastal topography leading to elevated runoff and seasonal floods. In this presentation I evaluate the biogeochemical impacts of these terrestrial-ocean transfers by reviewing recent results on the magnitude and composition of fluvial fluxes and their deposition/cycling in the coastal ocean. Preliminary estimates indicate that winter-time, flood-dominated inputs of terrestrial particulate organic carbon by coastal rivers may represent ~25% of the annual net air-sea CO_2 flux from the coastal zone and account for >50% of the carbon buried in shelf sediments. Inputs of freshwater and nutrients associated with winter floods result in elevated carbon-fixation rates that can be comparable to those observed during summer upwelling. Moreover, fluvial sediments delivered during floods are a major source of reactive iron and likely contribute to the higher productivity of the northern California Current region. Because coastal rivers respond to both climatic (*e.g.*, rainfall magnitude/intensity) and anthropogenic (*e.g.*, land use) forcings, they are expected to be especially sensitive to predicted future changes (*e.g.*, magnitude, frequency, timing of flood events) and have the potential to alter the biogeochemistry and ecology of the region.

October 16, 09:30 (S4-8887)

On small- and meso-scale dynamic processes responsible for long-term fluctuations of biological parameters of continental shelves and marginal seas

Vadim **Navrotsky**[1], Valeriy Liapidevskii[2], Vyacheslav Lobanov[1] and Elena Pavlova[1]

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It is known that continental shelves are the most productive and at the same time the most ecologically vulnerable zones of the World Ocean, the both characteristics being strongly dependent on multi-scale horizontal and vertical mixing. Multiple observations in the shelf zone and adjacent deep part of the Sea of Japan have shown that the most important for mixing are tides, mesoscale eddies and internal waves (IW). Initially, over the continental slope, tides and eddies serve to generate IW, which propagate in both directions from the shelf break. But these processes alone are not enough to produce the observed biological effects, if vertical mixing does not capture the saturated with nutrients near-bottom waters. Rich in nutrients sediments are characteristic for near-shore shallow waters. Our complex experiments have shown that the main mechanism for their drawing into biological processes is three-dimensional small-scale turbulence and horizontal turbulence of larger scale, produced by nonlinear and breaking IW in a shoaling thermocline. Here again mesoscale processes do their work. Due to tidal and eddy motions, turbulently mixed waters with intermediate density between the surface and bottom spread over the shelf and beyond it at intermediate depths, leading to easier mixing by wind and current shear instability and to higher water saturation by nutrients. Estimates of averaged vertical and horizontal flows of momentum and energy at different levels, as well as spatial and temporal fluctuations of chlorophyll fluorescence and turbidity denote important role of the near-shore wave-like and turbulent processes in biological cycles in shelves and marginal seas.

October 16, 09:50 (S4-8970)

An application of TrOCA to the East/Japan Sea

Dong-Jin **Kang**[1], Jae-Yeon Kim[2], Tongsup Lee[2], Pavel Tischchenko[3] and Kyung-Ryul Kim[4]

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The East/Japan Sea (hereafter EJS) is regarded as a 'Miniature Ocean' despite being a typical marginal sea, because it has an internal conveyor belt system, which comprises deep water formation, warm and cold currents at the surface, a sub-arctic polar front, and so on. Air-sea CO_2 gas exchange is very active in the EJS and, furthermore, anthropogenic CO_2 has penetrated all the way to the bottom.

A tracer, TrOCA (Tracer combining Oxygen, inorganic Carbon, and total Alkalinity), which is a composite of oxygen, dissolved inorganic carbon, and total alkalinity, has been proposed (Touratier and Goyet, 2004). Here we have applied TrOCA to the EJS as a tracer to understand basin-scale phenomena, using data obtained during the CREAMS (Circulation Research of the East Asian Marginal Seas) cruises in 1999. The CREAMS 1999 cruises were carried out on two research vessels (R/V Roger Revelle; 24 June-17 July, R/V Professor Khromov; 22 July-11 August) with almost full coverage of the EJS.

The map of the surface distribution of TrOCA shows very well the boundary of the sub-arctic polar front. The vertical profile of TrOCA has a peak in the central water at 200~1000m depth, where the East Sea Central Water (ESCW) is located, which may be evidence of recent ESCW formation. The TrOCA profile also shows the diffusion of the ESCW to the south.

The potential application of TrOCA to the EJS as a tracer to understand basin scale phenomena will be discussed further at the meeting.

October 16, 10:10 (S4-9011)

Multiple stressors in the coastal ocean ecosystem

Minhan **Dai**, Jinwen Liu, Wenping Jing, Hongjie Wang, Xianghui Guo and Guizhi Wang

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The coastal ocean ecosystem is subject to various anthropogenic forcings and thus is particularly vulnerable. Examples of these stressors on coastal ecosystems include rising temperature, eutrophication and associated hypoxia, and ocean acidification primarily caused by the rise in anthropogenic CO_2 in the atmosphere since the industrial revolution. The complication is that these stressors interact with each other at similar time scales, which presents an immense challenge to distinguishing individual factors and to examining their combined effects. This presentation will start with the illustration of different drivers that may induce ocean acidification in the coastal ecosystem in addition to the increase in anthropogenic CO_2. The presentation will continue with two case studies that demonstrate the combined effects of ocean acidification, deoxygenation, upwelling of low pH waters, and submarine groundwater discharge. The first case study was carried out in the East China Sea off the Changjiang Estuary, a seasonally hypoxic region where we observed enhanced ocean acidification due to respiration of organic matter associated with coastal eutrophication. The second study was conducted in a coastal coral reef system in Sanya Bay off Hainan Island in southern China. This coastal coral reef system is affected by both submarine groundwater discharge and upwelling of low-pH waters. Our presentation highlights that both the hydrodynamic regime and biogeochemistry should be taken into consideration and that a multidisciplinary research approach is essential in order to tackle the multiple stressors in the varying coastal systems.

October 16, 10:50 (S4-8953)

Calcium carbonate corrosivity in an Alaskan inland sea

Wiley **Evans**[1,2] and Jeremy T. Mathis[1,2]

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Ocean acidification is the hydrogen ion increase caused by the oceanic uptake of atmospheric CO_2. It is a focal point of marine biogeochemistry, in part because this chemical reaction reduces calcium carbonate saturation states to levels that are corrosive to shell-forming marine organisms. However, other processes drive carbonate mineral corrosivity, specifically, dilution by tidewater glacier discharge. We present carbon system data collected bi-annually from 2009 to 2012 from Prince William Sound (PWS), a semi-enclosed inland sea located on the south-central coast of Alaska, which is ringed with fjords, many containing tidewater glaciers. Initial sampling in PWS covered limited stations in the western sound, and corrosive calcium carbonate saturation states caused by meltwater dilution were observed in autumn. Beginning in the autumn of 2011, sampling expanded to cover stations in the western and central sound, including two tidewater-glaciated fjords: Icy Bay and Columbia Bay. Conditions in these glaciated fjords affected calcium carbonate corrosivity in the upper water column in PWS in two ways: (1) as spring-time formation sites of mode water with depressed calcium carbonate saturations, and (2) as point sources for surface meltwater plumes with undersatured calcium carbonate and carbon dioxide partial pressures (pCO_2). The unique state of the carbon system in these surface meltwater plumes enhances atmospheric CO_2 uptake, which exacerbates calcium carbonate corrosivity via ocean acidification. On the whole, autumn surface calcium carbonate saturations were ~1.5 units lower than those in spring, with lower pCO_2, making PWS susceptible to amplified calcium carbonate corrosivity and highly sensitive to climate change.

October 16, 11:10 (S4-9050)

Distributions of pCO_2 and their decadal changes in the Bering Sea

Zhong-yong **Gao**, Heng Sun and Liqi Chen

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Underway measurements of surface seawater and atmospheric partial pressure of CO_2 (pCO_2) along BR section in the Bering Sea were conducted during 5 summer cruises of the Chinese National Arctic research Expedition (CHINARE) from 1999 to 2012. CO_2 system parameters were measured in discrete water column samples as well. Latitudinal distributions of pCO_2 in the Bering Sea and their relationships with physical and chemical parameters will be discussed. According to the CO_2 uptake capacity, the Bering Sea was divided into 4 regions: Bering Shelf Region (BS), Bering Slope Current Region (BSC), the Northern Bering Basin Region (NBB) and the Southern Bering Basin Region (SBB). The air-sea CO_2 flux of BSC Region was high, twice as high as that of the northern basin and an order of magnitude higher than that of the southern basin. pCO_2 in the northern basin and on the slope increased with temperature, showing a positive correlation. However, pCO_2 on the slope and in the southern basin was not strongly correlated with temperature, suggesting that temperature was not the dominant controlling factor there. pCO_2 in the northern basin and shelf exhibited a positive correlation with salinity, indicating the importance of water mass mixing, whereas pCO_2 was not strongly correlated with salinity in the southern basin and on the slope. The different controlling factors will be discussed for each region, as well their changes in pCO_2 over the last decade, which reveal different controlling factors and different responses to global change.

October 16, 11:30 (S4-8876)

Spatiotemporal variability of air-sea CO_2 exchange in the California Current

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

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We use a coupled physical-biogeochemical model to investigate the spatial and temporal variability of air-sea carbon exchange in the California Current system. Our main focus is to quantify the impact of horizontal model resolution on CO_2 flux estimates, a relevant issue for upscaling/downscaling between coarser resolution global climate simulations and higher resolution regional simulations. The results indicate that horizontal resolution is important for two reasons: (1) to reproduce the sharp transition between shelf outgassing and offshore absorption, and (2) to resolve coastal topographic features associated with intensified shelf outgassing. While 1/3° is far too coarse to resolve either feature, 1/10° is sufficient to reproduce meridional CO_2 flux variability. However, at 1/10°, the transition between outgassing and absorption is too far offshore by 30-40 km, leading to an overestimation of net outgassing on the shelf by roughly 35% compared to a horizontal resolution of 1/30°. From a global carbon budget perspective, we find that offshore biological production generates sufficient absorption within a few hundred kilometers of the coast to offset the amount of carbon released to the atmosphere in the shelf outgassing region. This result is consistent with the fact that mid-latitude eastern boundary current upwelling systems act both as a sink and source for atmospheric CO_2, leading to near neutral net carbon exchange conditions.

October 16, 11:50 (S4-9053)

Implication of different Nitrous oxide distribution patterns between Canadian and Greenland Basin on Global Deep Ocean water nitrous oxide Production

Liyang **Zhan**[1], Liqi Chen[1,2], Jiexia Zhang[1,2] and Yuhong Li[1]

1 Key Laboratory of Global Change and Marine Atmospheric Chemistry, Third Institute of Oceanography, SOA, Xiamen, 361005, PR China
2 College of Ocean and Earth Science , Xiamen University, Xiamen, 361005, PR China

Nitrous oxide (N_2O) distribution in Canadian Baisn (CB) and Greenland Basin (GB) is studied during 4th and 5th Chinese Arctic Research Expedition (CHINARE) respectively. Result shows that the N_2O concentration in Canadian deep water of 3000m is ~12.4nM, the lowest concentration found in the global deep ocean. Result obtained from 14C data of earlier studies suggests that the Canadian deep water is ~500 years old, which might be water over flowed from Greenland Sea under certain event. Assuming this is true, N_2O in the CB may be a "relict" of 500 years ago, which may be nearly equilibrium with atmospheric N_2O of preindustrial mixing ratios of ~270ppb. Studies reveal that remineralization occurs in the deep Canadian Basin, so whether the N_2O concentration in CB represent the real back ground value of preindustrial need to be examined. The saturation anomaly (SA) of N_2O below the surface water could be calculated using "earlier" SST and atmospheric N_2O mixing ratios. Result shows that N_2O deeper than 50m in GB is oversaturated. Since no evidence of significant oxygen consumption in this water column could be found, N_2O production in this water column could possibly been neglected. The difference of N_2O SA between surface water and deeper water may result from winter ice formation process, when the N_2O is squeezed in brine water and sinks to the lower depth. If the N_2O distribution pattern is dominated by the same processes, the deep water N_2O concentration of11.8-12.5nM could be estimated from the 270ppb mixing ratios. This suggests that the N_2O production rate in CB may less than 0.0012nMa^{-1} during the past 500 years, and the N_2O concentration in CB is close to that of Greenland Sea preindustrial value. With this value, global deep ocean N_2O production could be evaluated more accurately.

October 16, 12:10 (S4-9214)

Temporal and spatial variability of carbon cycle in the Northwestern Pacific: A 3D physical-biogeochemical modeling study

Guimei **Liu**, Xuanliang Ji, Shan Gao and Hui Wang

Key Laboratory of Research on Marine Hazards Forecasting, National Marine Environmental Forecasting Center, Beijing, 100081, PR China

The Northwestern Pacific (NWP) has a wide range of the continental shelf and deep basins. The nutrients and carbon cycle in the NWP exhibit strong seasonal, interannual and decadal time scale variability. Based on the Regional Ocean Modeling System (ROMS), a 3D coupled physical-biogeochemical model including carbon cycle with the resolution 1/12º×1/12º, is established to investigate the physical variations, ecosystem responses, and carbon cycle consequences in the NWP. The ROMS-NPZD model is driven by daily air-sea fluxes derived from the National Centers for Environmental Prediction (NCEP) reanalysis from 1982 to 2005. The coupled model is capable of reproducing the observed seasonal variation characteristics over the same period along 32ºN section in the East China Sea. The integrated air to sea CO_2 flux over the entire NWP reveals a strong seasonal cycle, playing as a sink of CO_2 to the atmosphere from June to October, but serving as a source of CO_2 to the atmosphere in the other months. The 24-year mean air to sea CO_2 flux averaged over the entire NWP is 0.12 mol m^{-2} yr^{-1}, which is equivalent to a regional total of 0.297 Pg-C yr^{-1}, indicating that the NWP is a sink of CO_2 to atmosphere. The partial pressure of carbon dioxide (pCO_2 sea) in the NWP has an increasing rate of 1.11 µatm yr-1, but pH in the seawater has an opposite tendency, decreasing from 1982 to 2005 with the rate of -0.001 yr^{-1}. The sensitivity experiments show that the biological activity is the dominant factor that controls the pCO_2 sea in the NWP. The inverse relationship between the interannual variability of air to sea CO_2 flux and NINO3 SST (Sea Surface Temperature) index reveals that the ENSO phenomenon (El Niño-Southern Oscillation) has a tele-connection with the carbon cycle in the NWP.

S4 Oral Presentations, Day 2

October 17, 09:05 (S4-9165)

Anthropogenic impacts on the carbon cycle and related biogeochemical processes of western North Pacific continental margins

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Continental margins in the western North Pacific are bordered by the world's most densely populated coastal communities, which exert tremendous pressure upon the marine environment of the margins. Anthropogenic nutrients discharged through large rivers are among the most notable changes that humans have brought to the marine ecosystems of continental shelves and marginal seas. As an outstanding example, the Changjiang watershed has witnessed a 3-fold increase in the load of dissolved inorganic nitrogen over the three decades since 1970. It is conceivable that primary productivity has been enhanced by the anthropogenic nutrients, and, consequently, that benthic oxygen demand has also increased. Moreover, the impounding and diversion of freshwater for the purpose of irrigation, which is constantly on the rise, may cause significant biogeochemical changes in coastal seas. While ocean acidification is a global phenomenon, continental shelves and marginal seas appear to show faster rates of pH decline than does the open ocean. Enhanced primary production could be partially responsible for these trends. Emerging evidence indicates that the hydrological cycle is accelerating through the ocean-atmosphere-land system, probably as a result of global warming, which implies increases in river runoff with time. How these changes may alter carbon cycling and related biogeochemical processes on continental margins of the western North Pacific Ocean are explored by projections based on field observations and numerical modeling.

October 17, 09:30 (S4-8982)

Comparing hypoxia over the continental shelves off central Oregon, USA, and Concepción, Chile

John A. **Barth**[1], Oscar Pizarro[2], Kate Adams[1] and Nadin Ramirez[2]

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Continental shelves on the eastern sides of ocean basins are highly productive due to wind-driven coastal upwelling, but near-bottom shelf waters in these regions can experience low oxygen (hypoxia). Hypoxia can arise because the upwelled deep source waters are low in oxygen due to their isolation from the atmosphere and to respiration along the path from their formation regions at high latitudes. After upwelling onto the shelf, additional respiration occurs in the presence of the increased organic matter flux that results from high primary production. Physical processes such as advection, flushing and mixing can increase oxygen levels. The areal extent, severity and duration of shelf hypoxia have profound effects on shelf biogeochemical processes. To understand the processes leading to shelf hypoxia, we contrast two eastern boundary current upwelling shelves: central Oregon, where near-bottom shelf hypoxia is increasing in severity in recent years; and central Chile, where much of the shelf water column is hypoxic or even anoxic (zero oxygen). We use physical (temperature, salinity, pressure, velocity), biological (chlorophyll fluorescence) and chemical sensors (dissolved oxygen) from moorings located mid-shelf (~70-90m) off both central Oregon and central Chile. The cross-shelf structure of the upwelling region is sampled using underwater gliders capable of sampling the entire water column to a maximum of 1000m. Both regions have transitions from wintertime, well-oxygenated conditions to the summertime upwelling that is accompanied by lower near-bottom oxygen levels. The severity of low oxygen conditions in the two regions is influenced by oxygen levels in the upwelled source waters and modulated by shelf processes.

October 17, 09:50 (S4-9173)

Why the Strait of Georgia is not a dead zone

Sophia **Johannessen**, Diane Masson and Robie Macdonald

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Google Maps has awarded the Strait of Georgia, off the west coast of Canada, a dead fish icon (for eutrophic or hypoxic areas or Dead Zones). While it is true that the concentration of oxygen in the deep Strait of Georgia has declined (-0.45 to -1.3 mM yr^{-1} since 1971), the decline has resulted principally from the increasing hypoxia of upwelled Pacific Ocean water. Anthropogenic loadings have little potential to reduce bottom water oxygen. Hypoxic, upwelled water mixes vigorously with surface water in the tidal passages of Haro Strait before entering the deep Strait of Georgia during a series of deep-water renewal events in late spring and late summer. Remineralization and diffusive mixing reduce the bottom water oxygen concentration to a winter minimum of 90-110 mM. However, water mass modeling shows that the mixing with surface water in Haro Strait limits the potential of the shelf water to reduce the oxygen concentration in the deep Strait of Georgia: even should the shelf water become completely anoxic, the concentration of oxygen in bottom waters would level off just above 90 mM after three years. Increasing surface water temperature will reduce the solubility of oxygen, but this effect is projected to cause a further decline of only 2.2 mM over the next 25 years. Despite its restricted circulation, the deep Strait of Georgia is less threatened by hypoxia than are many other coastal areas, because of the combination of light-limited primary production and intense tidal mixing in the approaches.

October 17, 10:10 (S4-9147) - CANCELLED

Increasing nutrients, changing algal biomass, Noctiluca blooms and a declining benthic foodweb. Is eutrophication fueling the microbial food web and reducing the benthic-pelagic coupling in Puget Sound?

Christopher **Krembs**, Maggie Dutch, Julia Bos, Skip Albertson, Brandon Sackmann, Mya Keyzers, Laura Friedenberg and Carol Maloy

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In Puget Sound, nutrient concentrations have significantly increased, and nutrient ratios have steadily changed over the last 14 years. The cause and impacts of these trends are discussed in the context of human pressures, climatic and oceanic boundary conditions, and planktonic food web structure. Puget Sound, because of its proximity to the cold, nutrient-rich Pacific Ocean, is thought of as a diatom-dominated marine food web supporting higher trophic levels via a productive, short food chain. Phytoplankton species respond to nutrient availability, nutrient composition, and the physical character of the water column. Through our long-term monitoring program and aerial surveys, we frequently document extensive algal blooms, Noctiluca blooms, and jellyfish masses at the surface. Many of the phytoplankton blooms show high abundances of autotrophic flagellates. Depth-integrated algal biomass, on the other hand, shows a significant, steady decline from 1999 to 2012. These seemingly opposing observations - high algal biomass at the surface and decreasing integrated phytoplankton biomass below the surface - could be more clues to a shifting foodweb structure and a weakening benthic-pelagic coupling that could explain the decline in deeper-water benthic communities in Puget Sound.

October 17, 10:10 (S4-8906)

Variability in lower trophic levels on the Alaskan Shelf

Sonia **Batten**[1], Abigail McQuatters-Gollop[2] and Dionysios Raitsos Exarchopoulos[3]

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The Continuous Plankton Recorder has been deployed in the oceanic and shelf regions of the northern Gulf of Alaska since 2000. Although principally a zooplankton sampler, the CPR also retains larger hard-shelled diatoms and dinoflagellates, and a basic index of phytoplankton biomass is available through the Phytoplankton Colour Index (PCI). The seasonal and interannual variability of phytoplankton and zooplankton are investigated and presented here. Interannual variability has been considerable in recent years, with strong negative anomalies in 2011, which extended into the open ocean in the northern Gulf of Alaska. Large diatom abundance was greater in warm years, and there is some evidence from the time series that the seasonal timing of the spring diatom peak is related to spring stratification. Community composition analyses show a trend through time, and warmer years have a different composition. The base of the marine food chain in this region thus shows a strong response to climatic and regional drivers with likely implications for higher trophic levels.

October 17, 10:50 (S4-9162)

Species diversity in zooplankton responses to hypoxia and elevated pCO_2

Julie E. **Keister**, Anna McLaskey, Lisa Raatikainen, Amanda Winans and Bethellee Herrmann

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The effects of stressors such as hypoxia and ocean acidification on zooplankton are of increasing concern, especially as serious consequences have been demonstrated for many species. But how changes to zooplankton will affect ecosystems as a whole remains largely unknown. We are studying relationships between ocean chemistry and zooplankton in Puget Sound, Washington—a deep fjord in the Pacific Northwest that supports a diverse zooplankton community. In Puget Sound, hypoxia (<2 mg DO l^{-1}) and extremely low pH (<7.5) occur naturally as a result of inputs of upwelled ocean water, high surface production, and restricted circulation; anthropogenic

eutrophication and global climate change are increasing the severity of these conditions. In summer and late autumn, when the lowest oxygen and *p*H occur, conditions are particularly stressful for many organisms, yet abundant zooplankton and fish inhabit the region. How zooplankton behavior, species composition, growth, and energy flow to upper trophic levels are altered by the changing conditions is a focus of our research. Here we will examine zooplankton response to low oxygen and pH from field sampling and laboratory studies. The high variability that we have observed among species indicates that measuring and interpreting the effects on ecosystems will be challenging. Better understanding of species-level impacts will be necessary to understand how the stressors affect marine ecosystems directly and indirectly.

October 17, 11:10 (S4-9041)

Effects of ocean acidification on the physiological profile of the Japanese pearl oyster *Pinctada fucata*

Rui **Yin** and Atsushi Ishimatsu

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The present study aimed to assess the effects of a 7-week exposure to 1000 µatm pCO_2 on the Japanese pearl oyster *Pinctada fucata,* by examining the growth of soft and hard tissues, food intake, oxygen uptake and the RNA/DNA ratio of the mantle. Elevated pCO_2 completely inhibited the growth of soft tissues, with a growth rate of -0.001% day^{-1} as compared with 0.768% day^{-1} in the control oysters. In contrast, the growth of shell dry mass was unaffected (control 0.395% day^{-1}, experimental 0.576% day^{-1}). Food intake was also unaffected. Oxygen consumption was significantly lowered to 63% of the control level (control 3.38 µmol g^{-1} h^{-1}, experimental 2.14 µmol g^{-1} h^{-1}). The RNA/DNA ratio of the mantle tissue remained stable in the control oysters (ca. 3.3) whilst the ratio in the high-CO_2 oysters was significantly lower than in the control after 6 weeks. The observed inhibition of soft-tissue growth in the high-CO_2 oysters was possibly due to enhanced energy demand for shell growth (calcification) in the less favorable conditions, the inability to increase feeding, and reduced protein synthesis. The reduction in oxygen uptake indicates that the observed shell growth may not be sustained if CO_2 exposure is prolonged.

October 17, 11:30 (S4-8989)

Vulnerability of Canadian Pacific fisheries to ocean acidification

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Ocean acidification is a major consequence of rising atmospheric carbon dioxide concentrations. The potential effects of acidification on fisheries in the Northeast Pacific region remain uncertain. We provide a systematic review of ocean acidification's biological impacts on species that are relevant to Canadian Pacific fisheries. Many experiments have been conducted on marine organisms at lower trophic levels, such as phytoplankton, macroalgae, zooplankton and shellfish, but relatively few have been conducted on organisms at higher trophic levels. Findings include shell dissolution and reduced metabolic rates of shellfish, and increased growth rates for some species of phytoplankton. We discuss how changes at lower trophic levels might indirectly affect higher trophic levels. For example, acidification of surface waters may lead to higher primary production, changes in phytoplankton species composition, and increased toxin production by toxin-producing species; these effects might impact organisms at higher trophic levels. We use existing results to assess the possible consequences of projected acidification on local species, in order to provide a first synthesis of the vulnerability of commercial Canadian Pacific fisheries to acidification.

October 17, 11:50 (S4-9212)

Winter conditions in Oregon coastal waters as refugia from ocean acidification

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Temperate North American Pacific coastal waters are recognized as settings of dynamic carbon cycling, with many locations experiencing biomineral-corrosivity far in advance of projections for the open ocean. New observations of the biogeochemical structure of the water column and temporal evolution of surface and near-bottom waters have shown that the winter months provide a respite from the high CO_2 of upwelled-source waters. While there have been suggestions that winter conditions lead to exposure of surface waters to respiratory CO_2 that accumulated over the productive summer months, our observations show no surface exposure of this water, and persistently low pCO_2 and high mineral saturation states throughout the winter months. At the height of winter downwelling, shelf waters at the 120m isobath are unstratified with pCO_2 of the entire water column undersaturated with respect to atmospheric. As the season evolves, but still months before the spring transition, upwelled source water creeps as far landward as the 50m isobath, but is kept from outcropping or reaching estuarine sills by downwelling favorable winds and strong stratification driven by input of river-source fresh water. Augmented by river-nutrient supported blooms, coastal waters maintain mineral saturation at levels supporting early larval bivalve calcification for winter and spring spawning bivalve species. Evolving climate scenarios that suggest alterations in timing and duration of upwelling favorable winds and decreased riverine inputs will all lead to decreased windows of opportunity for successful cohort spawning and early larval development.

S4 POSTERS

S4-P1

New empirical equations for total alkalinity in surface waters over the Pacific Ocean from the PACIFICA database

Yusuke Takatani[1,2], Atsushi Kojima[1,2], Kazutaka Enyo[1], Yosuke Iida[1,2], Toshiya **Nakano**[1,2], Masao Ishii[2,1], Daisuke Sasano[2,1], Naohiro Kosugi[2], Takashi Midorikawa[3] and Toru Suzuki[4]

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We propose new empirical equations for total alkalinity (TA) in surface waters over the Pacific Ocean that were derived from the PACIFICA (PACIFic ocean Interior CArbon) database. A unique feature of the new equations is that sea surface dynamic height (SSDH) has been used as one of the explanatory variables. The variability in SSDH derived from satellite altimeter observations is known to be useful in describing seasonal and interannual variations in wind-driven circulation and eddies. We have found that salinity-normalized TA (NTA) is generally well-correlated with deseasonalized SSDH produced by the Japan Meteorological Agency. On the basis of the relationship between deseasonalized SSDH and NTA at S=35, we divided the Pacific Ocean into five domains. We derived the empirical equations of NTA for each of the five domains, using the variables SSDH and salinity. The error (root mean square error: RMSE) of the new equations as estimated from the difference between observed NTA values and those calculated from the equations is 7.8 μmol/kg over the Pacific Ocean. This value is smaller than that of the equations proposed by Lee *et al.* (2006) (8.5 μmol/kg). The RMSE of the new equations (7.8 μmol/kg) is much smaller than that of Lee *et al.* (2006) (13.7 μmol/kg) in the North Pacific subarctic – subtropical transition region, including the Kuroshio Extension region, where NTA shows large spatio-temporal variability due to the path states of the Kuroshio Extension and to the north-south shift of the frontal position.

S4-P2

Basin-to-basin comparison of radiocarbon in the East/Japan Sea

Boram **Sim**[1], Dong-Jin Kang[1], Cho-Rong Moon[1], Young Gyu Park[1] and Kyung-Ryul Kim[2]

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Radiocarbon is a powerful tool for studies of carbon cycling as well as of physical phenomena in the ocean. The development of accelerator mass spectrometry measurement technology has enabled researchers to measure radiocarbon easily in small samples. The East/Japan Sea (hereafter EJS), regarded as a 'Miniature Ocean,' has three deep basins (Japan, Yamato, and Ulleung Basins). Several studies of radiocarbon have been carried out in the EJS. However, these data did not cover all the basins in the EJS. Vertical profiles of radiocarbon from the surface all the way to the bottom at five stations covering all three basins were obtained from the samples collected during the CREAMS (Circulation Research of the East Asian Marginal Seas) cruises in 1999. Radiocarbon was measured by AMS in the graphite converted from the carbon dioxide extracted from the dissolved inorganic carbon in the seawater samples.

In the surface and bottom layers, $\Delta^{14}C$ values did not show significant differences among basins. In the intermediate layer (200-2000m), however, the maximum $\Delta^{14}C$ value was in the Eastern Japan Basin, while the minimum was in the Yamato Basin. The spatial comparison of radiocarbon in the EJS and the comparison with historical data will be further discussed at the meeting.

S4-P3

PACIFICA carbon data 2nd-level quality control

Masao **Ishii**[1], Toru Suzuki[2], Daisuke Sasano[1,3], Naohiro Kosugi[1], Yusuke Takatani[3], Masahide Wakita[4], Akihiko Murata[5], Lisa Miller[6] and Robert M. Key[7]

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PACIFICA (PACIFic ocean Interior CArbon) was an international collaborative project supported by the PICES Section on Carbon and Climate, for the synthesis of data on ocean interior carbon and its related parameters in the Pacific Ocean. It was started in October 2006, and the products were released publicly in May 2013 (http://pacifica.pices.jp/ and http://cdiac.ornl.gov/oceans/PACIFICA/.) To make the data products of PACIFCA, original data were adjusted to account for analytical offsets in dissolved inorganic carbon, total alkalinity, salinity, oxygen, and nutrients (nitrate and nitrite, phosphate, and silicic acid) for each cruise, during the 2nd-level quality control procedure, based on crossover analysis using data from deep layers (Tanhua *et al.*, 2010). PACIFICA includes datasets from a total of 306 cruises. These include 37 WOCE Hydrographic Program cruises in 1990s, 16 Repeat Hydrography/CO_2 cruises after 2000, 59 Line-P cruises since the mid-1980s, and 194 other cruises. Among these, 255 cruises include dissolved inorganic carbon data; analytical offsets were evaluated for 177 cruises; and the offsets were adjusted for 44 cruises. In addition total alkalinity data are included from 127 cruises. Analytical offsets were evaluated for 107 cruises, and the offsets were adjusted for 18 cruises. The 2nd-level QC for some cruises, *e.g.*, for the Line-P time series, were conducted separately. Some details of the 2nd-level QC of the dissolved inorganic carbon and total alkalinity data are presented for cruises other than the Line-P time series.

S4-P4

fCO_2 characteristics in the surface of marginal seas around Korea (East/Japan Sea and East China Sea)

Jae-Yeon Kim[1], Dong-Jin **Kang**[2], Tonsup Lee[1], Kyung-Ryul Kim[3], JeongHee Shim[4] and Hee-Dong Jeong[4]

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The fugacity of carbon dioxide, fCO_2, in surface seawater is a primary parameter in research on the carbon cycle at the air-sea interface. The distribution of fCO_2 is controlled by hydrological, physical and biological processes, and has a large spatial and seasonal variability. The East/Japan Sea (EJS) demonstrates an oceanic response of carbon chemistry to climate change, despite being a marginal sea, because of its oceanic characteristics. In addition, the East China Sea (ECS) is regarded as an important continental shelf pump area. This study shows the spatio-temporal distribution of fCO_2 and its controlling factors, based on underway measurements from the southwestern EJS and the northern ECS area around Korea. The surface seawater fCO_2 values in the EJS are relatively high in summer owing to elevated sea surface temperature (SST), and in winter, due to vertical entrainment of CO_2-rich subsurface water, despite the decreasing SST. Meanwhile, low fCO_2 values occur in spring and fall, due to biological effects. The fCO_2 distribution in the EJS is primarily controlled by SST, but shows temporal and seasonal variability due to biological uptake and vertical mixing. On the other hand, in the ECS, higher fCO_2 values occur in winter and summer than in spring and fall. Our study reveals that fCO_2in the ECS is mainly controlled by sea surface salinity and by the mixing ratio of source waters.

S5 BIO/FIS Topic Session
Marine ecosystem services and the contribution from marine ecosystems to the economy and human well-being

Co-sponsored by IMBER

Co-Convenors: Shang Chen (China), Keith Criddle (USA), Ekaterina Golovashchenko (Russia), Mitsutaku Makino (Japan), Jungho Nam (Korea), Minling Pan (USA) and Ian Perry (Canada)

Invited Speakers:
Leif Anderson (NOAA Fisheries, Northwest Fisheries Science Center, USA)
Kai Chan (University of British Columbia, Canada)
Shang Chen (First Institute of Oceanography, SOA, PR China)
Dan Lew (NOAA Fisheries, Alaska Fisheries Science Center, USA)

Marine ecosystem services are the benefits people obtain from the sea and ocean. Since the UN Millennium Ecosystem Assessment reports were published in 2005, the concept of ecosystem services has been broadly accepted by politicians, scientists, developers and the public. When politicians make policy decisions, they should know the value of the marine ecosystem services involved, and how much economic development and human well-being the marine ecosystem may support. As scientists, we have the responsibility to give the answers or the best estimates to these questions. The goals of this session are to provide scientists with a platform to exchange results from research on marine ecosystem services and to show how they contribute to the economy and human well-being. In turn, these research activities will be a demonstration of the contributions and significance of the work being done on this topic within PICES communities, including marine-related research institutes, universities, and management agencies, to marine science and national economies.

Tuesday, October 15 (09:00-15:30)

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

09:05 **Kai M.A. Chan, Anne Guerry, Patricia Balvanera, Sarah Klain, Terre Satterfield, *et al.* (Invited)**
Not impossible: Integrating ecological considerations and cultural values into decision-making (S5-9110)

09:35 **Shang Chen and Tao Xia (Invited)**
Marine ecological capital assessment: Methods and application in China seas (S5-8872)

10:05 **Linda D'Anna, Grant Murray and Sarah Dudas**
Social value of marine ecosystem services: Insights from multi-dimensional subjective well-being (S5-8960)

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

10:45 **Ling Huang, Subhash Ray, Kathleen Segerson and John Walden**
Evaluating the impact of sector management on the productivity of New England groundfish fisheries (S5-9077)

11:15 **Michio J. Kishi, Kenta Awa, Takeshi Miwa, Seokjin Yoon and Toru Nagasawa**
Ecosystem approach for management of artificial release of chum salmon from Japan coupled with NEMURO and NEMURO.FISH (S5-8962)

11:45 **Xianshi Jin, Xiu-Juan Shan, Jun Wang, Yunzhong Wang, Zhenliang Zhao, Shengrao Qiu and Jing Dong**
Fisheries and stock enhancement in the Bohai Sea, China (S5-8924)

12:05 ***Lunch***

13:30 **Kai M.A. Chan, Russell Markel, Rebecca G. Martone, Jessica Clasen, Jordan Levine, Brock Ramshaw, Gerald G. Singh, *et al.***
Sea otters, kelp forests, and coastal communities: Ecosystem services amongst trophic cascades (S5-9111)

13:50 **Ekaterina V. Golovashchenko and Andrey I. Solomin**
Bioeconomic modelling of the marine resource — Towards stable exploitation in the western Bering Sea marine ecosystem (S5-8949)

14:10 (*cancelled*) **John C. Field, Rebecca R. Miller, Jarrod A. Santora, Rosemary Kosaka and Cindy Thomson**
A spatially explicit account of California fisheries as ecosystem services (S5-8877)

14:30 **Michael C. Melnychuk, Jeannette A. Banobi and Ray Hilborn**
Overfishing and underfishing consequences for food security and economic value in U.S. fisheries (S5-9168)

14:50 **Patricia MacDonald, Michele Patterson and Grant Murray**
Capturing social values in the seafood sector: New tools for new times (S5-8957)

15:10 *Comments and Discussion*

15:30 *Session Ends*

CANCELLATIONS

10:45 (cancelled) **Leif E. Anderson and S. Todd Lee (Invited)**
Using discrete choice experiments to examine recreational use values in the Pacific Northwest region of the USA (S5-8991)

11:15 (cancelled) **Daniel K. Lew (Invited)**
Valuing marine resources in the U.S.: Applications of non-market valuation methods (S5-8933)

11:45 (cancelled) **Minling Pan**
Measuring the trade-off between conflicting demands on marine ecosystem services — A case study of Hawaii longline fisheries in the North Pacific Ocean (S5-9183)

16:30 (cancelled) **R. Jayaraman and Piyashi DebRoy**
Economic valuation of mangroves in Tamilnadu (INDIA) for their conservation and management (S5-9008)

S5 POSTERS

S5-P1 (*cancelled*) **Piyashi DebRoy, R. Jayaraman, M. Krishnan and Keith R. Criddle**
Willingness to pay for the ecological functions of mangrove ecosystem – A case study of Pichavaram mangroves in India

S5-P2 **Tatiana N. Semenova**
Ecotourism — An effective means of contributing to the economy and human well-being

S5-P3 **Ryotaro Okazaki and Yasunori Sakurai**
Influence of SST and PDO on the catches of walleye pollock, pink salmon and Japanese common squids in Rausu, Shiretoko World Natural Heritage, Japan

S5 Oral presentations

October 15, 09:05 (S5-9110)

Not impossible: Integrating ecological considerations and cultural values into decision-making

Kai M.A. **Chan**, Anne Guerry, Patricia Balvanera, Sarah Klain, Terre Satterfield, *et al.*

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Focusing on ecosystem services (ES) is seen as a means of improving decision-making. Research to-date has emphasized valuation of material contributions of ecosystems to human well-being (through *e.g.*, clean water, agricultural crops, reduced flood risk). Much less attention has been paid to characterizing how important 'cultural'/non-material values such as cultural heritage and identity, and artistic and spiritual inspiration, might be affected by ecological change. This gap persists because it is difficult to identify, quantify, and integrate non-material values in decision-making. This talk will focus on a framework for ES research that will meet three challenges identified by an international working group of scientists and practitioners: (i) non-material values are ill-suited to characterization in monetary terms; (ii) changes in non-material benefits are not easily attributed to ecological change; and (iii) non-material benefits are simultaneously produced by many ES, which complicates the separate valuation and summation of ES benefits. There is no magic bullet, but our framework—recently published in *BioScience*—may facilitate fuller and more socially acceptable integrations of ES information into planning and management.

October 15, 09:35 (S5-8872)

Marine ecological capital assessment: Methods and application in China seas

Shang **Chen** and Tao Xia

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The concept of marine ecological capital (MEC) is predicated on theoretical concepts related to natural capital and ecosystem services. MEC consists of those marine ecological resources which provide benefits for mankind. It includes living marine organisms and their habitat and the whole marine ecosystem. The value of MEC includes not only the value of standing stock of marine ecological resources but also the value of marine ecosystem services. Marine ecosystem services are the benefits human beings derive from marine ecosystems. The four types of services are: provisioning, regulating, cultural and supporting services. In 2012, State Oceanic Administration of China published the national standard "Technical Directives for Marine Ecological Capital Assessment" to guide the assessment of marine ecological resources, ecosystem services and ecological compensation fee at national, province and city levels.

The assessed coastal waters cover $19.31*10^4$ km^2 in China Seas. These waters provided 1,034.18 billion CNY of ecosystem services in 2008 and supported 1,740 billion CNY of marine industrial output. The average square km of coastal waters provided 5.57 million CNY of ecosystem services per year. In 2008, Bohai Sea's coastal waters provided 215.24 billion CNY of ecosystem services, Yellow Sea's coastal waters provided 328.86 billion CNY, East China Sea's coastal waters provided 191.48 billion CNY, while South China Sea's coastal waters provided 298.60 billion CNY.

The service value of China coastal ecosystem shows the following spatial patterns: (1) from onshore to offshore, service value decreases gradually; (2) the highest value regions are those that are used for mariculte and recreation.

The 11 provincial coastal waters are classified into 3 kinds of ecosystem service utilization models. Liaoning, Shandong, Guanxi and Hainan belong to the provisioning-service-dominated utilization model; Heibei and Tianjin belong to the cultural-service-dominated utilization model while Jiangsu, Shanghai, Zhejiang, Fujian and Guangdong belong to the balance utilization model.

October 15, 10:05 (S5-8960)

Social value of marine ecosystem services: Insights from multi-dimensional subjective well-being

Linda **D'Anna**[1], Grant Murray[1] and Sarah Dudas[2]

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The well-being concept offers a critical lens for describing and valuing marine ecosystem services, especially the non-material and non-economic benefits the oceans provide. Positive and negative impacts on cultural, social, spiritual, and psychological ecosystem services can have demonstrable effects on well-being. The subjective dimension of well-being contributes importantly to how individuals and groups evaluate ecosystem services in context, perceive impacts on those services, and assess alternative social-ecological system states. These evaluations have implications for marine policy, decision-making, and management. We will share empirical results from our work examining the effects of shellfish aquaculture on ecosystem services and community well-being in coastal communities in British Columbia. From our findings we have distilled broad categories of impacts to services that have both positive contributions to and negative effects on well-being including pride, alienation, and experience. Our work also demonstrates a critical limitation of depicting well-being through ecosystem services provisioning. While ecosystem services make important contributions to well-being, communities derive well-being from additional sources as well.

October 15, 10:45 (S5-8991)

Using discrete choice experiments to examine recreational use values in the Pacific Northwest region of the USA

Leif E. **Anderson** and S. Todd Lee

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We use a discrete choice experiment to measure the preferences of recreational saltwater fishermen in Oregon and Washington, USA. Anglers provided answers to survey questions that allow us to model trip choices as a function of attributes that include species, size, and bag limits. We use these data to estimate recreational demand models that provide the economic value of changes in measures such as catch rates, bag limits, or size distributions. Since the economic values we calculate are conditional on current levels of bag limits and catch rates, we use auxiliary creel data in order to construct a baseline for model simulations. In order to illustrate the approach, we select a few examples important to recreational fisheries management in the region: measures designed to conserve rockfish species in Puget Sound and the differences in use values for wild and hatchery salmon.

October 15, 11:15 (S5-8933)

Valuing marine resources in the U.S.: Applications of non-market valuation methods

Daniel K. **Lew**

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An understanding of the economic benefits of fishery and aquatic ecosystem goods and services, particularly "non-market" goods and services like recreationally-harvested fish, habitat functions, and species protection, is expected to become increasingly important as marine resource managers in the U.S. and worldwide move towards ecosystem-based management (EBM), a system-level approach that integrates ecological, economic, and social goals in planning and evaluation. In the United States, the approach is becoming an increasingly important and visible element in the National Ocean Policy. Implicit in EBM is the need to evaluate the inherent tradeoffs of a system-level approach that considers diverse societal objectives, including economic efficiency considerations for which non-market values are a critical part in marine ecosystems.

In this paper, I discuss the two approaches for measuring economic benefits associated with non-market goods and services in marine ecosystem contexts--revealed preference (RP) methods and stated preference (SP) methods. RP methods use information from observed behavior to infer preferences and values, and SP methods use responses to carefully-constructed questions asked of individuals or households to understand non-market values. I present several empirical examples from recent marine resource-focused applications. The strengths and weaknesses of the techniques as applied to the valuation of marine resources are discussed, and particular emphasis is given to the policy applications in which the values can be applied, and the situations in which they are inappropriate. Moreover, several challenges, both methodological and empirical, are discussed in the context of using these approaches to inform policy.

October 15, 11:45 (S5-9183)

Measuring the trade-off between conflicting demands on marine ecosystem services — A case study of Hawaii longline fisheries in the North Pacific Ocean

Minling **Pan**

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Marine ecosystems provide a complex stream of goods and services that benefit mankind. The benefits of these goods and services display themselves at local, regional, and global scales with often conflicting demands among stake holders within the same scale or across all levels. This study first illustrates such conflicting demands among stake holders at the same level and across levels in the North Pacific pelagic ecosystem by showing Hawaii longline fisheries management as an example. Second, this study presents a tool for assessing the conflicting demands between two types of services, specifically by measuring the trade-off between sea turtle conservation and sustainable marine fish production.

October 15, 13:30 (S5-9111)

Sea otters, kelp forests, and coastal communities: Ecosystem services amongst trophic cascades

Kai M.A. **Chan**, Russell Markel, Rebecca G. Martone, Jessica Clasen, Jordan Levine, Brock Ramshaw, Gerald G. Singh, *et al.*

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As sea otters return to the West Coast of Canada, they make human enemies by eating hordes of shellfish, which are mainstays of coastal communities. But otters also boost tourism and trigger ‘trophic cascades’ when the decimation of shellfish enables the recovery of shellfish ‘prey’-productive, habitat-forming kelp forests-and many other species dependent on kelp. To inform planning and management associated with near-shore ecosystems, colleagues and I seek to characterize a fuller suite of benefits and costs through ecosystem services. Towards this, we are (i) assessing the many ecological changes associated with otters and kelp forests, including ‘nutrient subsidies’ from kelp forests to adjacent and distant ecosystems and boosts to tourism; (ii) representing these changes in a spatial model that depicts the effects of various human interventions on ecosystems. We seek to enhance management and policymaking by better accounting for both direct and indirect effects of sea otters and kelp, and for a fuller set of values affected.

October 15, 13:50 (S5-8949)

Bioeconomic modelling of the marine resource — Towards stable exploitation in the western Bering Sea marine ecosystem

Ekaterina V. **Golovashchenko** and Andrey I. Solomin

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Providing an economic value overview of western Bering Sea marine productivity potential we continue our assessments in the ecosystem services evaluation area, started with estimations for Peter the Great bay, Eastern and Western Sakhalin waters. We are also developing integration of bioeconomic models into management. Bioeconomic analyses are used for predicting how the marine resources will respond to fish harvests and management actions. We also use bioeconomic models to analyze fully exploited resources such as blue king crab, seeking to identify optimally stable exploitation and economically effective harvest management strategies under alternative types of harvesting. According to different strategies of harvesting for the selected object, we show the different potential value of western Bering Sea marine productivity.

October 15, 14:10 (S5-8877)

A spatially explicit account of California fisheries as ecosystem services

John C. **Field**,[1] Rebecca R. Miller,[1] Jarrod A. Santora[2], Rosemary Kosaka[1] and Cindy Thomson[1]

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We evaluated spatiotemporal patterns of fisheries catches, including both volume and ex-vessel value, for a unique set of spatially referenced, long-term commercial catch data that were recently recovered for nearly all California (United States) marine fisheries. This dataset includes landings estimates at a 10 by 10 minute spatial resolution from 1928 to 2010 and extends the entire length of coastal California (up to approximately 180 kilometers from shore). We filtered the data to minimize implausible catches (based primarily on bathymetric criteria) and mapped climatologies of volume and the value (standardized to 2010 dollars) of catches by broad taxonomic categories (*e.g.*, groundfish, coastal pelagics, crustaceans, salmonids and highly migratory species). We quantified areas of high volume and high value fisheries catches both historically and contemporarily, as well as the sequential geographical patterns of fisheries development. Our results indicate that while the history of some fisheries (such as groundfish) reflected a development pattern in which catches occurred in deeper habitat, at a greater distance from ports, and in increasingly inclement weather conditions over time. However, this pattern does not hold for other California fisheries, given the nature of the interactions between fishermen and fisheries targets in this ecosystem over nearly a century. We expect that these results will contribute to efforts related to marine spatial planning, habitat impact assessments, quantification of ecosystem services, and ultimately to ecosystem-based approaches to management of marine fisheries and other resources.

October 15, 14:30 (S5-9168)

Overfishing and underfishing consequences for food security and economic value in U.S. fisheries

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Sustainable fishing can help meet growing food demands. Food security is threatened by overfishing in some cases, but by underfishing in others. Overfishing and underfishing both result in less long-term catch than if populations were fished at exploitation rates that generate maximum sustainable yield (FMSY). In the US, strong measures to ensure that exploitation rates (F) do not exceed FMSY have reduced the number of stocks experiencing overfishing but have also reduced exploitation rates of some other co-caught stocks. We used F/FMSY estimates for US stocks to estimate the loss of long-term potential catch and landed value due to overfishing or underfishing. If assessed US stocks were fished at FMSY, over 7 million t and $4.7 billion could be realized; currently 51% of this

potential yield and 49% of this potential value is foregone. Foregone amounts are mostly attributed to underfishing (49% yield, 38% value) rather than overfishing (2% yield, 11% value). Primary reasons for underfishing losses include ecosystem catch limits in the East Bering Sea and poor market conditions, whereas overfishing losses are incurred primarily by the slow recovery of some rebuilding stocks. Accounting for regional effects, the degree of underfishing was least (*i.e.* F/FMSY was greatest) for stocks that were targeted rather than caught incidentally, were under rebuilding programs, and had greater market demand. In contrast, the degree of overfishing was associated only, and positively, with ex-vessel price. Guards against overfishing are important, but analysis of trade-offs should also involve consequences of underfishing on food security.

October 15, 14:50 (S5-8957)

Capturing social values in the seafood sector: New tools for new times

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Social values are integral to human well-being. The benefit that individuals derive from all ecosystem services depends on how they assess the services based on their underlying system of values. The social values of a person's community and other reference groups provide the context for their assessment of their situation. An individual's held values are their criteria for desirable outcomes and the way in which people order their held values creates the foundation for their beliefs, interests, and attitudes. We used the Q Method to identify both shared and divergent values in a pilot study of seafood sector participants in a single coastal community on Vancouver Island. Drawing on the non-market/non-economic values literature, initial in-depth interviews, and secondary sources we developed a data gathering tool and protocol, which was administered to more than 30 individuals. Using a mix of statistical and qualitative analysis we identified groups of individuals that shared similar values, as well as values on which they diverged. We expect that a deeper understanding of how people assign value to the ocean and their community will provide the basis for developing appropriate indicators and contribute to a richer understanding of how humans derive benefit from ecosystem services. This may ultimately lead to better decisions related to both the eco-system and the social systems.

October 15, 15:30 (S5-9077)

Evaluating the impact of sector management on the productivity of New England groundfish fisheries

Ling **Huang**[1], Subhash Ray[1], Kathleen Segerson[1] and John Walden[2]

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A key goal of most fishery policies is to prevent fish stocks from declining and improve the economic performance of the fishery. One notable new example is the sector management in the New England groundfish fishery. On May 1, 2010, the New England groundfish fishery transited from a limited access program to a new management regime. Under this new regime, fish species are managed by voluntarily formed sectors allocated with Annual Catch Entitlements based on their catch history. Sectors are free from control of days at sea, area closures or trip limits, but need to implement hard limits on total allowable catch.

In this paper, we seek to contribute to the literature on the impact of fisheries management policies on the economic performance of fisheries by examining empirically the productivity change in the New England Ground Fishery due to the introduction of sector management. Productivity change is a very important indicator of economic performance and therefore needs to be carefully examined to understand management regimes. The implementation of this new management regime could significantly increase cost efficiency by reducing fishing effort per amount of fish. To understand the effect of sector management on productivity more completely, we propose to examine productivity impacts using multiple methodologies that account for the role of these other factors. These methods are 1) DEA (data envelope analysis) estimation of the multi-product production frontier, 2) Econometric estimation of a stochastic production frontier, and 3) Econometric estimation of a multi-product revenue function.

October 15, 15:50 (S5-8962)

Ecosystem approach for management of artificial release of chum salmon from Japan coupled with NEMURO and NEMURO.FISH

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An 'Ecosystem approach' was used to determine the optimal number of Hokkaido chum salmon to release. The constraining condition is the carrying capacity of North Pacific Ocean, which is calculated by a two-way version of NEMURO wherein prey density for chum salmon is calculated by physical- ecological coupled model NEMURO, and ZP (predatory zooplankton) are preyed by salmon and are decreased by grazing. In addition, salmon growth is treated as a function of prey density and water temperature. The objective function seeks to maximize total income to fishermen subject to decisions about the number of fish released from Japan? The unit price of chum salmon, which is used to calculate revenues, is determined by empirical data as a function of return ratio, which is a function of water temperature, and individual weight, which is calculated using the NEMURO.FISH bio-energetic model. We modeled the competition of chum and pink salmon for prey in Gulf of Alaska. NEMURO, which is a coupled model of ocean physics and lower trophic dynamics in the North Pacific, was used to calculate prey density and to predict wet weight of salmon. We calculated the suitable release number under present conditions and under conditions as they are expected to evolve due to global warming. Results indicate that present release numbers are optimal under current conditions.

October 15, 16:10 (S5-8924)

Fisheries and stock enhancement in the Bohai Sea, China

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The biomass of many commercial fish species greatly declined in the Chinese coastal waters, and high-valued, large-sized species were replaced by low-valued, small-sized species. Restocking of depleted fishery stocks becomes urgent. Besides control of fishing effort and habitat protection, aquaculture-based enhancement is also an important means of rebuilding depleted stocks. Here we review the progress of stock enhancement in China, and then focus on high value species Chinese fleshy prawn *Fenneropenaeuschinensis* enhancement in the Bohai Sea. Its catch decreased from more than 40,000 tons in 1979 to several hundred tons before the large-scale enhancement. In recent years, its production and wild resource had recovered to some extent due to stock enhancement, and its production reached to 2,377 tons in 2009, with a production value of about 315 million Yuan. The enhancement of blue crab *Portunustrituberculatus* and jellyfish *Rhopilemaesculentum* in the Bohai Sea has also shown encouraging results. The current successful practices indicate that stock enhancement is an effective management approach to enhance or restore depleted fishery resources. However, for large scale restocking of depleted species, improved stocking strategies should be fully considered, a responsible and scientific approach is needed to evaluate stock enhancement potential, and ecosystem based stock enhancement should be encouraged.

October 15, 16:30 (S5-9008)

Economic valuation of mangroves in Tamilnadu (INDIA) for their conservation and management

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In India, mangroves occur in an area of 4,639 sq.km (FSI, 2009), which is 0.14% of the country's total geographic area, 8% of the Indian coastline and more than 7% of the world's mangroves, The Pichavaram mangroves (39 sq.km) underwent the devastating effects of the December 2004 Tsunami. We carried out economic valuation of the Pichavaram mangroves in Tamilnadu state (India). The study was funded by the Indian Council of Social Science Research (ICSSR). The data were collected from 449 fisher households from 9 coastal villages surrounding the mangroves during 2010-11. The total economic value of the goods and services generated from the Pichavaram mangroves has been calculated to be Rs. 4321.5 million, and the valuation per ha has been found out to be Rs. 3.20 million (the total area of the Pichavaram mangroves being 1,350 ha). It means that the Pichavaram mangroves are economic assets producing economic goods worth Rs. 4321.5 million, and further this estimate is an under-estimate as only the existing mangrove area alone has been considered here, excluding the potential mangrove area. The spin-off benefits received by agricultural farmers and other villages are not considered. This estimate lends credence and support for adequate investment in the conservation and sustainable management of the Pichavaram mangroves.

S5 POSTERS

S5-P1

Willingness to pay for the ecological functions of mangrove ecosystem – A case study of Pichavaram mangroves in India

Piyashi **DebRoy**[1], R. Jayaraman[2], M. Krishnan[1] and Keith R. Criddle[3]

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Pichavaram mangroves located on the South-East coast of India have been highlighted in marine ecosystem conservation after the event of the devastating Indian Ocean Tsunami in December 2004.The significant role played by Pichavaram mangroves in protecting certain areas from the effects of the Tsunami was witnessed along the mangrove patches. The research aims at estimating the Willingness To Pay (WTP) for the existence of Pichavaram mangroves on account of its ecological services, particularly acting as a bio-shield against tsunami, in a fishing village named MGR Thittu in the vicinity of the mangroves. The residents of MGR Thittu were the respondents in the WTP survey, employed as a tool of economic valuation of mangroves. 73% of the respondents were willing to pay for the conservation of the mangroves. 69.97% of the respondents reported their WTP upto Rs. 500 per year (1 US $ equivalent to Rs. 45 in the year 2010, when the research study was carried out). The average WTP for the respondents was Rs. 564.46 per year, and the estimated WTP of the Pichavaram mangroves for the whole population of the village was Rs. 1,41,335.14 per year. It was further observed that more female respondents than the males were willing to pay for the Pichavaram mangroves. The research also provides evidence that the local respondents value mangrove ecosystem in a considerable way for protecting them from natural hazards, and this value would increase with the increase in the level of their awareness and education.

S5-P2

Ecotourism — An effective means of contributing to the economy and human well-being

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Seaside communities depend on marine ecosystems to varying degrees. Whenever communities shift attitudes to halt abuses of the ecosystem and to become more responsible, the term "ecotourism" appears. Ecotourism is a rather new (emerging in second half of 20th century) form of tourism that involves visiting relatively undisturbed natural areas and engaging in low-impact activities. Responsible ecotourism includes programs that minimize the negative aspects of conventional tourism on the ecosystem and enhance the cultural integrity of local people. Experts estimate that in 1994 there were approximately 211-310 million nature tourists and 106-211 million of wildlife-related tourists internationally. Spending by these tourists was estimated at more than 166-255 US$ and 83-166 billion US$, respectively (The International Ecotourism society, 2000). Ecotourism promotes simultaneous raising of the level of economic activity and stabilization of the economy of the region at the lowest cost. Calculating the economic impact, we should take into account not only the direct income, but also an opportunity to avoid or significantly reduce the ecosystem degradation and social instability caused by the traditional nature management (Nesterov, 2002). Social and ecological relations in the natural areas, where ecotourism is developing, intertwine closely, to make ecosystems, and social and economic systems of these areas more sustainable. In addition, ecotourism provides local people with employment and healthier environment which results in the noticeable improvement in their well-being.

S5-P3

Influence of SST and PDO on the catches of walleye pollock, pink salmon and Japanese common squids in Rausu, Shiretoko World Natural Heritage, Japan

Ryotaro **Okazaki** and Yasunori Sakurai

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Fisheries are major industry in Rausu, Shiretoko World Natural Heritage where they provide 40 percent of all employment. Walleye pollock (*Theragra chalcogramma*), pink salmon (*Oncorhynchus keta*), and Japanese common squid (*Tadarodes pacificus*) account for 80 percent of total catch. Thus, fluctuation in catches of these species has the potential to affect the economic viability of this community. We examined effects of variations in the marine environment (local sea surface temperature and the PDO index) on the catches of these species. We found that local SST was not correlated with catches of any of these species, presumably because they are all migratory. However, as noted in many previous reports, we found that the PDO was positively correlated with the annual catch of walleye pollock and negatively correlated with catches of Japanese common squid. We did not detect significant effects of variations in the PDO index on the catch of pink salmon, presumably because of the effects of artificial hatching and stocking. We also found that the catch of walleye pollock in Rausu was positively correlated with the catch by Russian trawlers in nearby areas.

S6 BIO/POC/TCODE/MONITOR/FUTURE Topic Session Recent trends and future projections of North Pacific climate and ecosystems

Co-Convenors: Jack Barth (USA), James Christian (Canada), Enrique Curchitser (USA), Chan Joo Jang (Korea) and Angelica Peña (Canada)

Invited Speakers:
Jason Holt (National Oceanography Centre, UK)
William Merryfield (Canadian Centre for Climate Modelling and Analysis, Environment Canada)

The North Pacific Ocean experiences change on a range of timescales, and is among the most difficult regions of the world ocean in which to detect secular climate trends associated with anthropogenic forcing against the background of natural variability. Understanding impacts on ecosystems and the human communities dependent on them requires understanding of the magnitudes of climate variability and change. Sustained observations of past and present states, modeling of future states with global climate models (GCMs), and downscaling of GCM projections to the regional scale are all key components of the scientific effort to understand impacts and inform adaptation efforts. Downscaling efforts are likely to include a variety of methods, both statistical and dynamical, including high-resolution regional ocean circulation models with embedded ecosystem/biogeochemical models, statistical models relating local population statistics to climate forcing or climate indices, and multi-species models forced by temperature or oxygen anomalies from regional or global models.

Day 1, Tuesday, October 15 (09:00-17:00)

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

09:10 **Jason Holt, Icarus Allen, Yuri Artioli, Laurent Bopp, Momme Butenschon, Heather Cannaby, Ute Daewel, Bettina Fach, James Harle, Dhanya Pushpadas, Baris Salihoglu, Corinna Schrum and Sarah Wakelin (Invited)**
Physical processes mediating climate impacts in shelf sea ecosystems (S6-9091)

09:40 **Chul Min Ko, Chan Joo Jang, Chun Yong Jung and Cheol-Ho Kim**
A Regional Climate Coupled Model for the western North Pacific: Assessment of a Present Climate Simulation (S6-9054)

10:00 **Michael Foreman, Wendy Callendar, Diane Masson, John Morrison and Isaak Fain**
Regional ocean climate model projections for the British Columbia continental shelf (S6-8882)

10:20 **Ryan R. Rykaczewski, John Dunne, Charles A. Stock, William J. Sydeman, Marisol García-Reyes, Bryan A. Black and Steven J. Bograd**
Investigating the upwelling intensification hypothesis using climate-change simulations (S6-9078)

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

11:00 **William Crawford and Angelica Peña**
Decadal changes in dissolved oxygen concentration in the thermocline of the Northeast Pacific (S6-9169)

11:20 **Dmitry V. Stepanov, Victoriia I. Stepanova and Nikolay A. Diansky**
Interdecadal variability of circulation in the northern Japan/East Sea based on numerical simulations (S6-8942)

11:40 **Yuri Oh, Chan Joo Jang, Sinjae Yoo and Chul Min Ko**
Effects of nutrient transport through the Korea Strait on the seasonal and interannual variability in the East Sea (Japan Sea) ecosystem (S6-9033)

12:00 (cancelled) **Kosei Komatsu**
3D structure and decadal change of the ecosystem in the Kuroshio jet region detected from historical data (S6-9126)

12:00 ***Lunch***

14:00 **William Merryfield (Invited)**
How predictable is the North Pacific? (S6-9171)

14:30 **Youngji Joh, Chan Joo Jang, Minho Kwon, Ho-Jeong Shin and Taewook Park**
An improvement of reproducibility of Pacific decadal oscillation in CMIP5 (S6-9017)

14:50 **James R. Christian**
Detection of anthropogenic influences on ocean biogeochemistry in the North Pacific (S6-9133)

15:10 **Vera Pospelova**
Environmental and primary productivity change in coastal waters of the eastern North Pacific revealed from the sedimentary phytoplankton record (S6-9140)

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

16:00 **Joo-Eun Yoon, Young Baek Son and Sinjae Yoo**
Primary productivity and its interannual variability in the East Sea, 1998-2007 (S6-9115)

16:20 **Sanae Chiba, Sonia Batten, Tomoko M. Yoshiki, Tadafumi Ichikawa and Hiroya Sugisaki**
Climate induced variation in the basin scale zooplankton community structure in the North Pacific (S6-8897)

16:40 **William T. Peterson and Jennifer L. Fisher**
The influence of ten El Niño events on pelagic ecosystem structure in the northern California Current (S6-9153)

17:00 *Session Ends*

Day 2, Wednesday, October 16 (09:00-12:00)

09:00 **Hiroshi Kuroda, Taku Wagawa, Yugo Shimizu, Shin-ichi Ito, Shigeho Kakehi, Takeshi Okunishi, Sosuke Ohno, Hiromi Kasai and Akira Kusaka**
Interdecadal decreasing trend of the Oyashio on the continental slope off the southeastern coast of Hokkaido, Japan (S6-8961)

09:20 **Taeki An, Hyun Je Park, Jung Hyun Kwak, Chung Il Lee, Hae Won Lee, Kangseok Hwang, Jung Hwa Choi and Chang-Keun Kang**
Seasonal shift of ecosystem structure around the Ulleung Basin of the East/Japan Sea (S6-9047)

09:40 **Elena I. Ustinova and Yury D. Sorokin**
Recent trends of air and water temperature and ice cover in the Far-Eastern Seas (S6-9081)

10:00 **Neil S. Banas, Robert G. Campbell, Carin Ashjian, Evelyn Lessard, Alexei Pinchuk, Evelyn Sherr, Barry Sherr and Jinlun Zhang**
Linking sea-ice retreat and increasing water temperature to plankton community structure and function in the eastern Bering Sea (S6-9158)

10:20 **Andrei Krovnin, Boris Kotenev and George Moury**
Climatic variability in the Northwest Pacific: Regimes, mechanisms, trends, impact on commercial fish populations (S6-8899)

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

11:00 **Hae Kun Jung, Chang-Keun Kang and Chung Il Lee**
Regional differences in the response of ocean environment and fisheries resources in Korean waters to the North Pacific regime shift and possible mechanisms (S6-9029)

11:20 **J. Anthony Koslow, Peter Davison, Ana Lara-Lopez and Mark D. Ohman**
Epipelagic and mesopelagic fishes in the southern California Current System: Ecological interactions and oceanographic influences on their abundance (S6-9058)

11:40 *Comments and Discussion*

12:00 *Session Ends*

S6 Posters

S6-P1 (*cancelled*) **Chan Joo Jang, Cheol-Ho Kim and Taewook Park**
Mixed layer depth in the North Pacific Ocean simulated from climate models: Common biases

S6-P2 **Sayaka Yasunaka, Yukihiro Nojiri, Tsuneo Ono, Shin-ichiro Nakaoka and Frank A. Whitney**
Monthly maps of sea surface nutrients in the North Pacific: Basin-wide distribution and seasonal to interannual variations

S6-P3 **Minwoo Kim, Cheol-Ho Kim and Chan Joo Jang**
Effects of grid refinement in the global ocean circulation experiments

S6-P4 **Cheol-Ho Kim, Chan Joo Jang and Minwoo Kim**
Sea level projection of the North Pacific Ocean using a non-Boussinesq ocean-sea ice model in the SRES A1B scenario

S6-P5 **Olga Trusenkova and Dmitry Kaplunenko**
Patterns of interannual to decadal sea level variability in the Japan/East Sea

S6-P6 **SM M. Rahman, Chung Il Lee and Chang-Keun Kang**
Regional differences in oceanic and fisheries variability in the East/Japan Sea related to north Pacific climate-ocean variability

S6-P7 **Allison R. Wiener, Marisol García-Reyes, Ryan R. Rykaczewski, Steven J. Bograd and William J. Sydeman**
Statistical downscaling of an ensemble of Global Climate Models output for the California upwelling region

S6-P8 **Wu Shuangquan, Gao Zhigang, Yang Jinkun and Yu Ting**
Numerical simulation of ocean ecological dynamics in Taiwan Strait

S6 Oral Presentations, Day1

October 15, 09:10 (S6-9091)

Physical processes mediating climate impacts in shelf sea ecosystems

Jason **Holt**[1], Icarus Allen[2], Yuri Artioli[2], Laurent Bopp[3], Momme Butenschon[2], Heather Cannaby[4], Ute Daewel[5], Bettina Fach[4], James Harle[1], Dhanya Pushpadas[5], Baris Salihoglu[4], Corinna Schrum[5] and Sarah Wakelin[1]

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How global scale climate change might impact coastal and shelf seas is far from straightforward. A myriad of physical processes can potentially act as vectors transferring the larger scale oceanic and atmospheric variability and change to shelf sea physics, biogeochemistry and ecosystems. Examples of the physical processes include upper ocean warming, seasonal/permanent stratification, wind mixing, convective mixing, light climate, terrestrial input, circulation and ocean-shelf exchange. These potentially impact ecosystem processes such as primary production, plankton community structured, bloom timing, and mid-water production. However, different processes often act in a different sense and are not necessarily additive, leading to damping or amplification effects. Here, we review the prevailing physical processes, and drawn on the experience of the MEECE (www.meece.eu) and QUEST_FISH (www.quest-fish.org.uk) projects to contrast climate impacts in five European shelf sea regions using three different model systems and twelve regions globally using a single model system. Using this ensemble of simulations, along with process sensitivity studies and multiple forcing studies, we are able to identify the important physical processes in each region, and how they interact. This builds up a picture of contrasting vulnerability, linking shelf sea characteristics, to different vectors of change and so to ecosystem response, which we might expect to be applicable to other shelf and coastal regions around the world. We also consider the methodology of these dynamical downscaling experiments and the extent to which they can 'add value' to the global simulations to provide robust information on future change.

October 15, 09:40 (S6-9054)

A Regional Climate Coupled Model for the western North Pacific: Assessment of a Present Climate Simulation

Chul Min **Ko**, Chan Joo Jang, Chun Yong Jung and Cheol-Ho Kim

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This study presents a regional coupled climate model (RCCM) for the western North Pacific, composed of the Regional Ocean Modeling System (ROMS) as the ocean component and by the Weather Research Forecast (WRF) as the atmospheric component through the Model Coupling Toolkit (MCT). The model is applied to a western North Pacific oceanic domain with a horizontal resolution of 1/12˚ and an East Asia region for the atmospheric domain with a horizontal resolution of 50km. For the assessment of the present climate simulation, we compared the RCCM simulations with observational data and reanalysis data.

The ocean model of the RCCM system is able to capture the inter-annual variability of seasonal SST and the fine scale spatial-temporal evolution of observed SST anomalies, although model shows a little climate drift due to long-term integration. It shows that the volume transports of Korea Strait, Tsugaru Strait, and Soya Strait simulated in the ocean model are similar to those in observational data. In addition, North Pacific Intermediate Water is found along about 165°E and the meandering of the Kuroshio Current and the East Korean Warm Current appeared along about 35°N and 38°N, respectively. Except that the simulated winter mixed layer depth (MLD) is deeper than observed in the Kuroshio extension, the climatological monthly mean spatial distribution of simulated MLD is comparable to the Montegut el al. (2004) climatology. In the atmosphere model of the RCCM system, the impacts of local air-sea interaction on the simulation of the interannual variability of the western North Pacific summer monsoon are investigated through coupled and uncoupled simulations, highlighting the importance of

air-sea coupling. Compared with the uncoupled model, the coupled simulation exhibits improvements in both the climatology and the interannual variability of rainfall over the western North Pacific. These results confirm that the RCCM can reproduce the observed regional structure of present climate reasonably well.

October 15, 10:00 (S6-8882)

Regional ocean climate model projections for the British Columbia continental shelf

Michael **Foreman**, Wendy Callendar, Diane Masson, John Morrison and Isaak Fain

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A regional, ocean-only, climate model has been developed and run for the British Columbia continental shelf using initial and forcing fields downscaled from the NARCCAP global and regional climate model archives. As the archived winds were shown to poorly capture upwelling winds over the baseline period of 1971-2000, a "pseudo global warming" strategy was adopted wherein future-minus-contemporary anomalies were added to the initial and forcing fields used in a recent Masson and Fine (2012) ROMS hindcast simulation for the same region. The simulated future conditions include warmer and fresher waters, stronger winter winds, an intensification of some seasonal eddies, but little change to the summer winds and contemporary upwelling conditions. Future work and the possible impact of these changes on regional ecosystems will be discussed.

October 15, 10:20 (S6-9078)

Investigating the upwelling intensification hypothesis using climate-change simulations

Ryan R. **Rykaczewski**[1], John Dunne[2], Charles A. Stock[2], William J. Sydeman[3], Marisol García-Reyes[3], Bryan A. Black[4] and Steven J. Bograd[5]

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Anthropogenic climate change impacts ecosystems of the Northeast Pacific through a number of processes. One of the most ecologically significant of these factors is potential long-term change in the magnitude of upwelling-favorable winds in the California Current. Given the increased heating of landmasses relative to oceans under increased greenhouse-gas concentrations, Bakun (1990) suggested that global warming could intensify continental thermal lows, increasing the ocean-continent atmospheric pressure gradients and the associated upwelling-favorable winds. Assessing this mechanism using observations is challenging, and relationships between winds and warming over the past decades remain equivocal. In an attempt to evaluate the upwelling intensification hypothesis comprehensively, we examined the strength and seasonality of alongshore winds in the California Current region using a suite of coupled ocean-atmosphere models assembled for the Fifth Assessment Report by the Intergovernmental Panel on Climate Change. In contrast to the hypothesized intensification, ensemble-mean model projections show a future weakening of winds in the core of the upwelling area. We suggest that the lack of a projected increased pressure gradient during summer is related to the changing relationships among temperature, pressure, and specific humidity. Additionally, we hypothesize that consistent changes in the seasonality and latitude of upwelling are associated with poleward migration of the major atmospheric pressure cells rather than ocean-continent temperature gradients. Such unexpected changes in upwelling winds demonstrate the potential sensitivity of upwelling to a variety of dynamic and thermodynamic processes, as well as the need to develop regionally downscaled climate models.

October 15, 11:00 (S6-9169)

Decadal changes in dissolved oxygen concentration in the thermocline of the Northeast Pacific

William **Crawford** and Angelica Peña

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We examine archived observations of dissolved oxygen concentration (O_2) in the Northeast Pacific Ocean east of 170ºW and north of 30ºN, to search for decadal trends along constant density surfaces in the permanent thermocline below the winter surface mixed layer. Our approach is to find relatively small geographical regions with homogeneous O_2 distribution and sufficient measurements in every decade since the 1940s to enable robust evaluation of decadal trends. We select seven stations off southern California sampled by the California Cooperative Fisheries Investigation (CalCOFI) and an additional four locations on the continental slope between central California and southern Vancouver Island. At all locations, O_2 increased from the 1950s to the 1980s and declined after the 1980s. Temperature generally varies inversely with O_2, but the changes in O_2 are greater than can be accounted for by the variation in O_2 solubility with temperature. Lower O_2 at most locations is also accompanied by shoaling of the constant density surfaces. At Ocean Station Papa at 50ºN, 145ºW, O_2 declined from the 1950s to the early 2000s, with considerable decadal variability. The decline in O_2 along the continental margin and in deep-sea waters is steepest from mid-1990s to mid 2000s. Some locations reveal a slight increase in O_2 in the past few years. The trends are more easily evaluated than the causes; the latter will be discussed in this presentation.

October 15, 11:20 (S6-8942)

Interdecadal variability of circulation in the northern Japan/East Sea based on numerical simulations

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Interdecadal variability of circulation in the northern Japan/East Sea (JES) is investigated based on numerical simulations. Using an ocean model (INMOM) we reconstruct large-scale circulation of the JES. INMOM is a three-dimensional, σ-coordinate, nonlinear, finite difference model which uses the hydrostatic and Boussinesq approximations. We use 1/10° mesh with 15 sigma levels to reproduce the large-scale circulation of the JES. Straits of the JES are closed with nudging condition for temperature and salinity. To represent the coastline and topography ETOPO2 is used. We use the initial temperature and salinity fields from Levitus data and the atmospheric forcing from CORE data. The general circulation of the JES was reconstructed from 1958 to 2006. To study the variability of circulation in the northern JES we analyzed the relative vorticity variability both in the layer from 500 m to 2500 m and at depths of 500, 800 and 2500 m. Harmonics with periods of 4-5 and 10 years dominate in the variability of circulation in the Japan Basin. It is supposed that the interannual variability is determined by the Japan Basin geographical features. We analyzed the potential density field during winter and established a connection between winter cooling and decadal variability of deep water circulation.

October 15, 11:40 (S6-9033)

Effects of nutrient transport through the Korea Strait on the seasonal and interannual variability in the East Sea (Japan Sea) ecosystem

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The nutrients supplied through the Korea Strait (KS) have been believed to have negligible effects on the nutrient budget and biological productivity of the southern East Sea (Japan Sea). However, recent studies based on observations suggest that large amounts of dissolved inorganic nitrogen and phosphorus, comparable to the levels in the Changjiang water and the Taiwan Strait, are transported through the eastern channel of the KS, with considerable interannual variation. This study aims to examine the effects of nutrient transport through the KS on the seasonal and interannual variability of the southern East Sea ecosystem. By using a four-compartment NPZD model coupled with a 3D physical model, three numerical experiments were conducted with different lateral boundary conditions of nutrient flux through the KS. The results suggest that the nutrient flux through the KS may contribute to primary productivity in the southern East Sea. The magnitude of phytoplankton blooms is also influenced by this nutrient transport. We discuss the direct or indirect contribution of the nutrient flux through KS to the primary productivity of the southern East Sea.

October 15, 12:00 (S6-9126) -CANCELLED

3D structure and decadal change of the ecosystem in the Kuroshio jet region detected from historical data

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The transport of heat and nutrient by the Kuroshio and its impacts on ecosystems in adjacent regions is an important issue with respect to the mechanisms of decadal changes of productivity in the western North Pacific. With a focus on nutrients and chlorophyll in the Kuroshio region, historical hydrographic data were analyzed to clarify their 3D structure and seasonal and interannual variability. A nutrient maximum was detected on the 24.5-25.5s_q surface along the jet in the whole Kuroshio region. The structure was analogous to the well-known Nutrient Stream found in the Gulf Stream region. It should be emphasized that the nutrient concentration on the 24.5-25.5s_q surface gradually decreases downstream along the Kuroshio. It implies that the high nutrient water originates from upstream and adjacent coastal regions, and is transported downstream along the Kuroshio as is the case with the Gulf Stream. Moreover, the along-jet maximum was detected only in spring, which is attributed to more active consumption by the phytoplankton on the inshore side of the jet under elevated irradiance, because the strong baroclinicity inclines the isopycnal surfaces and the water depth on the inshore side is much shallower. The decadal changes of nutrient concentration on the subsurface isopycnal surfaces was synchronized with the cycles of climate change in the Pacific, suggesting an effect on the nutrient supply to the euphotic layer in the Kuroshio region.

October 15, 14:00 (S6-9171)

How predictable is the North Pacific?

William **Merryfield**

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Our ability to predict the future evolution of the climate system using dynamical models has steadily improved owing to advancements in modeling, growing computing power, and the availability of increasingly comprehensive observations for forecast initialization and validation. Because the dominant "memory" that enables long-term climate prediction resides mainly in the oceans, a key development has been the application of coupled climate models that represent future evolution of the oceans as an integral part of the forecast. The evident promise of this approach has led numerous modeling centres including CCCma to explore the utility of extending the temporal horizon for such predictions from months to a decade or longer. Ultimately, however, the success of such efforts will be limited by the existence of natural bounds on the predictability of the climate system whose nature and severity are also being explored. This talk will review the current state of dynamical climate prediction on time scales of months to years in relation to the North Pacific, focusing on processes that impart predictability on these time scales, as well as the potential for practical forecasts to exploit this predictability for societal benefit.

October 15, 14:30 (S6-9017)

An improvement of reproducibility of Pacific decadal oscillation in CMIP5

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The Pacific decadal oscillation (PDO), defined as the first empirical orthogonal function mode of North Pacific sea surface temperature (SST), could affect variability of marine ecosystems as well as the climate system in the North Pacific. We evaluate PDO reproducibility simulated from coupled general circulation models (CGCMs) of phase 3 and 5 of the Coupled Model Intercomparison Project (*i.e.* CMIP3 and CMIP5, respectively) by investigating the interaction between PDO and El Niño - Southern Oscillation (ENSO), and teleconnections between extra tropics and tropics. PDO comparison between the CGCM simulation and observation during the period 1900-1998 shows that the PDO reproducibility has improved in CMIP5 relative to CMIP3. To assess how PDO reproducibility can be improved in CMIP5, sensitivity of precipitation to tropical SST and representation of the Pacific/North America pattern were analyzed. The CGCMs in CMIP5 show enhanced simulations of ENSO and teleconnections agreeing more with observations than those in CMIP3. Based on observations, anomalous warming of the tropical Pacific during El Niño events enhances tropical precipitation with energy transport from ocean to atmosphere and causes atmospheric waves to propagate into the extra tropics. Therefore, it is important to realistically simulate a response of precipitation in the tropical Pacific to SST and formation of planetary waves in appropriate locations. Our findings suggest that enhancement of ENSO reproducibility and teleconnections from tropics to extratropics contribute to the improvement of PDO reproducibility in CMIP5 CGCMs.

October 15, 14:50 (S6-9133)

Detection of anthropogenic influences on ocean biogeochemistry in the North Pacific

James R. **Christian**

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Changes in ocean chemistry and climate induced by anthropogenic carbon dioxide affect a broad range of ocean biological and biogeochemical processes. Anthropogenically-induced changes in ocean biogeochemistry have been present throughout the modern era of ocean observation. However, these are extremely difficult to detect against the background of natural variability given the relatively short duration of most oceanographic data records. Climate models offer a self-consistent, if imperfect, data record through which we can examine detection with more robust statistical inferences than are possible using observations. Some recent state-of-the-art climate model simulations will be used to examine detection of trends that impact ocean chemistry and biology particularly strongly in the North Pacific, where natural interdecadal variability is large and waters with low oxygen concentrations and $CaCO_3$ saturation states are close to the surface. Distinguishing anthropogenically induced secular trends from interdecadal variability is a difficult problem and will be made more difficult by successful mitigation of emissions, as the anthropogenic component will no longer be a monotonic trend.

October 15, 15:10 (S6-8897)

Environmental and primary productivity change in coastal waters of the eastern North Pacific revealed from the sedimentary phytoplankton record

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Understanding of causes and mechanisms of environmental change, whether it is related to climate change, ecosystem degradation due to natural variability, or anthropogenic activity, requires compilation of long term environmental data. When long-term measurements are scarce or unavailable, information can be obtained from sedimentary records that contain microfossils and geochemical proxies of past conditions. This presentation highlights research on the coastal and estuarine waters of western Canada and the United States, a region influenced by ENSO (El Niño/La Niña–Southern Oscillation). The history of annual to decadal variability in these climate oscillations is revealed by the study of the microfossils found in marine sediments (particularly dinoflagellate cysts), which reflect changes in freshwater input, sea surface temperature and primary productivity.

October 15, 16:00 (S6-9115)

Primary productivity and its interannual variability in the East Sea, 1998-2007

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We investigated the interannual variability of primary production in the East Sea for the 10-year period from January 1998 to December 2007. Primary production was calculated from satellite ocean color data using a local primary production algorithm for the East Sea. To identify the spatio-temporal patterns of primary production, empirical orthogonal function analysis was applied. Based on this, the East Sea was classified into several sub-regions using K-means clustering method. The primary productivity of each sub-region showed characteristic seasonal and interannual variability. The time series of primary productivity of each sub-region were compared with physical factors (wind stress, mixed layer depth, photosynthetic available radiation and volume transport of the Tsushima Warm Current) and climate indices, such as the Multivariate ENSO Index, the Siberian High Index and the East Asian Winter Monsoon Index. The seasonal and annual primary productivity in each sub-region show different relationships with physical forcing and climate indices. Here we discuss how the variability of primary production in the East Sea is linked to local and non-local forcing.

October 15, 16:20 (S6-9140)

Climate induced variation in the basin scale zooplankton community structure in the North Pacific

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Understanding of zooplankton variation to the level of community structure is indispensable to assessing the impact of large-scale climate forcing on marine ecosystems in various ways, e.g. biodiversity and productivity. We studied spatio-temporal variation of zooplankton community structure in the subarctic North Pacific (NP) using summer-time (June-July) samples taken by Continuous Plankton Recorder (CPR) survey for 2001-2011, with particular interest in the regionally specific mechanisms of variation between the western region (143-170°E) and eastern region (123-160°W) of the subarctic NP. In the western NP, zooplankton size structure indicates increase of large species (total length >=2.0mm) and decrease of small species (total length <2.0mm) after 2006 as SST increased, roughly coinciding with the negative shift of the PDO. As PDO indicates east-west dipole cool-warm cycle in the subarctic North Pacific, SST in the eastern NP decreased after 2006/2007. However, the relationship between size structure index and SST differed from that in the western NP: decrease of small species with SST decrease and no trend in the large species over the study period. The observed positive correlation between SST and small species ratio in the eastern NP is consistent with previous ecosystem change studies that have reported increase of smaller (warm water) species with warming trend. On the other hand, significant positive correlation between SST and large species occurrence in the western NP suggests that there must be another mechanism. Regionally specific mechanisms determining zooplankton community size structure will be discussed in the presentation.

October 15, 16:40 (S6-9153)

The influence of ten El Niño events on pelagic ecosystem structure in the northern California Current

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Fortnightly measurements of hydrography and zooplankton have been sustained along the Newport Hydrographic Line since 1996. This 18-year dataset was coupled with similar data gathered 40-50 years ago to gain insights into changes in ocean conditions over the past half-century. In this talk we compare the impacts of ten past El Niño events on the pelagic ecosystem structure in the northern California Current (NCC). Five strong El Niño events (max ONI ≥ 1.5) have occurred in equatorial waters since the early 1970s most of which were initiated in spring, and lasted ~ 12 months. Three events coincided with positive phases of the PDO (1982-83, 1991-92, 1997-98) while two occurred during negative PDO (1972-73 and 2009-10). Impacts on the ecosystem structure were severe during El Niño events which occurred when the PDO was positive, but ranged from slight (2006-07) to undetectable (1972) when the PDO was negative. The timing of the arrival of zooplankton also differed between the eastern Pacific-type and central Pacific-type El Niño events. Basin-scale forcing through the interaction of the PDO and ENSO are key physical drivers of variability in zooplankton species composition in the NCC. Climate models must include these drivers if they are to produce accurate projections of lower trophic level organisms.

S6 Oral Presentations, Day 2

October 16, 09:00 (S6-8961)

Interdecadal decreasing trend of the Oyashio on the continental slope off the southeastern coast of Hokkaido, Japan

Hiroshi **Kuroda**[1,3], Taku Wagawa[2], Yugo Shimizu[3], Shin-ichi Ito[2], Shigeho Kakehi[2], Takeshi Okunishi[2], Sosuke Ohno[2], Hiromi Kasai[1] and Akira Kusaka[3,1]

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We investigated an interdecadal trend of the Oyashio for 19 years (1993-2011) by combining altimetry and long-term *in situ* data obtained from "A-Line", extending southeastward from the southeastern coast of Hokkaido and regularly monitoring the Oyashio current system after 1988. Significant increasing trends of the altimetry sea levels are detected near the A-Line and distributed between the coast and the vicinity of the Kuril-Kamchatka Trench, where a maximum trend of 0.8 cm year^{-1} is estimated. Spatial trend maps of altimetry-derived geostrophic velocity show that a clockwise circulation anomaly is intensified, which signifies decreasing trends of the Oyashio and its return flow at the sea surface. Steric heights estimated from *in situ* data on the A-Line exhibit increasing trends as well as the altimetry sea levels. The steric height is determined primarily by the halosteric component, which tends to increase with decreasing trends in salinity at 200-2000 dbar. The decreasing salinity trends are also accompanied by downward displacement of isohalines. Since the maximum trends of the steric/halosteric height and salinity are located around the trench, the horizontal salinity/density gradient on the continental slope tends to be weakened. That is, there are decreasing trends of baroclinic transport of the Oyashio, which reaches, at least, -8 Sv for the 19 years. Additional analysis of wind stress over the North Pacific indicates decreasing westerly wind strength, which is connected to decreasing trends in the local Ekman pumping, and in Sverdrup transport at 44.5ºN integrated from the eastern to the western boundary.

October 16, 09:20 (S6-9047)

Seasonal shift of ecosystem structure around the Ulleung Basin of the East/Japan Sea

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The East/Japan Sea is one of the representative marginal seas in the northwest Pacific Ocean. The sea is semi-enclosed, with a thermohaline circulation system that allows warm and cold currents to fill the surface of the sea, and is thus called 'a miniature ocean'. In particular, the Ulleung Basin is located in the southwestern part of the sea, where the two water masses form a boundary. It has high primary productivity and species richness and is considered a 'biological hot spot'. In the present study, we document seasonal shifts in the major fishing species in the southwestern part of the East/Japan Sea by analysis of catch data of warm and cold water species, including Japanese squid, Pacific herring, chub mackerel and Pacific saury, during the last decade (2000-2011). Our results matched well with the environmental changes in water-column structure and nutrient dynamics. A clear seasonal switching of overall food web structure including phytoplankton, zooplankton, and target fishing species was observed consistently with the changes in environmental conditions. Especially, variability in cold water plankton was likely to lead to seasonal ecosystem switching. Finally, our results indicate that seasonal changes in ocean structure can result in shifts in the overall ecosystem, providing in situ background information for future research.

October 16, 09:40 (S6-9081)

Recent trends of air and water temperature and ice cover in the Far-Eastern Seas

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Recent climatic trends (for the last semicentennial period and 30-year running trends) and low-frequency variability of various environmental parameters are evaluated for different areas of the Japan/East, Okhotsk, and Bering Seas. Climatically significant parameters for monitoring are selected on the following principles: duration, uniformity and regularity of observations and the parameters' utility for marine ecosystem studies. SST trends are estimated using empirical orthogonal functions for each sea. The main feature of the changes is warming of the surface layer (0.1-0.2°C per decade), although in the southern Japan/East Sea the positive trend to warming is not significant in all seasons. The contribution of the positive trend to total variance of SST is substantially less in summer than in other seasons. The warming is accompanied by decreasing sea ice cover that is the most significant in the Okhotsk Sea (4% per decade) where the ice cover variation agrees well with the changes of air temperature of the Northern Hemisphere. In the Bering Sea and the Tatar Strait the negative trends in ice cover are not statistically significant for 1960-2013. While the Okhotsk Sea ice cover is sensitive to global temperature variations, large-scale oscillations such as El Niño and the Pacific Decadal Oscillation are more important for the Bering Sea ice cover. For thermal variables, the regime shifts of 1977/78 (to warming) and 2007/2008 (to cooling) are the strongest for the Bering Sea, the shift of 1988/1989 (to warming) for the Japan/East Sea, and regional shift of 1983/84 (to warming) for the Okhotsk Sea.

October 16, 10:00 (S6-9158)

Linking sea-ice retreat and increasing water temperature to plankton community structure and function in the eastern Bering Sea

Neil S. **Banas**, Robert G. Campbell, Carin Ashjian, Evelyn Lessard, Alexei Pinchuk, Evelyn Sherr, Barry Sherr and Jinlun Zhang

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A new, system-specific, data-driven planktonic ecosystem model for the eastern Bering Sea is presented. The model is designed around observations of phytoplankton, microzooplankton, copepod, and euphausiid biomass and composition and associated rate data from the 2007-2010 NSF BEST (Bering Ecosystem Study) field program. It is forced by ice cover, water temperature, and turbulent diffusivity from the three-dimensional BESTMAS (Bering Ecosystem Study Ice-Ocean Modeling and Assimilation System) model, and is run as an ensemble of flow-following 1-D water columns, in order to resolve patch-scale biological variability at low computational cost. A comparison of present-day and circa-2050 scenarios suggests that on the northeastern shelf, total spring-summer primary production is likely to increase 5-10% per decade, in close proportion to the increase in light availability as ice retreats earlier. Trophic coupling with microzooplankton does not change significantly, despite the inclusion of differing temperature sensitivities for the growth of phytoplankton and their grazers. Increasing temperature does, however, increase trophic transfer to large copepods (*Calanus* spp.), through acceleration of individual development in spring and thus a change in population structure. Implications for the future success of fisheries dependent on large crustacean zooplankton will be discussed.

October 16, 10:20 (S6-8899)

Climatic variability in the Northwest Pacific: Regimes, mechanisms, trends, impact on commercial fish populations

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The mean winter (January-March) index of the West Pacific (WP) teleconnection pattern is a good indicator of climatic variability in the Northwest Pacific and adjacent Far East Seas. During 1950-2013 its changes were characterized by existence of two multi-decadal regimes, with predominance of the negative values of the index from 1956 to 1986, and positive ones in the 1987-2011 period. The establishment of certain WP phase may be considered, to a large extent, as a result of evolution of the corresponding phase of the PNA/PDO pattern, with a lag of about 10 years. The duration of multi-decadal regimes in the eastern and western North Pacific is the same (approximately 30 years). The last (negative) PNA/PDO phase was formed in 2007, and thus we expect a new regime shift of the WP pattern in winter of 2016/2017. The signs of this shift appeared in the Northwest Pacific in the winter of 2011/2012 and continued during the cold season of 2012/2013. The influence of the Arctic Oscillation and atmospheric teleconnection patterns over Eurasia on the Northwest Pacific climate and the state of WP pattern, in particular, will be also considered in this paper. The impact of winter climate variability in the region on reproduction of highly abundant commercial fish populations (Far East salmon, walleye pollock) under the negative and positive phases of the WP pattern is discussed.

October 16, 11:00 (S6-9029)

Regional differences in the response of ocean environment and fisheries resources in Korean waters to the North Pacific regime shift and possible mechanisms

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The purpose of this study is to analyze the long term changes and possible mechanism of change of ocean and fisheries conditions around Korean waters due to the climate regime shift (CRS) in the North Pacific. In the mid 1970s CRS, Korean waters were influenced mainly by Aleutian Low Pressure (ALP), Pacific Decadal Oscillation (PDO) and East Asian Winter Monsoon (EAWM). On the other hand, in the late 1980s CRS, the state of Korean waters was highly correlated with all climate indices. In the CRS of the late 1990s, Korean waters were affected mainly by EAWM and the Arctic Oscillation (AO). After mid 1970s and late 1990s CRS, water temperature in the West Sea, South Sea and East China Sea (ECS) of Korea was lower than normal with decreasing warm water volume transport and increasing sea surface wind speed. As a result, total catch of pacific cod, herring, yellow croaker, with spawning grounds located in the West Sea and South Sea, mainly increased. On the other hand, in the case of the late 1980s CRS period, water temperature in all seas was higher than normal with increasing warm water volume transport and decreasing sea surface wind speed, and it was highly correlated with all of the climate indices. As a result, total catch of warm water species such as anchovy, common squid, and chub mackerel, with spawning grounds located in the South Sea and ECS, mainly increased.

October 16, 11:20 (S6-9058)

Epipelagic and mesopelagic fishes in the southern California Current System: Ecological interactions and oceanographic influences on their abundance

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Ecosystems in eastern boundary currents have been characterized as "wasp-waisted", with the intermediate trophic level dominated by one or two epipelagic planktivorous fish species (*e.g.* sardine, anchovy). Their variability was considered a key driver for populations of both their predators and prey. However, revised biomass estimates for mesopelagic fishes in the California Current indicate that this diverse group, dominated by plankton feeders, is about an order of magnitude larger than the biomass of epipelagic fish planktivores, and their prey consumption is estimated to be about 2-3-fold higher. Time series for planktivorous mesopelagic fishes were positively correlated with several key pelagic planktivores (anchovy, hake, and two mackerel species), indicating a predominance of bottom-up forcing. These meso- and epipelagic fishes were similarly correlated with key indices for the ocean environment: the Multivariate ENSO index (MEI) and the Pacific Decadal and North Pacific Gyre Oscillations. An index for the combined biomass of epipelagic and mesopelagic migratory planktivores was negatively correlated with the abundance of several key planktonic copepod and krill taxa, a possible indication of top-down forcing. But these correlations between planktivores and their prey appeared to arise instead from their opposite correlations with a common set of environmental drivers, rather than from their biological interactions. The wasp-waist model is inappropriate as a paradigm of food web structure and dynamics in the California Current.

S6 POSTERS

S6-P1

Mixed layer depth in the North Pacific Ocean simulated from climate models: Common biases

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Ocean mixed layers, the vertically quasi-homogeneous upper ocean, directly interact with the overlying atmosphere so that they influence important air-sea interaction processes including variability of sea surface temperature and ocean uptake of atmospheric CO_2. The thickness of ocean mixed layer or mixed layer depth (MLD) has been one of the challenging issues to simulate in climate models. In this study, we assess biases in the MLD simulated in climate models by comparing outputs from CMIP3 (coupled model intercomparison projects phase 3) models with a MLD climatology based on observational data. The most common biases in winter MLD are a deep bias in the Kuroshio Extension region (KE) and a shallow bias in the Oyashio region. The deep bias in the KE is mainly driven by the fact that the simulated KE is too broad and too far north. The deep bias also can be attributed to the overestimated mid-latitude westerlies in CMIP3 models. The shallow bias in the Oyashio region is related tostratification bias in the upper ocean. A preliminary analysis reveals that the CMIP5 climate models also show similar MLD biases, suggesting that CMIP5 models still suffer from substantial MLD biases that may contribute to biases in ecosystem simulation.

S6-P2

Monthly maps of sea surface nutrients in the North Pacific: Basin-wide distribution and seasonal to interannual variations

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This study produced 120 monthly maps of sea surface nutrient (phosphate, nitrate and silicate) concentrations for the North Pacific from 2001 to 2010 using a self-organizing map of temperature, salinity, chlorophyll *a* concentration and mixed layer depth with nutrient observations mainly obtained from commercial ships. Correlation coefficients between the estimation and the observation were greater than 0.8, and root-mean-square differences were 0.14 μmol kg^{-1} for phosphate, 1.80 μmol kg^{-1} for nitrate and 3.56 μmol kg^{-1} for silicate. Seasonal decrease of nutrient concentrations was large in the northwestern part, but the spatial distributions were slightly different among the elements. The stoichiometric ratio of seasonal decreases of silicate and nitrate was larger in the western subarctic Pacific and the Bering Sea than in eastern subarctic Pacific, suggesting differing prevalence of diatoms. According to the interannual variation, the Pacific Decadal Oscillation (PDO) induced the dominant variation in the North Pacific nutrient anomaly fields which showed the east-west seesaw pattern north of 35°N, mainly by changes in horizontal advection and partly by changes in vertical mixing and biological production.

S6-P3

Effects of grid refinement in the global ocean circulation experiments

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Global ocean circulation is simulated and compared using two different configurations of horizontal grid resolution in the global coupled ocean-sea ice model MOM4-SIS. The two model versions adopt roughly 1×1º (GCM_1) and 0.5×0.5º (GCM_0.5) grids respectively, with enhanced latitudinal resolution in the equatorial region. Both model versions employ the common CORE-II normal year forcing data for radiation, wind, air temperature, specific humidity, sea level pressure, precipitation and land runoff, and the same numerical schemes for tracer/momentum advection/diffusion, with the same coefficients of eddy viscosity and eddy diffusivity. After 1000 years of integration GCM_1 shows warm biases in sea surface temperature (SST) in the equatorial Western Pacific, Asian Marginal Seas, west of the South American coast and other major areas of the world ocean. Compared to GCM_1, GCM_0.5 reveals some improved SST patterns after 500 years of integration, showing much reduced warm- and cold-biased regions at the above mentioned areas. It is likely that the different temperature patterns of GCM_0.5 compared to GCM_1 is due to the more finely resolved current structures in the coastal and western boundary current regions.

S6-P4

Sea level projection of the North Pacific Ocean using a non-Boussinesq ocean-sea ice model in the SRES A1B scenario

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To predict future sea level change due to global warming for the East Asian Marginal Seas and the North Pacific Ocean, time-slice experiments were performed using a global non-Boussinesq ocean-sea ice coupled model (GFDL MOM4-SIS) with a horizontal resolution of about 0.5º. First, climatological mean ocean state is simulated with a long-term integration of 100 to 500 years with boundary conditions from CORE (Coordinated Ocean Reference Experiment) climatological mean ocean and atmospheric states. Next, for climate change experiments atmospheric forcing data are taken from the CMIP3 experiments of GFDL CM2.1, MIROC-Hi and ECHAM5,

following the SRES A1B scenario. Projected sea level from the ensemble runs of the three respective external forcings show different horizontal patterns, with different rate of increase for the 2050s. Greater sea level rise in the subtropical region, and very little increase in the off-equatorial region of the North Pacific occurs with GFDL CM2.1 forcing. Overall sea level rise in the North Pacific was greatest in MIROC-Hi among the three model projections; in ECHAM5 it was higher than GFDL CM2.1 but lower than MIROC-Hi.

S6-P5

Patterns of interannual to decadal sea level variability in the Japan/East Sea

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An increasing trend has been revealed in globally averaged sea level derived from tide gauges and satellite altimetric measurements. However, altimetric sea level trends in the North Pacific follow the PDO spatial pattern and they are non-uniform in the East Asian marginal seas. The hydrographic regime in the Japan/East Sea is strongly influenced by water exchange with the adjacent basins and the same can be expected for sea level and the dynamic and energetic characteristics derived from it. To study this variability, AVISO 0.25°-gridded weekly sea level anomalies (SLA) for the period from October 1992 onwards are used and eddy kinetic energy (EKE) is computed from SLA. Synchronous quasi-biennial (QB) oscillations of sea level were detected in the Japan/East Sea. Their strength is closely correlated with low-frequency spatially averaged EKE; both reveal decadal oscillatory rather than trend-like behavior and tend to follow transport variations in the Korea Strait. The east-west seesaw between two major pathways of northward transport of warm water from the Korea Strait emerges in both the southern and northern Japan/East Sea, manifesting itself in SLA, EKE, and sea surface temperature anomalies (SSTA). In the positive phase, SLA and SSTA are positive in the eastern Japan/East Sea and negative in the western Japan/East Sea, while EKE is increased in the eastern and southwestern areas and decreased in the northwestern area (north of 38°N). The anomalies change sign in the negative phase. The seesaw manifesting substantial changes in circulation patterns develops on semiannual, annual, QB, and 5-yr timescales.

S6-P6

Regional differences in oceanic and fisheries variability in the East/Japan Sea related to north Pacific climate-ocean variability

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This study aimed to identify the long-term fluctuation pattern in wintertime local environmental parameters (*e.g.* SWT) for the northern sub-polar front (NSPF) region and the southern Tsushima Warm Current (TSWC) region in the East/Japan Sea (EJS). Variations related to major Climate Regime Shifts (CRS) in 1976/77, 1988/89 and 1998 were detected, and we tried to identify regional differences for common climate indices. Results suggest that Arctic Oscillation (AO), Siberian High Pressure (SHP) and East Asian Winter Monsoon (EAWM) have direct influence on the surface air temperature (SAT) and surface water temperature (SWT, 0-50m) in both regions of the EJS whereas influence of Pacific Decadal Oscillation (PDO) and Aleutian Low Pressure (ALP) have different patterns. In NSPF region, SAT, SWT and sea level pressure (SLP) lag the PDO and ALP whereas surface zonal wind (SZW) has no lag. In the TSWC region, only SLP has lags while SAT, SWT and SZW have no lag although SWT also has some lags. After 1976/77 CRS, the positive phase of PDO, ALP and EAWM led to greater upper layer mixing in both regions; a colder regime occurred through the 1988/89 CRS and reversed after the 1988/89 CRS. Severe collapse of some commercial fisheries occurred in the EJS, specifically of Pacific saury, *Cololabis saira* in 1976 and walleye pollock, *Theragra chalcogramma* in 1982. After the 1988/89 CRS, the dominant fishery shifted from Pacific saury, Pacific cod (*Gadus macrocephalus*) and walleye pollock to common squid.

S6-P7

Statistical downscaling of an ensemble of Global Climate Models output for the California upwelling region

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The impact of climate change on coastal upwelling is of great interest for ecosystems and fisheries management, since upwelling drives regional biological richness. A growing number of global climate models (GCM) are available to simulate current and future trends in ocean and atmospheric properties under climate change. However, given their large computational needs, all GCM resolutions are coarser than that needed to resolve coastal upwelling processes. Methods to downscale model output include dynamical and statistical modeling, in which relationships between GCM output and higher resolution observations are constructed. Unlike the dynamical method, statistical downscaling is computationally simpler while yielding similar results. We used the statistical approach to downscale output from 15 GCMs included in the 5th IPCC assessment report in order to validate past and project future changes in coastal upwelling in the central California region. We related alongshore wind and sea surface temperature from NDBC buoys in the region to GCM data, and constructed an ensemble of high-resolution time series of coastal upwelling measurements. We found only 2 models that adequately represented coastal upwelling to some extent and therefore were ideal for downscaling, and that the relationship between data and model output changed by season. However, the downscaled data, in general, accurately reproduced historical conditions, suggesting potential for projecting future upwelling conditions in the California Current.

S6-P8

Numerical simulation of ocean ecological dynamics in Taiwan Strait

Wu **Shuangquan**[1,2], Gao Zhigang[1,2], Yang Jinkun[1] and Yu Ting[1]

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A NPZD ocean ecological model is developed according to characteristics of Taiwan Strait and observational data. The physical model is driven by reanalysis of monthly averaged ocean temperature, salinity and currents developed by the National Marine Data and Information Service (NMDIS). The chemical and ecological boundary conditions for the ecological model are from WOA05. Modeling results are compared to observations from six '908' marine stations. The average relative error of nutrient is 48%, while the primary production is 47%.

Modeling result shows that phytoplankton, zooplankton and detritus are of similar spatial pattern in Taiwan Strait. In winter, biomass in the northern Taiwan Strait is greater than in the southern Taiwan Strait, while biomass in the Fujian coastal zone is greater than in the central strait. In Spring, biomass in the central strait is a little higher than in the coastal zone, and the northern strait is higher than the central and southern strait. In Summer, there is typically a high biomass region in northern Taiwan Strait. In Autumn, biomass in the central strait is higher than in the coastal zone, and there are typically high biomass regions in the northern and central strait respectively.

S8 BIO/FIS/MEQ/TCODE/FUTURE Topic Session
Ecosystem indicators to characterize ecosystem responses to multiple stressors in North Pacific marine ecosystems

Co-Convenors: Vladimir Kulik (Russia), Chaolun Li (China), Ian Perry (Canada), Jameal Samhouri (USA), Peng Sun (China), Motomitsu Takahashi (Japan) and Chang-Ik Zhang (Korea)

Invited Speakers:
Isabelle Côté (Simon Fraser University, Canada)
Yunne-Jai Shin (Institut de Recherche pour le De'veloppment, France)
Mingyuan Zhu (First Institute of Oceanography, SOA, PR China)

Multiple natural and human stressors on marine ecosystems are common throughout the North Pacific, and may act synergistically to change ecosystem structure, function and dynamics in unexpected ways that can differ from responses to single stressors. These stressors can be expected to vary by region, and over time. Understanding the impacts of multiple stressors, and developing indicators which capture their behaviours and changes, are major challenges for an ecosystem approach to the North Pacific and for the PICES FUTURE project. The objective of this session is to present potential indicators of ecosystem responses to multiple stressors in the North Pacific (with the focus on multiple, rather than single, stressors). One goal of the session is to determine if these proposed ecosystem indicators can provide a mechanistic understanding of how ecosystems respond to multiple stressors. For example, 1) are responses to stressors simply linear or are changes non-linear such that small additional stressors result in much larger ecosystem responses; 2) do different parts of the ecosystem respond differently (*e.g.*, across trophic levels); 3) how do stressors interact and can these interactions be adequately captured by the proposed indicators? Conceptual, empirical and model-based analyses are welcome. The results of this session will contribute to the work of PICES Working Group 28 on *Ecosystem indicators for multiple stressors on the North Pacific*.

Day 1, Thursday, October 17 (09:20-17:30)

09:20	***Introduction by Convenors***
09:25	**Isabelle M. Côté and Emily S. Darling (Invited)** Testing and predicting synergy between multiple stressors (S8-9118)
09:30 **moved to Day 2**	**Skip McKinnell** A quantitative method for assessing the interactions of multiple stressors; How I learned to compare apples and oranges (S8-8851)
09:50	**Stephen Ban** Expert elicitation of a Bayesian Belief Network for climate change effects on the Great Barrier Reef (S8-9135)
10:10	**Helen J. Gurney-Smith, Catherine A. Thomson, Dan S. Sanderson, Jennifer Kimball and Stewart C. Johnson** A functional genomics approach to assessing ecosystem health and resilience in keystone bioindicator species (S8-9177)
10:30	***Coffee/Tea Break***
10:50	**Joanna Smith, Charlie Short, Steve Diggon, John Bones, Matthew Justice, Andrew Day and Stephanie King** Ecosystem-based management indicators for a marine planning process in BC's north coast-Marine Planning Partnership (MaPP) (S8-9166)
11:10	**Andrew Day, Thomas A. Okey, Micha Prins and Stephanie King** Developing social-ecological indicators for Canada's Pacific Marine regions: Steps, methods, results and lessons (S8-9170)

11:30 **Cathryn Clarke Murray, Megan E. Mach, Rebecca G. Martone, Gerald G. Singh, Kai M.A. Chan and Miriam O**
Assessing direct and indirect risk from human activities to significant ecosystem components in the Northeast Pacific (S8-9143)

11:50 **Rebecca G. Martone, Melissa M. Foley, Megan E. Mach, Corina I. Marks, Carrie V. Kappel, Kimberly A. Selkoe and Benjamin S. Halpern**
Groundtruthing cumulative impact models in nearshore ecosystems of the California Current (S8-8958)

12:10 (*cancelled*) **Kelly S. Andrews, Greg D. Williams, Jameal F. Samhouri and Phillip S. Levin**
Indicators, status and common trends of anthropogenic pressures in the California Current (S8-8990)

12:10 ***Lunch***

14:00 **Yunne-Jai Shin, Jennifer Houle, Alida Bundy, Marta Coll, Penny Johnson, Chris Lynam, Lynne Shannon and Laure Velez (Invited)**
A multi-model evaluation of ecosystem indicators' performance (S8-9119)

14:25 **Caihong Fu and Yunne-Jai Shin**
Exploring ecological indicators to evaluate fishing and environmental impacts on ecosystem attributes (S8-8999)

14:45 **Vladimir V. Kulik**
Comparing environmental changes over the past 10 years with the states and trends of the ecosystem indicators proposed by IndiSeas in the Sea of Okhotsk (S8-8972)

15:05 **Kirstin K. Holsman and Stephani Zador**
Methods to characterize risk of Alaskan marine habitats to multiple stressors and establish ecosystem reference points (S8-8992)

15:25 ***Coffee/Tea Break***

15:45 **Stephen B. Brandt and Cynthia Sellinger**
Growth rate potential as a quantitative ecosystem indicator of habitat quality (S8-9101)

16:05 **Doug Hay, Jake Schweigert, Jennifer L. Boldt, Jaclyn Cleary, Thomas A. Greiner and Kyle Hebert**
Decadal change in eastern Pacific herring size-at-age and gonad size: A climate connection? (S8-8988)

16:25 (*cancelled*) **Myron A. Peck, Marta Moyano and Marc Hufnagl**
Making meaningful links between modelled ocean physics and measured organismal physiology: Climate impacts on North Sea herring as a case study (S8-9179)

16:45 **Kisaburo Nakata**
The pelagic and benthic coupled biogeochemical cycle model study for Mikawa Bay estuary (S8-9005)

17:05 **Kyung-Su Kim, JeongHee Shim and Suam Kim**
The combined effects of elevated CO_2 and temperature on the survival, growth and skeletal formation of olive flounder larvae *Paralichthysolivaceus* (S8-8914)

17:25 *Comments and Discussion*

17:30 *Session Ends*

Day 2, Friday, October 18 (09:25-12:10)

09:05 (*cancelled*) **Mingyuan Zhu, Ruixiang Li, Zongling Wang and Mingzhu Fu (Invited)**
Ecosystem changes in Jiaozhou Bay, China (S8-9038)

09:30 (*cancelled*) **Jameal F. Samhouri, A. Ole Shelton, Blake E. Feist, Greg D. Williams, Krista Bartz, Ellie Canade, Hannah Fotherby, Mindi Sheer and Phillip S. Levin**
Land cover as a marine ecosystem indicator? Diversity and ecosystem functions along an urban gradient in Puget Sound (S8-9082)

09:25 ***Introduction by Convenors***

09:30 **Skip McKinnell**
A quantitative method for assessing the interactions of multiple stressors; How I learned to compare apples and oranges (S8-8851)

09:50 **Motomitsu Takahashi and Mingyuan Zhu**
Ecosystem responses to anthropogenic activities and natural stressors in the East China and Yellow Seas (S8-9073)

10:10 **R. Ian Perry, Jameal F. Samhouri and Motomistu Takahashi**
Developing indicators for ecosystem responses to multiple pressures: Case studies between the eastern and western North Pacific (S8-8993)

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

12:10 **Sarah Ann Thompson, William J. Sydeman, Heather Renner and John F. Piatt**
Regionalizing seabirds as indicators of forage fish in Alaska (S8-9157)

11:10 (*cancelled*) **Blake E. Feist, Marlene A. Bellman, Elizabeth A. Becker, Karin A. Forney, Michael J. Ford and Phillip S. Levin**
Potential overlap of cetaceans with groundfish fishing fleets in the California Current (S8-9135)

11:30 **Yuxue Qin, Yuichi Shimizu and Masahide Kaeriyama**
Risk management for recovering chum salmon populations in the Iwate coastal ecosystem after the Tohoku catastrophic earthquake and tsunami (S8-8977)

11:50 **Yongjun Tian**
Interannual-decadalvariability in the large predatory fish assemblage in the Tsushima Warm Current regime of the Japan Sea with an emphasis on the impacts of climate regime shifts (S8-9089)

12:10 (*cancelled*) **Caren Barceló, Richard D. Brodeur, Jameal F. Samhouri and Lorenzo Ciannelli**
Ecosystem indicators of the fluctuating pelagic forage fish and predator community in the Northern California Current (S8-9185)

12:10 *Session Ends*

S8 POSTERS

S8-P1 **R. Ian Perry and Diane Masson**
A statistical approach to the development of ecosystem indicators for multiple pressures in the Strait of Georgia, Canada

S8-P2 **Peng Sun, Zhenlin Liang, Yang Yu, Yanli Tang, Fenfang Zhao and Liuyi Huang**
Trawl selectivity induced evolutionary effects on age structure and size at age of hairtail (*Trichiurus lepturus*) in East China Sea, China

S8-P3 **Guanqiong Ye, Jie Liu and Loke M. Chou**
Designing a network of coral reef marine protected areas in Hainan Island, South China

S8 Oral presentations, Day 1

October 17, 09:05 (S8-9118)

Testing and predicting synergy between multiple stressors

Isabelle M. **Côté**[1] and Emily S. Darling[1,2]

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Most ecosystems are experiencing multiple simultaneous anthropogenic pressures, which can compound natural disturbance regimes. There is widespread concern that these multiple stressors will interact synergistically to accelerate biodiversity loss. While true synergies have the potential to drive future trends in biodiversity and ecosystem function, the prevalence and magnitude of such interactions remain unclear, in large part because of confusion in how to define and test for the presence of synergy. Here, we define synergy as just one of three alternative ways in which multiple stressors can interact and we review straightforward statistical approaches and common pitfalls to measuring interactions among stressors. Through meta-analyses of published literature, we estimate the prevalence of synergies in ecological experiments. We also provide an example of how to test the nature of the interaction between multiple stressors in the field, using long-term data of coral cover on Kenyan coral reefs exposed to fishing and climate change. Finally, we introduce the notion of co-tolerance – the possibility that traits that favour resistance to one stressor are also effective in response to other stressors – as a possible avenue to predict the occurrence of synergies. Understanding how stressors interact and the mechanisms that drive their interactions can inform conservation and management decisions for ecosystems subject to human impacts.

October 17, 09:30 (S8-8851)

A quantitative method for assessing the interactions of multiple stressors; How I learned to compare apples and oranges

Skip **McKinnell**

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Understanding the relative influences of multiple and often incommensurable stressors is both a philosophical and technical challenge. This talk deals mostly with the latter. Researchers are increasingly interested in the response of a stressand to multiple stressors. The stress and is typically some vital rate affecting some a species or population. The stressors are typically factors, measured in different units, on differing scales, that are hypothesized to affect the stressand. A method is described that can accommodate the varying scales of the stressors using bio-windows. It can evaluate the relative influences of each stressor on the stressand, test for interactions among the stressors to determine which interactions are the most important, and reflect the influence of the stressors and their interactions through easy to interpret parameters. A worked example will be given.

October 17, 09:50 (S8-9135)

Expert elicitation of a Bayesian Belief Network for climate change effects on the Great Barrier Reef

Stephen **Ban**

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Coral reefs globally face a variety of threats, both natural and anthropogenic, that may act synergistically in ways that are complex and currently not well understood. Bayesian belief networks present an ideal tool for modeling the range of uncertainties that exist in the interface between social and ecological systems. They enable decision makers to solicit input and preferences from experts and non-experts alike through the use of subjective or qualitative knowledge and preferences about costs, threats, and values. Beyond weighting network/model parameters, stakeholder input may also drive the structure of the model itself. In this study, expert opinion from coral reef ecologists and managers was solicited to construct a Bayesian belief network (BBN) about the Great Barrier Reef ecosystem that highlights potentially synergistic relationships of concern as well as areas with knowledge gaps. This Bayesian network was then applied under various climate change scenarios to explore the consequences of uncertainty on management decisions for the Great Barrier Reef.

October 17, 10:10 (S8-9177)

A functional genomics approach to assessing ecosystem health and resilience in keystone bioindicator species

Helen J. **Gurney-Smith**[1], Catherine A. Thomson[1], Dan S. Sanderson[1], Jennifer Kimball[2] and Stewart C. Johnson[3]

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Despite playing critical roles in the function of the marine environment, our coastal and estuarine ecosystems are being exposed to ever-increasing threats caused by human activities as well as through large-scale potential climate change impacts. Increasing levels of urbanization, industrialization, domestic and industrial water usage result in increases in pollutant levels, affecting the health and productivity of these ecosystems. Marine mussels are dominant members of coastal and estuarine communities and are established worldwide keystone bioindicator species, as well as being important aquaculture organisms. Significant mass mortality events in these species (*Mytilus* spp.) prompted research to assess particular stressors on animal function, using functional genomics to examine initial impacts. Through a Genome BC funded grant, we are using a combination of normalized and subtracted libraries generated by the *Myt*-OME project, along with a developed microarray and qPCR assays to study the responses of marine mussels (*Mytilus edulis* and *M. galloprovincialis*) to environmental and anthropogenic factors. To date approximately 35,000 ESTs have been generated from various tissues over timed exposures, following the application of environmental, biological and physical stressors. Bi-directional sequences were then trimmed and annotated where possible, before development of a 15K feature oligoarray (15,744). The final array composition includes *Myt*-OME sequences with informative annotation, *Myt*-OME sequences of unknown function, sequences from public sources and control features. A brief overview of the project and gene expression results will be given, followed by a discussion of methods and applicability of such tools to studies of species vulnerabilities to anthropogenic and climate change.

October 17, 10:50 (S8-9166)

Ecosystem-based management indicators for a marine planning process in BC's north coast-Marine Planning Partnership (MaPP)

Joanna **Smith**[1,2], Charlie Short[1,3], Steve Diggon[1,4], John Bones[1,5], Matthew Justice[1,3], Andrew Day[6] and Stephanie King[6]

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The Marine Planning Partnership for the North Pacific Coast (MaPP) is a collaborative planning process for coastal and marine areas in the north coast of British Columbia, Canada. MaPP is a co-led partnership between the Province of British Columbia and First Nations governments, represented by the Coastal First Nations-Great Bear Initiative, the North Coast-Skeena First Nations Stewardship Society, and the Nanwakolas Council. Marine plans are being developed for four sub-regions: Haida Gwaii, North Coast, Central Coast, and Northern Vancouver Island. MaPP is using an ecosystem-based management (EBM) framework and developing indicators for ecological integrity, human well-being, and governance. This talk will briefly outline the methodology (see submitted talk by Day et al for a detailed description) and present draft indicators for monitoring EBM in the North Pacific Coast of British Columbia. These indicators are forming the basis of a MaPP EBM Indicator Toolbox to monitor the regional frameworks and sub-regional plans including objectives and strategies for climate change adaptation, marine uses and activities, marine pollution, and marine protected areas. It is too early for us to present on the results of using the indicators because the marine planning process is still underway, however we will discuss the potential use of indicators in connection with our work to analyze the vulnerability of ecosystem types to marine stressors, as well as in the context of a draft cumulative effects assessment framework. Finally, we will briefly discuss ideas for implementation of a monitoring program for the indicators in the toolkit.

October 17, 11:10 (S8-9170)

Developing social-ecological indicators for Canada's Pacific Marine regions: Steps, methods, results and lessons

Andrew **Day**[1,2], Thomas A. Okey[1,3,4], Micha Prins[2] and Stephanie King[1]

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In the past decade there has been increasing interest in assessing marine ecosystems and developing indicators to track and understand changes over time. A key direction in conducting assessments and developing indicators is recognizing that biophysical and human systems are interconnected. The increasing prominence of the concepts of coupled social-ecological systems and ecosystem-based management, and the related incentives to identify and integrate ecological and human well-being indicators, have expanded and advanced the vision of integrated assessment and management. However, more applied examples are needed, as reflected in the PICES conference themes.

We outline the steps and methods we used to develop indicators for different areas of Canada's Pacific marine social-ecological systems. Our approach began with conceptual models that identified key aspects of ecological systems (structure, function, and environmental quality) and human systems (social, economic, institutional, and physical). We then identified associated elements, valued components, and features. We undertook an extensive 'bottom-up' approach to identify indicators associated with each feature or valued component, drawing on different knowledge sources, including scientists, managers, sectors, and First Nations and community members. Candidate lists of indicators were then compiled, reviewed, and rated based on three dimensions of indicator selection criteria assembled from the literature and other sources—scientific soundness, relevance, and practicality. Ecological ratings were then weighted based on expert perceptions of the relative importance of the criteria. Our approach relied primarily on literature reviews, expert surveys and judgment, and workshops. We will present the results, key limitations, and opportunities associated with implementing this approach.

October 17, 11:30 (S8-9143)

Assessing direct and indirect risk from human activities to significant ecosystem components in the Northeast Pacific

Cathryn **Clarke Murray**[1], Megan E. Mach[2], Rebecca G. Martone[2], Gerald G. Singh[3], Kai M.A. Chan[3] and Miriam O[4]

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Despite the importance and irreplaceability of coastal ecosystems and the services they provide, degradation and loss of coastal ecosystems is intense and increasing worldwide. This is in large part due to a lack of understanding of how multiple human activities cumulatively affect ecological systems. Given the complexity of ecosystems and the shifting role of species in response to global change, considering both direct and indirect impacts to ecosystem components and indicators of ecosystem health is a priority for scientists and managers. Risk assessment is emerging as a tool for assessing complex relationships between multiple human activities and ecosystems. Yet, the risk assessment literature thus far has not incorporated how ecological components interact with other species or populations, and how risk results from these interactions. Without this knowledge, we cannot easily predict how human activities will impact ecosystem function, whether via direct impacts to ecological components and/or indirectly by affecting supporting species or processes. Here we describe a probabilistic risk assessment method to assess both direct and indirect risk to significant ecological components by incorporating habitat and trophic linkages. This methodology was applied to significant ecological components of the Pacific North Coast Integrated Management Area in order to estimate cumulative risk from land, coastal and ocean-based human activities. A comprehensive estimate of risk to ecological components and indicators of ecosystem health can facilitate ecosystem-based management and the sustainable use of coastal resources.

October 17, 11:50 (S8-8958)

Groundtruthing cumulative impact models in nearshore ecosystems of the California Current

Rebecca G. **Martone**[1], Melissa M. Foley[1,2], Megan E. Mach[1], Corina I. Marks[1,3], Carrie V. Kappel[4,5], Kimberly A. Selkoe[4,5] and Benjamin S. Halpern[4,5]

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Coastal and marine ecosystems face intense and increasing degradation due to overlapping stressors from human activities. In response, marine management and planning efforts have developed frameworks to depict cumulative effects from multiple stressors on ecosystems. Many of these approaches incorporate risk-based assessments relying on expert judgment about stressors to predict relative impact in different parts of the ocean. In theory these modeled impact scores represent the amount of human degradation in ocean and coastal ecosystems, but few have been groundtruthed empirically. Our study seeks to examine the congruence between modeled and empirically estimated impact scores developed for the California Current (Halpern *et. al.* 2009) along the central and southern coast of California, where extensive field-based monitoring offers an opportunity to ground-truth the impact-model scores. Using uni- and multivariate techniques, including general additive models, general linear models, and redundancy analysis, we have characterized relationships between cumulative and single impact scores and biological indices developed from existing ecological data from rocky intertidal, kelp forest and soft sediment habitats to test whether the cumulative impact model for the region matches empirical estimates of ecosystem condition. Results indicate that ecological indices in these ecosystems are correlated both with geographic and physical factors as well as specific impact scores, although not necessarily cumulative impact scores. Understanding these relationships can help managers of marine ecosystems identify indicators and reference points of cumulative impacts and determine how new activities are likely to alter ecosystem health and improve the regulation of future development and use of ocean resources.

October 17, 12:10 (S8-8990)

Indicators, status and common trends of anthropogenic pressures in the California Current

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As human population size and demand for seafood increases, human activities in the ocean (*e.g.*, fishing and shipping activity) and on land (*e.g.*, pollutants and runoff from agricultural activities) must be incorporated into management. Because these pressures originate from human activities, we should be able to assess current and historic levels and predict future levels of the pressure. Predictions should then be useful in testing various management scenarios. Here, we evaluated and chose indicators best suited to capture the trends and variability of each pressure. Then we gathered data sets and created a time series describing the status and trends of each pressure across the U.S. West Coast. Most indicators showed either significant short-term trends or their current status was at historically high or low levels. Taken together, these results supported two primary conclusions: 1) decreasing trends of several pressures (*e.g.*, shipping related indicators, industrial pollution, and recreational activity) potentially reflect slowing economic conditions over the last few years and 2) pressures at historically high levels have leveled off and are not continuing to increase, although nutrient input has increased over the last decade and dredging and shellfish aquaculture are increasing and may increase to historically high levels if short-term trends persist over the next few years. The cumulative effects of these pressures are difficult to analyze due to possible synergisms and antagonisms, but using dynamic factor analysis we found common trends among the 23 pressures that may be useful in relating changes between pressure and biological responses.

October 17, 14:00 (S8-9119)

A multi-model evaluation of ecosystem indicators' performance

Yunne-Jai **Shin**[1,2], Jennifer Houle[3], Alida Bundy[4], Marta Coll[5], Penny Johnson[6], Chris Lynam[7], Lynne Shannon[2] and Laure Velez[1]

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Progress on the Ecosystem Approach to Fisheries (EAF) relies heavily on the ability of scientists to provide an assessment of past and current ecosystem effects of fishing and an evaluation of the effectiveness of management measures to promote resource sustainability. In response, IndiSeas, an international collaborative program endorsed by IOC/UNESCO and Eur-Oceans, aims to perform comparative analyses of ecosystem indicators from many of the world's marine ecosystems to quantify the impact of fishing and to provide decision support for fisheries management. To be useful to management, ecosystem indicators must respond in a consistent and predictable way to fishing. However, recent studies have shown that indicators may have different responses to different fishing strategies and target groups, and this may be strongly case-specific. In IndiSeas, we propose to test indicators performance by exploring three distinct indicators' properties: sensitivity (does the indicator vary significantly under fishing pressure?), specificity (does the indicator respond primarily to fishing compared to other drivers?) and responsiveness (Does the indicator respond rapidly to fishing?). To achieve our goals, we adopt a comparative approach across models (EwE, OSMOSE, Atlantis, size spectrum) and ecosystems where we analyze the various responses of a set of ecological indicators to different fishing scenarios and in different environmental conditions. These first simulation analyses allow us to assess indicators' performance and to define the conditions in which indicators can best support management decision.

October 17, 14:25 (S8-8999)

Exploring ecological indicators to evaluate fishing and environmental impacts on ecosystem attributes

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Ecosystem-based fisheries management (EBFM)accounts for fishing effects in conjunction with climate variability and species interactions when formulating fisheries management advice. To support the implementation of EBFM, it is important to develop and monitor ecological indicators to assess ecosystem status in relation to ecosystem properties, *i.e.*, stability, resilience, and productivity, and to evaluate the effectiveness of management strategies. In this study, an individual-based ecosystem model was applied to the Strait of Georgia in British Columbia, Canada to simulate three climate regimes over a period of 60 years and 30 fishing scenarios (single- and multiple-species fisheries at different fishing levels) for the purposes of exploring fishing and environmental impacts on four ecosystem attributes (stability, resilience, total biomass, and mean trophic level). Our results indicate that higher fishing mortalities tend to lower ecosystem stability and resilience, but the relative impacts between different fishing levels vary with the types of fisheries and climate regimes. Results indicate that fisheries management strategies should be evaluated in an ecosystem context and consider climate variability in order to implement effective EBFM.

October 17, 14:45 (S8-8972)

Comparing environmental changes over the past 10 years with the states and trends of the ecosystem indicators proposed by IndiSeas in the Sea of Okhotsk

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Indicators proposed by the IndiSeas working group http://www.indiseas.org/ were used to measure the states of the Sea of Okhotsk ecosystem every 2 years since 2003, and the decomposed time series were used to study trends over time. Total biomass in tons of surveyed species is considered to be highly biased due to annual variation of the research area, time period and methods of biomass calculation. The median of tons per square km was used instead. Thus "inverse fishing pressure" was corrected to catch the change in "biomass indicator" by substitution of the same unit (tons/km^2) in landings. The Russian monitoring system for the fisheries fleets do not contain information about the area covered by fishing gears. Instead, we tried to derive it through pattern recognition of vessel's tracks, types of vessels and their operations. There are 3 main groups of exploited fishes in the Sea of Okhotsk: walleye pollock, salmon and herring, which together accounted for over 90% of the catch or about 1.5 million tons in 2012, but we excluded salmon catches (and "salmon scientific surveys" consequently), because changes in the abundance of salmon reflect environmental conditions that were several times greater area than we observed. Jellyfish species were excluded, because their significant contribution to total biomass results mostly from water. Finally, we started statistical comparisons of time series of ecosystem indicators with lagged main modes from maximum covariance analysis of SST and sea ice concentrations, and the Siberian atmospheric index. We found strong correlations, which could be also related to the duration when resources were not available (*e.g.* under ice) to fisheries operations.

October 17, 15:05 (S8-8992)

Methods to characterize risk of Alaskan marine habitats to multiple stressors and establish ecosystem reference points

Kirstin K. **Holsman** and Stephani Zador

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The eastern Bering Sea (EBS) and Gulf of Alaska (GOA) are large marine ecosystems located at similar latitudes and separated by the Alaska Peninsula. The EBS habitat is dominated by a broad, soft-bottom continental shelf, whereas the GOA habitat is a diverse mix of rocky shelf, canyon and deep water. Each is host to a similar suite of species, but has fundamentally different food-web structure and function. Both ecosystems are exposed to multiple natural stressors and anthropogenic activities that include direct and indirect effects of fishing and climate change. We present a composite index of ecosystem condition from combined risk scores for each of these Alaskan marine habitats. The approach provides information on the relative risk of each habitat to combined climate and anthropogenic pressures ($Risk_h$) as well as an overall index of the present condition of the ecosystem that can be compared to a target ecosystem reference point (ERP). The ERP and $Risk_h$ values can also be used to evaluate the probability of dropping below a specified ERP (and/or individual $Risk_h$) threshold under status quo or future climate conditions and management actions. Ecosystem components identified as at risk can then be targeted for intervention and evaluated for management actions through subsequent management strategy evaluations. The presentation is a contribution to the work of PICES Working Group 28 on the development of ecosystem indicators to characterize ecosystem responses to multiple stressors.

October 17, 15:45 (S8-9101)

Growth rate potential as a quantitative ecosystem indicator of habitat quality

Stephen B. **Brandt** and Cynthia Sellinger

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Fish growth rate is a quantitative, integrative and nonlinear response of a fish to the prevailing biological and physical/chemical conditions of the ecosystem. It has thus been considered a good indicator of habitat quality. Modeling a fish's Growth Rate Potential is a relatively new approach that asks: How well would a fish growth if placed in a particular environment? Spatially-explicit modeling of fish growth rate potential is a quantitative tool that integrates prevailing, modeled or predicted physical (*e.g.* temperature), chemical (*e.g.* oxygen concentration) and biological (*e.g.* prey sizes and densities) conditions to map habitat quality. Fish growth rate potential is species and size-specific. It provides a physiological measure of the quality of the environment from the fish's perspective and is usually a nonlinear response with threshold responses. This approach has been used in the Gulf of Mexico, Chesapeake Bay and the Great Lakes to examine how physical and biological spatial complexities and dynamics, hypoxia, nutrient loading and climate change affect fishes and to compare habitat quality across ecosystems. We suggest that spatial and temporal distributions of growth rate potentials for key top predators (*e.g.* Salmon, Tuna) could be used in the North Pacific to reflect the spatial and temporal heterogeneity of habitat quality and quantity and that summary values (*e.g.* volume of habitat (quantity) capable of supporting growth, cumulative frequency distributions) could provide robust ecosystem-level indicators of multiple stresses. Moreover, integration of growth rate potential across space and/or time may provide an index of ecosystem production.

October 17, 16:05 (S8-8988)

Decadal change in eastern Pacific herring size-at-age and gonad size: A climate connection?

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Length-at-age and weight-at-age of post-recruit herring has decreased in all herring populations in BC since the 1970s. Prior to 1970 size-at-age of herring varied, with relatively larger-sized fish occurring in the 1950s and preceding years. Size-at-age has decreased in California and some Alaskan populations. Also, size-at-age has decreased both in exploited and unexploited populations. Climate change is a plausible explanation for decreasing size-at-age. Ocean temperatures and hypoxia are increasing in parts of the northeast Pacific, including habitats used by herring. These factors can retard somatic fish growth. There is no evidence, however, that the smaller herring of recent years are in poorer condition as reflected in changes in the length-weight relationship or any standard condition factors. In contrast there is evidence of a relative increase in the gonad sizes – or the 'gonosomatic' index (gonad weight/total weight). The relationship between herring weight and gonad weight is non-allometric: in general larger herring have proportionately larger gonads than smaller herring. When examined by specific length intervals, both females and males show a temporal increase in their relative gonad weight and a corresponding decrease in their somatic weight. Herring may be responding to climate change in a way that is consistent with established geographic trends: individuals from southern populations tend to be smaller but with proportionally larger gonads and higher relative fecundity. Presently BC herring now more closely resemble California herring (of several decades ago) because they are now slower-growing and, like more southern populations, have increased their relative gonad size.

October 17, 16:25 (S8-9179)

Making meaningful links between modelled ocean physics and measured organismal physiology: Climate impacts on North Sea herring as a case study

Myron A. **Peck**, Marta Moyano and Marc Hufnagl

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A multi-disciplinary approach is likely the best avenue to gaining a cause-and-effect understanding of the impacts of climate change and other drivers on key species. We provide an example of how organismal level measurements of physiology and ecosystem modelling can be combined to infer mechanisms acting to constrain the productivity of a key player in marine ecosystems. Measurements of thermal windows (including tolerance), prey requirements and biochemical-based growth proxies have been made to understand how multiple factors (both intrinsic and extrinsic) combine to affect potential growth and survival of larval Atlantic herring. These measurements are used to better parameterize a physiological-based biophysical model of larval herring foraging and growth. The model has been used to understand prey requirements necessary to sustain observed growth and to examine the potential causes of the poor recruitment recently observed in North Sea Atlantic herring despite high spawner biomass of that stock. We highlight how physiological-based laboratory measurements and biophysical models can be dovetailed to yield tools that not only advance our mechanistic (process-based) understanding of factors affecting key species but also increase our confidence in projections of future climate impacts on herring and other fishes.

October 17, 16:45 (S8-9005)

The pelagic and benthic coupled biogeochemical cycle model study for Mikawa Bay estuary

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A model project for planning the return to healthy environmental conditions from the view point of the biogeochemical cycle in coastal bay estuaries has been proposed by the Ministry of Environment in Japan. Mikawa Bay, Aichi Prefecture, is the one of the model sites selected for this project. We developed a pelagic and benthic coupled ecosystem model to understand what happens in the biogeochemical cycle of the coastal system with the present topography and without land reclamation (topography in 1960) in Mikawa Bay. In the pelagic system, the size structure of phytoplankton and zooplankton are taken into consideration. In the benthic system, suspension feeder, deposit feeder and meiofauna are taken into consideration as well as primary and secondary chemical reactions entering into the sediment flux model. The model results show that the material flow from the primary production to higher trophic levels is more effective without reclamation than in the reclamation case. The volumes of the hypoxic water mass and the Oxygen Demand Unit (ODU), mainly hydrogen sulfide in the sediment, becomes decreasing dramatic in the case without land reclamation. The model results suggest that creating tidal flats and shallows in Mikawa Bay is far more effective for returning the area to a healthy environment than is control of total pollution from land origins.

October 17, 17:05 (S8-8914)

The combined effects of elevated CO_2 and temperature on the survival, growth and skeletal formation of olive flounder larvae *Paralichthysolivaceus*

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Since the industrial revolution, elevated CO_2 in the atmosphere has been causing ocean acidification and global warming. This study investigated the effects of both climate problems on the early development stage of olive flounder *Paralichthysolivaceus*. Fertilized eggs of olive flounder were reared over four weeks from fertilization in artificial conditions. Rearing conditions were selected based on the climate change scenarios in the IPCC 2007 report, and combined three different CO_2 concentrations (400-present day, 850 and 1550ppm) with two different temperatures(18 and 22°C). During experimental rearing, larvae were sampled once a week, and these samples were used for analyses of RNA/DNA ratios. After four weeks, all live larvae were sampled and measured for length and weight; otolith size and bone density were examined for differences using a scanning electronic microscope (SEM). We also examined the hatching rate among the different conditions in order to check for any effects of these changing environmental conditions.

S8 Oral presentations, Day 2

October 18, 09:05 (S8-9038)

Ecosystem changes in Jiaozhou Bay, China

Mingyuan **Zhu**, Ruixiang Li, Zongling Wang and Mingzhu Fu

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Jiaozhou Bay is in the middle of the south coast of Shandong peninsula (120°6′E~120°21′E, 35°57′N~36°18′N) with an area of 397 km^2 and shoreline length of 187 km. It is the so-called Mother Bay of Qingdao City. In the recent half century, there have been big changes in the social and economic conditions in Qingdao City, such as increasing population, increased use of fertilizer, the area of aquaculture, *etc.*, which has reduced the area of the bay area by about 40% and increased inputs of nutrients. The ecosystem changes in Jiaozhou Bay include the increase of phytoplankton and decrease of zooplankton as well as the increase of Harmful Algal Blooms, jellyfish, and sea star blooms.

October 18, 09:30 (S8-9082)

Land cover as a marine ecosystem indicator? Diversity and ecosystem functions along an urban gradient in Puget Sound

Jameal F. **Samhouri**[1], A. Ole Shelton[1], Blake E. Feist[1], Greg D. Williams[1], Krista Bartz[1], Ellie Canade[2], Hannah Fotherby[2], Mindi Sheer[1] and Phillip S. Levin[1]

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The extent of human activity in a region often doubles as an indicator of natural ecosystem responses to multiple stressors. For instance, habitat conversion and reclamation, harvest and hunting, and human population density are frequently assumed synonymous with reductions in the abundance of wild animal populations. However, it is surprising how rarely such assumptions are actually tested against real-world observation of the relationships between stressors and components of ecosystem structure and functions. In this study we investigated how land cover, a potential indicator of stressors such as toxic contaminants, nutrient loads, and extractive uses, related to empirically measured ecosystem responses in the nearshore marine environment of Puget Sound, WA, USA. Specifically, we estimated how invertebrate diversity and four ecosystem functions (primary production, secondary production, decomposition, and predation) varied across 12 watersheds characterized by perennial streams flowing directly into Puget Sound. In addition to measuring land cover, which spanned a gradient from highly rural (>80% forested) to heavily urbanized (>80% developed), we also tracked other factors that could influence these ecosystem response variables, such as temperature, salinity, stream flow, and nutrient loads. Marine primary productivity and decomposition rates tended to be lower in more urban than less urban areas, while predation rates and diversity were largely invariant across the urban gradient. These preliminary results suggest that land cover indicators can provide useful information about changes in natural ecosystems. Because ecosystem responses can be idiosyncratic, though, this study also highlights the importance of groundtruthing stressor-ecosystem relationships to ensure that indicators are indeed meaningful.

October 18, 09:50 (S8-9073)

Ecosystem responses to anthropogenic activities and natural stressors in the East China and Yellow Seas

Motomitsu **Takahashi**[1] and Mingyuan Zhu[2]

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We assessed ecosystem responses to anthropogenic activities and natural stressors in the East China and Yellow Seas. Based on published scientific reports and governmental data sources, we scored vulnerabilities represented as spatial scale, frequency, functional impact, resistance, and recovery time in a stressors-habitats matrix, and identified the most influential activities/stressors in these ecosystems. In both systems, land reclamation has reduced areas of wetland in the intertidal and coastal habitats. Increases in dissolved inorganic nitrogen due to water discharge from rivers have resulted in eutrophication, harmful algal blooms, hypoxia and acidification in the Chiangjiang Estuary and the adjacent shelf waters in the East China Sea. Atmospheric deposition of pollutants has caused contamination of shellfish in the Yellow Sea. Decadal changes in water temperature have been associated with population alteration among cold, temperate and warm water fishery species, such as herring, sardine, hairtail and anchovy. Changing water temperature in addition to intense fishing pressure have changed predator-prey interactions in the bottom layers of the Yellow Sea. Our results demonstrate that coastal development and nutrient input directly and synergistically affect coastal ecosystems, and that increasing water temperature and fishing pressure alter the community structure of fish resources in the East China and Yellow Seas. Further studies and management actions are urgently needed to reduce environmental disturbances.

October 18, 10:10 (S8-8993)

Developing indicators for ecosystem responses to multiple pressures: Case studies between the eastern and western North Pacific

R. Ian **Perry**[1], Jameal F. Samhouri[2] and Motomistu Takahashi[3]

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The goal of PICES WG28 is to develop indicators of ecosystem responses to multiple stressors in the North Pacific, as a contribution to the FUTURE program. In general, two types of approaches have been taken to respond to this challenge: mesocosm experiments which attempt to isolate and control a few stressors to observe the system response; or whole ecosystem studies which use statistical methods to attempt to identify those pressures responsible for observed ecosystem changes. Each approach has different strengths and weaknesses, with a major difference being the ability to conduct repeated observations. In this presentation we use a comparative approach on entire ecosystems to attempt to identify general ecosystem responses to multiple pressures, and appropriate system-level indicators. We include three coastal ecosystems as case studies: the Seto Inland Sea, Japan; the Strait of Georgia, Canada; and Puget Sound, U.S. For each, we identify the significant system-level pressures and the ecosystem responses to these pressures, using literature sources, and our own data and model-based analyses. We then attempt to develop indicators for the responses of each ecosystem to their multiple pressures. The focus at this stage is the development of a practical approach to link pressures with ecosystem responses and indicators thereof, and to compare these among the three systems, as a contribution to the work of PICES WG28.

October 18, 10:50 (S8-9185) - TIME CHANGED TO 12:10

Ecosystem indicators of the fluctuating pelagic forage fish and predator community in the Northern California Current

Caren Barceló[1,2], Richard D. **Brodeur**[3], Jameal F. Samhouri[4] and Lorenzo Ciannelli[1]

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Understanding the relative influence of different spatial and temporal scale determinants on the pelagic nekton community composition will likely increase the accuracy and precision of future ecosystem based management tools in the California Current. Towards this goal, we characterized the pelagic forage fish and predator community composition sampled in the Northern California Current (NCC; from ~44-48°N) between 1998 and 2011, in relation to regional and basin scale environmental covariates. We use a variety of ecosystem indicators to characterize the pelagic diurnal community, namely diversity metrics (Simpson's Diversity and Evenness, as well as Taxonomic Distinctness) and community metrics (ordination axes scores), and assess the relative importance of potential environmental stressors. We use Generalized Additive Mixed Effects Models to characterize the non-linear relationships (both spatial and temporal) of assemblage structure and diversity with environmental co-variates, such as in-situ physical data as well as derived indices. Additionally, for the most commonly sampled forage species (Northern anchovy, Pacific sardine, and Pacific herring) and abundant predators (spiny dogfish), as well as possible competitors (jellyfish), we derive spatial indicators to quantify the change in spatial distribution of individual species through time as well as an index of potential overlap between competitors or predators in distinct seasons and years. We also discuss our ongoing research with the same dataset to identify future exposure and risk scenarios given current and future oceanographic conditions.

October 18, 11:10 (S8-9135)

Potential overlap of cetaceans with groundfish fishing fleets in the California Current

Blake E. **Feist**[1], Marlene A. Bellman[1], Elizabeth A. Becker[2], Karin A. Forney[2], Michael J. Ford[1] and Phillip S. Levin[1]

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Cetacean populations worldwide are confronted by a multitude of anthropogenic threats. Whaling, vessel and fishing gear interactions, resource competition, and habitat disturbance are just a few examples. While commercial fishing activity is directly associated with many of these threats, few studies have addressed the potential vulnerability of cetacean species to multiple fishing fleets operating over a large geographic area. We overlaid an existing spatially explicit model of predicted mean annual density of 11 cetacean species and one species guild within the California Current Large Marine Ecosystem (CCLME) with West Coast Groundfish Fishery commercial fishing effort data for fixed-gear, at-sea hake mid-water trawl, and bottom trawl fleets. We quantified the exposure of each species to each fleet type by multiplying the predicted mean annual cetacean density by the observed fishing fleet effort from 2002-2009. We found that there was large inter-specific and inter-fleet variability in the overlap between cetaceans and fishing fleets and this variability was not consistent over space or time. While many of the species had relatively low overlap rates, others had significantly more overlap with some fleets. While there is limited evidence of direct mortality from the activities of these fleets, our results suggest there is opportunity for fisheries interactions with some cetacean species, particularly in the fixed gear fleet. Our analyses are an important first step in generating formal risk assessments for quantifying the population level consequences of various fishing fleets on cetaceans living in the CCLME.

October 18, 11:30 (S8-8977)

Risk management for recovering chum salmon populations in the Iwate coastal ecosystem after the Tohoku catastrophic earthquake and tsunami

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To clarify the recovery process of coastal ecosystems and the life history of juvenile chum salmon in the Iwate neritic region after the Tohoku catastrophic earthquake and tsunami (TCET), we surveyed growth and trophic condition of juvenile chum salmon collected by a lamp-blanket net using analyses of scales, otolith thermal marking, and carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) stable isotopes during the spring of 2012. Juvenile chum migrated to the offshore at 90-100 mm FL in the middle May, and 70-80 mm FL in late May. Their body size and period at the offshore migration in 2012 was smaller and earlier than those before the Tohuku earthquake and tsunami (TCET). Juveniles had -15.726±0.791‰ in $\delta^{13}C$ and 12.139±0.633‰ in their $\delta^{15}N$. Their trophic level was the same as greenling, sculpin, and rock blenny, and was higher than Japanese eel, snipefish, juvenile Pacific cod, and mullet. It is therefore very important to clarify how the survival of these juveniles is affected by the difference in offshore migration pattern (smaller body size and earlier migration period), despite no change in their trophic level. Adopting a risk management approach for coastal ecosystems which include chum salmon populations will be necessary to ensure the sustainability of chum salmon in the Tohoku region after the TCET and under a warming climate.

October 18, 11:50 (S8-9089)

Interannual-decadalvariability in the large predatory fish assemblage in the Tsushima Warm Current regime of the Japan Sea with an emphasis on the impacts of climate regime shifts

Yongjun **Tian**

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Long-term variability in the catches of high trophic level, large predatory fishes (18 taxa including pelagic and demersal species) in the Tsushima Warm Current regime of the Japan Sea, were examined to identify their response to climate regime shifts. Total catch of these large predatory fishes decreased during the 1970s and 1980s but increased since the 1990s with large differences in individual species. Pelagic fishes such as yellowtail and tunas decreased during the 1980s and increased during 1990s; while the demersal species such as Pacific cod showed opposite variation pattern with the pelagic species. A principal component analysis for these 18 taxa suggested decadal variation patterns with step changes that occurred around the mid-1970s, late-1980s and late 1990s in the first two principal components (PC1-2). PC1 accounted for 52% of the total variance, and corresponded well with the winter water temperature in the Japan Sea, while PC2, which accounted for 16% of the total variance, showed a correspondence with both the summer water temperature and total catch of zooplanktivores. Generalized additive models (GAM) were applied to identify the effect of environmental factors on the PCs. These results suggested that the variability in the large predatory fishes were greatly associated with the late 1980 climatic regime shift as indicated by the winter temperature, while the summer water temperature and prey conditions may also have impacts on the trend.

October 18, 12:10 (S8-9157) - TIME CHANGED TO 10:50

Regionalizing seabirds as indicators of forage fish in Alaska

Sarah Ann **Thompson**[1], William J. Sydeman[1], Heather Renner[2] and John F. Piatt[3]

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Seabirds are conspicuous, highly mobile samplers of forage fish and have been shown to closely track environmental variability and forage fish abundance at a range of spatio-temporal scales. Seabird population parameters are monitored at colonies where large numbers gather annually to reproduce. Breeding success (productivity) is measured with relative ease and relates well with prey abundance (Cury *et al.* 2011). Phenology (timing) of breeding is a sensitive indicator of the seasonal timing of local prey abundance. Reproductive success and phenology (mean hatching date) data for four seabird species from 14 Alaskan colonies were collated. Six colonies in the Bering Sea and Aleutian Islands (BS-AI) with relatively complete time series were used in analyses (data from 1989-2008 for phenology and 1989-2012 for productivity). Missing values were filled with multiple imputation, and the covariance between species and sites was investigated using principal component analysis. Specifically, we addressed the question: Can sites or taxa be combined to produce regional indicators? Results show that combining sites but not genera is a valid approach to obtain a regional perspective. For each species, 3-5 colonies in the BS-AI ecosystem covaried sufficiently to be combined linearly as a proxy of environmental variation and/or prey abundance. By regionalizing the seabird "seascape" and linking these results to BS-AI seabird food habits (available for some, but not all species and sites), we provide a unique perspective on forage fish distribution and abundance to complement more traditional sampling methods.

S8 POSTERS

S8-P1

A statistical approach to the development of ecosystem indicators for multiple pressures in the Strait of Georgia, Canada

R. Ian **Perry**[1] and Diane Masson[2]

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A Driver-Pressure-State-Impact model of the Strait of Georgia, Canada, was developed as a framework to characterise the low frequency temporal responses of this system to natural and anthropogenic pressures since 1970, and to identify suitable indicators of these changes. Thirty-seven time series were assembled for multivariate statistical analyses. Principal component analyses identified regime-like shifts corresponding to those generally accepted for the NE Pacific. Redundancy analyses identified significant relationships in which the multiple natural and human explanatory driver/pressure variables accounted for 72% of the variability of the state/impact response variables. Partitioning this variance among the natural and human drivers/pressures attributed 4% to the natural drivers/pressures alone and 16% to the human drivers/pressures alone, but 53% to the interactions between natural and human drivers and pressures. Both sets of driver and pressure variables (natural and human) are necessary to account for the patterns of variability of the state and impact variables in the Strait of Georgia. Redundancy analysis also identified a reduced set of driver/pressure variables which accounted for a large proportion of the variability in the state and impact response variables: sea surface temperature, wind speed, the North Pacific Gyre Oscillation index, human population surrounding the Strait of Georgia, recreational fishing effort, and the number of hatchery releases of Chinook salmon (*Oncorhynchus tshawytscha*) into the Strait. These six explanatory variables are proposed as leading indicators for low frequency changes (regime shifts) in the Strait of Georgia marine social–ecological system for use within a broader monitoring program.

S8-P2

Trawl selectivity induced evolutionary effects on age structure and size at age of hairtail (*Trichiurus lepturus*) in East China Sea, China

Peng **Sun**[1], Zhenlin Liang[1,2], Yang Yu[1], Yanli Tang[1], Fenfang Zhao[1] and Liuyi Huang[1]

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In recent years, an increasing amount of evidence has demonstrated that life history traits have changed in many exploited fish populations, mainly because of the intense fishing mortality and the size-selectivity of fishing. Trawl fishing, which has been broadly and intensively used for a long period, has great potential to change the biological characters of exploited fish populations. We developed an individual-based model to explore interactions between trawl fishing and evolutionary changes of length at age and age structure for exploited fish populations. In our model, we simulated a perennial fish population with multiple age structure to examine the effects of long-term trawl fishing on hairtail in the East China Sea. The results revealed that the body length at age distribution and age structure of the fish population irreversibly changed under long-term trawl fishing. The simulated results confirm that the length at age was turning shorter with younger individuals dominant after fishing. Influences of trawl selectivity on the biological traits of fish populations can be very significant and these changes have potential evolutionary consequences on body length at age.

S8-P3

Designing a network of coral reef marine protected areas in Hainan Island, South China

Guanqiong **Ye**[1], Jie Liu[2] and Loke M. Chou[1]

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Hainan Island, situated in the South China Sea, has a 1823km long coastline harbouring a wide range of reef systems. To date, 110 hermatypic corals species from 34 genera have been identified representing two-thirds of the total hard coral species in China. Coral reefs play a vital role both in the island's economic development and biodiversity conservation. However, over-exploitation of reef resources and increasing coastal tourism have severely damaged the health of coral reefs. Live coral cover of the island's fringing reefs has decreased by 95% since the 1960s. Networks of Marine Protected Areas (MPAs) have been widely proposed as a most promising management tool for reef conservation. Since 1983, two national nature reserves and two provincial nature reserves have been designated for coral reef protection along the east coast of Hainan Island. However, only some reef sites are protected, and an MPA network has not been established. In this study, we used the most comprehensive information currently available on the distribution and condition of Hainan's coral reefs to assess reef status, and determined other important reef areas that require protection. We also examined current management schemes of MPAs to identify weaknesses and strengths for MPA network establishment. Using the coral reef status assessment and current management scheme, we incorporated other important reef sites with existing MPAs to form a reef management network for the island under the general framework of integrated coastal management.

S9 MONITOR Topic Session
Cost-effective, cooperative ocean monitoring

Co-Convenors: Steven J. Barbeaux (USA), Jennifer Boldt (Canada), Martin Dorn (USA) and Jaebong Lee (Korea)

Invited Speaker:
Sonia Batten (Sir Alister Hardy Foundation for Ocean Science, UK/Canada)
Chris Rooper (NMFS-Alaska Fishery Science Center, USA)

Long-term monitoring is a key component of an ecosystem-based approach to fisheries management. Data time series enable the examination of changes in oceanographic and community metrics. In addition to costly ocean monitoring systems with sensor arrays and autonomous vehicles, low cost cooperative monitoring efforts would enhance our understanding of marine ecosystems, as well as help insure their long-term viability. An important consideration for sustainable long-term ocean monitoring is the development of affordable solutions to deploying and retrieving sensors. Sustainable long-term ocean monitoring is successfully being implemented at regional scales with low-cost options as presented in the 2012 PICES Annual Meeting session entitled "Monitoring on a small budget: Cooperative research and the use of commercial and recreational vessels as sampling platforms for biological and oceanographic monitoring". Researchers from many nations are now working with other ocean going stakeholders such as fishers and mariners to collect oceanographic and fisheries data for little to no deployment and retrieval costs. This session is intended to provide a forum for researchers to present the development and results of cooperative monitoring projects world-wide. The session will also explore the feasibility of developing low-cost and long-term cooperative ocean monitoring networks based on the lessons learned from these projects. When combined with efforts such as the Global Oceans Observing System (GOOS), cooperative ocean monitoring networks will make an important contribution to achieving data-driven ecosystem-based management.

Tuesday, October 15 (09:00-10:35)

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

09:05 **Sonia Batten (Invited)**
Ship of opportunity sampling of lower trophic levels (S9-8905)

09:30 **Kyung-Il Chang, Ki-Wan Kim and Sang-Uk Lee**
Use of snow crab traps as sampling platforms for deep sea monitoring in the East/Japan Sea (S9-8895)

09:50 **J. Anthony Koslow and Jennifer Couture**
Are current ocean observation networks adequate? A model for cooperative observation programs as the basis for ecosystem-based management, ocean climate research and assessment of ecosystem change (S9-9059)

10:15 **Carrie C. Wall, Rodney A. Rountre and Francis Juanes**
Understanding the marine soundscape off Vancouver Island: An exploration of passive acoustic data from the NEPTUNE Canada ocean observing system (S9-9060)

10:35 *Session Ends*

CANCELLED

09:50 (cancelled) **Christopher N. Rooper, Michael H. Martin and Mark E. Wilkins (Invited)**
Using acoustic data to map the presence or absence of deep-water sponges and corals in closed areas in the Gulf of Alaska (S9-9191)

11:00 (cancelled) **John H. Harms**
The Northwest Fisheries Science Center's Southern California Hook and Line Survey for shelf rockfish in cooperation with the sportfishing industry (S9-8951)

11:40 (cancelled) **Steven J. Barbeaux, Dave Fraser, Lowell Fritz and Elizabeth Logerwell**
Developing real-time local fishery management through cooperative acoustic surveys in the Aleutian Islands (S9-9107)

S9 POSTERS

S9-P1 **Hisashi Yamaguchi, Hiroshi Murakami, Xu Yongjiu, Takayuki Kusunoki and Masahito Ebina**
Understanding the estimated error of the satellite chlorophyll *a* in Mutsu Bay

S9-P2 **Tomoko M. Yoshiki, Sanae Chiba, Tadafumi Ichikawa, Hiroya Sugisaki and Sonia Batten**
Geographical shift of warm water species distribution in western subarctic North Pacific based on CPR sample during 2001-2010

S9-P3 **Shin-ichi Ito, Kazushi Tanaka, Yuki Endoh, Takeshi Yamanome, Shinnosuke Kaga, Taku Wagawa and Shigeho Kakehi**
Reconstruction of coastal sea water temperature monitoring systems and real-time broadcast to fishermen in Iwate Prefecture

S9 Oral Presentations

October 15, 09:05 (S9-8905)

Ship of opportunity sampling of lower trophic levels

Sonia **Batten**

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Continuous Plankton Recorders (CPRs) have been deployed from commercial ships and other vessels of opportunity on their regular routes of passage for multiple decades and in several of the world's oceans. These surveys generate spatially and temporally referenced quantitative data on the abundance and distribution of many zooplankton and larger phytoplankton taxa, providing insights into the base of the marine food chain and lower trophic level responses to hydroclimatic variability. Benefits of the approach, (*e.g.* highly cost-effective sampling of large, remote oceanic regions) are discussed as well as limitations (*e.g.* lack of control over exactly when and where sampling occurs). In more recent years, the CPR has itself become a sampling platform with instrumentation added to the towed body which autonomously collects physical data (T, S, D) and chlorophyll fluorescence, or microplankton via a self-contained water sampler. The North Pacific CPR survey has also, in the past, made use of marine bird and mammal observers onboard the vessel. There is thus the potential to develop large scale, multi-trophic level monitoring programs with some supplemental physical data. While microscopic processing of all CPR survey data can take several months to complete, more recently a near-real-time approach has been adopted along some transects with data available within 60 days. This presentation will describe the CPR sampling program, its strengths and weaknesses and highlight its contribution to oceanographic monitoring.

October 15, 09:30 (S9-8895)

Use of snow crab traps as sampling platforms for deep sea monitoring in the East/Japan Sea

Kyung-Il **Chang**[1], Ki-Wan Kim[2] and Sang-Uk Lee[2]

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[2] OTRONIX, Seoul, 140-113, R Korea

The East Sea is a deep marginal sea and has been experiencing rapid changes in deep water properties. We devised a system to monitor deep sea environment and acquire full-depth profiles of water properties regularly, like an ARGO float, using snow crab fishing boats. The Korean snow crab fishing activities are widespread in the southwestern East Sea at about 40 locations in a depth range between 500m and 1500m. The deployment and recovery of traps take place regularly approximately once a weak if sea state permits. The system consists of a Microcat with dissolved oxygen sensor and a data logger. The Microcat, attached to a trap, profiles CTD and dissolved oxygen while the trap is deployed and recovered. It records water properties for about a week while it stays near the seabed with the trap. Once the trap is on the vessel's deck, data inside the Microcat are automatically transferred to the compact logger set in the bridge of the boat, and then transferred to our lab *via* any available communication system. Further details of the system and sample data acquired by the system will be presented.

October 15, 09:50 (S9-9191) -CANCELLED

Using acoustic data to map the presence or absence of deep-water sponges and corals in closed areas in the Gulf of Alaska

Christopher N. **Rooper**, Michael H. Martin and Mark E. Wilkins

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Corals and sponges are slow-growing and vulnerable to damage from fishing gear. As a result, many areas where corals and sponges are prevalent have been closed to fishing throughout the world. Three areas in the western Gulf of Alaska with little historical fishing effort and believed to contain significant sponge and coral habitat were closed to fishing in 2005. In August of 2010 we conducted a cruise aboard a chartered fishing vessel to evaluate the

prevalence of coral and sponge habitat in these areas. We conducted 73 camera drops within the three areas noting the presence of sponge and coral, while simultaneously collecting acoustic data from the vessel's echosounder. The objective of the analysis was to model the presence of coral and sponge habitat in the closed areas using the acoustic data, and to use the model to infer likely coral and sponge habitat throughout the designated closed areas. Depth, slope and seafloor hardness were estimated from the acoustic data and interpolated into raster maps. These variables were extracted at camera drop locations and used in GAM'sto predict the presence or absence of coral or sponge. The analysis indicated that only a small fraction of the areas have seafloor characteristics that would likely support significant coral and sponge formation. The acoustic data used in the analysis were collected with a commercial grade echosounder that is commonly available on fishing vessels in Alaska, highlighting the possibility of further opportunistic acoustic data collection to map coral and sponge habitat in Alaska.

October 15, 10:15 (S9-9059)

Are current ocean observation networks adequate? A model for cooperative observation programs as the basis for ecosystem-based management, ocean climate research and assessment of ecosystem change

J. Anthony **Koslow** and Jennifer Couture

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Are current ocean observation networks adequate for ecosystem-based management, ocean climate research and assessment of ecosystem change? We carried out a meta-analysis of Pacific Ocean observation programs, which indicated that while the physics is generally well-monitored, biological monitoring remains inconsistent, fragmented, ad hoc, and with critical data access issues still unresolved. We propose a model for cooperative monitoring between government fisheries and ocean agencies and academic oceanographic institutions that can provide the basis for fisheries stock assessment within the context of the physical and biological oceanographic environment. This partnership enhances ecosystem-based management and the development of robust ocean climate and ecosystem research that is able to provide time series for the ocean environment 'from winds to whales'. The CalCOFI program is offered as a model, albeit imperfect and continuing to evolve.

October 15, 11:00 (S9-8951) - CANCELLED

The Northwest Fisheries Science Center's Southern California Hook and Line Survey for shelf rockfish in cooperation with the sportfishing industry

John H. **Harms**

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Fishery-independent data on the abundance and biology of key fish stocks are essential for generating reliable stock assessments. In the current environment of fiscal restraint, research budgets are static or shrinking, but advances in computing power, the proliferation of specialized assessment software, and the constant need to reduce uncertainty in harvest recommendations require increasingly large and complex data sets. A challenge for today's fishery scientists is collecting information that supports modern data-intensive stock assessments but on reduced budgets. One option is to partner with the fishing industry whose vessels provide cost-effective research platforms and whose years of experience on the water can yield useful insights and observations about the resource.

On the U.S. West Coast, there is an established history of conducting research surveys aboard commercial fishing vessels. The AFSC conducted annual and triennial shelf trawl surveys from 1977-2001, and the NWFSC has conducted slope and shelf trawl surveys on chartered fishing boats annually since 1998. Here, we share our experience working with a different sector of the industry - commercial sportfishermen - to conduct a hook and line survey of shelf rockfish along the Southern California coast. The project began in 2002 in response to an acute need for data on overfished species and relied heavily on industry input in its design and methodology. The survey has been a success, having recently completed its 10th annual field season and has generated data that have been incorporated into 8 stock assessments for 5 different species.

October 15, 11:20 (S9-9060)

Understanding the marine soundscape off Vancouver Island: An exploration of passive acoustic data from the NEPTUNE Canada ocean observing system

Carrie C. Wall[1], Rodney A. Rountre[2] and Francis **Juanes**[1]

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NEPTUNE Canada is a cabled ocean network containing five nodes located in the Northeast Pacific Ocean. A suite of data is collected at each node to characterize the chemical, geological, physical, and biological properties of the surrounding ocean environment. In particular, passive acoustic data are recorded at two nodes, Folger Passage (100 m depth) and Barkley Canyon (985m depth). Elevated anthropogenic noise in marine soundscapes and their potential to decrease communication efficacy of marine organisms is of increasing global concern. The deepsea soundscape is particularly vulnerable to increasing anthropogenic noise while at the same time the ecosystem is being subjected to increasing pressures from resource users. Using the acoustic data collected at the Folger Passage and Barkley Canyon sites over a one year period, we sought to quantify the levels of ambient noise, including vessel traffic, and identify the occurrence of biological sounds, namely potential fish sound production. Acoustic files were recorded for 5 minutes every hour at a 96 kHz sample rate from approximately June 2010 to May 2011. A subset of acoustic data was analyzed manually to determine sounds and their associated frequencies recurring throughout the year. This analysis was supplemented with a semi-automated comparison of the amplitude and frequency ranges associated with soniferous fish and marine mammals, and vessel traffic. These efforts aimed to better understand the undersea soundscape and determine the potential impact of anthropogenic sound in masking acoustic communication. Complications due to extensive self-generated instrument noise will be discussed.

October 15, 11:40 (S9-9107) - CANCELLED

Developing real-time local fishery management through cooperative acoustic surveys in the Aleutian Islands

Steven J. **Barbeaux**[1], Dave Fraser[2], Lowell Fritz[1] and Elizabeth Logerwell[1]

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The development of spatially and temporally explicit fishery management system designed to limit fishery impacts on protected species based on cooperative acoustic surveys is explored. In Alaska, commercial fisheries have been implicated in the slow recovery of the endangered Western stock of Steller sea lions (*Eumetopias jubatus;* hereafter W-SSL). To address this issue the directed Aleutian Islands walleye pollock (*Theragra chalcogramma;* hereafter pollock) fishery was closed in 1999. Although the fishery was reopened in 2005, W-SSL critical habitat in the Aleutian Islands remained closed to directed pollock fishing; a de facto closure of the fishery as most Aleutian Islands pollock habitat overlaps with W-SSL critical habitat. In 2006 through 2008 fishery biologists with the Alaska Fisheries Science Center along with the Aleut Corporation, fish processors, and fishers explored the feasibility of conducting small-scale cooperative acoustic groundfish surveys. The surveys were designed by fishery biologists, but conducted by fishers. Biological data collected from the concurrent fishery were used to characterize acoustic backscatter. The surveys were meant to provide spatially and temporally relevant estimates of groundfish biomass that could be used to set acceptable biological catch levels inside W-SSL critical habitat. The technical feasibility of conducting scientific grade surveys aboard fishing vessels and using fishery data to supplement the acoustic surveys was successfully demonstrated. This paper discusses the extension of cooperative acoustic surveys to develop a novel cooperative management system for groundfish fisheries within W-SSL critical habitat and application of this approach to other fisheries with similar scale-dependent management concerns.

S9 POSTERS

S9-P1

Understanding the estimated error of the satellite chlorophyll *a* in Mutsu Bay

Hisashi **Yamaguchi**[1], Hiroshi Murakami[1], Xu Yongjiu[2], Takayuki Kusunoki[2] and Masahito Ebina[3]

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Satellite remote sensing data was used to examine the seasonal variation of chlorophyll *a*, which might be an index of the growth of cultured scallop, in Mutsu Bay. Fifteen years monthly averaged SeaWiFs and MODIS standard chlorophyll-a from 2002 to 2011 in west and east part of Mutsu Bay showed a maximum value in March and October and in February and October, respectively. Meanwhile, in-situ chlorophyll *a* in west and east Mutsu Bay showed a maximum value in February and October and in February and November, respectively. Estimated error of satellite chlorophyll *a* for *in situ* chlorophyll *a* is small from spring to summer and large from autumn to winter. Negative remote sensing reflectance in short-wavelength and relatively high remote sensing reflectance around 550nm were observed in high satellite chlorophyll *a* areas from autumn to winter. It is considered that this estimated error occurs by an atmospheric correction failure caused by absorptive aerosol and an in-water algorithm failure caused by suspended sediment. This research is part of the combined research between Japan Aerospace Exploration Agency and National Research Institute of Fisheries science.

S9-P2

Geographical shift of warm water species distribution in western subarctic North Pacific based on CPR sample during 2001-2010

Tomoko M. **Yoshiki**[1], Sanae Chiba[2], Tadafumi Ichikawa[1], Hiroya Sugisaki[3] and Sonia Batten[4]

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Spatial and temporal variation of copepod community structure, abundance and biodiversity was examined in the western subarctic North Pacific (40-55ºN, 142-170ºE) during 2001-2010. Continuous Plankton Recorder (CPR) observational data during summer season (June and July) was analyzed. The warm water species group increased in abundance and was highest in 2009-2010, while cold water species abundance decreased. Mean copepod species diversity increased after 2006. We found a significant positive correlation between warm water species abundance and SST, and also between warm water species abundance and copepod diversity in each sampling location. The most abundant warm water species was *Calanuspacificus* which accounted for more than 90% of the total warm water species abundance, and which occurred in higher SST area (>7.5ºC). Although a small number of *C. pacificus* occurred only in an area south of 47ºN during 2001-2005, the distribution extended to the northern area than above 50ºN after 2006. Also it was more abundantly observed over almost the whole sampling location between 40-52ºN in 2009-2010. The SST in the North Western Pacific was warmer during 2006-2010 than during 2001-2005, and this agrees with the PDO pattern. The SST increase of 2006-2010 was considered to cause the geographical shift of warm water species distribution, and subsequently, the northward extension of the warm species was considered to be a one of the cause of the higher biodiversity.

S9-P3

Reconstruction of coastal sea water temperature monitoring systems and real-time broadcast to fishermen in Iwate Prefecture

Shin-ichi **Ito**[1], Kazushi Tanaka[2], Yuki Endoh[2], Takeshi Yamanome[2], Shinnosuke Kaga[2], Taku Wagawa[1] and Shigeho Kakehi[1]

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Iwate Prefecture is located in the northern part of Japanese Main Island and faces to the North Pacific. Since the Oyashio, the western boundary current of the subarctic gyre, transports nutrient rich water to the coastal region, the prefecture was one of the most active aquaculture spots in Japan. On the other hand, the environmental variability is very high and sometimes aquaculture has been damaged by extreme high/low temperature. Therefore, dense monitoring system (automated thermistor at six ports) to monitor the water temperature had been established along the coast. However, the tsunami caused by the Great East Japan Earthquake on 11 March 2011 caused serious damage on the Pacific coast of East Japan. The coastal water temperature monitoring system in Iwate was not an exception. For smooth recovery of aquaculture from the disaster, the reconstruction of the monitoring system is needed. In 2013, we reconstructed the monitoring system at two ports (Kamaishi and Noda) and are planning to reconstruct four other systems by 2015. In addition, we set two current meters to provide velocity information to the fishermen. The observed data are broadcasted on the web site and also available on cellular phones.

S10 FIS/TCODE Topic Session
Banking on recruitment curves; Returns on intellectual investment

Co-Sponsored by ISC

Co-Convenors: Anne Hollowed (USA), Skip McKinnell (PICES), Hiroshi Okamura (Japan) and Cisco Werner (ISC)

Invited Speakers:
Louis Botsford (University of California at Davis, USA)
Jon Brodziak (NOAA/PIFSC, USA)

During the first half of the 20th century, one of the fundamental issues in the then nascent discipline of fisheries science was determining how many individuals could be removed from a fish population without affecting its ability to keep producing fish for a fishery. In the 1950s, theoretical solutions to this problem were discovered in mathematical formulations that emerged from the work of Ricker, Beverton, Holt and others. These closed-form solutions led to widespread adoption as electronic computing technology became widely available in fisheries labs in the 1960s. Concepts that emerged from their equations underpin current estimation of biological reference points used to set harvest strategies for many of the world's fisheries. Spawner-recruitment (S-R) curves serve as the foundation for what of a fish population remains to be conserved. With so much at stake, it is surprising that their application in contemporary fisheries is taken for granted. This session will delve into the good, the bad, and the ugly consequences of using recruitment curves, with an idea of determining whether an intellectual course correction is needed for the next 50 years. This topic session seeks papers that introduce new approaches to modeling the relationship between spawners and recruitment including: (1) incorporating predator prey interactions in S-R models, (2) use of coupled bio-physical models in identifying mechanisms linking spawners and recruitment, (3) consideration of the role of cohort resonance, (4) techniques for incorporating environmental variability into S-R functions, (5) stage-based S-R approaches, (6) comparative studies testing the performance of different methods relative to observations, and (7) decision rules regarding how to utilize knowledge of S-R relationships in formulating harvest advice. Enthusiasm for this topic session will be used to seek publication in a Special Issue in a primary journal.

Thursday, October 17 (09:00-15:30)

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

09:05 **Louis W. Botsford, J. Wilson White, Alan Hastings, Lauren Yamane, Flora Cordoleani, Patrick Kilduff and Allison Dedrick (Invited)**
Stock-recruitment and population variability in a changing, uncertain world (S10-8889)

09:30 **Michio J. Kishi, Seokjin Yoon, Takeshi Terui, Satoshi Suyama, Masayasu Nakagami and Shin-ichi Ito**
A Lagrangian modeling approach for Pacific saury migrations (S10-8963)

09:50 **Cheryl S. Harrison and David A. Siegel**
The tattered curtain hypothesis revisited: Coastal jets limit cross-shelf benthic larval transport (S10-9155)

10:10 **La Treese S. Denson and David B. Sampson**
Using environmental data to inform spatial stock assessments with Stock Synthesis (S10-9123)

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

10:50 *(cancelled)* **Jon Brodziak and Marc Mangel (Invited)**
Understanding and predicting population resilience via steepness (S10-9108)

11:15 *(cancelled)* **Ron A. Heintz and Edward V. Farley, Jr. (**
Measures of fish condition integrate environmental variability and reduce uncertainty in recruitment models (S10-9127)

10:50 **Jonathan I. Richar, Gordon H. Kruse, Albert J. Hermann and Enrique Curchitser**
Effects of shifting population demographics, oceanography, and predation on apparent stock-recruit relationships for Tanner crabs in the eastern Bering Sea (S10-8931)

11:10 **Catherine J.G. Michielsens, Mike Lapointe and Carl J. Walters**
Exploring density dependence, delayed density dependence and time varying productivity to explain decreased productivity of Fraser River sockeye salmon (S10-8919)

11:30 **Kirstin K. Holsman, Kerim Aydin and Jim Ianelli**
Using multi-species food-web and assessment models to evaluate climate change impacts on fisheries (S10-8920)

11:50 ***Lunch***

14:00 **Skip McKinnell**
A simple model framework for assessing salmon production and setting escapement targets (S10-8959)

14:20 **Robyn E. Forrest, Murdoch K. McAllister, Steven J.D. Martell and Carl J. Walters**
Modelling the effects of density-dependent mortality in juvenile red snapper caught as bycatch in Gulf of Mexico shrimp fisheries: Implications for management (S10-8855)

14:40 **Cody S. Szuwalski, Katyana A. Vert-Pre, Andre E. Punt, Trevor A. Branch and Ray Hilborn**
Environment drives recruitment dynamics for most marine fisheries (S10-8857)

15:00 (*cancelled*) **Anne B. Hollowed and Cody S. Szuwalski**
Setting biological reference points under a changing climate (S10-9095)

15:20 *Comments and Discussion*

15:30 *Session Ends*

October 17, 09:05 (S10-8889)

Stock-recruitment and population variability in a changing, uncertain world

Louis W. **Botsford**[1], J. Wilson White[2], Alan Hastings[3], Lauren Yamane[1], Flora Cordoleani[1], Patrick Kilduff[1] and Allison Dedrick[1]

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A central challenge facing marine science is to anticipate how marine populations will respond to new perturbations, such as climate change and ocean acidification, along with existing impacts, such as fishing. Predictions are constrained by meager observations of individual-level effects over short time periods, and uncertain stock-recruit relationships, especially at low abundance. Stochastic, age-structured models indicate both a) the average, equilibrium level of populations, and b) their frequency-dependent response to environmental variability depend on the interplay between: 1) the nature of the stock-recruit relationship and 2) the age distribution of spawning, through cohort resonance. Cohort resonance refers to the greater spectral sensitivity of populations to a) slowly changing environmental variability and b) variability on generational time scales. It is a characteristic of locally stable populations driven by environmental variability, typically on the left-hand, ascending limb of the stock-recruit relationship. Age-structured models allow available short-term observations of changes in individual growth, reproduction and survival patterns in the presence of direct anthropogenic effects, such as fishing, to be scaled up to predict the longer-term population-level changes in both mean equilibrium population levels and spectral sensitivity to the environment. Here we describe how the spectral sensitivity of recruitment, egg production and catch to variability in survival and growth rate change with fishing and the individual-level effects of ocean acidification. We also characterize cohort dominance in sockeye salmon and generational scale variability in Chinook salmon as extreme forms of cohort resonance.

October 17, 09:30 (S10-8963)

A Lagrangian modeling approach for Pacific saury migrations

Michio J. **Kishi**[1,3], Seokjin Yoon[1], Takeshi Terui[2,3], Satoshi Suyama[4], Masayasu Nakagami[4] and Shin-ichi Ito[4]

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A two-dimensional Individual-Based Model (IBM) coupled with fish bioenergetics model (NEMURO.FISH) has been developed to simulate the migration and growth of Pacific saury. In the model, fish movement was controlled by feeding and spawning migrations with passive transport by ocean currents. Feeding migration was assumed to be governed by the search for local optimal habitats, which was estimated from spatial and temporal data of water temperature and prey density. Migration was determined as a function of fish size, which depends on optimum temperature and best growth based on prey density. For instance, fish outside optimal temperature ranges move toward these regions until they reach the optimal regions, while fishes in the optimal temperature move towards a place with maximum growth condition, which is a function of prey density and fish stage. Spawning migration was modeled based on a "larval fitness algorithm", *i.e.*, spawning fishes search for locations where their larvae can grow best. In the model, the spawning period depends on the body length; the spawning migration starts one month prior to the spawning period and continues for two months. The model's environmental forcing included satellite data of SST, surface chlorophyll *a* concentration (which is converted to zooplankton density), and simulated surface current velocity. Spawning grounds were located between 30°N and 40°N but biased eastward; adding an artificial westward migration, the observed spawning area was obtained during the spawning season.

October 17, 09:50 (S10-9155)

The tattered curtain hypothesis revisited: Coastal jets limit cross-shelf benthic larval transport

Cheryl S. **Harrison**[1] and David A. Siegel[2]

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The exchange and retention of nearshore waters are important for understanding dispersal of coastally-originating material and thus the dynamics of marine ecosystems. Motivated by observations of larval recruitment patterns, a hypothesis was put forward in the 1980's describing the coastal upwelling front as a "tattered curtain," retaining coastally released larvae, but broken up by filaments and eddies. Here we revisit and revise the tattered curtain hypothesis using an idealized ocean model of an eastern boundary upwelling current driven by realistically time-varying winds. Larval settlement patterns in the model are largely controlled by retention in the upwelling jet. During settlement events, the upwelling jet is coherent along the coast on scales of 20-100 km, broken up by large squirts accommodating fast offshore transport. Regions of high coastal retention are bounded by high velocity shear at the flanks of the jet. Squirts, filaments and poleward moving eddies and meanders locally modulate settlement patterns, while dense packets move equatorward within the upwelling jet. High settlement events only weakly correlate with upwelling wind relaxation (r=0.33) and are better explained by a 20-day integrated wind product (r=0.62). Settlement is low after strong persistent upwelling completely tatters the jet; for moderate extended upwelling, coastal retention is high but highly variable in magnitude. These results suggest that jet cores should act as an important transport barrier and retention mechanism in coastal systems, a view supported by a wide range of observations, modeling studies and theoretical insights.

October 17, 10:10 (S10-9123)

Using environmental data to inform spatial stock assessments with Stock Synthesis

La Treese S. **Denson**[1] and David B. Sampson[2]

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Stock assessments evaluate the status of a stock and predict its future under alternative decisions for harvest management. Age-structured assessment models such as Stock Synthesis rely on data that describe the life history characteristics of the target stock as well as data describing the catch characteristics of the fishery. These models also have the ability to incorporate linkages to environmental data. The majority of assessed stocks consist of multiple heterogeneous subpopulations, which interact at various levels. Spatial differences have been identified in age-composition data for various nearshore species along the US West Coast. It is assumed that environmentally driven dispersal of larvae determines the spatial settlement pattern. Post settlement there is limited movement of young fish, which when coupled with non-uniform spatial harvesting, can generate important spatial structure within a stock. To examine the effects of spatial heterogeneity on stock assessment results, we simulated data for two subpopulations within a spatially structured stock. Simulation experiments manipulate environmental indices that drive relative recruitment to the subpopulations. A second experimental factor is the pattern of spatial exploitation. We then assess the simulated stock using an age structured estimation model, Stock Synthesis, which is used for the majority of federally managed stocks on the US West Coast. Within the estimation model we examine the importance to the accuracy of stock assessment results of survey abundance data, environmental data and spatial assumptions of the model.

October 17, 10:50 (S10-9108)

Understanding and predicting population resilience via steepness

Jon **Brodziak**[1] and Marc Mangel[2,3]

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[2] Center for Stock Assessment Research, University of California, Santa Cruz, CA, 95064, USA
[3] Department of Biology, University of Bergen, Bergen, 5020, Norway

Predicting population resilience to harvest perturbation is an important factor in establishing precautionary harvest control rules for marine fisheries management. While production of recruiting early life history (ELH) stage fish is determined jointly by maternal and environmental factors, applied models to predict stock productivity typically emphasize maternal factors. Mangel and Brodziak (*e.g.*, Mangel *et al*. 2013, A perspective on steepness, reference points, and stock assessment. Canadian Journal of Fisheries and Aquatic Sciences 70:930-940) have developed a life cycle simulation method based on life history, reproductive ecology, and environmental information that can be directly applied to estimate the steepness parameter of stock-recruitment relationships. Steepness determines population resilience and also effectively sets biological reference points, such as maximum sustainable yield, which are used to set harvest limits. The ability to apply the life history parameter method critically depends on accurate characterization of ELH survival rates. Currently, there are few meta-analyses that provide information on ELH survival rates and the basic ichthyoplankton research data are diffusely distributed. We propose a research initiative to collect, document, and archive world-wide information on ELH survival of marine fishery resources, similar to the Ram Myers Legacy Stock-Recruitment Database. We submit that such an information resource will be vital for understanding and predicting population resilience in a changing climate.

October 17, 11:15 (S10-9127) - CANCELLED

Measures of fish condition integrate environmental variability and reduce uncertainty in recruitment models

Ron A. **Heintz** and Edward V. Farley, Jr.

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Stock assessments and management systems rely on the relationship between recruitment and spawning stock biomass. But, environmental variation and changes in the survival constraints faced by juvenile fishes act to decouple stock-recruit relationships. For many fish stocks, the unexplained variability in recruitment is typically on the order of 60%. Climate induced changes in oceanographic conditions are likely to increase this variability, further impacting the ability of managers to predict recruitment. A mechanistic understanding of recruitment process offers the opportunity to reduce this variability. Surveys in the Bering Sea directed at age-0 pollock over the last 10 years have revealed processes that link climate variability and recruitment. Changes in the timing of sea-ice retreat in the Bering Sea not only influence the timing of larval metamorphosis and the time juveniles have for pre-winter provisioning, but also the abundance and quality of prey available for provisioning. When these processes act in concert, relatively large age-0's with increased lipid reserves are produced prior to winter and recruitment is improved. A fish's size and lipid contents are reflected in their energy content providing a valuable index to future performance. Over the last 10 years the average energy content of age-0 pollock in the Fall has explained 78% of the variability in recruitment to age-1 in the Bering Sea stock assessment. Coupling indices of age-0 performance, such as energy content, with acoustically-derived estimates of age-0 abundance can be a powerful tool for developing recruitment models that incorporate environmental variation and understanding climate impacts on fish production.

October 17, 11:15 (S10-8920)

Using multi-species food-web and assessment models to evaluate climate change impacts on fisheries

Kirstin K. **Holsman**, Kerim Aydin and Jim Ianelli

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Climate change is expected to impact marine ecosystems globally, with largest changes anticipated for Arctic and sub-Arctic ecosystems. The 2°C projected increase in mean summer sea surface temperature for Alaskan marine ecosystems may alter trophic demand, predator and prey distributions, and overall system productivity. We use multi-species food-web and assessment models to link changes in the physical environment and food-web to recruitment and survival and help distinguish fishery impacts from large-scale climate pressures. Recently, model runs have been completed for the Bering Sea using a 10km^2 Regional Ocean Modeling System (ROMS) model coupled to a Nutrient-Phytoplankton-Zooplankton (NPZ) model to produce detailed hindcasts for the period 1970-2012 and forecasts using IPCC scenarios through 2040. These results drive a climate-driven Multispecies Statistical Model (MSM) for use in a management strategy evaluation of three groundfish species from the Bering Sea (walleye pollock, Pacific cod, arrowtooth flounder). First, ROMS model results modulate bioenergetics, food supply, growth, recruitment, and species overlap (*i.e.*, functional responses and predation mortality) as fit in the MSM using hindcast-extracted time series. Then the MSM model is applied to downscaled IPCC climate projections via a ROMS and NPZ model projection of temperature, circulation, and zooplankton abundance. Climate effects on population projections under various recruitment models and management strategies will be discussed.

October 17, 11:35 (S10-8931)

Effects of shifting population demographics, oceanography, and predation on apparent stock-recruit relationships for Tanner crabs in the eastern Bering Sea

Jonathan I. Richar[1], Gordon H. **Kruse**[1], Albert J. Hermann[2] and Enrique Curchitser[3]

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The eastern Bering Sea stock of Tanner crabs (*Chionoecetes bairdi*) has been subjected to boom-and-bust fisheries for five decades. Uncertainty about processes responsible for this variability inhibits sustainable harvest policies. We fitted alternative stock-recruit (S-R) models to abundance estimates of juvenile (R) and adult female crabs (S). A strong negative relationship between ln (R/S) and S supports a Ricker model. Nevertheless, this apparent relationship is likely an artifact of autocorrelated recruitment variability. Indices of S and R oscillate out of phase because recruitment appears driven by a ≈13yr environmental cycle, which is roughly double the mean generation time (≈7yr). To investigate environmental causes, larval crab advection patterns were simulated by a Regional Ocean Modeling System (ROMS) over 1978-2004 based on hatching sites inferred from adult female distributions sampled during annual trawl surveys. Analyses of retention and connectivity reveal that the Pribilof Islands area became much more important than Bristol Bay for crab settlement after 1990, consistent with an observed geographic shift in fishery productivity. Modeled spatial distributions of settling larvae were compared to a gauntlet of potential mortality factors, such as settlement in areas of unsuitable habitats, cold pool, and high densities of predatory groundfish and cannibalistic crabs. In addition to the leading role for retention, ROMS indicates that bottom temperature >1ºC is important for juvenile survival. Predation appears to have mediated recruitment, with Pacific cod (*Gadus macrocephalus*) playing a role in the 1980s and flathead sole (*Hippoglossoides elassodon*) becoming more important in the 1990s.

October 17, 11:55 (S10-8919)

Exploring density dependence, delayed density dependence and time varying productivity to explain decreased productivity of Fraser River sockeye salmon

Catherine J.G. **Michielsens**, Mike Lapointe and Carl J. Walters

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Overall productivity, as defined by the number of recruits-per-spawner, has decreased for Fraser River sockeye salmon since 1950. Our study explores three different hypotheses regarding population dynamics of Fraser River sockeye salmon (density dependence, delayed density dependence and non-stationary productivity) by fitting historical stock-recruit data to different stock-recruit relationships (Ricker, Larkin and Kalman filter stock-recruit models). While our study does not answer all the questions explaining productivity declines in Fraser River sockeye salmon, it does provide an overview of how alternative stock-recruit models can be used to explain changes in productivity and identifies certain circumstances under which the results of some models are unreliable. The aim of this study was not to do another statistical evaluation of the models using standard performance criteria (*e.g.*, AICs, BICs, MPE, MAE, *etc.*), but to step back and evaluate which of the assumptions underlying the various models can explain the recent observed trends in population dynamics of Fraser River sockeye salmon, *i.e.*, decreasing productivity.

October 17, 14:00 (S10-8959)

A simple model framework for assessing salmon production and setting escapement targets

Skip **McKinnell**

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Concepts that have proven useful in ordering things easily achieve such authority over us that we forget their earthly origins and accept them as unalterable givens. (A. Einstein)

Ricker's Curve brought order and elegance to fisheries science in the 1950s. It was an organizing principle that answered many fundamental questions for managers of exploited fish populations. It has since become one of Einstein's unalterable givens of fisheries science; a curve that is so well accepted that it is routinely fit to fisheries production data that do not share its characteristics. There has been little discussion of the problems associated with Ricker's Curve and novel alternatives are few. This study reviews the list of problems and offers a new but simple model framework organized around polynomials of increasing complexity to synthesize production data. It follows Einstein's and Occam's advice to seek no greater complexity in explaining nature's variability than is warranted. Examples are drawn from sockeye salmon production in the Fraser River.

October 17, 14:20 (S10-8855)

Modelling the effects of density-dependent mortality in juvenile red snapper caught as bycatch in Gulf of Mexico shrimp fisheries: Implications for management†

Robyn E. **Forrest**[1], Murdoch K. McAllister[2], Steven J.D. Martell[2*] and Carl J. Walters[2]

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Density-dependent mortality of juvenile fishes is a key population regulation mechanism that is usually assumed to occur before fish recruit to fisheries. When density-dependent mortality occurs simultaneously with bycatch of juvenile fish but is not accounted for in stock assessments, estimates of population size and fishery reference points may be biased. This paper develops an instantaneous, age-structured model accounting for simultaneous density-dependent mortality and bycatch in age-0 red snapper (*Lutjanus campechanus*), using equations derived from the Beverton-Holt stock-recruit function. Two simplified Bayesian models (with and without post-

recruitment density-dependent mortality) are fitted to simulated indices of abundance and age composition data to explore the estimability of model parameters under different amounts of process and observation error, and also to illustrate policy implications of model mis-specification in terms of timing of density-dependent processes. Results show that failure to account for post-recruitment density-dependent mortality in stock assessments can lead to overestimation of true abundance, recovery potential and the fishery reference points MSY and B_{MSY}. These analyses also illustrate the problematic nature of defining and calculating reference points in the presence of numerous sources of mortality that affect different demographic components of the population. Because the model without post-recruitment density-dependence is a special case of the model with density-dependence, we suggest that it may be advisable to use the latter model if there is a possibility that post-recruitment density-dependent mortality is a factor governing population dynamics, although further simulation testing is recommended.

†Forrest, R.E., McAllister, M.K., Martell, S.J.D, Walters, C.J. 2013. Modelling the effects of density dependent mortality in juvenile red snapper caught as bycatch in Gulf of Mexico shrimp fisheries: implications for management. *Fisheries Research*, 146: 102-120

October 17, 14:40 (S10-8857)

Environment drives recruitment dynamics for most marine fisheries

Cody S. **Szuwalski**, Katyana A. Vert-Pre, Andre E. Punt, Trevor A. Branch and Ray Hilborn

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Fisheries scientists often assume the number of young fish entering a population (recruitment) is related to the number of spawning adults and that recruitment dynamics do not change over time due to a changing environment. These assumptions inform a manager's perception of the 'health' of a fishery and form the basis for calculating sustainable catches. However, we show recruitment is not positively related to spawning biomass for 62% of 224 stocks from the RAM Legacy Stock Assessment Database and, of the 182 stocks influenced by the environment, 75% have shifts in recruitment dynamics. Recruitment shifted synchronously in 9 of 11 Large Marine Ecosystems, and shifts often coincided with shifts in climate indices. Our results show the environment more strongly influences recruitment than spawning biomass over the observed stock sizes for many stocks. Consequently, currently used metrics for determining the health of stocks may misrepresent reality and environmental influence should be included in definitions of the 'health' of some stocks. Ecosystem wide recruitment dynamics for the eastern Bering Sea and the Gulf of Alaska will be explored and some pitfalls to model-based assessment of recruitment dynamics will be discussed.

October 17, 15:00 (S10-9095)

Setting biological reference points under a changing climate

Anne B. **Hollowed**[1] and Cody S. Szuwalski[2]

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[2] University of Washington, School of Aquatic and Fishery Science, Seattle, WA, 98105, USA

Climate change is expected to impact the distribution and abundance of commercial fish and shellfish through direct and indirect pathways. The temporal signature of these projected changes will differ from interannual, decadal, and multi-decadal variability and thus may necessitate new approaches to setting biological reference points for management. This issue is particularly relevant when climate change negatively impacts recruitment. We explore the potential impacts of climate change and fishing on population dynamics of key fish and shellfish populations by considering case studies of stocks that exhibited one-way downward trajectories in spawning biomass. We attempt to distinguish negative responses of fish populations to climate induced change from those attributable to other natural and anthropogenic drivers. Case studies were mined from the Ram Legacy Stock Assessment Database. We then examine potential management strategies to sustain stocks under changing climate conditions.

BIO Paper Session

Co-Convenors: Michael Dagg (USA) and Atsushi Tsuda (Japan)

The Biological Oceanography Committee (BIO) has a wide range of interests spanning from molecular to global scales. BIO targets all organisms living in the marine environment including bacteria, phytoplankton, zooplankton, micronekton, benthos and marine birds and mammals.

Thursday, October 17 (09:05-17:30)

09:05 ***Introduction by Convenors***

09:10 **Huamei Shao, Yuka Morita, Shiori Sonoki, Kenji Minami, Norishige Yotsukura, Masahiro Nakaoka and Kazushi Miyashita**
Spatiotemporal analysis of kelp forest distribution characteristics in sea desertification areas using acoustic and direct sensing methods (BIO-P-8973)

09:30 **Angelica Peña and Nina Nemcek**
Phytoplankton and nutrient dynamics along Line P in the NE subarctic Pacific (BIO-P-9161)

09:50 **Woo Yul Yi, Hyung-Ku Kang, Bome Song and Joong Ki Choi**
Egg production rate and hatching success in relation to feeding rate of the planktonic copepod *Paracalanusparvuss*.l. at a fixed station, southeastern coast of Korea (BIO-P-8879)

10:10 **Rui Saito, Atsushi Yamaguchi, Hiromichi Ueno, Hiromu Ishiyama, Hiroji Onishi, Ichiro Imai and Ichiro Yasuda**
Influence of Aleutian eddies on calanoid copepods south of the western Aleutian Islands during summer (BIO-P-8883)

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

10:50 **Corinne Pomerleau, Brian P.V. Hunt, R. John Nelson, Akash Sastri and William J. Williams**
Spatial patterns in zooplankton communities and stable isotope ratios ($\delta^{13}C$ and $\delta^{15}N$) in relation to oceanographic conditions in the sub-Arctic Pacific and Western Arctic regions during the summer of 2008 (BIO-P-8929)

11:10 **Yoshiyuki Abe, Masafumi Natsuike, Kohei Matsuno, Takeshi Terui, Atsushi Yamaguchi, Michio J. Kishi and Ichiro Imai**
Variation in assimilation efficiencies of dominant *Neocalanus* and *Eucalanus* copepods in the subarctic Pacific: Consequences for population structure models (BIO-P-8902)

11:30 (cancelled) **Moira Galbraith and Mary Arai**
Aglantha digitale (O.F. Müller, 1776) in the NE Pacific (BIO-P-8956)

11:30 (moved from 16:40) **Trevor W. Joyce and Lisa T. Ballance**
Effects of El Niño/La Niña–Southern Oscillation oceanographic variation on the at-sea distribution and foraging ecology of piscivorous seabirds in the oceanic eastern tropical Pacific (BIO-P-9022)

11:50 **Ah-Ra Ko and Se-Jong Ju**
Seasonal and spatial variations of food sources of krill *Euphausia pacifica* in Yellow Sea using fatty acids analysis (BIO-P-9067)

12:10 **Jeffrey G. Dorman, Ramona L. Zeno, Jarrod A. Santora and William J. Sydeman**
Modeling krill 'hotspots' in the central California Current: Results from variation in diel vertical migration schemes (BIO-P-9102)

12:30 ***Lunch***

14:00 **C. Tracy Shaw, Leah R. Feinberg and William T. Peterson**
A tale of two krill: Who, when, where, and how many? The euphausiids *Euphausia pacifica* and *Thysanoessa spinifera* in the coastal upwelling zone off the Oregon Coast, USA (BIO-P-9152)

14:20 **Se-Jong Ju, Ah-Ra Ko, E.J. Yang, William T. Peterson and C. Tracy Shaw**
Understanding the food selectivity of *Euphausia pacifica* in Yellow Sea: *in-situ* live feeding experiment with natural food assemblages (BIO-P-9076)

14:40 **Jessica A. Miller, William T. Peterson, Louise Copeman, Marisa N.C. Litz, Angela L. Sremba and Laurelyn Perry**
Is the growth of larval and early juvenile northern anchovy (*Engraulismordax*) related to the biochemical climatology of the Northern California Current? (BIO-P-9146)

15:00 **Strahan Tucker, Mark Hipfner, John R. Candy, Colin Wallace, Terry D. Beacham and Marc Trudel**
Stock-specific and condition based predation of juvenile pink, chum and sockeye by rhinoceros auklets (*Cerorhinca monocerata*) (BIO-P-8904)

15:20 **Jarrod A. Santora, Isaac D. Schroeder, John C. Field, Brian K. Wells and William J. Sydeman**
Melding space and time: Mesoscale structuring of predator-prey relationships off central California (BIO-P-8918)

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

16:00 **Mayuko Otsuki, Kazuo Amakasu, Minoru Kitamura, Shigeto Nishino, Takashi Kikuchi, Yoko Mitani and Kazushi Miyashita**
The presence of fin whale vocalizations is correlated with zooplankton abundance in the southern Chukchi Sea (BIO-P-9020)

16:20 **Szymon Surma**
Ecological interactions between forage fish, rorquals, and fisheries in HaidaGwaii (BIO-P-9062)

16:40 (moved to 11:30) **Trevor W. Joyce and Lisa T. Ballance**
Effects of El Niño/La Niña–Southern Oscillation oceanographic variation on the at-sea distribution and foraging ecology of piscivorous seabirds in the oceanic eastern tropical Pacific (BIO-P-9022)

17:00 (cancelled) **Jeffrey M. Napp, Adam Spear, Phyllis J. Stabeno and Charles F. Greenlaw**
Temporal variation in Bering Sea zooplankton biomass and distribution using two complementary acoustic methods (BIO-P-8983)

17:20 *Comments and Discussion*

17:30 *Session Ends*

BIO-Paper Session POSTERS

BIO-P-P1 (*cancelled*) **Ludmila S. Belan, Tatyana A. Belan and Boris M. Borisov**
Composition and distribution pattern of amphipod crustaceans along the pipeline route at the Lunskoye field (NE Sakhalin Island Shelf)

BIO-P-P2 **Daichi Arima, Atsushi Yamaguchi, Yoshiyuki Abe, Kohei Matsuno, Rui Saito, Hiroki Asami, Hiroshi Shimada and Ichiro Imai**
Seasonal changes in the zooplankton community and number of generations per year of small copepods in Ishikari Bay, Sea of Japan

BIO-P-P3 **Wen-Tseng Lo, Shwu-Feng Yu and Hung-Yen Hsieh**
Epipelagic siphonophores associated with summer mesoscale hydrographic features in the waters around Taiwan,western North Pacific Ocean

BIO-P-P4 (cancelled) **Alexander V. Zavolokin**
Jellyfish outbreaks in the Far Eastern Seas of Russia: Regional differences in strength and potential for blooms

BIO-P-P5 **Moira Galbraith and Sonia Batten**
Interannual variability in the abundance of *Pseudocalanus* spp.

BIO-P-P6 **Kyoungsoon Shin, Bonggil Hyun, Keun-Hyung Choi, Pung-Guk Jang, Min-Chul Jang and Woo-Jin Lee**
Effects of increased CO_2 and temperature on the growth of diatoms in laboratory experiments

BIO-P-P7 **Bonggil Hyun, Kyoungsoon Shin, Keun-Hyung Choi, Woo-Jin Lee, Pung-Guk Jang, Min-Chul Jang and Chang-Ho Moon**
Changes in coastal phytoplankton community structure under future climate conditions: A mesocosm study

BIO-P-P8 **Seokjin Yoon, Michio J. Kishi, Satoshi Nakada, Yoichi Ishikawa, Tomonori Isada and Sei-Ichi Saitoh**
Estimating carrying capacity for scallop aquaculture using a bioenergetics model

BIO-P-P9 (*cancelled*) **Michelle A. Kappes, Scott A. Shaffer, Yann Tremblay, David G. Foley, Daniel M. Palacios, Steven J. Bograd and Daniel P. Costa**
Reproductive constraints influence habitat accessibility, segregation, and preference of sympatric albatross species in the North Pacific

BIO-P-P10 **Erin J. Fedewa, Jessica A. Miller and Thomas P. Hurst**
Interannual variation in pre- and post-settlement processes of northern rock sole (*Lepidopsettapolyxystra*) in relation to temperature variability in the Gulf of Alaska

BIO-P-P11 **Oleg N. Katugin, Mikhail A. Zuev and Gennadyi A. Shevtsov**
Distribution patterns of *Gonatus onyx, G. pyros* and *G. berryi* (Gonatidae, Teuthida) in the northwestern Pacific Ocean and adjacent marginal seas

BIO-P-P12 **German Novomodny**
Is unexpected 2013 flood on the Amur River an evidence of future probable drastic, unprecedented changes in the Amur bioresources state?

BIO-Paper Session, Oral Presentations

October 17, 09:10 (BIO-P-8973)

Spatiotemporal analysis of kelp forest distribution characteristics in sea desertification areas using acoustic and direct sensing methods

Huamei **Shao**[1], Yuka Morita[2], Shiori Sonoki[1], Kenji Minami[2], Norishige Yotsukura[3], Masahiro Nakaoka[4] and Kazushi Miyashita[2]

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Desertification in kelp forests occurs in coastal waters off Shimokita Peninsula, Aomori, Japan, has negative effects on coastal fisheries and ecosystems. In order to identify the mechanisms causing desertification in this area, monitoring the current distribution characteristics and changing trends of kelp forests is important. The objective of this study was to evaluate kelp forest thickness, spatial distribution and sea urchin inhabitation using acoustic and direct sensing methods in coastal waters off Shiriyazaki and Ishimochi, Shimokita Peninsula, Aomori, Japan, from 2011 to 2013. Data on the presence/absence and thickness of kelp forests were collected via acoustic observation on transects using a small quantitative echosounder. Acoustic data were geostatistically interpolated, and the areas covered by kelp forests were estimated using GIS. Separation of kelp forest from other seaweeds and identification of sea urchins were obtained using an underwater camera. In the present study, the average thickness, Sa (area backscattering strength) and kelp distribution area decreased from June to November, 2012 in Ishimochi. The decline was probably due to kelp harvest in the fishing season. The average thickness and Sa of kelp forests from acoustic data in Shiriyazaki were similar in 2011 and 2012 with low values. Forest distributions tended to be the same in both years. More sea urchins were observed in barren areas than in kelp forests and the average size was less than 6cm. A high density of sea urchins is one important reason for desertification, and sea urchins seem to be associated in the Shiriyazaki area with low thickness and density of kelp.

October 17, 09:30 (BIO-P-9161)

Phytoplankton and nutrient dynamics along Line P in the NE subarctic Pacific

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Phytoplankton form the trophic base of nearly all marine ecosystems and play key roles in climate regulation, carbon sequestration and oxygen production. A better understanding of the links between phytoplankton abundance, community composition and environmental conditions is required to predict potential future responses of phytoplankton to climate change. In this study, we examine seasonal and interannual variability in phytoplankton assemblage composition (as determined by HPLC-derived phytoplankton pigment concentrations) and phytoplankton abundance along Line P in the northeast subarctic Pacific. Chlorophyll concentrations are usually low (<0.5 mg m^{-3}) year around in the Fe-poor prymnesiophyte dominated offshore waters, whereas high seasonal variability in phytoplankton biomass occurs in the nutrient-rich diatom dominated inshore waters. Despite the lack of seasonality in phytoplankton abundance in offshore waters, diatoms are more abundant in spring and dinoflagellates in summer. Unusually high chlorophyll concentrations (~1.3 mg-Chl m^{-3}) were observed at the offshore end of Line P in August 2008 following a natural volcanic Fe fertilization. Although an increase in diatoms was observed, the relative composition of phytoplankton was similar to that of Aug/Sep of previous years. The observed spatiotemporal variability in phytoplankton along Line P will be discussed in relation to changes in environmental conditions that could potentially control this variability.

October 17, 09:50 (BIO-P-8879)

Egg production rate and hatching success in relation to feeding rate of the planktonic copepod *Paracalanusparvus*s.l. at a fixed station, southeastern coast of Korea

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Egg production rate and feeding rate of the copepod *Paracalanusparvus*s.l. were measured monthly at a fixed station near Tong-yeong, southeastern coast of Korea, for one year, from January to December 2012.The adult female copepods were incubated in surface water for 24 hr and their egg production rate and hatching success were measured. At the same time, feeding rate of the copepods on phytoplankton and protozoans was evaluated by the removal method. For feeding experiments, phytoplankton was divided into three size groups (*i.e.* >20μm, <3μm and 3-20μm) and biomass was measured as chlorophyll *a* concentration. Protozoan diets were categorized into three taxonomic groups, dinoflagellates, ciliates and flagellates, and each group was divided into two size categories (*i.e.* >20μm, <20μm).Water temperature, salinity and chlorophyll *a* concentration were measured monthly as environmental factors. We will discuss the relative contribution of phytoplankton and protozoan diets to variation of egg production rate and hatching success of the copepods in coastal waters.

October 17, 10:10 (BIO-P-8883)

Influence of Aleutian eddies on calanoid copepods south of the western Aleutian Islands during summer

Rui **Saito**[1], Atsushi Yamaguchi[2], Hiromichi Ueno[3,4], Hiromu Ishiyama[4], Hiroji Onishi[3], Ichiro Imai[2] and Ichiro Yasuda[1]

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Mesoscale anticyclonic eddies have been observed south of the Aleutian Islands. Eddies in the Gulf of Alaska are known to transport coastal water and coastal copepods to the offshore open ocean. The impacts of mesoscale anticyclonic eddies formed south of the western Aleutian Islands (Aleutian eddies) on calanoid copepods are not fully understood. In the present study, we describe the population structure of calanoid copepods within an Aleutian eddy and outside the eddy in July 2010. Based on sea level anomaly, the Aleutian eddy was formed south of Attu Island in February 2010, and moved in a southeast direction in the next five months. Large oceanic copepods, *Neocalanus cristatus, Eucalanus bungii* and *Metridia pacifica* were more abundant in the eddy than outside. The life stage of *N. cristatus* was more advanced and *Neocalanus* spp. accumulated more lipids within the eddy than outside. These conditions probably reflected the higher primary production in the eddy where production was enhanced by nutrients introduced due to advection. Since the Aleutian eddy was formed in an oceanic region, it contained mostly oceanic copepods. The improved food conditions in the eddy presumably induced higher growth and survival rates of oceanic copepods, resulting the higher abundance, advanced life stage and greater lipid accumulation.

October 17, 10:50 (BIO-P-8929)

Spatial patterns in zooplankton communities and stable isotope ratios ($\delta^{13}C$ and $\delta^{15}N$) in relation to oceanographic conditions in the sub-Arctic Pacific and Western Arctic regions during the summer of 2008

Corinne **Pomerleau**[1], Brian P.V. Hunt[3], R. John Nelson[2], Akash Sastri[4] and William J. Williams[1]

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Spatial patterns of stable isotopes of carbon and nitrogen in zooplankton can be related to regional oceanography and used to assess biogeographic domains. During summer of 2008, we sampled zooplankton communities in the sub-Arctic Pacific and western Arctic regions. We identified eight specific zooplankton assemblages that fell into the following geographic regions: Gulf of Alaska, Bering Sea Slope, St-Lawrence Island Polynya, Western Bering Strait, Eastern Bering Strait, Barrow Canyon, Beaufort Sea Gyre and Beaufort Sea Shelf. *Neocalanus* spp., *Eucalanus* spp. and *Metridia pacifica* were abundant in the warmer and saltier waters of the Gulf of Alaska and on the Bering Sea Slope, whereas *Calanus hyperboreus*, *Calanus glacialis* and *Metridia longa* were most abundant in the cold and fresher Arctic waters on the Beaufort Shelf and in the Beaufort Sea Gyre. Latitude, Salinity, Deep Chlorophyll maximum (DCM) depth, and Station depth were the main drivers in zooplankton species assemblages and spatial distribution. Stable isotope analysis of nitrogen and carbon revealed that $\delta^{15}N$ and $\delta^{13}C$ varied between the biogeographic regions in most species. $\delta^{15}N$ values were less enriched in the Gulf of Alaska and on the Bering Sea Slope and more enriched in the eastern portion of Bering Strait and in Barrow Canyon. $\delta^{13}C$ values were more depleted in the Gulf of Alaska and in the Beaufort Sea regions and were more enriched in Western Bering Strait. Our results highlight the existence of large intra- and inter-specific differences in zooplankton isotopic signatures in relation to community composition and environmental conditions. Annual sampling is continuing and will allow for monitoring change in the Arctic zooplankton.

October 17, 11:10 (BIO-P-8902)

Variation in assimilation efficiencies of dominant *Neocalanus* and *Eucalanus* copepods in the subarctic Pacific: Consequences for population structure models

Yoshiyuki **Abe**, Masafumi Natsuike, Kohei Matsuno, Takeshi Terui, Atsushi Yamaguchi, Michio J. Kishi and Ichiro Imai

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Assimilation efficiency of zooplankton is an essential parameter required to estimate the energy transfer to higher trophic levels in marine ecosystems. However, little information is available for large oceanic copepods, especially *Neocalanus* and *Eucalanus* species dominant in the subarctic Pacific. In this study, using eight phytoplankton species as food, assimilation efficiencies of C5 stages of *N. cristatus, N. flemingeri* and *E. bungii* were evaluated. Average assimilation efficiencies of *N. cristatus, N. flemingeri* and *E. bungii* ranged between 45-66%, 44-66% and 34-65%, respectively. Assimilation efficiency was highly variable depending on the food type. In all species, assimilation efficiency showed a significant negative relationship with the ash content of phytoplankton (r^2=0.79-0.87, p<0.001). Assimilation efficiency of large-body sized *N. cristatus* on large-sized diatoms was higher than the other copepod species. In population models of *N. cristatus*, changes in assimilation efficiency affect growth and survival rates of the population. A Lagrangian Ensemble Model (LEM) for *N. cristatus* showed that the population could not be maintained when assimilation efficiency was <57%. Since variation in assimilation efficiency may have a significant effect on the copepod population, its variability should be incorporated into marine ecosystem models in the future.

October 17, 11:30 (BIO-P-8956)

Aglantha digitale (O.F. Müller, 1776) in the NE Pacific

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Aglantha digitale is one of the most common hydromedusae in north Pacific waters, widely distributed from 40° northwards into Arctic waters, making up to 80% of hydromedusae abundance. This study combines data from three long term monitoring programs off the west coast of British Columbia: Strait of Georgia, LaPerouse and Line P; to examine interannual variability of *Aglantha digitale* in the NE Pacific. Seasonality off the west coast of Vancouver Island shows a large summer peak with smaller early winter peak in immature stages (<5 mm) with mature individuals appearing in the late summer and again in the late winter where Line P peaks in September for the immature stage with larger individuals found throughout the summer. *Aglantha digitale* is more numerous offshore than on the shelf and shows a high maximum associated with cold years. This paper will attempt to compare and contrast the different study areas and speculate on environmental influences on the abundance of *Aglantha digitale*.

October 17, 11:50 (BIO-P-9067)

Seasonal and spatial variations of food sources of krill *Euphausia pacifica* in Yellow Sea using fatty acids analysis

Ah-Ra **Ko** and Se-Jong Ju[1]

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Krill, *Euphausia pacifica,* is known as a key species in the Yellow Sea ecosystem but their feeding ecology has not been sufficiently studied over conditions observed during high seasonal variability of food quality and quantity. In order to understand the seasonal and spatial variations of their food sources, we sampled *E. pacifica* and particulate organic matter (POM) during the spring (April) and summer (August) in 2012 and 2013 and analyzed their dietary lipid markers. Lipids of *E. pacifica* in the Yellow Sea, mainly comprised of phospholipid (41-86% of total lipids), showed seasonal (spring > summer) and regional (spring: north > south; summer: north < south) variation. These may be related to various factors (*e.g.*, water temperature, spawning, and diet composition) as part of their survival strategy. Fatty acids (FAs) of *E. pacifica* were dominated by saturated FAs (SAFAs) 16:0 and polyunsaturated FAs (PUFAs) 20:5(n-3) and 22:6(n-3), known to be from diatoms and dinoflagellates, respectively. Their FA composition also showed significant regional differences (offshore *vs.* inshore) based on principal component analysis (PCA) of FA abundance. In spring, samples (krill and POM) from inshore had high abundance of allochthonous FAs (*e.g.*, 16:1(n-9), 24:1(n-9)), whereas samples from offshore had many autochthonous FAs (*e.g.*, 18:1(n-7), 20:5(n-3), BrFA)). Especially, FA composition of *E. pacifica* in summer was very similar with that of POM, but not in spring. This suggests that their food sources could be very limited within the cold bottom water (≤10°C) and in-situ production region of the central Yellow Sea, whereas in spring their food sources wouldn't be as limited as in the summer.

October 17, 12:10 (BIO-P-9102)

Modeling krill 'hotspots' in the central California Current: Results from variation in diel vertical migration schemes

Jeffrey G. **Dorman**, Ramona L. Zeno, Jarrod A. Santora and William J. Sydeman

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The spatial organization of prey resources is critical to the foraging success of predators. In the central California Current, krill form a key prey resource for a diverse array of predators from fish to seabirds and marine mammals. Previous research has shown that krill occur in large patches (or 'hotspots') of abundance that are typically found downstream from centers of upwelling in this system (Santora *et al.* 2011). In this study, we use a coastal ocean model (ROMS), integrated with an individual-based model parameterized for *Euphausiapacifica,* to investigate if we could reproduce known krill 'hotspots' in our time-space domain. In our experiment, we compared the resulting distribution of krill particles while varying the upper limit of vertical migration from 0 to 40 meters. Based on 90-day model runs initiated on February 15 over 9 years (2000-2008), we found that some of our known hotspots were better reproduced when the upper limit of vertical migration was deeper in the water (40 meters). We also found that krill particles were rarely retained in hotspots over the course of an entire model run and that particle retention time was greater in certain hotspots than in adjacent non-hotspot regions. This study highlights the role of transport and vertical migration in the maintenance of krill hotspots along the central California coast. The lack of particle retention in certain hotspots highlights the potential role of other factors (behavior, reproduction, predation, *etc.*) in the formation and maintenance of krill spatial structure in the California Current.

October 17, 14:00 (BIO-P-9152)

A tale of two krill: Who, when, where, and how many? The euphausiids *Euphausia pacifica* and *Thysanoessa spinifera* in the coastal upwelling zone off the Oregon Coast, USA

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Euphausiids are an important component of the food web in the northeast Pacific Ocean, serving as prey for fish (including salmon and hake), seabirds, and marine mammals. The dominant euphausiid species off the Oregon Coast are *Euphausia pacifica* and *Thysanoessa spinifera*. The ongoing time-series study off Newport, Oregon, USA, has collected environmental and biological data twice per month since 2001, a period encompassing warm and cold years (positive *vs* negative PDO) and different upwelling conditions (strong, weak, late, *etc.*). Measurements such as abundance and biomass are often reported as seasonal or annual averages but what is relevant to predators are when krill are abundant, which species they are, and where they are located during a particular season or year. The biomass of *E. pacifica* was similar during warm and cool years, with a consistent cross-shelf pattern of lower biomass inshore and significantly higher biomass offshore, with the highest values during cool conditions. *T. spinifera* biomass was significantly higher at inshore stations during cool conditions and similar at offshore stations regardless of whether conditions were warm or cool. Euphausiids also varied in species composition, size (length), timing of reproduction, and other parameters. The timing of when and where euphausiids are abundant has implications for the predators that rely on them. Possible effects of environmental variability on these two species of euphausiids, and how these potential changes may propagate through the food web, will be discussed.

October 17, 14:20 (BIO-P-9076)

Understanding the food selectivity of *Euphausia pacifica* in Yellow Sea: *in-situ* live feeding experiment with natural food assemblages

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Euphausia pacifica play a key role in the transfer of energy to higher trophic levels and maintain the function and structure of the Yellow Sea ecosystem because of their abundance and high biomass. Although understanding their feeding ecology is necessary to accurately elucidate the structure and function of the Yellow Sea ecosystem, very limited information is available on their feeding ecology and behavior through the season. Therefore, we conducted short-term live feeding experiments for adult *E. pacifica* with natural food assemblages at selected stations during spring and summer 2013. All live animals were collected and maintained in filtered seawater for ~6 hours before the experiments, to reduce their gut contents. Then 2~5 individuals were incubated in a glass jar (2 or 4 L) under dark and *in-situ* temperature conditions with or without natural food assemblages for 10~12 hours. At the end of the incubation, water samples for Chl-*a*, nutrients, POC, and microplankton assemblages were collected and analyzed to track any changes during incubations. The preliminary results suggest that adult *E. pacifica* seems to selectively feed on ciliates and heterotrophic dinoflagellates among natural diet assemblages during spring algal blooms even though a large amount of other food items (diatoms, autotrophic dinoflagellates, *etc.*) were available. However, no clear changes were detected in other measurements. Therefore, *in-situ* feeding experiments provide detailed information on the seasonal variation of food selectivity and the role of *E. pacifica* in Yellow Sea trophodynamics.

October 17, 14:40 (BIO-P-9146)

Is the growth of larval and early juvenile northern anchovy (*Engraulismordax*) related to the biochemical climatology of the Northern California Current?

Jessica A. **Miller**[1], William T. Peterson[2], Louise Copeman[3], Marisa N.C. Litz[1], Angela L. Sremba[1] and Laurelyn Perry[1]

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The influence of climate variation on the productivity of marine species has long been recognized although the mechanistic linkages remain poorly understood. In the Northern California Current, the coastal copepod community oscillates between a diverse assemblage dominated by warm-water species and a less diverse assemblage of lipid-rich, boreal species. Studies indicate that growth of early stages of northern anchovy is greater when the boreal copepod community dominates, which suggests that growth variation may be related to the lipid quantity and/or fatty acid (FA) composition of their zooplankton prey. However, this hypothesis has not been explicitly evaluated. Therefore, we initiated a 16-month study to characterize seasonal variation in lipid and FA composition of phytoplankton, copepods, and early stage northern anchovy. Initial data, which were collected biweekly from June to December 2012, demonstrate a clear decline in total lipids present in the copepod community (r=-0.655) and changes in their FAs, including significant increases in bacterial markers, r=0.904), after the fall transition to downwelling conditions. Larval and early juvenile anchovy collected from July to November demonstrated a moderate decline in total lipids after the fall transition (r=-0.572) but a proportional increase in sterol and wax esters (1% to 18%).Overall, anchovy FAs indicate an increased reliance on zooplankton after the fall transition. Daily growth variation of anchovy (23-52 mm SL) will be compared with the lipid and FA composition of phytoplankton and copepods throughout summer and early fall to further evaluate the relationship between growth and prey quality.

October 17, 15:00 (BIO-P-8904)

Stock-specific and condition based predation of juvenile pink, chum and sockeye by rhinoceros auklets (*Cerorhinca monocerata*)

Strahan **Tucker**[1], Mark Hipfner[2], John R. Candy[1], Colin Wallace[1], Terry D. Beacham[1] and Marc Trudel[1]

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Mortality rates of Pacific salmon (*Oncorhynchus spp*.) generally exceed 90% during their marine life. Much of this mortality is thought to occur due to predation in coastal waters during the first few weeks to months after ocean entry. The timing of the seaward migration of pink, chum and sockeye salmon coincides with the chick provisioning period of the rhinoceros auklet, an avian predator known to feed on them. The vast majority of juvenile salmon from Southern and Central BC funnel past aggregations of breeding auklets totalling hundreds of thousands of individuals nesting at key points along coastal migration pathways in Central and Northern BC. The component of juvenile salmon in chick provisioning diets typically ranges between 0-20%, representing 1-5 individual salmon delivered whole to chicks. We sampled predated salmon in summer 2012 at 3 colonies along migration pathways. 51% of predated salmon were sockeye, 31% pink and 18% chum salmon. DNA stock identification revealed a full 98% of sockeye originated from the Fraser River system at all colonies; for pink, southern colonies were dominated by Puget Sound stocks (93-99%) and the northern colony was split between these and North coast stocks; for chum, colonies were split between Fraser River, Puget Sound and Vancouver Island stocks. Sampling at bird colonies was concurrent with coast-wide trawl surveys of juvenile salmon. For all species, size and condition were significantly lower for predated salmon at each colony relative to respective survey salmon providing evidence for size-selective predation and suggesting a relationship between condition and predation susceptibility.

October 17, 15:20 (BIO-P-8918)

Melding space and time: Mesoscale structuring of predator-prey relationships off central California

Jarrod A. **Santora**[1], Isaac D. Schroeder[2], John C. Field[3], Brian K. Wells[3] and William J. Sydeman[1]

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Studies of predator-prey numerical responses and the physical drivers of such relationships are rare, yet required for predicting future changes in the dynamics and structure of marine ecosystems. Here, we hypothesize that predator-prey numerical responses vary spatially and relate to underlying physical conditions. To test this hypothesis, we quantified spatio-temporal variability in hydrographic conditions, krill, and forage fish to model predator (seabird) numerical responses over 21 years (1990-2010). We used principal component analysis and spatial correlation maps to assess coherence among ocean conditions, krill, forage fish, and generalized additive models to quantify seabird breeding success. The first principal component of 4 hydrographic measurements yielded an index which partitioned 'warm/poor-upwelling' and 'cool/good-upwelling' years. Partitioning of krill and forage fish time series among shelf and oceanic regions yielded spatially-explicit indicators of prey availability. Krill abundance within the oceanic region was consistent between years and considerably different than krill abundance on the shelf with marked interannual fluctuations in relation to cool, upwelling years. Anchovy abundance varied within shelf habitats, but was greater in warm years characterized by greater stratification and less upwelling. Spatio-temporal variability of juvenile forage fish covaried strongly, were weakly correlated with hydrographic conditions, yet closely associated with krill in the shelf domain. Numerical responses between seabird breeding success and prey availability revealed spatially-variable associations indicative of the dynamic nature of the habitat-prey relationships that determine successful reproductive efforts. Spatially-explicit numerical responses in seabird breeding success demonstrate the need for species-specific thresholds for marine spatial planning relative to central place foraging predators, as well as depth of understanding for forecasting response of seabirds to future ecosystem change due to natural or anthropogenic factors.

October 17, 16:00 (BIO-P-9020)

The presence of fin whale vocalizations is correlated with zooplankton abundance in the southern Chukchi Sea

Mayuko **Otsuki**[1], Kazuo Amakasu[2], Minoru Kitamura[3], Shigeto Nishino[4], Takashi Kikuchi[4], Yoko Mitani[5] and Kazushi Miyashita[5]

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The fin whale (*Balaenoptera physalus*), which feeds on euphausiids and schools of small fish, migrates seasonally through Arctic waters. However, their movements between the North Pacific and Arctic Oceans are still not well understood, and their distribution will likely expand as the extent of sea ice decreases due to global climate change. Therefore, changes in oceanographic variables could affect the distribution and abundance of migrating fin whales. In this rapidly changing environment, we compared the timing of fin whale vocalizations and zooplankton abundance. An Acoustic Underwater Sound Monitoring System (AUSOMS) was deployed in the southern Chukchi Sea from July 17 - October 1, 2012 to monitor fin whale vocalizations. In addition, an Acoustic Zooplankton Fish Profiler (AZFP) was deployed to measure zooplankton abundance. Fin whale calls occurred from August through October, when the mean volume backscattering strength measured by the AZFP was considerably higher as compared to July. The results from the AZFP determined that the organisms were without swim bladders and showed diel vertical migration, suggesting the presence of euphausiids, a known prey species of fin whales. The correlation between zooplankton abundance and fin whale call frequency provides an explanation for the timing of fin whale migration from the Pacific Ocean to the feeding grounds in the Chukchi Sea.

October 17, 16:20 (BIO-P-9062)

Ecological interactions between forage fish, rorquals, and fisheries in HaidaGwaii

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The aim of this study was to examine the effects of the potential recovery of depleted rorqual populations on the marine ecosystem of HaidaGwaii. Some theoretical considerations suggest that such a recovery could adversely affect the biomasses of local forage fish stocks and predatory marine vertebrate populations, as well as leading to noticeable directional changes in the yields of local fisheries. This study evaluated the plausibility of these theoretical suggestions in the case of HaidaGwaii. The local pre-exploitation abundances of blue, fin, sei, and humpback whales were estimated based on the total catches of each species recorded by whaling stations, the current abundances of these species in the waters near HaidaGwaii, and intrinsic population growth rates for rorquals in similar ecosystems. The ecological effects of population recovery were then simulated for each of these species using a mass-balanced model of the HaidaGwaii food web constructed in Ecopath with Ecosim 6. The results of this simulation confirm that the potential recovery of some rorqual species (particularly humpback whales) could have noticeable adverse effects on the biomasses of some forage fish species (notably Pacific herring) and predatory marine vertebrates (especially pinnipeds and seabirds). However, these results also show that the effects of rorqual recovery on fisheries yields are more difficult to predict, particularly for fisheries targeting species at high trophic levels. These findings have numerous practical implications for ecosystem-based management of forage and other fish stocks and for conservation of rorqual populations in the waters of HaidaGwaii.

October 17, 16:40 (BIO-P-9022)

Effects of El Niño/La Niña–Southern Oscillation oceanographic variation on the at-sea distribution and foraging ecology of piscivorous seabirds in the oceanic eastern tropical Pacific

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El Niño events are often considered detrimental to seabird foraging based on negative impacts on breeding success and adult survival observed particularly in species associated with coastal upwelling systems in the tropical and sub-tropical Pacific. However, the influence of El Niño/La Niña–Southern Oscillation (ENSO) variability on the distribution and foraging ecology of oceanic seabirds at sea has received much less attention. Understanding this response may allow for improved forecasts of future range expansions or contractions under global change scenarios by describing the sensitivity of these mobile marine predators to fluctuations in oceanographic conditions. In addition, piscivorous seabirds form one component of a larger community of epipelagic predators including tunas and dolphins in the eastern tropical Pacific (ETP). Understanding changes in the distribution of seabird species and foraging aggregations may thus provide insight into the influence of ENSO variability on the broader ecosystem. This analysis draws upon repeated strip transect surveys of seabirds and subsurface predator-associated seabird feeding flocks collected by observers during seven NOAA/NMFS cetacean and ecosystem assessment cruises in the ETP spanning the period 1989-2006. Distribution changes of seabird species are described in anomaly maps generated by subtracting a binomial generalized additive model (GAM) probability of occurrence surface under positive or negative ENSO conditions from the GAM probability of occurrence surface under neutral conditions. Changes in the distribution of different seabird feeding flock types (dolphin and tuna associated, tuna-only associated, Sooty Tern dominated, Wedge-tailed Shearwater-Juan Fernandez Petrel dominated, Booby dominated)are similarly described in distribution anomaly maps.

October 17, 17:00 (BIO-P-8983)

Temporal variation in Bering Sea zooplankton biomass and distribution using two complementary acoustic methods

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Zooplankton biomass and distribution in the eastern Bering Sea are strongly connected to variations in climate, and influence recruitment success of planktivorous fishes (*e.g.* walleye pollock, *Gadus chalcogramma*). The broad continental shelf in this region is remote and not easily sampled by ships, particularly during cold winters and springs when sea ice covers the region. We simultaneously deployed two different acoustic samplers during spring, summer, and fall of 2007, 2009, and 2010 on the southeastern middle shelf (Site M2). The two samplers, a 300 kHz Acoustic Doppler Current Profiler (ADCP) and a Tracor Acoustic Profiling System (TAPS-8; 8 frequencies between 104 and 3000 kHz) each provided volume backscatter data. We used results from the two sensors to examine different aspects of the zooplankton community (*e.g.* biomass and diel vertical migration). Acoustic data revealed seasonal and interannual variations in volume backscatter and the size distribution of scatterers. Power spectra from both instruments exhibited peaks at the diurnal frequency without obvious peaks at longer periods (*e.g.* fortnightly period). The acoustically-derived sizes of diel migrators corresponded with our expectations from knowledge of the community composition, and the length of time migrators spent in the surface waters was inversely related to day length. This latter observation, while not new, provides an energetic opportunity to pelagic, night time feeding planktivores like age-0 pollock which must accumulate sufficient depot lipids by the end of summer to survive their first winter.

BIO-Paper Sesion POSTERS

BIO-P-P1

Composition and distribution pattern of amphipod crustaceans along the pipeline route at the Lunskoye field (NE Sakhalin Island Shelf)

Ludmila S. **Belan**[1], Tatyana A. Belan[2] and Boris M. Borisov[2]

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Results are presented from an investigation of amphipod crustaceans along the marine pipeline route at the Lunskoe field. A total of 63 species of amphipods were identified in the depth range of 1-45 m during July of 2006. The highest amphipod density was detected in the depth range of 1-3 m (in average, 4001 ind/m^2); the maximal biomass (15.2 g/m^2) at a depth of 25 m; and the highest species richness (32 species) at a depth of 20 m. The high density was due to strong concentration of *Eogammarus hirsutimanus* at a depth of 3 m, and species of *Ischyrocerus* and *Orchomenella* at 25 m. Cluster analysis revealed 4 amphipod taxocenes. The first one, located between 1 and 3 m in mixed sands and gravel, included 9 species dominated by *E. hirsutimanus*. The taxocene of *Eohaustorius eous eous* was situated on fine sands between 10 and 15 m. Thirty-four species were identified in the assemblage. Grouping, where *Anonyx lilljeborgi* and *Ischyrocerus* sp. (24 species) dominated, inhabited fine sands with gravel at a depth of 25 m. The taxocenes of *E. eous eous* and *Grandifoxus longirostris* (31 species) were observed between 20 and 30 m, on fine sands.

BIO-P-P2

Seasonal changes in the zooplankton community and number of generations per year of small copepods in Ishikari Bay, Sea of Japan

Daichi **Arima**[1], Atsushi Yamaguchi[1], Yoshiyuki Abe[1], Kohei Matsuno[2], Rui Saito[3], Hiroki Asami[4], Hiroshi Shimada[4] and Ichiro Imai[1]

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Seasonal changes in the zooplankton community and life cycle of small copepods in Ishikari Bay, northern Sea of Japan were studied based on monthly samples collected by fine mesh net (100μm) during March 2001 to May 2002. Zooplankton abundance had a peak in May, and was composed mainly of copepodid stages of copepods. Cluster analysis based on copepod abundance separated the community into two main groups: group A was observed during January to June and group B during July to December. Group A and B were composed of cold and warm water species, respectively. For the numerically dominant three copepods (*Paracalanus parvus, Pseudocalanus newmani* and *Oithona similis*), seasonal changes in prosome length (*PL*) were common (larger in winter). However, seasonal changes in lipid storage (both composition of oil sac contents and oil sac volume) showed a species-specific pattern: i.e. oil sac volume of *P. parvus* was greater in summer, while *P. newmani* and *O. similis* were greater in spring. Lipids are utilized for reproduction which seasonally varied among species. From analysis of seasonal changes in *PL*, *P. parvus* is considered to have up to 5 generations per year, *P. newmani* up to 5 generations per year, and *O. similis* 2 generations per year.

BIO-P-P3

Epipelagic siphonophores associated with summer mesoscale hydrographic features in the waters around Taiwan,western North Pacific Ocean

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This is the first attempt to examine the relationship between the spatial distribution of siphonophores and mesoscale hydrographic features in the waters around Taiwan in summer. A total of 59species of siphonophores, consisting of 12 Physonectae and 47 Calycophorae, were identified from our samples. The most abundant species were *Lensiasubtiloides* (49.7% of the total collection by number), *Diphyeschamissonis* (12.1%), *Chelophyesappendiculata* (9.3%), *C.contorta* (8.1%), and *Bassiabassensis* (5.2%). Two clear assemblages were associated with shelf waters (influenced by the South China Sea Surface Current) and oceanic waters (influenced by the Kuroshio Current), respectively. The shelf water assemblage was characterized by low diversity and high abundance of *L.subtiloides*, whereas the oceanic assemblage showed greater diversity and was dominated by *C.appendiculata*, *C.contorta*, and *B.bassensis*. We discovered strong correlations between temperature and zooplankton and siphonophore abundances, suggesting that temperature and prey concentration are important in determining the spatial distribution of siphonophores. In addition, lower abundance and higher species diversity of siphonophores were observed after the passage of typhoons. This study provides basic knowledge on the distributional patterns of siphonophores, which is essential information to further understand the ecological roles played by siphonophores and the irresponses to the hydrological conditions in the waters surrounding Taiwan.

BIO-P-P4 - CANCELLED

Jellyfish outbreaks in the Far Eastern Seas of Russia: Regional differences in strength and potential for blooms

Alexander V. **Zavolokin**

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In many regions of the World Ocean, occasional jellyfish blooms can have significant negative consequences for ecosystems, fisheries, industry and tourism. I estimated jellyfish biomass in the Far Eastern Seas and adjacent waters, examined its regional pattern and assessed the potential for large-scale jellyfish blooms in the Far East of Russia. The study was based on data from trawl catches conducted by TINRO-center in the northwestern Japan Sea, Okhotsk Sea, western Bering Sea, western Chukchi Sea and northwestern Pacific Ocean in 1990-2012. The highest jellyfish biomass (average about 2000 kg/km^2) occurred in the northwestern Bering Sea and eastern Okhotsk Sea. The lowest biomass (50 kg/km^2) was in the north-western Japan Sea. The Scyphomedusae *Chrysaora* spp., *Cyanea capillata* and the Hydromedusa *Aequorea* spp. dominated the jellyfish biomass in the trawl catches. For all regions studied, the maximum concentrations of jellyfish were observed in shelf waters. Relative biomass was 2-3-fold higher in the shelf regions in comparison with deep-water basins. In comparison with many other regions of the World Ocean, jellyfish outbreaks in the Far Eastern Seas were relatively weak. At least partially, this was due to severe climate conditions. Most (>70%) of the shelf in the studied area is located in the cold regions covered with ice for 9-11 months in the Chukchi Sea and for 7-10 months in the Okhotsk and Bering Seas. Thus, large-scale and long-term jellyfish blooms in the Far Eastern Seas of Russia are unlikely under the current climate conditions.

BIO-P-P5

Interannual variability in the abundance of *Pseudocalanus* spp.

Moira **Galbraith**[1] and Sonia Batten[2]

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This study combines data from two long term monitoring programs to examine interannual variability in *Pseudocalanus* spp. abundance in the NE Pacific. This small copepod is often overlooked in favour of the larger sub arctic species, yet it is an important member of the mesozooplankton group. It is a significant prey item for larval and juvenile fish such as herring, sand lance and salmonids and so forms an important link between primary production and upper trophic levels. The genus occurs in large numbers in samples across the region and in recent years has shown unusually large variability. We combine data from the DFO Line P and West Coast Vancouver Island surveys, and the North Pacific CPR survey to examine this variability in more detail, and to speculate on causes and potential impacts.

BIO-P-P6

Effects of increased CO_2 and temperature on the growth of diatoms in laboratory experiments

Kyoungsoon **Shin**, Bonggil Hyun, Keun-Hyung Choi, Pung-Guk Jang, Min-Chul Jang and Woo-Jin Lee

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We examined the combined impacts of future increases of CO_2 and temperature on the growth of four marine diatoms (*Skeletonema costatum*, *Chaetoceros debilis*, *Chaetoceros didymus*, *Thalassiosira nordenskioeldii*). The four strains were incubated under four different conditions: present (pCO_2: 400 ppm, temperature: 20°C), acidification (pCO_2: 1000 ppm, temperature: 20°C), global warming (pCO_2: 400 ppm, temperature: 25°C), and greenhouse (pCO_2: 1000 ppm, temperature: 25°C) conditions. With incubation at higher temperatures, growth of *S. costatum* was suppressed, while *C. debilis* showed enhanced growth. Both *C. didymus* and *T. nordenskioldii* showed similar growth rates under current and elevated temperature. None of the four species appeared affected in their cell growth by elevated CO_2 concentrations. *Chaetoceros* spp. showed an increase of pH per unit fluorescence under elevated CO_2 concentrations, but no difference in pH from that under current conditions was observed for either *S. costatum* or *T. nordenskioeldii*, implying that *Chaetoceros* spp. can take up more CO_2 in the future climate conditions. Our results of cell growth and pH change per unit fluorescence suggest that both *C. debilis* and *C. didymus* are better adapted to future oceanic conditions of rising water temperature and CO_2 than are *S. costatum* and *T. nordenskioeldii*.

BIO-P-P7

Changes in coastal phytoplankton community structure under future climate conditions: A mesocosm study

Bonggil **Hyun**[1,2], Kyoungsoon Shin[1], Keun-Hyung Choi[1], Woo-Jin Lee[1], Pung-Guk Jang[1], Min-Chul Jang[1] and Chang-Ho Moon[2]

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The coastal phytoplankton community under predicted ocean acidification and sea surface warming conditions was studied using an outdoor mesocosm approach. Nine mesocosm bags were filled with coastal waters from Jangmok bay in the South Sea of Korea. Control and two different treatments for the level of CO_2 and temperature were set up in triplicates (control: 380 ppm, treatment I: 980 ppm, treatment II: 980 ppm and +3°C). Nutrients (nitrate, phosphate and silicate) were amended at the start of the experiment to facilitate phytoplankton growth. During the first 12 days of incubation when nutrients were replete, the highest phytoplankton biomass was observed in treatment I where diatoms were predominant (>95% of total phytoplankton biomass). As diatoms

decreased, dinoflagellates increased for all conditions during the subsequent nutrient depleted period. The response of different phytoplankton species to the CO_2 and temperature perturbations differed significantly. The diatom *Skeletonema* spp. showed positive growth in treatment I and II during the nutrient replete period, but no significant growth was observed during the nutrient deplete period. *Chaetoceros socialis* showed positive growth in treatment I, but in treatment II, negative growth was observed during the nutrient deplete period. *Cerataulina dentata* showed negative growth in both treatment I and II during the nutrient deplete period. The different responses of phytoplankton species to seawater pCO_2 and temperature manipulation suggest that future climate change could change the structure of the phytoplankton community, and these changes are expected to alter marine ecosystems.

BIO-P-P8

Estimating carrying capacity for scallop aquaculture using a bioenergetics model

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The scallop industry plays an important role in the economic and social welfare of the coastal communities and has grown to become the most successful marine shellfish farming venture in Japan. The measurement of growth rate has received a great deal of attention owing to its importance for fisheries management and aquaculture. The most common method of assessing energy balance in an individual organism is to measure the components of the energy budget equation where: C=F+U+R. The primary source of energy is food consumption (C), whereas energy expenditures include fecal losses (F), excretory products (U), and respiratory heat loss (R). In order to evaluate the effects of environmental factors such as water temperature and food availability on the growth of scallops and to estimate the carrying capacity for scallop aquaculture in Funka Bay, Hokkaido, Japan, we developed an ecosystem model by coupling a scallop bioenergetics model, based on the common method, with a lower trophic ecosystem model (NEMURO). The models indicated the scallop grew up during the spring bloom, whereas its biomass rapidly decreased during summer and fall due to insufficient food availability. That contradicted the observational data. Therefore, we introduced an 'energy partitioning algorithm' into the model: a scallop allocates a part of its energy to growth and stores the rest when it remains in positive energy balance, *i.e.*, if the absorbed ration exceeds total metabolic losses. When the latter exceed the former, energy reserves are utilized for maintenance.

BIO-P-P9

Reproductive constraints influence habitat accessibility, segregation, and preference of sympatric albatross species in the North Pacific

Michelle A. **Kappes**[1,6], Scott A. Shaffer[2,6], Yann Tremblay[3,6], David G. Foley[4,5], Daniel M. Palacios[4,5], Steven J. Bograd[5] and Daniel P. Costa[6]

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We examined the foraging behavior and marine habitat selection of Laysan (*Phoebastria immutabilis*) and black-footed (*P. nigripes*) albatrosses throughout their eight month breeding cycle at Tern Island, Northwest Hawaiian Islands, to evaluate how variable constraints of breeding influenced foraging decisions. Hawaiian albatrosses are unique compared to southern hemisphere species in that they forage in warm, oligotrophic waters during the energetically demanding chick-brooding period. We used satellite tracking and light-based geolocation to determine foraging locations of individuals, and modeled habitat preference under a case-control design. Remotely-sensed oceanographic data were used to characterize albatross habitats in the North Pacific. Individuals of both species ranged significantly farther and for longer durations during incubation and chick-rearing compared to the brooding period. Interspecific segregation of core foraging areas was observed during incubation and chick-

rearing, but not during brooding. At-sea activity patterns were most similar between species during brooding; neither species altered foraging effort to compensate for presumed low prey availability and high energy demands during this stage. Habitat selection during long-ranging movements was most strongly associated with sea surface temperature for both species, with a preference for cooler ocean temperatures, compared to overall availability. Low explanatory power of habitat models during brooding reflected the narrow range of available marine habitats, and suggested an opportunistic foraging strategy. Our results highlight how regional environment, seasonal variability, and reproductive constraints can influence the distribution, behavior, and habitat preference of an upper-trophic-level marine predator in the North Pacific.

BIO-P-P10

Interannual variation in pre- and post-settlement processes of northern rock sole (*Lepidopsettapolyxystra*) in relation to temperature variability in the Gulf of Alaska

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Northern rock sole (NRS) is a commercially valuable flatfish species in the Gulf of Alaska, however, processes driving recruitment and productivity are largely unexplained. Ocean temperature can directly affect growth dynamics and indirectly affect the timing of early life history events (*e.g.* spawning, hatching and settlement). Regime shifts and recent warming in the Gulf of Alaska (GOA) therefore have implications for understanding the role of climate on NRS. Studies suggest that thermal conditions experienced during spawning and larval periods could carry over and influence size and growth variation in settled NRS. However, it is not clear how these early life history traits vary in relation to temperature. We will present information on interannual variation in the timing of hatch and settlement in addition to larval and juvenile growth rates of NRS collected in two nursery habitats in Kodiak Alaska (2005-2013). NRS early life history characteristics will be related to regional temperature variability in the GOA to determine influences on hatch, growth and settlement processes. Notably, the time period of the study encompasses a wide range of temperature variation, including cooler years (2007-2008) during which we observed delayed hatch and settlement and slower growth. Results will determine whether post-settlement size/growth is related to temperature-driven phenological shifts in the time of spawn and hatch, physiological shifts in larval growth rates, or a combination of the two factors. By disentangling the effects of temperature on early life stages, we will advance the understanding of processes that drive productivity of NRS in the GOA.

BIO-P-P11

Distribution patterns of *Gonatus onyx*, *G. pyros* and *G. berryi* (Gonatidae, Teuthida) in the northwestern Pacific Ocean and adjacent marginal seas

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Patterns of spatial, temporal and bathymetric distribution of three species of the oegopsid squid family Gonatidae (*Gonatus onyx*, *G. pyros* and *G. berryi*) were analyzed based on data collected in TINRO-Centre trawl surveys. *Gonatus onyx* was the most common of these three species, and occurred in a wide depth range almost throughout the research area in the northwestern Pacific Ocean, in the southern Okhotsk Sea and western Bering Sea, being rather frequent in the upper epipelagic layer almost all the year round. The other two species occurred less regularly in trawl catches, mainly in the Pacific Ocean, notably less commonly in adjacent seas, being distributed in the mesopelagic layers throughout the year, and in the epipelagic zone mostly in summer. Ontogenetic, seasonal and bathymetric patterns of occurrence were basically concordant in the ocean and marginal seas for each of the three species. Early life stages of *G. onyx* were found from spring through autumn in the epi and upper-mesopelagic layers, and were not found deeper than 500 m. On the contrary, young *G. pyros* and *G. berryi* were distributed mainly in deep layers, and were captured in the upper water column occasionally. Mature individuals of all three species were rare, and were distributed primarily in deep layers.

FIS Paper Session

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

This session invites papers addressing general topics in fishery science and fisheries oceanography in the North Pacific and its marginal seas, except those covered by FIS-sponsored Topic Sessions.

Tuesday, October 15 (09:05-17:10)

09:05 ***Introduction by Convenors***

09:10 **Nadezhda V. Yarosh and Victor F. Bugaev**
Seasonal growth of juvenile coho salmon *Oncorhynchus kisutch* scales in the Bolshaya River, West Kamchatka (FIS-P-8852)

09:30 **Cameron Freshwater, Marc Trudel and Francis Juanes**
Effects of body size, marine entry timing, and marine growth on the migration of juvenile sockeye salmon (FIS-P-8878)

09:50 **Beverly A. Agler, Gregory T. Ruggerone, Lorna Wilson and Edward V. Farley, Jr.**
Size-selective mortality of Kvichak River, Bristol Bay, Alaska sockeye smolts in relation to smolt characteristics, ocean conditions, and sockeye productivity (FIS-P-8997)

10:10 **Gregory T. Ruggerone and Brendan M. Connors**
Are there too many pink salmon in the ocean? The productivity and life history of Fraser River sockeye in relation to pink and sockeye salmon abundance across the North Pacific (FIS-P-9079)

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

10:50 **Eric Hertz, Marc Trudel, Strahan Tucker, Terry D. Beacham, Chuck Parken and Asit Mazumder**
Implications of the interannual variability in the feeding ecology of juvenile Chinook salmon (FIS-P-8984)

11:10 (cancelled) **David G. Stormer and Francis Juanes**
The effects of variable water temperature and food availability during summer on juvenile Chinook salmon early marine survival, growth and energetics (FIS-P-9084)

11:30 **Marisa N.C. Litz, Robert L. Emmett, Andrew M. Claiborne, Jessica A. Miller and David J. Teel**
Seasonal variability in juvenile fish and invertebrate prey available to Columbia River salmon entering the ocean (FIS-P-9145)

11:50 **Christine C. Stawitz, Timothy E. Essington, Anne B. Hollowed, Trevor A. Branch, Melissa A. Haltuch, Paul D. Spencer and Nathan Mantua**
Can we predict synchronous production dynamics? Applications to somatic growth (FIS-P-8932)

12:10 **Megan M. Stachura, Timothy E. Essington, Nathan J. Mantua, Anne B. Hollowed, Melissa A. Haltuch, Paul D. Spencer, Trevor A. Branch and Miriam J. Doyle**
Linking recruitment synchrony to environmental variability (FIS-P-8952)

12:30 ***Lunch***

14:00 **Kiva L. Oken and Timothy E. Essington**
Using surplus production models to study predation in age-structured populations (FIS-P-8934)

14:20 **Osamu Tamaru, Go Takayama, Hideo Takahara and Toshihiro Watanabe**
Constructing a 3-D simulation model of squid schooling behavior at jigging operations with the Boids Algorithm (FIS-P-8884)

14:40 **Irene D. Alabia, Sei-Ichi Saitoh, Hiromichi Igarashi, Yoichi Ishikawa, Norihisa Usui, Masafumi Kamachi, Toshiyuki Awaji and Masaki Seito**
Persistent summer pelagic hotspots of neon flying squid (*Ommastrephes bartramii*) in the western North Pacific (FIS-P-8980)

15:00 **Haruka Nishikawa, Yoichi Ishikawa, Takahiro Toyoda, Shuhei Masuda, Yuji Sasaki, Mitsuo Sakai and Toshiyuki Awaji**
Impact of climate variability on the neon flying squid (*Ommastrephes bartramii*) winter-spring cohort stock (FIS-P-9066)

15:20 **Chen-Yi Tu, Yongjun Tian and Chih-hao Hsieh**
Climate effects on spatial-temporal variation of the demersal fish assemblage in the Tsushima Warm Current region of the Japan Sea (FIS-P-9131)

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

16:00 **Chiyuki Sassa, Motomitsu Takahashi and Youichi Tsukamoto**
Distribution, growth, and mortality of larval *Benthosema pterotum* (Pisces: Myctophidae) in the shelf region of the East China Sea (FIS-P-8939)

16:20 **Jennifer L. Boldt, Jake Schweigert, Jaclyn Cleary, Linnea Flostrand, Vanessa Hodes, Gordon McFarlane, Stephane Gauthier, Moira Galbraith and Dave Mackas**
Potential for competitive interactions between Pacific sardine and Pacific herring in British Columbia, Canada (FIS-P-8908)

16:40 (cancelled) **Richard D. Brodeur, Lorenzo Ciannelli, A. Jason Phillips, William G. Pearcy and John Childers**
Spatial and temporal variations in albacore habitat in the Northeast Pacific transition zone using remotely-sensed environmental data (FIS-P-9178)

16:40 **Tetsuichiro Funamoto, Lorenzo Ciannelli and Kazushi Miyashita**
Non-stationary effects of environmental conditions on walleye pollock larval distribution (FIS-P-9141)

17:00 *Comments and Discussion*

17:10 *Session Ends*

FIS-Paper Session POSTERS

FIS-P-P1 **Mikhail A. Stepanenko and Elena V. Gritsay**
Annual variability of pollock resources, distribution, reproduction and environment in the Bering Sea

FIS-P-P2 **Mikhail A. Zuev**
Fish by-catch during the schoolmaster gonate squid *Berryteuthis magister* (Berry, 1913) trawl fishing near northern Kuril Islands

FIS-P-P3 **Xiu-Juan Shan, Peng-Fei Sun, Qiang Wu, Yun-Long Chen and Xianshi Jin**
Seasonal variations infish community structure in Laizhou Bay and the Yellow River Estuary, China

FIS-P-P4 **Chiyuki Sassa, Yoshinobu Konishi and Youichi Tsukamoto**
Late winter larval fish assemblage in the southern East China Sea, with emphasis on spatial relations between mesopelagic and commercial pelagic fish larvae

FIS-P-P5 **Ah Reum Kim, Ho Jin Bae and Chul-Woong Oh**
Age and growth of filefish *Thamnaconus modestus* off the Jeju Island

FIS-P-P6 (cancelled) **Chunsheng Liu and Siqing Chen**
Medusa consumption and prey selection of silver pomfret *Pampus argenteus* juveniles

FIS-P-P7 **Yang Liu, Sei-Ichi Saitoh, Yu Ihara, Toru Hirawake, Katsuhisa Baba and Kanamori Makoto**
Development of the 3-D growth prediction model for Japanese scallop in Funka Bay, Japan

FIS-P-P8 **Lyse Godbout, Carrie A. Holt, Peter Tchaplinski, Don Mcubbing, James Irvine and Marc Trudel**
Climate change, emigration timing to sea and salmon marine survival

FIS-P-P9 **Hiroko Sasaki, Irene D. Alabia, Koji Matsuoka, Hiromichi Igarashi, Yoichi Ishikawa, Norihisa Usui, Masafumi Kamachi, Toshiyuki Awaji, Masaki Seito and Sei-Ichi Saitoh**
Potential habitat overlap between neon flying squid (*Ommastrephes bartramii*) and marine mammals in the western North Pacific: Possible trophic linkages

FIS-P-P10 **Xun Zhang, Sei-Ichi Saitoh, Toru Hirawake, Satoshi Nakada, Koji Koyamada, Toshiyuki Awaji, Yoichi Ishikawa and Hiromichi Igarashi**
Potential fishing zone prediction map of Japanese common squid in the coastal water, southwestern Hokkaido, Japan

FIS-P-P11 **David G. Stormer and Francis Juanes**
Overwintering ability of juvenile ocean-type Chinook salmon: Effect of water temperature and food deprivation on growth, energetics and survival

FIS-P-P12 **Nadezhda L. Aseeva**
Some features of *Lycodes soldatovi* biology and parasitology in the Okhotsk Sea

FIS-P-P13 **PilSoo Kim, Jae Bong Lee and Jin-Woo Bae**
Metagenomicanalysis of the fish gut microbiota

FIS-P-P14 **Nadezhda A. Rastyagaeva**
Some results of salmon origin identification and of figuring out the age structure of identified stocks by different methods

FIS-P-P15 **A. Jason Phillips, Lorenzo Ciannelli, Richard D. Brodeur, William G. Pearcy and John Childers**
Spatio-temporal associations of albacore catches in the Northeastern Pacific with regional and climate environmental variables

FIS-P-P16 **Sunkil Lee, Jae Bong Lee, Dae-Soo Chang and Jong-Bin Kim**
Comparisons of trophic level in ecosystem by effects of fishing in Korean waters

FIS Paper Session, Oral Presentations

October 18, 09:10 (FIS-P-8852)

Seasonal growth of juvenile coho salmon *Oncorhynchus kisutch* scales in the Bolshaya River, West Kamchatka

Nadezhda V. **Yarosh** and Victor F. Bugaev

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Scale structure of juvenile coho salmon, collected in the lower part of the Bolshaya River (West Kamchatka) in 2007-2012, is examined. The first annulus, bounding the central plate at scale of underyearling coho salmon, appears when body length gets on average 38 mm. Restoring the seasonal growth and formation of annual rings in juvenile coho salmon in the lower part of the river takes place massively in the third decade of May: early May in one-year-old and late May in two-year-old fish. Seasonal juvenile growth gets visibly lower, when cooling water in the last half of September, until its' complete stagnation in October. During season of growth juvenile coho salmon can obtain additional zones of dense scale annuli. In the lower part of the Bolshaya River juvenile coho salmon of different ages obtain one annulus for a similar time span: 12,9 days from June to the last half of September for underyearlings, 10,1 days from June to the last half of September for one-year-old fish and 11,2 days from June to July for two-year-old fish.

October 18, 09:30 (FIS-P-8878)

Effects of body size, marine entry timing, and marine growth on the migration of juvenile sockeye salmon

Cameron **Freshwater**[1], Marc Trudel[2] and Francis Juanes[1]

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Sockeye salmon (*Oncorhynchus nerka*) are an essential component of northeastern Pacific cultures, economies, and ecosystems, but have experienced widespread declines in recent decades. Mortality rates during marine life stages appear to be sufficiently high to influence fishery production and are likely growth dependent. Juvenile growth rates also appear to influence sockeye migration; individuals in northern regions tend to be larger and possess a higher energy content than southern individuals from the same stock. Differential growth and migration may create a "race to the north" scenario whereby larger, faster individuals are the first to move to productive offshore feeding grounds and experience higher over-winter survival rates as a result. Despite the observation of a latitudinal gradient in body size, it is unclear whether this pattern is a result of large initial body size, early marine entry, rapid early marine growth, improved growth over the course of northern migration, or an interaction of several of these hypotheses.

We confirmed the formation of marine entry checks and daily growth rings in sockeye otoliths by smolting individuals in controlled conditions. We also examine the effects of size, marine entry timing, and shifting growth rates on juvenile sockeye migration by analyzing the otolith microstructure of individuals from four British Columbian stocks captured along a south-north gradient. Differences in growth and marine entry between years and stocks will be used to gauge the relative effect of juvenile growth on recent returns to Vancouver Island and the Fraser River. An increased understanding of how size and growth impact the migration rates of juvenile sockeye has the potential to improve our understanding of salmonid life history and production.

October 18, 09:50 (FIS-P-8997)

Size-selective mortality of Kvichak River, Bristol Bay, Alaska sockeye smolts in relation to smolt characteristics, ocean conditions, and sockeye productivity

Beverly A. **Agler**[1], Gregory T. Ruggerone[2], Lorna Wilson[1] and Edward V. Farley, Jr[3]

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Mortality of salmon in the ocean is believed to be size-selective such that smaller, slower growing fish are less likely to survive. However, little is known about how size-selective mortality of Kvichak River, Bristol Bay sockeye salmon varies over decades in response to ocean conditions and climate shifts. To estimate Kvichak River sockeye smolts size, we developed a smolt length/scale radius regression from juvenile salmon scales and back-calculated size of age-1 and age-2 smolts from adult sockeye scales, 1955 to 2008. Size of surviving smolts was compared with observed smolt size entering Bristol Bay, and the degree of size-selective mortality was estimated for each smolt age and adult age group. We examined potential fyke net avoidance by larger age-2 smolts during the past five decades but found little evidence that avoidance might bias patterns of size-selective mortality. Size of surviving smolts after 2-3 years at sea did not shift over time, but selectivity was greater after the mid-1970s regime shift in response to smaller smolts leaving freshwater. Analyses indicated selectivity was higher in abundant sockeye smolt years, perhaps reflecting early marine density-dependent growth and survival. Selectivity was correlated with age-0 pollock abundance in the southeastern Bering Sea possibly because larger sockeye smolts can eat larger, more energetic juvenile pollock, providing a highly important prey in warm water years.

October 18, 10:10 (FIS-P-9079)

Are there too many pink salmon in the ocean? The productivity and life history of Fraser River sockeye in relation to pink and sockeye salmon abundance across the North Pacific

Gregory T. Ruggerone[1] and Brendan M. **Connors**[2,3]

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3 ESSA Technologies, Vancouver, BC, V6H 3H4, Canada

The productivity of sockeye salmon populations from Southeast Alaska through British Columbia to Washington State has declined synchronously over the past two decades with consequences for both coastal ecosystems and economies. Because these declines have occurred over a large spatial scale it is likely that the primary mechanism(s) driving this decline also operate at a large, multi-regional spatial scale at sea. However, to date the identification of such a mechanism has remained elusive. Using hierarchical models of stock-recruit dynamics we tested the hypothesis that competition between pink and sockeye salmon for prey has led to reduced growth and productivity and delayed maturation of up to 36 sockeye populations spanning the region of synchronous productivity during the past 50 years. Our findings suggest that the abundance of North Pacific pink salmon beginning in the second year of sockeye life at sea is a key factor in the decline of sockeye salmon productivity. In addition, length-at-age of sockeye salmon declined with greater sockeye and pink salmon abundance, and age-at-maturity increased with greater pink salmon abundance. The relationships we quantify suggest that an increase in North Pacific pink salmon from 100 million to 600 million (*i.e.*, the observed range) reduces the total number of adult sockeye returning to the Fraser River by up to 65%. These findings provide strong evidence that competition with another species for prey at sea can affect survival and life history characteristics of sockeye salmon, highlighting that consideration of ocean basin scale ecological relationships among salmon should improve policy and management.

October 18, 10:50 (FIS-P-8984)

Implications of the interannual variability in the feeding ecology of juvenile Chinook salmon

Eric **Hertz**[1], Marc Trudel[1,2], Strahan Tucker[2], Terry D. Beacham[2], Chuck Parken[2] and Asit Mazumder[1]

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Many Chinook salmon (*Oncorhynchus tshawytscha*) stocks are declining along the west coast of North America. The early marine life of these fish is hypothesized to be important for determining overall survival rates, and mortality during this time may be size-selective. As such, factors that affect the early marine growth of Chinook salmon may have effects on their ultimate survival rates. Growth rates are expected to vary as a function of diet (*i.e.* the quality and quantity of prey available). We used stable isotope analysis of nitrogen and carbon in muscle tissue to assess the long-term feeding ecology of juvenile Chinook. Stable isotopes of nitrogen ($\delta^{15}N$) are typically used as an indicator of trophic position in foodweb studies, while stable isotopes of carbon ($\delta^{13}C$) are an indicator of the basal resource pool and may indicate primary productivity in marine systems. Juvenile Chinook salmon were sampled in Southeast Alaska and the west Coast of Vancouver Island during the fall of 2000-2010 using a mid-water trawl. Juvenile salmon were tested for stock-of-origin, stable isotope values as well as a metric of growth. West coast of Vancouver Island Chinook salmon growth and survival rates were found to be related to diet, while Southeast Alaska Chinook salmon were not. The regional differences may be related to size, or differences in foodweb structure. The relationship between $\delta^{13}C$ and survival for West Coast of Vancouver Island Chinook from 2000-2009 was used to predict the survival of 2010 migrants (2013 returns).

October 18, 11:10 (FIS-P-9084)

The effects of variable water temperature and food availability during summer on juvenile Chinook salmon early marine survival, growth and energetics

David G. **Stormer** and Francis Juanes

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The North Pacific region has experienced long-term sea surface warming over the last several decades. Long-term ocean warming has been associated with an altered production cycle in the Strait of Georgia (SOG), thus driving variability in the prey field encountered by migrating Pacific salmon during early marine life. Pacific salmon are cold water fishes and warming ocean temperatures could have negative impacts on recruitment, particularly during the early marine phase of their life cycle. Such warming has been implicated in the recent declines of southern British Columbia, Canada's Chinook salmon (*Oncorhynchustshawytscha)* returns, but the mechanisms remain unclear. The objectives of this study were to experimentally evaluate how juvenile ocean-type Chinook salmon responded to climate and food variability during their first summer. By controlling water temperature and food availability during summer 2013, we simulated match/mismatch dynamics in prey abundance associated with regional SOG summer thermal regimes, and assessedsurvival, growth and energetics. Fish were randomly assigned to eighteen 240 liter (l) experimental aquaria with one of three water temperatures (15, 18 and 21°C), simulating the 1940-1975 (pre-decline), 1976-2010 (decline) and projected 35 year (future) average summer sea surface temperatures respectively. Within each water temperature treatmentfish were subjected to three feeding regimes based on bi-weekly fish sampling for weight; 4.5% body weight per day (BWD), 1.5% BWD and 0.5%BWD representing high, medium and low daily food availability respectively to create the factorial design (3 temperature x 3 feeding regime) with single replicates per treatment combination. Preliminary results will be presented.

October 18, 11:30 (FIS-P-9145)

Seasonal variability in juvenile fish and invertebrate prey available to Columbia River salmon entering the ocean

Marisa N.C. **Litz**[1], Robert L. Emmett[2], Andrew M. Claiborne[3], Jessica A. Miller[1] and David J. Teel[4]

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The phenological match/mismatch between prey resources and larval fish has been hypothesized as a mechanism explaining variable recruitment in fish, but may also explain juvenile fish recruitment. Different populations of juvenile Pacific salmon (*Onchorynchus* spp.) in the Columbia River basin migrate to the ocean at different times and speeds, occupy different habitats,and probably encounter different ocean prey assemblages. However, the ocean prey of juvenile salmon has not been extensively sampled.We evaluated juvenile salmon prey species composition variability by sampling both salmon ocean prey and juvenile salmon at monthly intervals (May-September) during 2011 and 2012. Based on multivariate community analyses, we identified three seasonal prey assemblages corresponding with peak migration periods of yearling and subyearlingsalmon: spring (May-June), early summer (July) and late summer (August-September). Columbia River flow, sea surface temperature, and chlorophyll fluorescence were strong predictors of the prey field community. In spring during both years, when yearling salmon migrate to sea, the prey community was dominated by juvenile flat fishes (Pleuronectidae) and crab megalope, prey diversity was highest (22 species), but average prey biomass was low (0.08 mg m^{-3}). In early summer, when subyearling Chinook salmon (*O.tshawytscha*) migrate to sea, average prey biomass was lowest (0.05 mg m^{-3}). In late summer, juvenile northern anchovy (*Engraulismordax*) dominated the prey community, species diversity was lowest (3-13 species), but average biomass was highest (0.58 mg m^{-3}). SubyearlingChinook salmon conditionwas highest during months of high anchovy biomass, supportingthe hypothesis that prey field abundance influences growth, and potentially survival.

October 18, 11:50 (FIS-P-8932)

Can we predict synchronous production dynamics? Applications to somatic growth

Christine C. **Stawitz**[1], Timothy E. Essington[1], Anne B. Hollowed[2], Trevor A. Branch[1], Melissa A. Haltuch[3], Paul D. Spencer[2] and Nathan Mantua[4]

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Oceanographic conditions can significantly affect productivity in fish stocks, so incorporating these effects into stock assessment models may improve estimates and forecasts. Somatic growth is an important driver of fish production dynamics. Thus, by identifying shared growth dynamics patterns across stocks, we can identify groups which respond similarly to environmental conditions. An important initial step is to quantify growth in a robust way that can detect changes attributable to cohort-based effects (*e.g.* via density-dependence or other drivers of first-year growth) or annual-based effects (*e.g.* changes in food availability or environmental conditions that affect several cohorts simultaneously). Here, we developed an approach to identify patterns in growth dynamics and related these dynamics to life history traits. We found that state-space models were able to robustly detect and distinguish cohort and annual growth effects. Moreover, this modeling approach can provide time-series of growth patterns for use in a statistical meta-analysis to identify groups of stocks with synchronous production dynamics. Broader application of this method will permit consideration of the relative importance of growth versus recruitment variability on production dynamics and to identify groups that respond to environmental dynamics in similar ways.

October 18, 12:10 (FIS-P-8952)

Linking recruitment synchrony to environmental variability

Megan M. **Stachura**[1], Timothy E. Essington[1], Nathan J. Mantua[2], Anne B. Hollowed[3], Melissa A. Haltuch[4], Paul D. Spencer[3], Trevor A. Branch[1] and Miriam J. Doyle[5]

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We investigated the hypothesis that synchronous recruitment is due to a shared susceptibility to environmental processes using stock-recruitment residuals for 52 marine fish stocks within three Northeast Pacific large marine ecosystems: the Eastern Bering Sea and Aleutian Islands (BSAI), Gulf of Alaska (GOA), and California Current (CC). We identified moderate coherence in terms of exceptionally strong and weak year classes and significant distributions of cross-stock correlation. Based on evidence of synchrony from these analyses, we used Bayesian hierarchical models to relate recruitment for groups of stocks with similar susceptibility to environmental processes to environmental covariates. There were consistent relationships among stocks to the covariates, especially within the GOA and CC. Within the GOA the best model included Northeast Pacific sea surface height data as predictor of recruitment, and was particularly strong for stocks dependent on cross-shelf transport during the pelagic larval phase for recruitment. In the CC the best-fitting model included San Francisco sea level height data as predictors, with higher recruitment for many stocks corresponding to high sea level the year before spawning and low sea level the year of spawning. For the BSAI stocks the best model included several environmental variables as covariates and there was some consistency in sensitivity to these variables. Future research may be able to utilize these cross-stock environmental influences, in conjunction with a mechanistic understanding of ecological processes across early life history stages at appropriate temporal and spatial scales, to improve identification of environmental drivers of recruitment.

October 18, 14:00 (FIS-P-8934)

Using surplus production models to study predation in age-structured populations

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There is growing evidence of strong species interactions in coastal marine ecosystems and the importance of accounting for such interactions for sustainable management of living marine resources. Predation is commonly strongly size-structured, implying that effects are felt at discrete life history stages. However, time series data that might be used to evaluate effects of predation on production are usually less detailed (*e.g.* total biomass). Here, we explored whether size-structured predation could be reliably detected from time series of total biomass of predators and prey. We simulated age-structured populations of mid-trophic level fish with four varying life history strategies, exposed them to variable predation at different life stages, and fit surplus production models to resulting aggregated data. Predation that targets the recruitment and juvenile life stages generally led to larger fluctuations in surplus production dynamics, and was thus easier for models to detect. However, realistic levels of observation error and recruitment stochasticity were able to mask most predator signals. Inclusion of a second predator in the operating and statistical models sharply decreased the detectability of both predators, even when the signal is easily detected with a single predator. We conclude that our failure to often detect species interactions from biomass time series may be largely due to the variability and complexity of the populations we study, rather than the true absence of an interaction. We furthermore recommend simulation testing to see if a specific predator is likely to be detected before analyzing such data.

October 18, 14:20 (FIS-P-8884)

Constructing a 3D simulation model of squid schooling behavior at jigging operations with the Boids Algorithm

Osamu **Tamaru**[1], Go Takayama[1], Hideo Takahara[2] and Toshihiro Watanabe[1]

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In Japan, many scientists and engineers have researched and developed Light Emitting Diode (LED) fishing lights for the Japanese squid jigging fishery. LED fishing lights are energy-saving lights compared with metal-halide (MH) lamps, but the fishers who use LED fishing lights for squid jigging fishery catch less amount of squid than the fishers using MH lamps. Therefore, many scientists are trying to reveal why current LED fish lights are not useful for the Japanese squid jigging fishery. Some scientists use experimental tanks for observing individual squid reaction toward various light sources, and others conduct squid jigging operating experiments for observing squid schooling behavior with regards to fishing lights. But, the results of the field experiments are sometimes different from the results of the experimental tanks. In this study, we constructed a 3D simulation model of squid schooling behavior at squid jigging operations with the Boids Algorithm, and controled the settings of this model from the results from experimental tanks. According to the simulation results, schools of virtual squid make a round of fishing boat and enter the shade area under the fishing boat from the stem and stern area of the fishing boat. We can observe the same behavior at field experiments and real jigging fishery operations. We concluded that this simulation model is useful in designing LED fishing lights and making the squid jigging fishery system more efficient.

October 18, 14:40 (FIS-P-8980)

Persistent summer pelagic hotspots of neon flying squid (*Ommastrephes bartramii*) in the western North Pacific

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

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We identified summer oceanic hotspots of neon flying squid (*Ommastrephes bartramii*) in the western North Pacific and explored potential mechanisms responsible for the formation of these biological features. The data used for analyses include fishery, satellite (sea surface temperature, sea surface height and eddy kinetic energy) and model-derived (sea surface salinity and mixed layer depth) information between May-July 2000-2005. The squid habitat hotspots were inferred from a 5-parameter generalized additive model (GAM) and were subsequently evaluated based on abundance and degree of persistence across the 5-year summer period. The identified habitat hotspots revealed spatio-temporal patterns that were invariably linked with the presence, timing and characteristics of oceanographic features deduced from the environmental proxies. From the early to latter phases of summer, patches of squid habitat hotspots develop within the Kuroshio-Oyashio transition zone (TZ) from 35-40°N and gradually extend north towards the subarctic frontal zone (SAFZ) from 40-45°N. The persistent squid habitat hotspots were further located in regions upstream and along the boundaries of the transition zone chlorophyll *a* front (TZCF) and the subarctic front, defined by the 18°C isotherm and 33.8 isohaline, respectively. The degree of persistence in habitat hotspots also varies with the predictability and dynamics of oceanographic features off the principal hydrographic provinces of the western North Pacific. Although many of the predicted squid habitat hotspots appeared to be patchy and ephemeral, ecologically relevant regions with persistently elevated squid abundance have been recognized. These insights could be useful for marine spatial planning and tactical resource management.

October 18, 15:00 (FIS-P-9066)

Impact of climate variability on the neon flying squid (*Ommastrephes bartramii*) winter-spring cohort stock

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A significant positive correlation has been found between the CPUE (Catch Per Unit Effort) of the neon flying squid (*Ommastrephes bartramii*) winter-spring cohort and the chlorophyll *a* concentration in their spawning grounds (135–180ºE, 20–25ºN). This correlation suggests that feeding environment of paralarvae affects future stock abundance. However, data of paralarvae prey, such as particulate organic matter and zooplankton, are not monitored. In this study, we used the North Pacific Ecosystem Model for Understanding Regional Oceanography (NEMURO), that is basedI on the physical environmental data from the ocean reanalysis dataset from a 4-dimensional variational (4DVAR) data assimilation experiment, to estimate the particulate organic matter and zooplankton abundance in squid spawning grounds. The 4DVAR dataset can provide a realistic time series of dynamically self-consistent circulation fields, and is thereby suitable for use in an ecosystem model experiment. In the model, the autumn-winter mixed layer development controls the winter-spring forage in the spawning grounds, and this in turndepends on sea surface cooling. Thus, this realistic and consistent physical-biological coupled model suggests that climate conditions in the subtropical North Pacific Ocean affects the neon flying squid winter-spring cohort stock through the bottom-up control.

October 18, 15:20 (FIS-P-9131)

Climate effects on spatial-temporal variation of the demersal fish assemblage in the Tsushima Warm Current region of the Japan Sea

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We examine climate effects on the spatial-temporal variation of demersal fishes by using single-trawler fishery data (1972-2002) in the Tsushima Warm Current region of the Japan Sea. This single-trawler fishery targets multiple species with different geographical affinities and life history traits. As such, these data are suitable for examining the biological mechanisms of how species respond to climate variability at different temporal scales. Our results indicate that species distributional changes in response to interannual climate variability are best explained by geographical affinity, as most cold-water species exhibit a poleward shift. For species with distributional change at both interannual and decadal scales, the marginal significance in asymptotic length suggests the large species are more likely to demonstrate distributional changes. Because these large species generally experience higher exploitation rates than smaller species, the result also suggests some influence from fishing. However, none of the variables examined are able to explain the shift in abundance at both interannual and decadal scales combined. It is worth noting that the life history traits and geographic affinities can only partially explain the species' responses to environmental changes, suggesting that other factors, such as interactions among species, are involved in mediating individual species responses.

October 18, 16:00 (FIS-P-8939)

Distribution, growth, and mortality of larval *Benthosema pterotum* (Pisces: Myctophidae) in the shelf region of the East China Sea

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We examined the distribution, growth, and mortality of larval *Benthosema pterotum*, a dominant pseudoceanic myctophid in the shelf region of the East China Sea, based on specimens collected on the shelf during late summer when the primary spawning has been predicted. This species is a major prey item for both pelagic and demersal fishes, including many commercially important species in this area. High abundances of the larvae, mostly preflexion larvae of <4mm body length (BL), occurred in the mixed layer between 60 to 90m bottom depth, confirming that *B. pterotum* reproduces in this area. This is a markedly shallower area than previous reports for the spawning grounds of myctophids. Occurrence of the larvae was restricted to the onshore side of the shelf-break salinity front (33.7 isohaline at sea surface), indicating that this front acted as a barrier restricting the offshore dispersion of the larvae. The length-specific growth rate showed a constant value of 0.26 mm d^{-1} during the larval stage (1.3–11.4mm BL), and fell within the previously reported ranges of other subtropical-tropical myctophid species. The weight-specific growth rate was 0.011 mg dry weight (DW) d^{-1} up to 15 d old, and increased greatly to 0.132 mg DW d^{-1} for postflexion larvae (>15 d old). Daily instantaneous mortality coefficient (*Z*) was estimated to be 0.28 d^{-1} (equivalent to 24.7% mortality d^{-1}) for larvae <15 d old, showing a similar value to the reported mean *Z* of epipelagic and demersal fish larvae occurring on the shelf.

October 18, 16:20 (FIS-P-8908)

Potential for competitive interactions between Pacific sardine and Pacific herring in British Columbia, Canada

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Changes in climate can alter key physical and biological processes in the marine environment. For example, off the west coast of Vancouver Island (WCVI), Canada summer upwelling, the timing of spring transition, and El Niño events can affect the timing and duration of the peak zooplankton biomass and zooplankton community composition. Trophodynamic consequences of such changes (*e.g.*, predation and competition) can extend to planktivorous fish and predators. Pacific Sardine migrate to marine waters of British Columbia during the summer to feed on abundant plankton resources (diatoms, copepods, and euphausiids) and are a potential competitor for Pacific Herring. The extent of the northward migration of sardine is in part related to warm ocean conditions. Pacific Herring on the outer coast have demonstrated a long term decline in abundance. A hypothesis recently proposed in the literature is that competitive interactions between herring and sardine may be one factor impacting the recovery of herring. The goal of this study is to assess the potential for competitive impacts of sardine on herring. The objectives are to examine the spatial extent of overlap in herring and sardine distributions, and quantify and compare stomach fullness and prey composition of both species in areas where they do and do not co-occur. Initial results indicate a high degree of spatial and dietary overlap in the summer. This information, along with data on zooplankton, other fish species, and environmental conditions, could support future modeling efforts to predict herring and sardine distributions.

October 18, 16:40 (FIS-P-9178)

Spatial and temporal variations in albacore habitat in the Northeast Pacific transition zone using remotely-sensed environmental data

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Albacore tuna (*Thunnus alalunga*) occur through much of the temperate waters of the North Pacific and undergoe zonal feeding migrations across the entire basin. Oceanic habitat preferences and the 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) to evaluate this hypothesis. 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 both combined or split east and west of 130°W. Finally, we plotted binary prediction maps 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, with most of the catch occurring in waters 15-18 °C and just north of the Transition Zone Chlorophyll front. The results may allow identification of environmental factors that could be refined and used in predictive habitat modeling.

October 18, 17:00 (FIS-P-9141)

Non-stationary effects of environmental conditions on walleye pollock larval distribution

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The distribution of fish larvae is typicallyinfluenced byvarious oceanographic conditions. Although we maydetect a particular relationship between larval distribution and environments at any given point in time, this relationship maychange with the lapse of time (*i.e.*, be non-stationary). In this study, we investigated the non-stationary effects of water temperature and salinity on larval distribution using Japanese Pacific stock (JPS) of walleye pollock (*Theragracalcogramma*).From 2005 to 2010, data on density of pollock larvae and oceanographic conditions were collected in Funka Bay, where the main larval nursery ground of JPS is located. A generalized additive mixed model (GAMM) was applied to explore the association of larval density with temperature and salinity. GAMM results indicate that in years with high average temperature and salinity (2006, 2007, and 2009), pollock larvae were widely dispersed in the bay, but higher densities were observed under higher salinity conditions. By contrast, in years when average temperature and salinity were low (2005, 2008, and 2010), pollock larvae were concentrated in high temperature and salinity areas. The distribution of pollock larvae in Funka Bay seems to be affected by salinity throughout the sampling period, and under the strong influence of temperature only during low temperature and salinity period. Oceanographic conditions in Funka Bay are mainly controlled by Coastal Oyashio (CO) current. It is likely that JPS larvae show non-stationary environment-distribution relationships depending on the demeanor of CO.

FIS-Paper Session POSTERS

FIS-P-P1

Annual variability of pollock resources, distribution, reproduction and environment in the Bering Sea

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Bering Sea pollock fishery management is based on the synthesis of annual stock assessment and recruitment data and various ecosystem indicators. Pollock recruitment, abundance of year classes, spatial distribution in spawning and feeding periods and fisheries are correlated with climate variables, water temperature, and plankton abundance and distribution. In 2010-2012, Eastern Bering Sea pollock biomass increased and stabilized at average level (6.0-7.0 million tons?), which was a result of four relatively numerous year classes – 2006, 2008, 2009 and 2010. The pollock catch in Russian and US EEZs changes basically synchronously. Annual catch in US water decreased in 2008-2010 (0.80-0.99 million tons?) and increased rapidly in 2011-2012 to 1.25 mln t. In Russian EEZ annual catch also decreased in 2009-2010 (323.5-311.5 thousand tons?) and increased in 2011-2012 (332.8-385.5 thousand tons).

The annual spatial distribution of pollock in spawning and feeding period correlated with water temperature, age composition and abundance of year classes, and plankton distribution. In 2012 there was observed a shift in spawning location from the southeastern Bering Sea to the northern part and most of 5-year old pollock of numerous 2008 year class spawned in the Pribilof Island area. Potentially it resulted from a cold winter and low water temperature. The developing of pollock females' ovaries in prespawning period of 2013 was much slower but longer time on average, therefore peak spawning in 2013 occurred later. These data supports the hypothesis that long term climate shifts, as well as short term variations in temperature, have strong influence on pollock distribution and reproduction. The relationship of reproduction of pollock and climate shift is very complicated and associated not only with direct influence of temperature but also with plankton community variability, its abundance and species composition. Recently, new data appeared that good survival of young-of-the year pollock is observed in a short time period of climate shift. Probably it's associated with rapid changing in composition of plankton community and increasing range of diversity of plankton size groups and potentially good food supply.

The scale of northward pollock migration in summer period 2010-2012 increased in spite of cold water temperature in the northwestern Bering Sea.

FIS-P-P2

Fish by-catch during the schoolmaster gonate squid *Berryteuthis magister* (Berry, 1913) trawl fishing near northern Kuril Islands

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The Pacific side of Northern Kurile Islands is a traditional region for commercial harvest for schoolmaster gonate squid since 1980s. Catch data were collected during June-July of 2012. Two-hundred trawl tows were arranged at the depth of 190–450 m. Depending on the abundance of squid, time of trawling continued from 30 minutes up to 7 hours. From 5 to 12 vessels had been working on aggregations of *B. magister* at different days. During the observations 1126.8 tons of raw squid were caught. However, 28 species of fish (18.3 tons in total) were caught as by-catch along with the squid. Several species have a commercial value – Alaska pollock *Theragra chalcogramma* (catch 16891 individuals weight 15.7 tons), rockfish *Sebastes sp.* (967ind./0.7tons), Pacific halibut *Hippoglossus stenolepis* (54ind./0.16tons), Kamchatka flounder *Atheresthes evermanni* (287ind./0.5tons), Greenland halibut *Reinhardtius hippoglossoides matsuurae* (124ind./0.15tons), Pacific cod *Gadus macrocephalus* (66ind./0.2tons) and rock grenadier *Albatrosia pectoralis* (30ind./0.1tons). Most of these fishes were of commercial size.

According to the fishing license, percentage of by-catch taken in the squid fishery should not exceed 2% of the total catch weight. Also, after the catch separation all the fish was dumped overboard. During the lifting of the trawl on board and moving of the catch to the fish shop, demersal squids and fish died. Having the license to use by-catch for sale will allow to better use the ecosystem of this fishery region.

FIS-P-P3

Seasonal variations infish community structure in Laizhou Bay and the Yellow River Estuary, China

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Seasonal variations in fish community structure characteristics in Laizhou Bay and the Yellow River Estuary were analyzed by combining data collected from bottom trawl surveys on 9 different voyages in May-November, 2011 and March-April, 2012 with existing historical data. A total 62 fish specieswere caught, belonging to 11 orders and 34 families, which mainly comprised warm water and warm temperate species. Perciformes were the most abundant (37 species), followed by Scorpaeniformes (7 species) and Pleuronectiformes (6 species). In terms oftotal catch per haul (kg) and the number of individuals per haul,warm temperate species were more abundantthanwarm water species, which were more abundant that and cold temperate species.Catches of warm temperate specieswere highest in spring in the coastal region, whereas catches of warm water and warm temperate species were higher in summer and autumn and were mostly distributed in the northeast Laizhou Bay deep-water area in autumn. Warm temperate specieswere widely distributed in summerwhilewarm water specieswere mostly distributed in the coastal region of southern Laizhou Bay.The dominant species in spring were mainly non-commercial demersal fish,*Chaeturichthysstigmatias, Callionymusbeniteguri*,*Synechogobius hasta,* and *Enedriasfangi*, which accounted for 66.4% of the total catch. The dominant species in summer were also mainly non-commercial demersal fish species,*C.stigmatias*and *C. beniteguri,* which accounted for 44.6% of the total catch. While in autumn, the dominant species were mainly commercial pelagic fish, *Engraulisjaponicus, Sardinellazunasi*, and *Konosiruspunctatus*, whichaccounted for 40.8% of the total catch. According to the dominance curve, the dominant species were most prominent in summer, followed by autumn, and spring. The catch per haul also exhibited significant seasonal variation, being highest in autumn (22.66 kg/h) followed by summer (16.75kg/h) then spring (1.29 kg/h). The average catch per haul of the dominant species in spring (May) was 0.69kg/h, which is only 0.3%, 0.3%, 1.7%, and 541.2% of the average catch per haul observed in surveys in the spring (May) of 1959, 2003, and 2008, respectively. Despite the small increase in fish resources, the overall trend shows a substantial decrease. Species composition exhibited higher similarities in adjacent months, i.e. each month of the same season and the months of summer and autumn. The number of fish species and abundance and diversity indices were all highest in summer, followed by autumn and then spring. However, the evenness index calculated by number was highest in summer and lowest in spring, this trend was inversed when the index was calculated by weight. The species abundance and diversity indices were significantly correlated with sea surface temperature (P<0.01). The species abundance index and evenness index were significantly correlated with sea surface salinity (P<0.01).

FIS-P-P4

Late winter larval fish assemblage in the southern East China Sea, with emphasis on spatial relations between mesopelagic and commercial pelagic fish larvae

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We describe larval fish assemblages in the southern East China Sea in February 2007 where large spawning grounds of several commercial pelagic fishes are formed. Our samples included a total of 191 species or taxa of larval fish belonging to 118 genera and 94 families. Mesopelagic fish larvae, mainly Myctophidae and Gonostomatidae, accounted for 68.4% of the total catch, while commercial species such as *Trachurus japonicus*, *Scomber* spp., and *Trichiurus japonicus* for 16.6%. Based on the species composition, three assemblages were recognized: Kuroshio

(KUR), Shelf-break (BRE), and Shelf (SHE) assemblages. KUR assemblage was mainly characterized by various mesopelagic fishes such as *Sigmops gracilis*, *Diaphus* spp., and *Myctophum asperum*, BRE assemblage by both commercial pelagic and mesopelagic species, SHE assemblage by demersal species such as *Lepidotrigla* spp. and Gobiidae spp. Both abundance and species diversity were highest in KUR assemblage. KUR and BRE assemblages occurred broadly in our study area and the border was clearly defined by the Kuroshio front. SHE assemblage occurred in a narrow area shallower than 110 m depth. Except for *Benthosema pterotum* occurring mainly on the shelf, the center of distribution of mesopelagic fish larvae was observed in the Kuroshio waters, and differed from that of the commercial species. However, a northward intrusion of the Kuroshio branch current transported mesopelagic fish larvae onto the shelf, forming the BRE assemblage. This suggested that competition for prey between mesopelagic and commercial pelagic fish larvae would potentially occur if the intrusion is strong.

FIS-P-P5

Age and growth of filefish *Thamnaconus modestus* off the Jeju Island

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The filefish (*Thamnaconus modestus*) is a commercially important species exploited in the southern waters of Korea. We collected 1698 specimens captured in the commercial trawl fishery off of Jeju Island, ranging in size from 11.3 cm to 42.1 cm. The sex ratio was not significantly different from a 1:1 ratio (p>0.05). The gonadosomatic index (GSI) for both sexes was the highest in May to June, indicating May to June as the main spawning period. Length at sexual maturity of female was 25.92 cm. The length-weight relationship of filefish was W=0.0121 $L^{3.0536}$ (n=1692, r^2=0.9034, p<0.001). The age of the sampled individuals, which ranged from 0 to 9 years, was estimated using counts of growth rings recorded on the vertebrae. The filefish showed a high variation in total length at the same age. Length-at-age data were fitted using von Bertalanffy growth model. The estimated von Bertalanffy growth parameters of filefish were L_∞=42.04 cm, k=0.21 year^{-1}, and t_0=-1.56 year for females; L_∞=41.20 cm, k=0.18 year^{-1}, and t_0=-2.36 year for males. These results represent biological information that can be used for future fishery management of the filefish resource in Korean waters.

FIS-P-P6 - CANCELLED

Medusa consumption and prey selection of silver pomfret *Pampus argenteus* juveniles

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The current study explored the consumption of *Aurelia aurita* and *Rhopilema esculentum* by silver pomfret juveniles, as well as prey selection by pomfret between the two jellyfish species. Silver pomfret juveniles weighing 1±0.1 g actively preyed on both species of jellyfish. Their daily consumption of *A. aurita* was 11.6 times their own body weight, regardless of the size of *A. aurita* medusae. The daily consumption of *R. esculentum* by pomfret was 13, 9.1, 5 and 4.1 times their own body weights when the *R. esculentum* medusae were 10, 20, 30 and 40 mm in bell diameter, respectively. The survival rates of the *R. esculentum* were higher than those of the *A. aurita*. When *R. esculentum* medusae were more than 30 mm in bell diameter, their survival rate exceeded 92%. Pomfret were fed alternative diets for 20 days, in which *A. aurita* medusae were either the sole food source or mixed with other prey. Results showed an increase in body weight in both groups, although the growth rates were slightly lower in the mixed diet group. This suggests that *A. aurita* medusae may be used as fish diet in silver pomfret artificial breeding.

FIS-P-P7

Development of the 3-D growth prediction model for Japanese scallop in Funka Bay, Japan

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The Japanese scallop (*Mizuhopecten yessoensis*) is an important commercial species in Funka Bay, Japan. The hanging culture method in 20 m water depths is successfully used for scallop in the coastal areas of Funka Bay. Our study used 3 dimensional data: 1) the monthly observation data at every water depth from Yakumo station during 2003 to 2010, including sea temperature, chlorophyll-a, full weight and adductor muscle weight of scallop. 2) Satellite remote sensing data from MODIS, including spatial chlorophyll *a* and sea surface temperature in the whole Bay. 3) 4-D VAR vertical water temperature data from Ocean general circulation models (OGCMs), with 4 vertical levels (6m, 10m, 14m and 18m) from the sea surface. A generalized adding model (GAM) was applied to station observation data, satellite data and 4-D VAR data to reveal the influence of environment factors (Chl-*a*, temperature, depth) on the growth of scallop, and develop the 3-D growth prediction model for Japanese scallop in Funka Bay. The results revealed that GAM is an effective model to predict the vertical growth of scallop, the predict results were well verified by in-situ data from different depths (r^2=0.83~0.94). From the 3-D growth distribution maps, we could see that scallop growth becomes faster as the water depth increased. Also scallop growth varies in different regions and different years. This change is due perhaps to ocean environment and climate change. Adaptation to these changes should be considered when developing plans and management for scallop aquaculture.

FIS-P-P8

Climate change, emigration timing to sea and salmon marine survival

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Although previous studies have suggested links between climate-driven changes in the migration of Pacific salmon and marine survival, there is limited empirical evidence supporting this hypothesis. Here we investigated the importance of temperature on the phenology of juvenile salmon emigration from freshwater spawning grounds to sea. We also assessed the consequences of a potential mismatch between the timing of ocean entry and their prey on salmon marine survival for populations with diverse life-history strategies and freshwater habitats (streams *vs* lakes). We expected that phenological responses to changes in temperature would be less important for salmon rearing in lakes than those living in streams, due to heat buffering in large lake systems.Changes in the phenology of juvenile outmigration timing were assessed using ~30 years of juvenile salmon abundance and temperature data. We assessed the phenological response throughout the emigration periodby developing percentile models of emigration timing against predictor variables, including year and temperature effects. In investigating the potential mismatch between juvenile salmon and their prey, seasonality in the phytoplankton blooms, zooplankton, and seasurface temperatures were used as a proxy for prey abundance. Our results suggest that emigration timing has become earlier over the last 30 years, and is correlated with earlier spring temperatures, such that warmer conditions are generally associated with earlier migration.

FIS-P-P9

Potential habitat overlap between neon flying squid (*Ommastrephes bartramii*) and marine mammals in the western North Pacific: Possible trophic linkages

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The neon flying squid (*Ommastrephes bartramii*) is widely distributed in subtropical and temperate waters, and is an important component of the western North Pacific food web. We explored the hypothesis that its forage habitat overlaps with that of other high trophic species, such as marine mammals. Squid potential habitat between May-July 2003-2007 was inferred from Maximum Entropy (MaxEnt) models constructed using fishery data, satellite data (sea surface temperature, sea surface height and eddy kinetic energy) and 4D-var model-generated (sea surface salinity and mixed layer depth) environmental variables. To investigate potential habitat overlap between squid and whales, we overlaid sperm and sei whales' sighting positions on squid potential habitat distributions and compared the extracted squid occurrence probability (habitat suitability index, HSI) at the recorded mammal sightings. Whale sightings were independently collected from JARPN-II surveys, compiled monthly and then mapped at 0.25° spatial resolution. Model-based squid potential habitat ranged from 0.2-0.7 and initial comparative analyses revealed that whale sightings were dominantly distributed in regions of higher HSI in May-June (median HSI > 0.35) relative to that in July (sperm whale: 0.26 and sei whale: 0.27). It appears that squid forms an important prey source for the sperm whales and at the same time actively competes for prey with sei whales. These results, albeit preliminary, may provide an understanding of the diverse and complex trophic linkages in the western North Pacific ecosystem.

FIS-P-P10

Potential fishing zone prediction map of Japanese common squid in the coastal water, southwestern Hokkaido, Japan

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Japanese common squid (*Todarodes pacificus*) is of high commercial importance for Japanese fisheries, and there is an increasing concern for its conservation in recent decades. To understand the mechanisms behind this species spatial and temporal distribution, we evaluated fisheries data derived from Meteorological Satellite Program/Operational Linescan System (DMSP/OLS) to represent locations of the daily presence and absence of squid aggregations. Combined with model-derived environmental factors from the 4D-VAR data assimilation system, we investigated the correlation between squid distributions and various environmental factors in different water depths. Bathymetry and other habitat factors which had close correlations were applied to predict daily potential fishing zones (PFZ) using habitat suitability index (HSI) model coupled with presence/absence squid fishing aggregation database. Validations based on an independent dataset showed a better performance of the model predictions of squid aggregations than our previous model, which was established with satellite-derived environmental data. Additionally, the model-derived data can provide future predictions without weather restrictions. With the assistance of local fishery associations, we facilitate local fishing activities with our models. Our four-day prediction distribution was delivered to fishermen every day from July in 2013 to help their selecting fishing positions. We examined performance of our prediction model in comparison between NPP/VRIIS night

light images and PFZ maps. We will present the effect of environmental factors on Japanese common squid distribution and share information of applications of PFZ modeling. This study is supported in part by the 'Hakodate Marine Bio Cluster Project'.

FIS-P-P11

Overwintering ability of juvenile ocean-type Chinook salmon: Effect of water temperature and food deprivation on growth, energetics and survival

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In pelagic fishes including Chinook salmon (*Oncorhynchustshawytscha*), metabolic demands typically increase with temperature. Thus, the warm winter water temperatures that have been projected under the current global ocean warming regime could negatively affect juvenile Chinook salmon during their first winter of life if food resources are not available or abundant enough to meet the increased physiological demands. Our objectives were to experimentally evaluate how juvenile ocean-type Chinook salmon responded to climate and food variability during early marine life. Fish were assigned to experimental aquaria with either 6.5°C (cool) or 10.5°C (warm) water temperature and one of three feeding regimes (fed once daily to satiation continuously throughout the entire study period, food deprived for two weeks, and food deprived for four weeks). Feeding was restored for four weeks to the food deprived treatments to assess the capacity for compensatory growth. Survival was similar between warm (89%) and cool (85%) temperature treatments irrespective of feeding regime. Food deprivation resulted in reduced weight only in the warm temperature/four-week food deprived fish. Compensatory growth was evident only in fish subjected to the cool water/two-week food deprived treatment. The respiration rate of juvenile Chinook was highest in the warm treatments. The combined effects of temperature and food deprivation on juvenile Chinook salmon growth and metabolism could have a negative impact on early marine survival if projected regional winter nearshore ocean temperatures approach those simulated in the warm temperature treatments of this study, particularly during prolonged periods of poor resource availability.

FIS-P-P12

Some features of *Lycodes soldatovi* biology and parasitology in the Okhotsk Sea

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Lycodes soldatovi is one of 5 the most common fish species of the Okhotsk Sea and have a commercial value, but its biology is still poorly known. It dwells in wide depth range, with the densest aggregations at depths of 450-700 m at northwestern Kamchatka. Its body length in trawl catches ranges from 14-73 cm, with the average 53.6 cm. Previously, the parasitic copepods *Naobranchia sp*. (Naobranchiidae) and *Acanthochondria sp*. (Chondracanthidae) were considered as the only parasites of this species, but recently 8 new parasitic species (3 species of myxosporeas, 4 species of helminthes, and 1 species of copepods) have been described. The parasitic fauna of *Lycodes soldatovi* corresponds to its trophic links: its favorite prey is euphausiids and amphypods, which are intermediate hosts for helminthes and myxosporeas. High infestation by parasites contribute to the light color of the lycod's body, as parasitic copepods destroy blood vessels in its gills and cause lowered haemoglobin concentration in its blood. The species composition of parasites is slightly different for juveniles and adults, corresponding to their vertical distribution; young lycods are usually distributed in deeper layers than the adults. *Lycodes soldatovi* is caught mostly as a by-catch in trawl and longline catches of halibut, and net catches of rockfish.

FIS-P-P13

Metagenomicanalysis of the fish gut microbiota

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Gut microbiota contribute to host organismwell being throughbeneficialeffects on metabolism, immune response, andethological aspects. Host organisms also select commensal microbiota that provide advantages to survival or fitness of host. In recent papers, the composition of bacterial communities in gut has been found to be determined by various factors, including diet, habitat, phylogeny and the age of the host.Although previous studies have suggested host-microbe interactions and co-evolutionary histories between microbiota and their vertebrate hosts, gut microbiota in most vertebrate species,particularly fish,are uncharacterized. In this study, we investigated uncultivablebacterial community of distal gut and luminal contents from 300 fishes that represent 50 species in East Sea, Korea.The extracted bacterial metagenomic DNAfrom gut and luminal fluid of each fish species were amplified with barcoded primers targeting V1-2 region of the 16S rRNA gene,and then sequenced by high-throughput next generation sequencing (454 pyrosequencing). The use of culture-independent technology helps to understand previouslyunrevealed host-gut microbe interaction in fish, and providescircumstantial clues for trends of co-evolotion in vertebrate and commensal microbes.

FIS-P-P14

Some results of salmon origin identification and of figuring out the age structure of identified stocks by different methods

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The material for the research was a pool of otoliths collected from Pacific salmon adult escapement in the Bolshaya River basin and from spawning coho salmon in the lake Bolshoy Viliuy in 2008-2010. Identification of wild and hatchery salmons and analysis of their age structure were provided on scale and otoliths.

The analysis has indicated the maximum contribution of hatchery salmon to the catches in the Bolshaya River outlet in 2010 as 10%. The average age of the spawners in four hatchery populations was less comparing to the average age of wild spawning stock. Trends of age structure simplification and getting the age at return younger are observed.

Reading from otoliths and scales for the hatchery fish doesn't bring same results. Reading from scale normally gives more number of age classes, and most likely that is due to particular impossibility to read the ages of hatchery individuals correct due to deviations from schemes of marking in some years. The differences can be result of poor quality of scale in some cases.

FIS-P-P15

Spatio-temporal associations of albacore catches in the Northeastern Pacific with regional and climate environmental variables

A. Jason **Phillips**[1], Lorenzo Ciannelli[2], Richard D. Brodeur[3], William G. Pearcy[2] and John Childers[4]

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This study investigated the spatial distribution of juvenile North Pacific albacore (*Thunnus alalunga*) in relation to local environmental variability (*i.e.*, sea surface temperature (SST)), and two large scale indices of climate variability, the (Pacific Decadal Oscillation (PDO) and the Multivariate El Niño/Southern Oscillation Index (MEI)). Changes in local and climate variables were correlated to 48 years of albacore troll catch per unit effort (CPUE) at 1° latitude/longitude cells, using Generalized Additive Mixed Models (GAMM). Model terms were included to account for nonstationary and spatially variable effects of the intervening covariates on albacore CPUE. Results indicate that albacore CPUE rates increased with SST both before and after the 1976-77 regime shift of the North Pacific, but CPUE geographically shifted north after 1977. SST had a predominantly positive and spatially-variable effect on albacore CPUE, with increasingly positive effects to the North, while the PDO had an overall negative effect. This is the first study to demonstrate the non-stationary spatial dynamics of albacore tuna, linked with a major shift of the North Pacific. Our results imply that if ocean temperatures continue to increase, west coast fisher communities reliant on commercial albacore fisheries are likely to be negatively impacted in the southern areas but positively benefited in the northern areas, where current albacore landings are highest.

FIS-P-P16

Comparisons of trophic level in ecosystem by effects of fishing in Korean waters

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This study compared effects of fisheries on marine ecosystems in Korean waters with investigating characteristics of Korean fisheries resources. A self-organizing mapping technique was applied to classify groups with 86 marine species in Korean waters, based on six ecological variables. Trophic levels of catches in three marine ecosystems, *i.e.*, the East/Japan Sea (EJS), Yellow Sea (YS), and East China Sea (ECS) were estimated, and their structure and composition of species groups for the ecosystems were analyzed. The piscivorous demersal fishes at high trophic levels decreased, whereas planktonivorous pelagic fishes and crustaceans at low trophic levels increased in all three ecosystems. The decadal means of the trophic level (TL) declined from 3.51 in the 1960s to 3.36 in the 2000s ($P<0.001$) of Korean waters. When we assessed TL index in three ecosystems, the TL index in the YS ecosystem decreased from 3.58 in the 1960s to 3.26 in the 2000s, and from 3.62 to 3.37 in the EJS, and from 3.5 to 3.39 in the ECS ecosystem during the same period ($P<0.001$). Therefore, the fishing activity incorporating with ecological term such as trophic level was a good indicator to assess the effects of fisheries on Korean marine ecosystems.

MEQ Paper Session

Co-Convenors: Chuanlin Huo (China), Elizabeth Logerwell (USA), Olga Lukyanova (Russia), Darlene Smith (Canada) and Lyman Thorsteinson (USA)

Invited Speaker:
Stanley (Jeep) Rice (retired, NOAA)

Papers are invited on all aspects of marine environmental quality research in the North Pacific and its marginal seas, except those covered by Topic Sessions covered by the Marine Environmental Quality Committee (MEQ).

Tuesday, October 15 (14:00-17:25)

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

14:05 **Stanley D. Rice (Invited)**
Oil development in the Arctic: What are the science needs? (MEQ-P-9186)

14:30 **Leslie Holland-Bartels and Lyman Thorsteinson**
An evaluation of science needs to inform decisions on outer continental shelf energy development in the Chukchi and Beaufort seas, Alaska (MEQ-P-8954)

14:45 (cancelled) **Dee Williams**
Monitoring effects related to offshore petroleum development in Coastal Alaska (MEQ-P-8955)

14:45 (cancelled) **David Rivkin**
Environmental impact factors of renewable energy production facilities in marine environments (MEQ-P-8873)

15:00 ***Coffee/Tea Break***

15:35 **Kathryn Higley, Elizabeth Ruedig, Emily Caffrey, Mario Gomez-Fernandez, Michelle Comolli and Delvan Neville**
Relating radiation dose to effect: The importance of accurate dosimetry in assessing the impact of radioactivity on marine organisms (MEQ-P-9182)

15:50 **Jinqiu Du, Ziwei Yao, Hui Gao, Guangshui Na and Chuanlin Huo**
Characteristics of radionuclides in sediment samples from coastal waters of Dalian Bay and Liaodong Bay (MEQ-P-9187)

16:05 **Delvan Neville, Kathryn Higley and Richard D. Brodeur**
Radiocesium and jellyfish: Where's the biomagnification? (MEQ-P-9181)

16:20 **Wen Yu, Men Wu, Jianhua He, Yusheng Zhang and Tao Yu**
Measured distribution of seawater radioactivity from Fukushima Daiichi Nuclear Power Plant in North Pacific (MEQ-P-9194)

Jianhua He, Wen Yu, Men Wu, Tao Yu and Yusheng Zhang
Radioactivity of marine cephalopoda and fish species after 2011 Fukushima Daiischi Nuclear Power Plant accident in the Northwest Pacific (MEQ-P-9197)

16:45 **Shin-ichi Ito, Hiroshi Kutsukake, Kazuhiro Takeuchi, Hideki Kaeriyama, Masashi Kodama, Shigeho Kakehi, Kazuhiro Aoki, Hiroshi Kuroda, Hiroshi Yagi, Ambe Daisuke and Tsuneo Ono**
Estimation of river discharges and fluxes of suspended substances to the North Pacific after the Fukushima Dai-ichi nuclear power plant accident (MEQ-P-9006)

17:00 (cancelled) **Vyacheslav Lobanov, Vladimir Goryachev, Aleksandr Sergeev, Dmitry Kaplunenko, Natalia Shlyk, Natalia Treshcheva, Sergei Prants and Maksim Budyansky**
Fukushima 2011 derived radionuclides in the Japan and Okhotsk seas and subarctic front region of the Northwestern Pacific, one year later (MEQ-P-9190)

17:00 **John N. Smith, Robin Brown, Marie Robert, Bill Williams and Richard Nelson**
Detection of radioactivity from the 2011 Fukushima accident in the Eastern North Pacific and Arctic Oceans (MEQ-P-9113)

17:15 *Comments and Discussion*

17:25 *Session Ends*

MEQ-Paper Session POSTER - CANCELLED

MEQ-P-P1 (cancelled) **Sharon N. Nuñal, Sheila Mae Santander-De Leon, Jiro Koyama, Tadahide Noro, Takeshi Yoshikawa and Hiroto Maeda**
Enhanced bioremediation of heavy oil-contaminated sediment by combining biostimulation and bioaugmentation strategies

MEQ Paper Session, Oral Presentations

October 15, 14:05 (MEQ-P-9186)

Oil development in the Arctic: What are the science needs?

Stanley D. **Rice**

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Predicting and measuring impacts from an oil spill in the Arctic will be a difficult task, and priorities for the supporting science will be needed. There are lessons learned from both the Exxon Valdez spill (1989) and the Gulf of Mexico spill (2010); oil persists, some life stages are quite sensitive, response/clean up options are not nearly as effective as we would hope, some habitats are more vulnerable than others, and they do repair over time. Life goes on, but is it the same? Extrapolating these concepts to the Arctic marine environment is risky because baseline information base is limited and the "normal seasonal stressors" are extreme. Except for some high profile species (*e.g.* polar bears, bowhead whales), we seldom have good quantitative estimates of numbers and vital rates, nor do we have a good estimates of impacts of the "normal" seasonal and annual changes without oil stress. To understand regional shifts in populations, such as those projected from climate change, and assess/predict changes from development and spill events, we will need key population estimates along with biomarkers that are not just indicative of exposure, but predict biological impacts.

October 15, 14:30 (MEQ-P-8954)

An evaluation of science needs to inform decisions on outer continental shelf energy development in the Chukchi and Beaufort seas, Alaska

Leslie **Holland-Bartels**[1] and Lyman Thorsteinson[2]

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Oil and gas potential in the Chukchi and Beaufort seas is significant. On March 31, 2010, Department of the Interior Secretary Ken Salazar, asked the U.S. Geological Survey (USGS) to conduct an initial, independent evaluation of the science needs that would inform the Administration's consideration of the right places and the right ways in which to develop oil and gas resources in the Arctic Outer Continental Shelf. The evaluation included descriptions of the physical and biological environments (geology, oceanography, climate, ecology and subsistence) and examined the state-of-the-science and science sufficiency with respect to (1) oil-spill risk, response, and impact; (2) marine mammals and noise; (3) climate change impacts; and (4) cumulative impacts. Lessons learned from the *previous oil spills* guided an inventory of valuable "pre-positioned" science and scientific approaches for improved response and reduced uncertainty in damage assessments and restoration. Structured Decision Making was evaluated as an important tool for incorporating information into a comprehensive process for priority setting and decision making. The assessment informs multiple governmental interagency planning activities and coordination (National Ocean Policy and Interagency Arctic Research Policy Committee). Many of the science issues identified for oil and gas development are the same, or similar to those associated with climate and ecosystem change. Linkages between USGS science and other contemporary initiatives (Pacific Arctic Gateway Ecosystem Study and Marine Arctic Ecosystem Study) are discussed with respect to coordination in planned large-scale ecosystem studies and relevance to PICES missions in the FUTURE Scientific Program.

October 15, 14:45 (MEQ-P-8955)

Monitoring effects related to offshore petroleum development in Coastal Alaska

Dee **Williams**

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The Environmental Studies Program (ESP) of the Bureau of Ocean Energy Management was established and funded by the United States Congress to support the offshore oil and gas leasing program of the Department of Interior in pursuit of national energy policies. Since 1973, the consistent mission of the ESP has been to establish the information needed for assessment, prediction and management of potential environmental and social impacts from energy development on the Outer Continental Shelf and coastal environments. With over $425 million invested in Alaska research, the ESP has maintained a strong marine natural science emphasis in the study of physical oceanography, oil spill fate and effects, biology, and protected species. The ESP has also supported a longstanding social science research component to monitor and mitigate effects on the human environment, with notable gains in the effort to integrate traditional ecological knowledge with scientific data collection. This presentation will provide a brief review of the current scope and scale of agency-funded scientific research in Alaska and focus on collaborative keystone projects in the arctic that advance prospects for science-based decision making.

October 15, 15:00 (MEQ-P-8873)

Environmental impact factors of renewable energy production facilities in marine environments

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Renewable energy production facilities located in marine environments bring many similar issues as oil and gas facilities, however many differences are also present. As more types of renewable energy are developed, the diversity of designs and their resulting environmental impacts diverge greatly. This presentation will introduce several renewable energy technologies, briefly describe common issues for renewable energy and oil and gas facilities, and finally discuss several issues needing to be studied in renewable energy production and the information needs related to ecosystem-based management . Wind farms, Hydrothermal, Wave and Tidal energy systems will be presented with a summary of designs, a discussion of currently identified impacts on the marine environment, and the presentation of some factors not often discussed that are unique to these new technologies. As an example of commonly known impacts, wind farms present obstacles to migrating birds and bats and their platforms can act as artificial reefs for marine fish and invertebrates. However, the exact nature of the potential impacts from new high density farm designs is difficult to predict. The impact of highly toxic rare earth metal based generators, should there be a catastrophic loss of the turbine into the sea, has not been studied to date. Regulations on the various fields of renewable energy are new and must be highly adaptable as new technology enters the field. The diversity of the renewable energy field makes the education of regulators, managers, and policy makers especially difficult. Given the commonality of subject matters, marine scientists and renewable energy researchers need to explore and work on these topics together.

October 15, 15:35 (MEQ-P-9182)

Relating radiation dose to effect: The importance of accurate dosimetry in assessing the impact of radioactivity on marine organisms

Kathryn **Higley**[1], Elizabeth Ruedig[2], Emily Caffrey[1], Mario Gomez-Fernandez[1], Michelle Comolli[1] and Delvan Neville[1]

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The release of radioactive contaminants from the Fukushima Daiichi nuclear accident has refocused attention on the potential for ecological effects from radioactive discharges into the marine environment. While the measurement of concentrations of radionuclides in both seawater and marine organisms is a relatively straightforward process, the calculation of absorbed dose in non-human organisms is not. However, standardized and accurate dosimetry is crucial when relating impacts to dose. Several organizations have developed technical approaches for addressing this issue, including the U.S. Department of Energy and Argonne National Laboratory's RESRAD-Biota Code, the European Union's ERICA Assessment Tool, and the International Commission on Radiological Protection's tabulated dose conversion factors. Each of these methodologies incorporates simplifying assumptions regarding both organism geometry and the distribution of radionuclides within the organism. A more robust approach, originally pioneered for use in human dose calculations, was recently adapted for use with non human biota (including terrestrial and aquatic animals and plants). This presentation examines the methodology being used at Oregon State University to develop so-called voxel phantoms for a variety of marine species. While this technique can provide substantially more accurate dose estimates, it is more labor intensive than other existing methods. The benefits and challenges inherent in the development of voxelized dosimetric data will be discussed, and a comparison made between the results of simplified versus more detailed dosimetric calculations.

October 15, 15:50 (MEQ-P-9187)

Characteristics of radionuclides in sediment samples from coastal waters of Dalian Bay and Liaodong Bay

Jinqiu **Du**, Ziwei Yao, Hui Gao, Guangshui Na and Chuanlin Huo

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Physical and biological processes define the characteristics of radionuclides in the marine environment. Radionuclides are dispersed in seawater upon entering the ocean, they are then absorbed by marine organisms through food webs, enriched by clay materials and eventually buried in sediment. The concentration and distribution of radionuclide are thus significant indicators for the related researches on marine environmental quality. In this study, the target areas for radionuclides monitoring were the coastal waters of Liaodong Bay in Bo Sea and Dalian Bay in Yellow Sea. Three surface sediment samples were collected from Liaodong Bay and Dalian Bay in July and November 2012 respectively, which were then measured using a HPGe gamma spectrometer GEM-MX7080. The results show that ^{137}Cs, ^{226}Ra, ^{238}U, ^{40}K and ^{210}Pb were detected in the samples, the concentration ranges of ^{137}Cs, ^{226}Ra, ^{238}U, ^{40}K and ^{210}Pb in sediment samples are 1.53~1.80, 27.69~37.33, 35.94~46.92, 798.94~848.93, 38.38~39.32 Bq/kg dry weight respectively in Liaodong Bay, and 0.76~2.70, 28.64~54.13, 51.34~64.11, 677.59~770.33, 33.78~54.32 Bq/kg dry weight respectively in Dalian Bay. These ranges are consistent with previously reported levels. The concentrations of ^{226}Ra and ^{210}Pb increased with distance offshore and the ratio value of ^{210}Pb/^{226}Ra was >1 at all stations. It can be concluded that levels of excess ^{210}Pb are present and the Uranium series are unbalanced in each bay. There was no obvious distribution pattern of other radionuclides, this may be due to station selection and strong disturbance from coastal waters.

October 15, 16:05 (MEQ-P-9181)

Radiocesium and jellyfish: Where's the biomagnification?

Delvan **Neville**[1], Kathryn Higley[1] and Richard D. Brodeur[2]

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Radiocesium (especially ^{137}Cs and ^{134}Cs) is one of the more important radionuclides of interest following an accidental release from an operating reactor or from spent nuclear fuel. Cesium is generally observed to biomagnify in terrestial, aquatic, and marine food chains. However, few data are available for radiocesium levels in gelatinous marine organisms from anywhere in the world. Since most gelatinous zooplankton are relatively short-lived and respond quickly to changing ocean conditions, they may be sensitive indicators of natural and anthropogenic changes in marine ecosystems. We present radiocesium concentrations in several gelatinous taxa from the Northern California Current, including schyphomedusae, pelagic tunicates and ctenophores. We examine how these concentrations vary across trophic levels as well as how they relate to radiocesium concentrations in non-gelatinous organisms of similar trophic status. We discuss where differences in diet and physiology may (and may not) explain the reduced biomagnification observed in some of these species.

October 15, 16:20 (MEQ-P-9194) combined with (MEQ-P-9197, below)

Measured distribution of seawater radioactivity from Fukushima Daiichi Nuclear Power Plant in North Pacific

Wen Yu, Men **Wu**, Jianhua He, Yusheng Zhang and Tao Yu

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In order to understand the distribution of the radioactive contaminants released in the Fukushima accident, the State Oceanic Administration of China (SOAC) implemented a monitoring cruise during June 16 – July 4, 2011. The monitoring region laid at 145~149°E and 34~40°N. Surface seawater samples were collected at 35 stations (forming 4 sections) for radionuclide analysis including Cesium-134, Cesium-137, and Strontium-90. The radio-analytical results showed that radioactivity of Cesium-137, Cesium-134 and Strontium-90 in the surface seawater of the northwest Pacific significantly exceeded the background levels. The highest activity concentration of Cesium-137, 75 times higher than the average background, was observed at the station 615 km away from the Fukushima NPP. Relatively high activity of Cesium-134 was also found in the surface seawater samples, confirming that the monitoring area was impacted by the Fukushima accident release. The results can be subsequently utilized in model adjustment or radiological risk assessment.

October 15, 16:20 (MEQ-P-9197) combined with (MEQ-P-9194, above)

Radioactivity of marine cephalopoda and fish species after 2011 Fukushima Daiischi Nuclear Power Plant accident in the Northwest Pacific

Jianhua He, Wen Yu, Men **Wu**, Tao Yu and Yusheng Zhang

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To evaluate the radiological impact from Fukushima Daiichi Nuclear Power Plant to the marine species, several cephalopoda and fish samples (*Ommastrephes bartrami*, *Prionace glauca*, *Cololabis saira* and *Coryphaena hippurus*) were collected in the Chinese marine environmental monitoring cruise to the Northwest Pacific during Jun-Jul and Nov-Dec 2011. Cesium-134, Cesium-137, Strontium-90 and Silver-110m in the samples were analyzed, among other radionuclides. The results indicate that (1) the radioactivity in marine species was significantly higher than the background level and increased with time following the Fukushima accident; (2) juvenile squids (*Ommastrephesbartrami*) have a higher ability for radionuclide uptake and concentration than adult squids; (3) cephalopods had high concentration factors for Silver-110m and Strontium-90, while fish tended to concentrate Cesium more so than other radionuclides.

October 15, 16:45 (MEQ-P-9006)

Estimation of river discharges and fluxes of suspended substances to the North Pacific after the Fukushima Dai-ichi nuclear power plant accident

Shin-ichi **Ito**[1], Hiroshi Kutsukake[2], Kazuhiro Takeuchi[2], Hideki Kaeriyama[3], Masashi Kodama[3], Shigeho Kakehi[1], Kazuhiro Aoki[1], Hiroshi Kuroda[4], Hiroshi Yagi[5], Ambe Daisuke[3] and Tsuneo Ono[3]

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Radioactive cesium (Cs: Cs134+137) due to the Fukushima Dai-ichi Nuclear Power Plant (FNPP) accident was partly deposited on the land and, through riverine transport, discharged to the North Pacific. However, since the deposited area is large and the data of river discharge and Cs is limited, the discharge of Cs to the North Pacific is still unclear. We estimated the river discharge in 2011 using water level - water discharge equations or the Soil and Water Assessment Tool (SWAT). The suspended substance (SS) flux was also estimated using discharge - SS equations. Class A rivers (Kyu-Kitakami, Naruse, Natori, Abukuma, Kuji, Naka, and Tone rivers) showed higher SS discharge. However, the total SS discharge by class B rivers in the southern part of Fukushima Prefecture was comparable to those of the Naruse and Natori rivers. All rivers showed extremely high SS discharge in September 2011. A record precipitation on 21th September 2011 by the typhoon Roke caused immediate peaking in class B rivers and one-day delayed peaking in the Abukuma River. Water quality monitoring by the Ministry of Environments revealed that Cs concentrations in the river waters were undetectable. However, Cs concentrations in river sediments changed from 630 (550) in July to 43 (14200) Bq/kg-dry in September in the Natsui (Abukuma) River, The Cs discharge was estimated as 0.017 to 0.25 (8.9 to 230) GBq from the Natsui (Abukuma) River on 21st (22nd) September 2011. After this spike in discharge, the Cs discharge was substantially reduced.

October 15, 17:00 (MEQ-P-9190) - CANCELLED

Fukushima 2011 derived radionuclides in the Japan and Okhotsk seas and subarctic front region of the Northwestern Pacific, one year later

Vyacheslav **Lobanov**, Vladimir Goryachev, Aleksandr Sergeev, Dmitry Kaplunenko, Natalia Shlyk, Natalia Treshcheva, Sergei Prants and Maksim Budyansky

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During 2012, oceanographic sampling to determine the distribution of radionuclides in the ocean around the Russian Far East was conducted on board the R/V *Professor Gagarinsky*. The geographic coverage of the monitoring included radionuclides sampling in the Japan and Okhotsk seas and the ocean area southeast of Kuril Islands. The field work was completed in June-July 2012 and covered a region of the subarctic front associated with the mixing of Oyashio and Kuroshio currents. Samples of surface and subsurface water (down to 1000m), suspended matter and marine biota were taken and analyzed for isotopes of cesium (^{134}Cs and ^{137}Cs) and tritium (^{3}H). A cruise track was planned and maintained in the field based on numerical modeling of particles transport and satellite imagery. The field observations confirmed the modeling results on the concentration of radionuclides in the areas of convergence associated with anticyclonic eddies (in particular Kuroshio warm-core rings) to the south east of Kuril Islands. Elevated concentrations of ^{134}Cs and ^{137}Cs were found in the vicinity of the eddies and were reported to be 12-20 Bq/m^3 in the surface layer and 2-5 Bq/m^3 higher at 100-400 m depth. Higher than background radionuclide concentrations were found at 1000 m in the area of subarctic front. Slightly increased concentrations of ^{134}Cs and ^{137}Cs (1,5-6 Bq/m^3) were observed in the Japan and Okhotsk seas and related to atmospheric transport and deposition. Our monitoring shows that one year after the Fukushima-1 NPP incident a high level of radionuclides is present in the western Pacific. Ocean processes occurring at the fronts and eddies caused the retention and transport of Cs in surface waters to great ocean depths.

October 15, 17:15 (MEQ-P-9113) - TIME CHANGED TO 17:00

Detection of radioactivity from the 2011 Fukushima accident in the Eastern North Pacific and Arctic Oceans

John N. **Smith**[1], Robin Brown[2], Marie Robert[2], Bill Williams[2] and Richard Nelson[1]

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An earthquake-triggered tsunami on March 11, 2011 caused extensive damage to the nuclear power facilities in Fukushima, Japan resulting in the discharge of large quantities of radioactivity into the western North Pacific Ocean. The radioactivity plume was transported northeastward towards North America under the influence of the Kuroshio Current. A Canadian monitoring program was immediately established to detect the arrival of Fukushima radioactivity in the eastern North Pacific and Arctic Oceans. Water samples were collected for the detection of radioactivity on three missions of the CCGS Tully in June of 2011, 2012 and 2013 to a location (Sta. P26), approximately 1500 km west of Victoria, BC. Measurements of Cs isotopes in June, 2011 are consistent with background fallout sources of radioactivity. However, Cs measurements on water samples collected in June, 2012 at Sta. P26 detected ^{134}Cs at levels (>0.2mBq/l) indicating the presence of contamination from the Fukushima nuclear reactor accident. The trans-Pacific transit time for the arrival of this radioactivity signal at Sta. P26 of <1.3y is slightly faster than the 2.5y predicted by most ocean transport models indicating that atmospheric transport and deposition was a contributing factor. Measurements of Cs isotopes carried out on water samples collected on the CCGS Louis S. St. Laurent in the southern Canada Basin in September, 2012 showed elevated levels of ^{137}Cs associated with the transport of radioactivity from European nuclear reprocessing plants, but negligible levels of ^{134}Cs associated with discharges from Fukushima.

MEQ-Paper Session POSTER - CANCELLED

MEQ-P-P1

Enhanced bioremediation of heavy oil-contaminated sediment by combining biostimulation and bioaugmentation strategies

Sharon N. **Nuñal**[1,2], Sheila Mae Santander-De Leon[1,2], Jiro Koyama[2], Tadahide Noro[2], Takeshi Yoshikawa[2] and Hiroto Maeda[2]

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During the past few years the rising incidences of oil pollution worldwide have lead to extensive research on depuration of hydrocarbon-polluted environments. Bioremediation of oil-contaminated sites is a popular option when cost-effectiveness and safety are considered. In bioremediation, the decision to implement bioaugmentation, biostimulation, or both should be supported by the information of its effects on the dynamics of the microbial community and the mechanisms of contaminant degradation. In this study, the efficiency of heavy oil degradation by an immobilized oil-degrading bacterial consortium was investigated in the seawater-sediment microcosms with or without other bioremediation techniques. Temporal changes in bacterial abundance and community composition, and degradation of oil components were analyzed. Results showed degradation of *n*-alkanes of up to 99% achieved after 60 days in the microcosms with a supplementation of the nutrients and immobilized bacterial cells. GC-MS analysis revealed *n*-alkane-degrading activities of indigenous oil-degraders in the soil. Highest degradation of total PAHs and alkyl PAHs were also detected in the microcosm with both nutrient supplementation and immobilized cells. All of the biostimulated treatments sustained high microbial biomass and numbers of oil-degraders until the end of the experimental period. The results showed that maximum degradation can be achieved by the combined addition of the developed immobilized bacterial consortium and nutrients. Although these results may not solely predict field performance, they can be very useful in designing more efficient bioremediation approaches.

POC Paper Session

Co-Convenors: Kyung-Il Chang (Korea) and Michael Foreman (Canada)

Papers are invited on all aspects of physical oceanography and climate in the North Pacific and its marginal seas, except those covered by POC-sponsored Topic Sessions.

Friday, October 18 (09:00-11:30)

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

09:05 **Rong-shuo Cai and Jun-pen Zhang**
The role of the East Asian monsoon in the responses of the marine environment in the East China Sea to the East Asian climatic jump around 1976/77 (POC-P-8900)

09:25 **Kirill Kivva and Denis Chulchekov**
Evidence of local upwellings in the north-western Bering Sea in 2012 (POC-P-9085)

09:45 (cancelled) **Vyacheslav Lobanov, Aleksandr Sergeev, Igor Gorin, Pavel Scherbinin, Aleksandr Voronin, Dmitry Kaplunenko, Oleg Popov, Timofei Gulenko and Svetlana Ladychenko**
Cascading of dense water along Peter the Great Bay Slope in the northwestern Japan Sea (POC-P-9189)

09:45 **Seung-Tae Yoon and Kyung-Il Chang**
Heat content variations in the southwestern East/Japan Sea (POC-P-8874)

10:05 **Chanhyung Jeon, Jae-Hun Park, Sergey Varlamov, Jong-Hwan Yoon, Young-Gyu Park, Young Ho Kim, Seong Bong Seo, Hong Sik Min and Jae-Hak Lee**
Seasonal effects on generation and propagation of semi-diurnal internal tides in the East/Japan Sea (POC-P-8886)

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

10:45 **Seong Bong Sea, Young-Gyu Park, Jae-Hun Park, Chang-Woong Shin and Chanhyung Jeon**
Properties of internal tides observed in the southwestern part of the East Sea (POC-P-9025)

11:05 **Viktor Kuzin, Elena Golubeva and Gennady Platov**
Some results from the use of the numerical model in the Arctic Ocean climate simulation (POC-P-8975)

11:45 (cancelled) **Qingyang Song, Huaming Yu and Xueen Chen**
A new global tidal model based on a finite volume method and satellite altimetry data (POC-P-8875)

12:05 (cancelled) **Pavel A. Fayman, Vladimir I. Ponomarev, Vyacheslav Dubina and Jong-Hwan Yoon**
The Okhotsk Sea currents: Numerical simulation and satellite data (POC-P-9075)

11:25 *Comments and Discussion*

11:30 *Session Ends*

POC-Paper Session POSTERS

POC-P-P1 **Hiromichi Ueno**
Decadal variation of temperature inversions along Line P

POC-P-P2 (poster and oral) **Kyung-Jae Lee and Kyung-Il Chang**
Mesoscale eddies in the East/Japan Sea: Detection algorithms and characteristics of eddy properties

POC-P-P3 **Qing-hua Qi and Rong-shuo Cai**
Spatial-temporal evolution of SSTA in the South China Sea (SCS): An implication for the SCS summer monsoon outbreaks

POC-P-P4 (cancelled) **Akira Okuno, Tatsuro Watanabe, Taiki Ishihara, Shota Shimizu and Osamu Abe**
Numerical detection of a spawning ground of Pacific bluefin tuna in the Japan Sea

POC-P-P5 **Chang-Woong Shin and Dong Guk Kim**
Trends of the coastal upwelling index along the southeastern coast of Korea

POC-P-P6 **Tsuyoshi Wakamatsu, Yusuke Tanaka and Yoichi Ishikawa**
Detection of attracting Lagrangian coherent structures in the Oyashio and the Oyashio-Kuroshio transition zones using the ocean data assimilation system

POC Paper Session, Oral Presentations

October 18, 09:05 (POC-P-8900)

The role of the East Asian monsoon in the responses of the marine environment in the East China Sea to the East Asian climatic jump around 1976/77

Rong-shuo **Cai** and Jun-pen Zhang

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A series of numerical experiments was conducted to investigate the role of the East Asian monsoon (EAM) in the responses of the marine environment in the East China Sea and its adjacent waters (ECS) to the East Asian climatic jump by using a regional ocean model (ROMS). The numerical experiment results indicate that while the EAM weakens after the climatic jump around 1976/77, the marine environment (SSH, sea surface temperature, salinity and currents) in the ECS presents distinct variation characteristics in different seasons. In summer, an obviously positive SSH (a negative salinity) anomaly arises in the vicinity of the Changjiang river estuary (CRE), Hangzhou Bay and in the south of the Yellow Sea. A negative sea surface temperature anomaly is centered in the southwest area of Jeju Island, as a result of the accumulation of Changjiang river discharge (CRD) and the coastal sea water in the vicinity of CRE, Hangzhou Bay and in the south of the Yellow Sea. Anomalous cyclonic oceanic currents are formed in the ECS, which are induced by the weakening EAM. Similarly, with the weakening of the EAM, the anomalous marine environment in winter is caused by the weakening of CRD diffusion, the China coastal currents and the Yellow Sea warm currents, and the strengthening of upper Kuroshio and Taiwan warm currents in the ECS. It is therefore suggested that the EAM played a great role in the responses of the marine environment in the ECS to the East Asian climatic jump around 1976/1977.

October 18, 09:25 (POC-P-9085)

Evidence of local upwellings in the north-western Bering Sea in 2012

Kirill **Kivva**[1] and Denis Chulchekov[2]

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Upwelling areas in the ocean are known to enhance primary production (PP) due to deep layer water, which is rich in nutrients, being transported into the surface layer. A few recent publications have argued that local upwellings in the northern and north-western Bering Sea are important for PP in these areas. Herein we present *in situ* data of CTD casts, dissolved oxygen and nutrient samplings from July and August 2012. These data clearly reflect evidence of two local upwellings on the Koryak shelf and in the Chirikov Basin. Low oxygen saturation (<100%) and high phosphorus, silica and total inorganic nitrogen concentrations (>1, 20 and 15µM, respectively) were observed in these areas. Our data also show upwelling-like features in the western part of the Anadyr Bay where nutrient-rich deep water was upwelled up to 5m depth. Based on published data and our field data, we conclude that quasi-stationary upwelling has an effect on the examined areas. According to our estimates, these local areas are responsible for about 20 % of the PP in the region.

October 18, 09:45 (POC-P-9189) - CANCELLED

Cascading of dense water along Peter the Great Bay Slope in the northwestern Japan Sea

Vyacheslav **Lobanov**, Aleksandr Sergeev, Igor Gorin, Pavel Scherbinin, Aleksandr Voronin, Dmitry Kaplunenko, Oleg Popov, Timofei Gulenko and Svetlana Ladychenko

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Slope convection at Peter the Great Bay in the northwestern Japan Sea is one of the processes that ventilate the sea interior. Direct observations of dense water cascading along the slope of Peter the Great Bay with measurements of currents and oceanographic parameters by mooring systems and repeated CTD surveys during winters of 2010-2012 are presented. It is shown that the cascading events usually occur in February-March. Their duration and intensity vary from a few days to 3 weeks in different years. During winter 2012, a larger volume of dense shelf water has been passing over the moorings continuously in middle February-early March and for a few days in late March. These cascading events down the slope resulted in a number of intrusions of colder, less saline, higher oxygen content and turbidity water revealed by CTD casts. Their thickness varied typically around 50-150 m. Most of them occurred between 200 and 700 m thus ventilating a layer of intermediate high salinity water, while some signals of higher oxygen were observed down to 2000-2800 m indicating ventilation down to the bottom of the slope. Nevertheless this has not resulted in significant renewal of Japan Basin bottom waters comparable with one that occurred in winter of 2001.

October 18, 10:05 (POC-P-8874) - TIME CHANGED TO 09:45

Heat content variations in the southwestern East/Japan Sea

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Heat content anomaly (HCA) in the upper 500m of the Ulleung Basin of the East Sea is calculated during the period between 1976 and 2011 using archived data from the Korea Oceanography Data Center (KODC). The HCAs at the upper (0~50m; UHCA) and lower (100~400m; LHCA) layers are calculated separately because of different long-term trends at those layers, an increasing trend for the UHCA and a decreasing trend for the LHCA. Concurrent inter-decadal variations of HCA are obvious at both layers before 1994, characterized by high HCA from 1976 to 1980 and from 1987 to 1993 and low HCA from 1981 to 1986. The HCAs at the two layers, however, show different patterns afterward. The inter-decadal variation in the LHCA lasts longer until 2000, while the UHCA shows a predominant positive anomaly with no distinct inter-decadal variation after 1994. A persistent negative anomaly characterizes the LHCA after 2000, opposite to that of the UHCA. Analyses of temperature distribution and depths of isotherms indicate that the UHCA and LHCA are mainly determined by strengthening or weakening of the East Sea Intermediate Water (1~5°C) and the Tsushima Warm Water (>10°C), respectively.

October 18, 10:45 (POC-P-8886) - TIME CHANGED TO 10:05

Seasonal effects on generation and propagation of semi-diurnal internal tides in the East/Japan Sea

Chanhyung Jeon[1], Jae-Hun **Park**[1], Sergey Varlamov[2], Jong-Hwan Yoon[3], Young-Gyu Park[1], Young Ho Kim[1], Seong Bong Seo[1], Hong Sik Min[1] and Jae-Hak Lee[1]

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This talk presents seasonal changes of semi-diurnal internal tides in the East/Japan Sea using 2-year-long outputs from a real-time ocean forecasting system operated by Kyushu University. The model composes a forecasting system nudging temperature and salinity fields to reproduce realistic oceanic currents and stratification. In addition to atmospheric forcing, it also includes tidal forcing of 16 major components along open boundaries. Simulated barotropic tides agree well with those from coastal tide-gauge stations and shipboard ADCP measurements. The model generates energetic semi-diurnal internal tides around the northern mouth of the Korea Strait where the

barotropic tides encounter a sudden depth change of continental shelf-slope. Simulated amplitude and phase of semi-diurnal internal tides agree well with two-hourly interval 25-hour CTD castings obtained during spring and neap tidal periods at a site near the internal tide generation region. Converted energy from barotropic to baroclinic (internal) tides has seasonal variation ranging from 0.07−0.08 GW during summer and 0.02−0.03 GW during winter due to stratification changes near the internal tide generation region. Generated internal tides travel far to the northern part of the East/Japan Sea during summer but not during winter. Propagating distance of internal tide energy appears to be associated with not only its generation intensity but also its wavelength. Longer (shorter) wavelength during summer (winter) makes internal tide energy dissipates less (more). Our result provides an example implying that spatio-temporal variation of internal-tide-induced mixing due to its seasonality should be considered to simulate more realistic water masses and circulation in the East/Japan Sea.

October 18, 11:05 (POC-P-9025) - TIME CHANGED TO 10:45

Properties of internal tides observed in the southwestern part of the East Sea

Seong Bong Sea, Young-Gyu **Park**, Jae-Hun Park, Chang-Woong Shin and Chanhyung Jeon

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We investigated the properties of internal tides observed near the continental slope of the southwestern East/Japan Sea using two sets of 25-hr long hourly CTD and LADCP profiles and numerical simulations. The profiles spanned the whole water column from the surface to about 260m depth. A semi-diurnal internal tide was strongest below the main thermocline (150-200m) where the 5ºC isotherm was displaced more than 50m. The Richardson numbers were low (0-0.25) in layers where large vertical displacements were observed, suggesting internal tide induced mixing. Numerical simulations using an idealized vertical 2.5-dimensional numerical model based on the ROMS revealed that the semi-diurnal internal tide was predominantly generated on the continental slope. By analyzing the observed data and model results, we were able to investigate the internal tide generation mechanism and its impact on ocean mixing in this region.

October 18, 11:25 (POC-P-8975) - TIME CHANGED TO 11:05

Some results from the use of the numerical model in the Arctic Ocean climate simulation

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A 3D mathematical ice–ocean model is used to simulate possible Arctic Ocean climate changes under atmospheric forcing. The ocean model has been constructed at the INM&MG SD RAS for the North Atlantic and the Arctic Ocean basins. The numerical experiments consist of two stages. The first one concerns changes of the Arctic Ocean circulation and thermal regime during the last half of the XX century under reanalysis data forcing. The influence of the North Atlantic Oscillation (NAO) index sign for these processes is discussed in the paper. In the second stage we try to produce the future behavior of the oceanic system in the framework of one of the scenarios of the IPCC models for the period 2010-2050. The scenario forcing corresponds to increasing atmospheric temperature, especially in the polar region. The atmospheric forcing was adopted from the results of CNRM-CM5 model of the CNRM/CERFACS. The results show essential changes in the temperature and ice regimes. Despite the fact that the ice cover is decreasing, some ice still exists in summer until 2050.

October 18, 11:45 (POC-P-8875) - CANCELLED

A new global tidal model based on a finite volume method and satellite altimetry data

Qingyang **Song**, Huaming Yu and Xueen Chen

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A new global tidal model based on a finite volume method and unstructured mesh grids, which employs altimetry data from the TOPEX/POSEIDON satellite series for assimilation is built in this study. We introduce the tidal forcing term of the M_2 constituent and the self-attraction effect in hydrodynamic equations. The solutions for the M_2 constituent obtained from solely solving those equations can reveal the main tidal pattern in oceans. The accuracy of the harmonic constants turns out to be lower than some former assimilation results when compared with those from 273 tide gauges in oceans. But the comparison with tide gauges in the coastal waters of China indicates that the M_2 solution in this area is relatively credible. To improve the model accuracy, two simple assimilation strategies, successive correction analysis and the nudging method, are chosen. The altimetry data covering 18.6 years are analyzed and applied to the assimilation. Through successive correction analysis, the simulated accuracy for amplitude of the M_2 constituent improves by 3cm in oceans and 4cm in the coastal waters of China. The error in phase-lag for M_2 is also reduced by 6° for phase-lag in oceans. The rms error of M_2 after this assimilation turns out to be 3.1 cm in amplitude and 6.3° in phase-lag by comparing the harmonic constants at 273 sites in oceans. The nudging method, which has a similar effect in improving accuracy with successive corrections, reflects a better assimilated effort to the tidal current through adjusting the surface elevation.

October 18, 12:05 (POC-P-9075) - CANCELLED

The Okhotsk Sea currents: Numerical simulation and satellite data

Pavel A. **Fayman**[1], Vladimir I. Ponomarev[2], Vyacheslav Dubina[2] and Jong-Hwan Yoon[3]

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The aims of the present study are the numerical simulation and research of sea water circulation in the Okhotsk Sea and exchanges with the Pacific Ocean. The Okhotsk sea circulation model is based on the RIAM Ocean Model (RIAMOM) with 1/18° horizontal resolution and validated by comparing model results with satellite imagery. The model domain covers the whole area of the Okhotsk Sea, northern part of the Japan Sea and north-western part of the Pacific Ocean which is adjacent to the eastern coast of the Kamchatka peninsula, Hokkaido and Kuril islands.

Total circulation is cyclonic with main volume transport over the continental slope. The main currents that exist most of the year are: West-Kamchatka Current, over North-Okhotsk continental slope current, Middle-Okhotsk, North-Okhotsk, East-Sakhalin current (both branches), North-Eastern current, and Soya Current. Other currents (Compensation, Penzhin, Yamskoye currents, North-Okhotsk countercurrent, and Amur current) are not so stable throughout the year. Another main feature is the anticyclonic circulation pattern in Shelihov Bay and over the Kuril Basin.

The volume transport of the Kuril-Kamchatka Current, West-Kamchatka Current, over North-Okhotsk continental slope current, and the second branch of the East-Sakhalin current is maximum in winter and minimum in summer. Volume transport through the Fourth Kuril strait and Kruzenshterna strait exhibits the same behaviour. Thus we can conclude that circulation in Okhotsk Sea partially depends on the inflow from the Pacific Ocean and from wind curl over sea.

Maximum volume transport of the Yamskoye current, North-Okhotsk current, first branch of the East-Sakhalin current occurs in autumn. This is an effect of arrested topography waves. Estimation of vorticity in the central part of Okhotsk Sea shows the importance of geostrophic balance.

Satellite observations were compared with results of the numerical simulations.

POC-Paper Session POSTERS

POC-P-P1

Decadal variation of temperature inversions along Line P

Hiromichi **Ueno**

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Hydrographic data measured for 50 years along Line P between the North American west coast and mid Gulf of Alaska as well as data from profiling float observations were analyzed to study the formation and variation of temperature inversions in the eastern subarctic North Pacific. Remarkable decadal to inter-decadal variation was observed in the magnitude of temperature inversions. This variation was mostly attributed to the variation of southward Ekman transport, eastward geostrophic transport and surface cooling.

POC-P-P2

Mesoscale eddies in the East/Japan Sea: Detection algorithms and characteristics of eddy properties

Kyung-Jae Lee and Kyung-Il **Chang**

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Mesoscale eddies are important in physical oceanography and marine ecosystems in that they transport water mass, heat, nutrients, and biomass. It is an important issue how the changing climate would alter the present eddy fields in a statistical sense. The advent of satellite altimetry allows a basin-scale view of the spatial and temporal structure of eddy variability using automatic eddy detection algorithms. We investigate the mesoscale eddy field in the East Sea using the vector geometry based eddy detection algorithm (VGBA, Nencioli *et al.*, 2010), which was shown to be more efficient in detecting eddies as compared to other algorithms when it was applied to results from a high-resolution numerical model. To use the VGBA, a simple linear interpolation is applied to the gridded 1/4° AVISO altimeter data to increase the resolution to 1/32°. A size constraint is also imposed to remove small eddies that cannot be resolved in the original altimeter data. The results are compared with those from manual detection and widely used winding angle algorithm, and are shown to have a small error rate and reasonably high success rate in detecting eddies. We then analyze number and size of mesoscale eddies, eddy intensity, and regional eddy probability based on 19-year long altimeter data.

POC-P-P3

Spatial-temporal evolution of SSTA in the South China Sea (SCS): An implication for the SCS summer monsoon outbreaks

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Spatio-temporal variations of the sea surface temperature anomaly (SSTA) in the South China Sea (SCS) were investigated based on the China Ocean Re-Analysis (CORA) dataset from 1986 to 2003. With focus on the evolution of the SSTA on a seasonal scale, its relation with the SCS summer monsoon (SCSSM) onset was discussed. The analyzed results show that there exists a significant evolution mode on a seasonal scale in which the positive SSTA develops first in the western area of Palawan in the SCS in April, and extends westward and northward so rapidly that the positive SSTA presents in most of the SCS in May. The SSTA in the SCS plays a transition from negative to positive in June. This evolution of the SSTA could be related closely with the seasonal variation of the SCS warm pool (SCSWP). The correlation analysis suggests that the variability of intraseasonal progress of the SSTA in the SCS is expected to give rise to the interannual difference (early or later) of the SCSSM onset, and the SSTA variations in April imply potential earlier or later outbreaks of the SCSSM.

POC-P-P4 - CANCELLED

Numerical detection of a spawning ground of Pacific bluefin tuna in the Japan Sea

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We developed a numerical system to detect the spawning ground of Pacific bluefin tuna *Thunnus orientalis* based on sampled larvae in the Japan Sea, using backtracking simulation. The system utilizes hydrodynamic data produced by JADE (JApan Sea Data assimilation Experiment), an ocean forecast system operated by Japan Sea National Fisheries Research Institute, Fisheries Research Agency. In the simulation, we release a batch of virtual particles that represent the existence of a single larva, and then track the horizontal movement of each particle toward the past. Horizontal movement of each particle is controlled by advection and random dispersion. After backtracking until the day of spawning, the final distribution of the particles corresponds to a probability map of the spawning ground of the larva. We applied this backtracking to 26 larvae collected in the Japan Sea in the summer of 2011. The spawning date of each larva was estimated based on otolith analysis. From the simulation results for all larvae, it is suggested that a major spawning ground formed between the Oki islands and the Noto Peninsula in 2011. Moreover, the major spawning ground was surrounded by velocity shear due to the Tsushima Warm Current and small eddies; thus it is also suggested that velocity shear (or associated oceanic structures) influences the formation of the spawning ground. Sea surface temperature (SST) of the detected spawning ground varied in each backtracking, ranging from 23.8 to 25.6°C; this SST range corresponded well to the spawning temperature reported in preceding studies.

POC-P-P5

Trends of the coastal upwelling index along the southeastern coast of Korea

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Korea is influenced by the East Asian monsoon. Predominant winds are northwesterly in winter but southwesterly in summer. Southwesterly winds produce coastal upwelling along the southeast coast of Korea in summer. Primary production in Ulleung Basin is affected by the upwelling. To investigate the coastal upwelling trend along the southeastern coast of Korea, daily sea surface temperature (SST) at Gampo and hourly winds at Busan of more than 40 years were analyzed. Upwelling signals were defined by temperature drops from a fitted line that connects temperature peaks. These signals were closely related to the southwesterly winds blowing parallel to the coast (r=-0.64 in June, -0.59 in July, and -0.62 in August). A negative correlation meant that if the along shore wind blows in a positive direction (northeastward), then the temperature decreases. The coastal upwelling index based on Ekman transport was positive from April to August, with a maximum in July. A linear trend of the index for spring from March to May was positive. However, the trend was negative in the summer due to the surface atmospheric pressure change. Southwesterly winds weakened in summer but increased gradually in spring. Northerly winds tended to decrease in spring. The long-term correlation between the upwelling index and Gampo SST after removing short frequency variations including the seasonal signal indicates a correlation of the upwelling index with the temperature anomaly (r=0.54). However, no correlation evidence with ENSO index was found.

POC-P-P6

Detection of attracting Lagrangian coherent structures in the Oyashio and the Oyashio-Kuroshio transition zones using the ocean data assimilation system

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Attracting Lagrangian coherent structures (LCSs) are defined as material surfaces which exhibit locally the strongest attraction in a flow. The dynamical feature of LCSs has been recently recognized in the oceanographic community as a powerful tool to identify an oceanic front, which is associated with a convergent flow and subsequent nutrients flux, from satellite data and ocean model output. Past studies hypothesized that high productivities observed in many ocean current systems are partly attributed to their active mesoscale and sub-mesoscale oceanic fronts. In order to analyze the contribution of the LCSs in oceanic fronts to their high productivities, an online scheme for calculating the three-dimensional structure of the attracting LCSs is implemented in a variational ocean data assimilation system for the Oyashio and the Oyashio-Kuroshio transition zones. The impact of Argo data in the detected LCSs will be discussed.

GP General Poster Session

GP-P1 **Xiao-Hua Zhu, Yu Long and Xinyu Guo**
Variations of Kuroshio nutrient transport

GP-P2 **Pavel K. Afanasiev, Alexei M. Orlov and Roman N. Novikov**
Sablefish, *Anoplopoma fimbria*, from catches of passive and active fishing gears in the northwestern Pacific

GP-P3 **Alexei M. Orlov, Alexei A. Baitalyuk and Dmitry V. Pelenev**
Distribution and size composition of Arctic lamprey, *Lethenteron camtschaticum*, in the North Pacific

GP-P4 (cancelled) **Madhu Thapa**
Climate change impact and adaptability in Nepal

GP-P5 **James P.W. Robinson, Andrew M. Edwards, Ivor D. Williams, Rusty Brainard and Julia K. Baum**
Steepening spectra. Size-based analyses describe the effects of fishing on Pacific coral reef fish communities

GP-P6 **Dmitry V. Stepanov, Evgeniya A. Tikhomirova and Vladimir A. Luchin**
Interannual heat content variability in the Okhotsk Sea based on temperature dataset

GP-P7 **Amelia A. Porter, Tom Child and Peter S. Ross**
Coastal pollution: Towards a risk-benefit analysis of traditional seafood of coastal First Nations in British Columbia

GP-P8 **V. Crego-Prieto, Francis Juanes, A. Roca, F.J. Taylor and E. Garcia-Vazquez**
Aquaculture as a gate for invasions: Hybrid zones of invasive NIS and native *Mytilus* mussels are linked to farm density on Vancouver Island

GP-P9 **Hiromichi Igarashi, Toshiyuki Awaji, Masafumi Kamachi, Yoichi Ishikawa, Norihisa Usui, Masaaki Iiyama, Mitsuo Sakai, Yoshiki Kato, Irene D. Alabia, Sei-Ichi Saitoh and Masaki Seitoh**
Modeling the optimal habitat suitability of neon flying squid in central North Pacific by using 3-D ocean data assimilation product

GP-P10 **Olivia McMillan, David G. Stormer and Francis Juanes**
Effects of simulated winter and summer environmental conditions on the behavioural ecology of juvenile ocean-type Chinook salmon (*Oncorhynchustshawytscha*)

GP-P11 **Kirill Kivva, Nadezhda Torgunova and Alina Agatova**
Spatial and temporal variability of dissolved organic matter in the western Bering Sea

GP-P12 **Jung-no Kwon and JeongHee Shim**
Effects of meteorological and oceanographic variability on *Porphyra* production at the Nakdong River estuary, south coast of Korea

GP-P13 **Georgiy Moiseenko, Igor Shevchenko and Vadim Burago**
The annual variability of the remote sensing reflectance empirical orthogonal functions for the Okhotsk Sea

GENERAL POSTER SESSION

GP-P1

Variations of Kuroshio nutrient transport

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Based on absolute geostrophic velocity calculated from repeated hydrographic data of 39 cruises from 2000 to 2009 and nitrate concentrations measured at the same sections from 1964 to 2011, we obtained averaged nitrate flux (the product of velocity and nitrate concentration) and nitrate transport (integration of flux over a section) through 4 sections along the Kuroshio path from the East China Sea (sections PN and TK) to south of Japan (sections ASUKA and 137E). The mean nitrate flux shows a subsurface maximum core with a value of 10, 10, 11 and 11 mol $m^{-2}s^{-1}$ at sections PN, TK, ASUKA and 137E, respectively. The depth of subsurface maximum core changes among four sections and is approximately 400, 500, 500 and 400 m at sections PN, TK, ASUKA and 137E, respectively. The mean downstream nitrate transport is 199.3, 176.3, 909.2 and 1385.5 kmol s^{-1} at sections PN, TK, ASUKA and 137E, respectively. The nutrient transports at these sections suggest the presence of Kuroshio nutrient stream from its upstream region to downstream. In addition, the positive difference between the downstream nitrate transport through section ASUKA and the nitrate transports from the East China Sea, as well as the positive difference of downstream nitrate transport between sections 137E and ASUKA, suggest that the Kuroshio recirculation significantly intensifies the downstream (eastward) nitrate transport by the Kuroshio.

GP-P2

Sablefish, *Anoplopoma fimbria*, from catches of passive and active fishing gears in the northwestern Pacific

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Features of distribution and some biological characteristics of sablefish, *Anoplopoma fimbria*, in the Pacific waters off southeastern Kamchatka, continental slope of the western Bering Sea, underwater Shirshov Ridge and Commander Islands are considered based on the data taken during commercial trap, longline and bottom trawl fisheries. Maximal trap catches were observed in the Pacific waters of southeastern Kamchatka, while longline and bottom trawl data certify most frequent sablefish captures in the western Bering Sea off Koryak slope north up to Navarin Cape. Character of sablefish vertical distribution has been changed considerably in various areas. Rate of trap catches in various areas was different and depended on trap type and soaking period. Sablefish size composition, condition factor and proportion of males and females in catches varied considerably depending on gear type and geographic area. In whole, in the Russian Far Eastern waters, female sablefish become mature at mean fork length 71 cm, while males attain sexual maturity at mean fork length 57 cm. Total sablefish biomass in the studied areas based on trap catches was estimated ca. 750 metric tones. Current level of sablefish abundance does not allow us to recommend its target fishery. This species may be fishes as bycatch only during bottom trawl and longline fisheries.

GP-P3

Distribution and size composition of Arctic lamprey, *Lethenteron camtschaticum*, in the North Pacific

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Results of long-term research of spatial and vertical distributions of parasitic anadromous Arctic lamprey, *Lethenteron camtschaticum*, and its size composition in the North Pacific are provided. Most frequently this species is recorded in the northwestern Sea of Japan and western Bering Sea. Its maximum catches occurred in waters off southern Primorye, southwestern Sakhalin, northwestern Sea of Okhotsk and northern Bering Sea that probably associated with advanced abundance in these areas of its main prey Pacific salmons. Near the bottom, Arctic lampreys are extremely rare and occur mainly at depths shallower 400m. They are very abundant in the pelagial where occupy upper 100 m layer. Catches are represented by lampreys with total length 15 to 79cm. Presence in catches of several size classes may testify that Arctic lamprey inhabits marine environment no less than 4 years. Relationship between Arctic lamprey total length and capture depth was not found. Relationships between total length and body weight, total length and condition factor are analyzed, seasonal variations of these characteristics are also considered.

GP-P4

Climate change impact and adaptability in Nepal

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In Nepal climate changes have implications on reduction of snow pack on the mountains, water supply shortages, increase forest fires, increase in extreme weather, increase demand for irrigation, decreases power generation; wells dry up due to lower water table. Climate change seeks the two actions on the mitigation of greenhouse gases and adaptation to the climate change. This paper also describes the climate change issues of Nepal; similarly it deals with the potential threats of climate change to water supply, agriculture and food security, temperature increase, run-off patterns, glacial melt and floods.

GP-P5

Steepening spectra. Size-based analyses describe the effects of fishing on Pacific coral reef fish communities

James P.W. **Robinson**[1], Andrew M. Edwards[2], Ivor D. Williams[3], Rusty Brainard[3] and Julia K. Baum[1]

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On coral reef ecosystems the impacts of anthropogenic disturbance are often assessed using diversity indices, measures of biomass, and coral cover. We may complement these approaches with size-based analyses to describe changes to community structure where, by quantifying the allometric relationship between body size and abundance, size spectra represent the distribution of body sizes in a community. We expect fishing to steepen the size spectra by removing large bodied individuals from the system and potentially enabling compensatory increases in small-bodied individuals. In the Pacific Ocean, the Hawaii, Marianas, and American Samoa island groups support reefs degraded by various levels of fishing pressure and reefs that are considered near pristine. Here, taking a body size approach and using an extensive dataset of fish abundance and body size across these islands, we explore changes to community structure attributable to fishing pressure. Size spectra of degraded reefs are steeper than their near-pristine counterparts in each region, indicating a consistent and ocean-basin wide impact of fishing on the reef fish community.

GP-P6

Interannual heat content variability in the Okhotsk Sea based on temperature dataset

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Interannual variability of heat content anomaly of the cooling near surface layer and intermediate water of the Okhotsk Sea (OS) is studied based on temperature dataset from 1949 to 2010. The temperature data consists of two datasets. First dataset was collected from 48 7768 stations and from surface to 290 m depth. Temperature observations were carried out from May to July and from 1932 to 2009. First dataset was used to obtain locations of the upper and lower boundaries of the cooling surface layer. Second dataset is produced by temperature data from 27 413 stations and from 300 m depth to bottom. Temperature observations were carried out from January to December for a period from 1932 to 2009. Second dataset was used to obtain location of lower boundary of the intermediate water. Having obtained annual mean of temperature on the 2 to 2 grid, we calculated the heat content anomalies of the cooling surface layer and intermediate water of the OS. We showed that the harmonics with the periods of 2-3, 6-7 and 14 years dominate in the heat content variability of the cooling surface layer. The heat content variability of the intermediate intermediate water of the OS is characterized by harmonics with the periods of 2-3, 6-7 and 17-20 years. We revealed that there is linear trend in the variability of the intermediate of the OS. However, we did not observe linear trend in the variability of the cooling surface layer of the OS.

GP-P7

Coastal pollution: Towards a risk-benefit analysis of traditional seafood of coastal First Nations in British Columbia

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Coastal First Nations communities in British Columbia rely on subsistence practices in obtaining marine foods. Traditional marine foods are beneficial to First Nation peoples for nutritional and cultural reasons. However, concernes of contaminants in the marine foodweb including persistant organic pollutants (POPs) have prompted a need for risk assessment associated with cunsuming marine foods. Our study involves two components in preperation for risk analysis: exposure and contaminant assessments. To evaluate exposure, consumption levels were investigated through dietary surveys administered to five First Nations communities located around coastal Vancouver Island; the Ahousaht, Pacheedaht, Quatsino, Snuneymuxw and Weiwaikum. Contaminant concentrations were measured in four species, harbour seals; sockeye salmon; Dungeness crab; and butter clams, collected from traditional harvesting sites. Results of dietary surveys determined that coastal First Nations seafood consumption is 15 times that of the average Canadian. Salmon was the number one consumed seafood with an average of 105 grams per person per day. Total seafood consumption averaged 165 grams per person per day, equivalent to two servings per day. Contaminant analysis revealed trophic level differences with seals being the most contaminated of the four species. PCBs were found in all four species at varying concentrations with the highest concentration of 831 ug/kg in seals. Current Health Canada consumption guidelines may not be protective of coastal First Nation's communities, as they consume 15 times the average Canadian. This study allows for subsequent risk-benefit analysis enabling First Nations communities to make choices that reduce the risk of toxicity.

GP-P8

Aquaculture as a gate for invasions: Hybrid zones of invasive NIS and native *Mytilus* mussels are linked to farm density on Vancouver Island

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Aquaculture promotes the introduction of non-indigenous species (NIS) into wild marine environments, especially when containment is not secured and larvae and/or adults escape from farms. NIS escapees may hybridize with natives and cause profound changes at the genotypic level. Here we analyze mussels sampled from fourteen coastal locations with different farm densities on Vancouver Island (British Columbia, Canada). Two NIS, *Mytilus edulis* and the invasive *M. galloprovincialis*, are cultivated in those farms. Mussels were genotyped for two species-specific loci (Glu-5' and Me 15/16). The mitochondrial cytochrome c oxydase subunit 1 (COI) gene was employed to characterize the maternal species in hybrids. The proportion of NIS and hybrids of *M. galloprovincialis* and the native *M. trossulus* was positively correlated with farm density. In addition, hybrids between the two native *M. trossulus* and *M. californianus* were also identified. Marine currents and different habitat preferences of NIS provide additional explanations of the present distribution of alien and native species along Vancouver Island coasts. As a whole, our results emphasize the role of aquaculture as a vector for the introduction of invasive species and a promoter of hybrid zones.

GP-P9

Modeling the optimal habitat suitability of neon flying squid in central North Pacific by using 3-D ocean data assimilation product

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The neon flying squid (*Ommastrephes bartramii*) has a wide-spread distribution in subtropical and temperate waters in the world ocean. In the North Pacific, it plays an important role in the pelagic ecosystem and is one of the major targets in Japanese squid fisheries. There are two main fishing grounds for Japanese commercial vessels, east of northern Japan in winter and the wide north Pacific area (35-45 N) around the dateline in summer. In this study, the suitable habitat area for the neon flying squid in central North Pacific in summer was investigated using MOVE (Meteorological Research Institute multivariate ocean variational estimation) ocean reanalysis product, which can provide realistic fields of 3-dimensional ocean circulation and environmental structures including meso-scale eddies (Usui *et al.*, 2006). The Japanese commercial fisheries data of neon flying squid from June to July during 2000-2012 and MOVE reanalysis have been applied to the identification and characterization of possible habitat suitable areas for the summer fishing ground of neon flying squid by using several kinds of habitat suitability models (HSI, GLM, GAM, *etc.*). The results indicate the 3-dimensional structure of temperature and salinity is highly correlated with the squid catch in the summer fishing area, which suggests that the position of the subarctic frontal zone (SAFZ) and the meso-scale eddy activity around SAFZ could control the formation of the suitable habitat for neon flying squid.

GP-P10

Effects of simulated winter and summer environmental conditions on the behavioural ecology of juvenile ocean-type Chinook salmon (*Oncorhynchustshawytscha*)

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Many stocks of Chinook salmon (*Oncorhynchustshawytscha*) in Canada and the US are in decline despite reductions in fishing effort and the implementation of conservation initiatives. These declines have been partially attributed to poor ocean conditions leading to reduced over winter marine survival, and the influence of a changing early marine environment on the behavioural ecology of juvenile Chinook has not been investigated. As part of a larger study examining the effects of different environmental winter conditions on sub-yearling juvenile Chinook salmon, our objectives were to assess the interaction between water temperature and food availability on fish behaviour. We controlled water temperature in two treatments of 5.5 and 10.5ºC, representing cool and warm winters respectively, and implemented three feeding regimes: fed once daily at liberty, one two-week food deprivation period and one four-week food deprivation period. The four-week treatment phase was followed by a four-week re-feeding phase. Activity level and aggression were assessed by direct observation of fish in each treatment and compared throughout the eight-week study period. Results showed that cool water and continuously fed treatments were sedentary, while the highest activity level was exhibited by fish in the warm temperature treatments. Aggression was highest in food deprived warm temperature fish until feeding was restored. No aggression was observed in cool temperature continuously fed treatments. Results of this study will be presented along with an ongoing project using a similar approach to examine the effect of simulated summer conditions on sub-yearling Chinook salmon behaviour using direct observations and video analysis.

GP-P11

Spatial and temporal variability of dissolved organic matter in the western Bering Sea

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The Bering Sea is one of the most productive areas of the global ocean. Nevertheless, rates of destruction of organic matter (OM) could exceed rates of primary productivity in some coastal areas. In other words, heterotrophic metabolism could prevail. Therefore it is important to investigate the rates of production and destruction of OM, OM quantity, composition and distribution. Present study is based on the data on dissolved organic carbon and nitrogen (DOC and DON, respectively) from June 1992, July 1993, and July-November 2012. Unfortunately, the data set is too short to make any strong conclusions on interannual variability of field of OM. So we explain the differences between years as seasonal variability. In summer in the western deep Bering Sea we observe DOC concentrations between 1.02 and 5.77 with 0-1000 m water column average value of 2.54 mg C l^{-1}, and autumn concentrations were between 1.02 and 4.04 (average 1.81) mg C l^{-1}. DON concentrations in summer were between 0.01 and 0.39 (average 0.12) mg N l^{-1}. Autumn DON concentrations were substantially higher than summer concentrations: 0.09 to 0.69 with average of 0.2 mg N l^{-1}. Molar DOC/DON ratio in summer was 7-53 (average 26), and in autumn it was 2-29 (average 9). The main differences in OM profiles within the water column were explained through dynamic and biochemical seasonal changes. For the Anadyr Bay shelf area, one of the most important factors influencing OM distribution is river inflow.

GP-P12

Effects of meteorological and oceanographic variability on *Porphyra* production at the Nakdong River estuary, south coast of Korea

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The common laver, *Porphyrayezoensis*, is one of the world's most important maricultured seaweeds and has been cultivated for more than 530 years in Korea. Total mass production of *Porphyra*in South Korea was about 0.3 million tonin fresh weight and consisted of 52% of world laver production in 2011.Nakdong River estuary known as ecologically affluent and productive area, has produced about ~8% of Korea *Porphyra* production though it covers only 1~3% of aquaculture-licensed area. To understand effects of meteorological and oceanographic environments on *Porphyra* production at Nakdong River estuary, we analyzed the meteorological and oceanographic factors (air temperature, wind speed, precipitation, sunshine hours, water temperature, salinity, nutrients, pH, *etc.*) with yearly and monthly variations of *Porphyra* production for 10 years (2003-2013). Air temperature, wind speed and water temperature were major factors affecting the variability of *Porphyra* production. The lower of air and water temperature and the stronger of wind speed, the more *Porphyra* harvested. However, the main factors related to monthly-based *Porphyra* production was different according to life cycle (culturing stage) of *Porphyra*. Young *Porphyra* needs more stable environments for adaptation on wild environment, while matured *Porphyra* grows well in longer daylight due to enhance photosynthesis. These results indicate that rapid change of weather and water caused by global climate change will negatively affect the *Porphyra* production and thus, socio-economical seaweeds service. We will discuss in more details on the variability and near-future predictions of *Porphyra* production with statistical analysis and simple model study.

GP-P13

The annual variability of the remote sensing reflectance empirical orthogonal functions for the Okhotsk Sea

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The statistical approach based on the empirical orthogonal functions (EOF) analysis can be used for estimations Chl-*a* and others constituents in optically complex waters. In such waters standard algorithms and their modifications for remote sensing data processing have low accuracy. The approach is based on the use of regression equations which connect the estimated parameters with coefficients of serial expansion for remote sensing reflectance on the basis of empirical orthogonal functions.

The main problem in this method is the choice of the basis. In most cases it is the most significant eigenvectors for the remote-sensing reflectance covariance matrix. They can vary depending on the area of the research and the time interval when data are collected.

The variability of empirical orthogonal functions for the Okhotsk Sea remote sensing reflectance is investigated. For this purpose the annual array of level L1b MODIS data for each year (2003-2012) was collected and empirical orthogonal functions were calculated. The results of this study are presented and discussed.

W1 Workshop
Comparison of size-based and species based ecosystem models

Co-sponsored by ICES

Co-Convenors: Jeffrey Polovina (USA), Anne Hollowed (USA), Shin-ichi Ito (Japan) and Myron Peck (Germany)

Invited Speakers:
Julia Blanchard (University of Sheffield, UK)
Julia K. Baum (University of Victoria, Canada)
Villy Christensen (University of British Columbia, Canada)

Size-based and species-specific ecosystem models are two different approaches to ecosystem modeling, based on different assumptions and designed to address somewhat different questions. In recent years considerable development of size-based models has occurred within the ICES community while the PICES community has typically focused on species-specific models for its applications. The objective of this workshop is to bring together the two communities of modelers to: (1) advance our understanding of the advantages and limitations of these two modeling approaches, especially in the context of modeling climate impacts on ecosystems, (2) make direct comparisons of the predictions of ecosystem structure and dynamics, both top-down and bottom-up, from both these model types applied to the same regional ecosystem, where possible under climate change forcing, and (3) discuss the benefits and feasibility of developing hybrid size-based and species-specific models. The workshop will be structured with a series of talks to kick off discussion on these 3 topics.

Saturday, October 12 (09:00-18:00)

09:00	***Introduction by Convenors***
09:05	**Jeffrey Polovina on behalf of Julia Blanchard (Invited)** Contrasting size- and species-based food web model responses to fishing and environmental change
09:35	**Villy Christensen, Jeroen Steenbeek, Joe Buszowski, Marta Coll and Carl J. Walters (Invited)** Modeling food web dynamics and spatial-temporal environmental variability (W1-9205)
10:05	**James R. Watson, Charles A. Stock and Jorge L. Sarmiento** The role of movement in determining the global distribution of marine biomass (W1-8880)
10:30	***Coffee/Tea Break***
10:50	**Rowan Trebilco, Julia K. Baum, Anne Salomon and Nick Dulvy (Invited)** Size-based constraints on the pyramids of life (W1-8936)
11:10	**Myron A. Peck, Klaus B. Huebert, Markus Kreus and Johannes Pätsch** Examining thetrophodynamic consequences of climate variability on the growth and survival of North Sea fish larvae: A coupled model approach utilizing size spectrum theory (W1-9180)
11:30 (cancelled)	**Phoebe Woodworth-Jefcoats, Jeffrey Polovina, Evan Howell and Julia Blanchard** Two takes on the impacts of climate change and fishing: Comparing a size-based food web model and an Ecopath with Ecosim model in the central North Pacific (W1-8995)
11:30 (cancelled)	**William T. Peterson and Jennifer L. Fisher** Comparison of a size-based and species-based representation of copepod biomass in the northern California Current (W1-9154)

12:10 (*cancelled*) **Ivonne Ortiz and Kerim Aydin**
Effects of size selectivity and prey preference on trophic interactions in ecosystem models (W1-9055)

11:50 **Xuanliang Ji, Guimei Liu and Shan Gao**
Parameter sensitivity study of the ecosystem model in the Northwestern Pacific (W1-9215)

12:10 ***Lunch***

14:00 *Open Discussion*

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

15:50 *Open Discussion*

18:00 *Workshop Ends*

W1 Oral Presentations

October 12, 09:35 (W1-9205)

Modeling food web dynamics and spatial-temporal environmental variability

Villy **Christensen**[1,2], Jeroen Steenbeek[2], Joe Buszowski[1,2], Marta Coll[2,3] and Carl J. Walters[1]

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To date, species distribution models and ecosystem models offered limited capabilities to work jointly to produce direly needed integrated assessments: assessments that take both food web dynamics and spatial-temporal environmental variability into account. The updated *Ecospace* model of the *Ecopath with Ecosim* approach and software offers the ability to drive foraging capacity from multiple physical, oceanographic, and environmental factors such as depth, bottom type, temperature, salinity, oxygen concentrations, *etc.*, which have cumulative impacts on the ability of functional groups to forage. In the implementation of the foraging capacity model, cell capacity is calculated for every functional group at every *Ecospace* time step, and this modification makes the model fully temporal and spatially dynamic. This new development bridges the gap between envelope environmental models and classic ecosystem food-web models, progressing towards the ability to predict changes in marine ecosystems under scenarios of global change and explicitly taking food-web direct and indirect interactions into account.

October 12, 10:05 (W1-8880)

The role of movement in determining the global distribution of marine biomass

James R. **Watson**, Charles A. Stock and Jorge L. Sarmiento

Atmospheric and Oceanic Sciences Program, Princeton University, NJ, 08544, USA. E-mail: jrwatson@princeton.edu

Modeling the dynamics of marine populations at a global scale - from phytoplankton to fish - is necessary if we are to quantify how climate change and other broad-scale anthropogenic actions affect the supply of marine-based food. Here, we estimate the abundance and distribution of fish biomass using a simple size-based food web model coupled to simulations of global ocean physics and biogeochemistry. The global simulations provide estimates of zooplankton biomass and mortality rates, which are used in the size-based food web model to simulate predator-prey interactions between a number of discrete fish size classes. We focus on the spatial distribution of biomass, identifying highly productive regions - coastal areas, shelf seas and major upwelling zones, and examine the role of movement. Allowing fish to move did not strongly impact the total biomass of the global ocean, but it had a profound impact on its spatial distribution, the prevalence of top-down versus bottom-up control, and the shape of community size spectra. These results suggest that similar macroecological models should, in order to be accurate, include explicit descriptions of movement. Our work lays a foundation for integrating high-trophic species into future earth system and general ecosystem models.

October 12, 10:50 (W1-8936)

Size-based constraints on the pyramids of life

Rowan Trebilco[1], Julia K. **Baum**[2], Anne Salomon[3] and Nick Dulvy[1]

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Attempts to unravel the mysteries of ecological food webs are typically approached from one of two angles: detailed food web models or descriptions of the food web's bulk properties. In the latter approach, biomass distribution and energy flow are often described using trophic pyramids or size spectra. Although trophic pyramids are visually intuitive, the absence of an underlying quantitative theory has limited this approach's utility. Here, we show that trophic pyramids and size spectra are in fact interchangeable representations of the same information. Explicitly linking pyramids to size spectra connects them to metabolic and size-based theory, illuminating size-based constraints on pyramid shape. We show that bottom-heavy pyramids should predominate in the real world, whereas top-heavy pyramids indicate overestimation of predator abundance or energy subsidies. Making the link to ecological pyramids establishes size spectra as a central concept in ecosystem ecology, and provides a powerful framework both for understanding baseline expectations of community structure and for evaluating future scenarios under climate change and exploitation.

October 12, 11:10 (W1-9180)

Examining thetrophodynamic consequences of climate variability on the growth and survival of North Sea fish larvae: A coupled model approach utilizing size spectrum theory

Myron A. Peck, Klaus B. **Huebert**, Markus Kreus and Johannes Pätsch

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Changes in marine plankton communities driven by global climate change can affect the coupling between lower and upper trophic levels. We examined the implications of changing phytoplankton productivity and zooplankton size spectra for marine fish populations in the North Sea using a coupled model approach. A 3-D ecosystem model(ECOHAM4) provided estimates of seasonal changes in phytoplankton productivity and temperature that were used to model prey fields for early life stages of marine fishes. Modelled prey fields were corroborated with field sampling and compared to physiological requirements for the successful foraging, growth, and survival of Atlantic herring (*Clupeaharengus*) and European anchovy (*Engraulisencrasicolus*) larvae. We highlight how subtle differences in the slope of the size spectrum as well as the range of prey sizes consumed by fish early life stages influence model-derived estimates of fish growth and survival. The presentations discusses the pros and cons of utilizing size spectra to couple models of lower and upper trophic levels to examine how climate-driven changes in bottom-up factors may affect marine ecosystem productivity.

October 12, 11:30 (W1-8995)

Two takes on the impacts of climate change and fishing: Comparing a size-based food web model and an Ecopath with Ecosim model in the central North Pacific

Phoebe **Woodworth-Jefcoats**[1], Jeffrey Polovina[1], Evan Howell[1] and Julia Blanchard[2]

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We compare climate change and fishing scenarios carried out by two independent ecosystem models and discuss the similarities, disparities, strengths, and weaknesses of each. Output from an earth system model forced by the Intergovernmental Panel on Climate Change (IPCC) special report on emission scenario A2 and fishing mortality from the Hawaii-based pelagic longline fishery were combined to create four 21st century scenarios for the central North Pacific. These scenarios were used to force both a size-based food web model and an Ecopath with Ecosim (EwE) model. The size-based food web model uses size-based predation to drive continuous growth and mortality across all sizes from zooplankton to large fish. Conversely, the EwE model uses detailed species-based diets and trophic relationships. Because these two models are structurally and computationally quite different, comparing their output provides insights that may not be evident when using the models individually, as is often the case. And, because the ecosystem models are forced with the same scenarios, similarities in their output further supports previous work highlighting the compounding effects of fishing and climate change. Disparities in their handling of these scenarios may identify previously overlooked areas of uncertainty.

October 12, 11:50 (W1-9154)

Comparison of a size-based and species-based representation of copepod biomass in the northern California Current

William T. **Peterson**[1] and Jennifer L. Fisher[2]

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If ecosystem models of the northern California Current are to produce realistic results, copepod population dynamics must be parameterized accurately since these taxa are the dominant link between phytoplankton and planktivorous fish. In this talk we explore the idea that a species-based approach will produce a very different result than a size-based approach. This is done through analysis of an 18+year time series of hydrography, phytoplankton and zooplankton that has resulted from biweekly cruises completed along the Newport Hydrographic Line. The copepod time series exist chiefly as data on biomass of individual species. Using these data, we will demonstrate that very different conclusions can be drawn from such a data set, depending upon how the data are parsed. For example, results from analysis of the time series of "total copepod biomass" are very different compared to time series of species grouped by their water mass affinity (*e.g.*, cold neritic and warm neritic species) — the former tracks the NPGO whereas the latter track the PDO and ENSO. For our talk, we will discuss these results in detail along with analysis that of the Newport copepod biomass time series that is parsed out by size (by biomass in various size-categories). Finally, we will touch on the use of a lipid-based approach to the biomass calculation, rather than carbon or nitrogen.

October 12, 12:10 (W1-9055) - CANCELLED

Effects of size selectivity and prey preference on trophic interactions in ecosystem models

Ivonne **Ortiz**[1] and Kerim Aydin[2]

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We use FEAST (Forage Euphausiid Abundance in Space and Time), a bioenergetics length based spatial ecosystem model for the Bering Sea, to compare the outcomes of the use of length or species as the basis of prey preference. The underlying prey preference function in FEAST is a combination of a gamma distribution for length preference and a scaling factor for species preference. The model keeps track of daily numbers at length at age by species. We will present results of one-year simulations under three scenarios: i) native FEAST model where prey preference is based both on length and prey species; ii) gamma distribution for length preference approaching a uniform distribution but species-specific preference; and iii) gamma distribution for length preference but same preference across species. Since FEAST has a spatial resolution of 10 km across the Bering Sea, we will also show some of the effects on movement and distribution under each of these scenarios and show the effect of different prey size and abundance in different regions across the eastern Bering Sea shelf and slope.

October 12, 12:10 (W1-9215)

Parameter sensitivity study of the ecosystem model in the Northwestern Pacific

Xuanliang **Ji**, Guimei Liu and Shan Gao

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For the purpose of developing a coupled basin scale model of ocean circulation and biogeochemical cycling, we present a model of plankton dynamics and nitrogen cycling which is used to study the ecosystem in the Northwestern Pacific (NWP). The biogeochemical model consisted of 12 components, including one phytoplankton and zooplankton, two kinds of nutrients and detritus, etc. Considering the characteristics of biological activity in the Coastal China Sea, the formulation of phytoplankton mortality and zooplankton growth are modified. The results indicate that the modified model has a good capacity of reproducing the biological process. By the sensitivity experiments, the four major sensitivity biological parameters are obtained and they are zooplankton assimilation efficiency rate (ZooAE_N), zooplankton basal metabolism rate (ZooBM), maximum specific growth rate of zooplankton (μ20) and maximum chlorophyll to carbon ratio (Chl2C_m). Simultaneously, several experiments are conducted by changing the parameter μ20, half-saturation for phytoplankton NO_3 uptake (KNO_3) and remineralization rate of small detritusN (SDeRRN), which demonstrates that the biogeochemical model is quite sensitive to the zooplankton grazing parameter. The KNO_3 and SDeRRN also play an important role in determining the nitrogen cycle in the model. The modeled surface NH_4 concentration increases from 0.01 to 0.05 mmol m^{-3} when the strength of the KNO_3 varies from 0.1 to 4 (mmol m^{-3})$^{-1}$, and the modeled surface NO_3 concentration increases from 1.6 to 2.1 mmol m^{-3} when the SDeRRN varies from 0.01 to 0.1 d^{-1}.

W2 POC/BIO/MONITOR/FUTURE Workshop
Identifying mechanisms linking physical climate and ecosystem change: Observed indices, hypothesized processes, and "data dreams" for the future

Co-sponsored by ICES

Co-Convenors: Jack Barth (USA), Emanuele Di Lorenzo (USA), Marc Hufnagl (Germany) Jacquelynne King (Canada), Arthur Miller (USA), Shoshiro Minobe (Japan), Ryan Rykaczewski (USA) and Kazuaki Tadokoro (Japan)

Invited Speakers:
Jürgen Alheit (Leibniz Institute for Baltic Sea Research, Germany)
Bryan Black (University of Texas, USA)
Carolina Parada (Instituto de Investigación Pesquera, Chile)
Hans-O. Pörtner (Alfred-Wegener-Institute, Germany)

Climate variability and change in the ocean is now recognized as a significant driver of marine ecosystem response, from primary production to zooplankton composition, and through the trophic chain to fish, marine mammals and other top predators. Past studies have often relied upon existing datasets to draw correlative conclusions (associated with indices and discovered time-lags in the system) regarding the possible mechanisms that may control these linkages. In this workshop, we seek to identify and model key processes that enable us to succinctly and quantifiably explain the mechanisms underlying the correlative relationships in physical-biological datasets, both in the North Pacific and North Atlantic. The description and modeling of these key processes may (a) involve few or several variables (but not full complexity), (b) use dynamical (*e.g.*, eddy-resolving ocean models, NPZ, IBM, *etc.*) or statistically based methods (*e.g.*, Bayesian, linear inverse models, etc.), (c) explain variability in low or high tropic levels (although we seek to emphasize secondary and higher producers), and (d) include uncertainty estimation. We also solicit ideas and hypotheses concerning new mechanisms of physical-biological linkages that can only be tested by establishing novel long-term observational strategies, where the harvest of understanding will eventually be reaped by future generations of ocean scientists, as well as by developing creative modeling datasets, where ecosystem complexities can be effectively unraveled. The workshop format will be a mixture of talks and group discussions that aim at enriching the exchange of ideas and concepts between physical and biological ocean scientists. The ultimate goal is to deliver: (1) a set of new hypotheses of the mechanisms of marine ecosystem response to climate forcing, and (2) a description of the observational and modeling datasets required to test these hypotheses using process models.

Friday, October 11 (09:00-18:00)

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

09:05 **Bryan A. Black (Invited)**
From the trees to the seas: Multi-species perspectives on long-term climatic and ecological variability (W2-9142)

09:35 **Emanuele Di Lorenzo, Mark D. Ohman and Salvador Lluch-Cota**
A filtering hypothesis to explain climate synchrony in fish populations (W2-9099)

09:55 **Kenneth Denman**
Modelling the changing structure of marine ecosystems in response to changes in the physical climate (W2-9136)

10:15 *Open Discussion*

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

10:50 **Jürgen Alheit (Invited)**
How the coupled ocean-atmosphere system of the North Atlantic impacts on dynamics of small pelagic fish populations and ecosystem regime shifts in the eastern North and Central Atlantic by modulating multi-decadal climate variability (W2-9150)

11:20 **Colleen M. Petrik, Janet T. Duffy-Anderson, Franz Mueter, Katherine Hedstrom, Seth Danielson and Enrique Curchitser**
How eastern Bering Sea climate variability affects the distribution of walleye pollock early life stages (W2-9174)

11:40 **Carolina Parada (Invited)**
Biophysical gauntlet regulating young walleye pollock survival in the Gulf of Alaska: Emphasis on meso and submesoscale eddies (W2-9134)

12:10 *Open Discussion*

12:30 ***Lunch***

14:00 **Hans-O. Pörtner (Invited)**
An integrated view of climate sensitivity in marine organisms: The need for proxies indicating molecular to ecosystem-level changes (S1/W2-9216)

14:30 **Jennifer L. Fisher and William T. Peterson**
Listen while the copepods speak: How different copepod indices respond to environmental indices in the northeast Pacific (Newport, Oregon, USA) (W2-9160)

14:50 **Cheryl S. Harrison and David A. Siegel**
Coastal retention in upwelling currents: Mechanisms and sensitivity to wind forcing (W2-9156)

15:10 **Kazuaki Tadokoro, Shigeho Kakehi, Akinori Takasuka, Kiyotaka Hidaka, Tadafumi Ichikawa, Yuichi Hirota, Haruyuki Morimoto, Takahiko Kameda, Satoshi Kitajima, Kou Nishiuchi and Hiroya Sugisaki**
Geographical and temporal variations in mesozooplankton biomass around Japan, western North Pacific (W2-9106)

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

15:50 **Albert J. Hermann**
A rapid multivariate method for estimating regional forecast uncertainty (W2-9121)

16:10 **Shoshiro Minobe**
Some changes of marine ecosystem in the 21st century in model projections (W2-9070)

16:30 **Yury Zuenko, Vladimir Rachkov and Victoria Nadtochy**
Coastal ecosystem response to climate change in Peter the Great Bay (Japan Sea): Advances and failures of long-term monitoring (W2-9096)

16:50 **Frank A. Whitney**
Some implications of ocean deoxygenation in the subarctic Pacific (W2-9192)

17:10 *Open Discussion*

18:00 *Workshop Ends*

W2 POSTER

W2-P1 **David Timothy and Robie Macdonald**
Climatology and long-term trends of sediment flux and composition in the subarctic Northeast Pacific Ocean

W2 Workshop Oral Presentations

October 11, 09:05 (W2-9142)

From the trees to the seas: Multi-species perspectives on long-term climatic and ecological variability

Bryan A. **Black**

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Climate variability and change substantially impact the structure and functioning of marine ecosystems, yet establishing these relationships is complicated by the relatively short timespans covered by existing instrumental records and observational biological time series. One way to address this issue is through the analysis of annual growth increments in the hard parts of long-lived fish, mollusk, and coral species. Growth-increment chronologies are exactly placed in time, extend over multiple decades, and can be used to quantify impacts of climate on growth and hind-cast climate prior to the start of instrumental records. Moreover, chronologies can be integrated with observational records of phenology, growth, community composition, and reproduction to yield ecosystem-level perspectives on climate impacts. For example, a Pacific rockfish and salmon chronologies have been combined with records of seabird reproductive success and tree-ring chronologies to document the importance of winter climate in the California Current and adjacent terrestrial systems. A network of growth-increment chronologies in the northeast Pacific (20+) is rapidly expanding and represents a tool to identify key climatic variables and their effects within and among species, trophic levels, and ecosystems. Similar efforts are underway in the North Atlantic and the Southern Ocean. However, more work is necessary to identify species or sites that will fill gaps or complement existing datasets. Just as importantly, there is tremendous potential to incorporate modeling into these almost exclusively correlative studies to more effectively establish mechanisms underlying observed climate-growth relationships and forecast the possible impacts of climate change.

October 11, 09:35 (W2-9099)

A filtering hypothesis to explain climate synchrony in fish populations

Emanuele **Di Lorenzo**[1], Mark D. Ohman[2] and Salvador Lluch-Cota[3]

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Fish populations like sardines and anchovies exhibit an apparent temporal synchrony on a global scale that has been documented in the major boundary current systems. The dynamics controlling this synchrony are heavily debated and remain unclear. We present a simple theory to explain why fish populations characterized by inter-decadal variability, like sardines and anchovies, would exhibit a natural tendency for synchrony in their variability and why this synchrony tends to align with global scale low-frequency changes of the climate system. Previous work shows that double integration of white noise atmospheric forcing by the ocean (1x integration) and subsequently by the biology (2x integration) can explain the emergence of strong transitions and prolonged state changes in marine populations. We expand the double integration model to simulate fish species that are sensitive to multiple, independent, regional forcing functions. We show that if the different forcing functions have a small imprint (*e.g.* 5-10% of the standard deviation of the forcing) from a global scale, multi-decadal climate signal like the Atlantic Multidecadal Oscillation (AMO), the double integration acts as a powerful filter that amplifies the common climate signal leading to synchrony among the fish population. Although this theory does not explain the regional mechanisms that link fish variations to the external forcing, it does suggest that no matter what the mechanisms, if the fish forcing functions are multiple (*e.g.* >4) and contain a common global scale, multi-decadal climate signal, the fish species will tend to synchronize.

October 11, 09:55 (W2-9136)

Modelling the changing structure of marine ecosystems in response to changes in the physical climate

Kenneth **Denman**

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We expect the structure and functioning of marine ecosystems to change over this century in response to changes in key ocean variables associated with a changing climate. However, we have limited capability to predict the response/adaptation of individual species to the expected long-term change in any climate-related variable, much less to predict the response/adaptation of whole ecosystems to changes in multiple stressors, which is a key question to be addressed in the future. At present our coupled climate carbon cycle models rarely exhibit abrupt change or regime shifts (*e.g.* in the decreasing area of summer Arctic Sea ice, the Meridional Overturning Circulation, or food web structure and function). In planktonic food web models, does this 'gradual change only' behaviour result from the 'fixed' compartmental structure of current models, where few if any parameter values vary over time in response to the changing environment? Adaptive distributional models (a subset of Complex Adaptive System models) may provide a more realistic view of how future ocean ecosystems might evolve. I present simulations with a simple CAS model (with a frequency distribution of phenotype/species traits that vary in response to changes in environmental variables) as a possible approach to this problem. In particular I explore the effect of the timescale of variability of the physical climate on the ability of marine ecosystems to adapt to change.

October 11, 10:50 (W2-9150)

How the coupled ocean-atmosphere system of the North Atlantic impacts on dynamics of small pelagic fish populations and ecosystem regime shifts in the eastern North and Central Atlantic by modulating multi-decadal climate variability

Jürgen **Alheit**

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The Atlantic Multi-decadal Oscillation (AMO) represents a basin-scale mode of variability in North Atlantic sea surface temperature (SST) on decadal and longer time scales with a periodicity of 60-70 years. Dynamics of abundance and migrations of populations of small pelagic clupeoid fish such as anchovy, sardine, sardinella, sprat and herring in the eastern North and Central Atlantic between Senegal and Norway vary in synchrony with the warm and cool phases of the AMO, as shown by observations dating back to the mid-19th century. It is not primarily the temperature which drives the dynamics of the small pelagic fish populations. Instead, the AMO seems to be a proxy for complex processes in the coupled atmosphere-ocean system of the North Atlantic which is manifested in large-scale changes in the circulation system moving around North Atlantic water masses, very likely with involvement of the North Atlantic Oscillation (NAO), the Atlantic Meridional Overturning Circulation (AMOC), the Mediterranean Overflow Water (MOW) and the sub-polar gyre (SPG). The contractions and expansions of the SPG play apparently a key role. This was particularly obvious in the mid-1990s, when the SPG abruptly contracted with the result that warm sub-tropical water masses moved to the north and east. Small pelagic fish populations in the eastern North and Central Atlantic, including those in the Mediterranean, responded fast by changing abundances and migrating northwards. It seems that the complex ocean-atmosphere changes in the mid-1990s caused a regime shift in the ecosystems of the eastern North and Central Atlantic. This presentation will draw comparisons to similar processes in North Pacific.

October 11, 11:20 (W2-9174)

How eastern Bering Sea climate variability affects the distribution of walleye pollock early life stages

Colleen M. **Petrik**[1], Janet T. Duffy-Anderson[2], Franz Mueter[3], Katherine Hedstrom[4], Seth Danielson[5] and Enrique Curchitser[6]

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We present a dynamical method for examining the mechanisms underlying correlative relationships in physical-biological datasets. Specifically, we will address the correlation between thermal conditions and the distribution of walleye pollock early life stages in the eastern Bering Sea. The eastern Bering Sea recently experienced a prolonged warm period followed by a prolonged cold period. Analyses of observational data indicated that spatial distributions of walleye pollock early life stages were influenced by both broad- and fine-scale variables, with the greatest amount of variation in abundance explained by temperature over wind, spawning stock biomass, and zooplankton biomass. Under warmer-than-average thermal conditions, distributions were shifted to the east, suggesting a relationship with the predominant wind patterns over the shelf in these years. Additionally, roe-fishery data indicated a spawning time delay by as much as one month when temperatures were colder than average. We developed a coupled biological-physical model (ROMS-TRACMASS) to examine how variable physical forcing affects the spawning, transport, and distribution of walleye pollock early life stages in the eastern Bering Sea. The individual-based biophysical model is being used to test the effects of atmospheric (wind), oceanographic (ice, water column temperature), and biological (time and location of spawning) conditions on the distribution, growth, and transport of walleye pollock eggs and larvae. Model results will help elucidate the dominant physical mechanisms responsible for observed changes. A strength of this modeling approach is the ability to individually test mechanisms to quantitatively assess the impact of each on the distribution of pollock.

October 11, 11:40 (W2-9134)

Biophysical gauntlet regulating young walleye pollock survival in the Gulf of Alaska: Emphasis on meso and submesoscale eddies

Carolina **Parada**

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Early life survival is thought to be determinant of the year-class strength for marine groundfish in the Gulf of Alaska (GOA). The survival of young fish is regulated in space and time by climate-driven variability in a biophysical gauntlet comprising offshore and nearshore habitat quality, species interactions, larval and juvenile transport, and successful arrival/migration into suitable nursery habitats. Walleye pollock is an important fishery of GOA characterized by spawning and nursery habitats spatially disaggregated. Historically, a large part of the egg production has been associated with Shelikof Strait, which is advected southwest along Alaska Peninsula, where by summer and through early fall, juveniles arrive at the Shumagin Islands nursery area. The role of meso and submesoscales eddies on connectivity, transport and survival of the young pollock is not well understood. A coupled IBM of young walleye pollock, an NPZ providing prey fields, and a ROMS model were nested to explore the impact of biophysical processes on survival during the young pollock life cycle. In addition, predator interactions were inferred from small, large trawl mesh and groundfish GOA surveys and integrated with the models. These biophysical simulations aimed to disentangle the biophysical gauntlet of young pollock embedded in mesoscale and submesoscale eddy features. GIS, eddy identification techniques, and statistical spatial analyses were used to analyze model output. This study is being developed in the framework of Gulf of Alaska Integrated Ecosystem Program.

October 11, 14:00 (can be found in S1 October 14, 16:30 (S1/W2-9216))

An integrated view of climate sensitivity in marine organisms: The need for proxies indicating molecular to ecosystem-level changes

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October 11, 14:30 (W2-9160)

Listen while the copepods speak: How different copepod indices respond to environmental indices in the northeast Pacific (Newport, Oregon, USA)

Jennifer L. **Fisher**[1] and William T. Peterson[2]

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We have been exploring the relative effects of basin-scale forcing (PDO, ENSO, NPGO) versus local upwelling on copepod community structure and biomass in the northeast Pacific at stations that represent the nearshore coastal upwelling zone and the shelf break (46 km from shore) over the past 17 years. The copepod community dynamics nearshore are synchronyzed with those offshore, and the inter-annual variations in specific copepod communities are driven largely by basin-scale processes at different time lags as opposed to processes associated with local upwelling. We do not quantifiably explain these relationships, instead we review how the different copepod indices respond to different environmental indices and measured physical metrics. We hope this will spark discussion concerning the temporal and spatial (cross-shelf) scale that different biological and physical observations provide.

October 11, 14:50 (W2-9156)

Coastal retention in upwelling currents: Mechanisms and sensitivity to wind forcing

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The exchange and retention of nearshore waters are important for understanding dispersal of coastally originating material and thus dynamics of marine ecosystems. Motivated by observations of larval recruitment patterns, a hypothesis was put forward in the 1980's describing the coastal upwelling front as a "tattered curtain", retaining coastally released larvae, but broken up by filaments and eddies. Here we revisit and revise the tattered curtain hypothesis using an idealized ocean model of an eastern boundary upwelling current driven by realistically time-varying winds. Larval settlement patterns in the model are largely controlled by retention in the upwelling jet. During settlement events, the upwelling jet is coherent along the coast on scales of 20-100km, broken up by large squirts accommodating fast offshore transport. Regions of high coastal retention are bounded by high velocity shear at the flanks of the jet. Squirts, filaments and poleward moving eddies and meanders locally modulate settlement patterns, while dense packets move equatorward within the upwelling jet. High settlement events only weakly correlate with upwelling wind relaxation ($r=0.33$) and are better explained by a 20-day integrated wind product ($r=0.62$). Settlement is low after strong persistent upwelling completely tatters the jet; for moderate extended upwelling, coastal retention is high but highly variable in magnitude. These results suggest that jet cores will act as important transport barriers and that increased upwelling wind will decrease coastal retention for passive plankton in upwelling systems.

October 11, 15:10 (W2-9106)

Geographical and temporal variations in mesozooplankton biomass around Japan, western North Pacific

Kazuaki **Tadokoro**[1], Shigeho Kakehi[1], Akinori Takasuka[2], Kiyotaka Hidaka[2], Tadafumi Ichikawa[2], Yuichi Hirota[2], Haruyuki Morimoto[3], Takahiko Kameda[4], Satoshi Kitajima[4], Kou Nishiuchi[5] and Hiroya Sugisaki[5]

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We investigated the geographical and temporal variations in mesozooplankton biomass (wet weight g m^{-2}) around Japan based on a long-term dataset of egg and larval surveys for small pelagic fishes. The database includes about 130,000 data of mesozooplankton biomass from 1978 to 2008. Zooplankton samples were collected by a vertical haul of two types of plankton nets: Marutoku and Norpac (opening diameter: 45cm; mesh size: 0.33mm) at depths either greater than or equal to 150 m or less than 150 m. We calculated the monthly mean biomass for each year on 0.2 degree lat/lon grids. The biomass in the grid cells where data were absent was estimated by using the spherical weighted interpolation method. Climatologically, biomass started to increase from February in the East China Sea and Sea of Japan and from March in the other areas. The peak biomass appeared in April in the East China Sea, Sea of Japan, and the Kuroshio area. On the contrary, the peak biomass appeared in May in the Oyashio area. We will discuss the interannual variation in the biomass and relationship with environment at the workshop.

October 11, 15:50 (W2-9121)

A rapid multivariate method for estimating regional forecast uncertainty

Albert J. **Hermann**

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Model-based downscaling is an increasingly popular approach used to forecast the effects of global climate change on regional seas and their ecosystems over multiple decades. As in weather forecasting, there is an inherent uncertainty in these global and regional projections. Individual realizations of a global forecast model can be applied one-by-one as forcing to a regional model; this generates a regional forecast ensemble which retains all of the nonlinear processes in both global and regional simulations. However, computational and human resources presently limit the size of this ensemble, since the regional models typically utilize a finer spatial grid, a smaller time step, and more biological detail than their global counterparts. Here we explore a possible solution using multivariate EOFs to summarize the typical behaviors - both Eulerian and Lagrangian - of the coupled, nonlinear, regional biophysical system. These EOFs may be calculated using a modest number of multi-decadal realizations. Since they compactly summarize the covariance structure among multiple elements of the large-scale forcing and the regional-scale response, the modes so derived may subsequently be 'forced', at low computational cost, with a very large number of possible realizations of our global future. This efficiently generates both a mean trajectory and an envelope of uncertainty for regional properties, and retains much of the nonlinearity of the full system.

October 11, 16:10 (W2-9070)

Some changes of marine ecosystem in the 21st century in model projections

Shoshiro **Minobe**

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Climate change may affect marine ecosystems in a number of routes, and the influence of nutrient supply changes on photosynthesis is a major route. A widely accepted hypothesis is that a strengthened surface stratification due to the global warming reduces water mixing between the surface euphotic zone and a deeper layer, resulting in weakened nutrient supplies to the surface layer that cause reduced production. However, other factors such as wind-driven circulation and upwellings may also play a role. In this presentation, we analyzed outputs of marine biogeochemical/ecosystem models archived in Coupled Model Intercomparison Project Phase 5 in order to identify major changes over the North Pacific.

We examined the difference between the "historical runs" for the 20th century and "Representative Concentration Pathway (rcp) 8.5 runs" for the 21st century. The rcp8.5 scenario is the high-end of the anthropogenic radiative forcing (8.5 W/m2 at the end of 21st century) among different scenarios, but the recent increase in CO_2 emissions is slightly above this scenario. Thirteen models that have downward flux of particle organic carbon at 100 m depth are analyzed. This parameter is a measure to how much carbon is exported from the surface layer to deeper levels, and is closely related to the primary production. The carbon export indicates an overall reduction over the central and western North Pacific between the late 20th century to the late 21st century, with pronounced maxima around 40N and around 25-30N in the western North Pacific. The former is related to the reduced upper-layer nutrient concentration associated with a change in ocean circulation, while the latter is associated with the reduced mixed layer thickness. These results indicate the importance of non-uniform physical condition changes in marine ecosystems and marine biogeochemistry.

October 11, 16:30 (W2-9096)

Coastal ecosystem response to climate change in Peter the Great Bay (Japan Sea): Advances and failures of long-term monitoring

Yury **Zuenko**, Vladimir Rachkov and Victoria Nadtochy

Pacific Fisheries Research Center (TINRO-Center), 4 Shevchenko Alley, Vladivostok, 690091, Russia. E-mail: zuenko_yury@hotmail.com

Water temperature has been monitored near Vladivostok since 1901, and irregular but frequent observations of chemical parameters and plankton began in the 1980s; now the data series for the main components describing lower-trophic levels of the coastal ecosystem in Peter the Great Bay are long enough to characterize changes of climatic scale (>3 decades). Links between the components of the coastal ecosystem are more complicated than for "ideal" deep-water ecosystems and are related to both global-scale (Arctic Oscillation), regional-scale (winter and summer monsoons), and local (river discharge) processes; their mechanisms are discussed. The multi-scale nature of variability for different components of the coastal ecosystem breaks the "normal" bottom-up linkages: for example, the zooplankton abundance depends more on monsoon-induced water exchange between the shelf and deep-water sea than on primary production and abundance of phytoplankton. Long-term tendencies and regime shifts connected with climate change are revealed. However, these estimations of long-term dynamics are characterized by strong uncertainty because of noise induced by spatial patchiness and short-term variability in all parameters of the coastal zone and because of lack of climate indices applicable for this region (the applicability of a new index for summer monsoon proposed by T.A. Shatilina and G.I. Anzhina is discussed). Another problem is the high cost of frequent monitoring observations. Possible methods for optimization of observations are discussed.

October 11, 16:50 (W2-9192)

Some implications of ocean deoxygenation in the subarctic Pacific

Frank A. **Whitney**

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The pycnocline waters of the subarctic Pacific are losing oxygen as fast as any region of our global oceans. The reasons for oxygen loss are fairly well understood and include increased surface ocean stratification and reduced dense water formation in the Sea of Okhotsk. Consequences are not so well understood. Some of these include nutrient redistribution, probable habitat compression especially of the vertical migrators that enhance the transport of C, N and Si into the ocean interior, and acidification of waters that may lead to increased carbonate dissolution in sinking particles.

W2 POSTER

W2-P1

Climatology and long-term trends of sediment flux and composition in the subarctic Northeast Pacific Ocean

David **Timothy** and Robie Macdonald

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The magnitude and composition of sinking particles into the deep ocean are indicators of ocean productivity and ecosystem functioning. Sediment traps caught these particles at Ocean Station Papa (OSP; 50°N, 145°W) in the Alaska Gyre from September 1982 to June 2006. We have used this time series to create the climatology (*i.e.*, average annual cycle) of particle flux and composition. This climatology can be used to evaluate the statistical significance of singular events and of long-term trends, but it has also proven to be a very powerful tool when interpreting the climatologies of other ocean properties such as mixed-layer nutrient concentration and phytoplankton and zooplankton biomass. We present the flux climatologies in the context of other physical and biogeochemical properties, and use them to interpret the long-term trends in particle flux and composition. This time series from OSP, unique in its length and completeness, shows evidence of two "regime shifts" in the Northeast Pacific Ocean. Other sediment-trap time series may be too short or too incomplete to show long-term trends, but they may be large enough to generate robust climatologies. We propose that sediment-trap data of adequate length (≥ ~4 years) from other ocean basins be treated similarly, with the ultimate goal of describing the average seasonality, magnitude and composition of particle flux globally.

W3 BIO Workshop
Marine bird and mammal spatial ecology

Co-Convenors: Robert Suryan (USA), Rolf Ream (USA), William Sydeman (USA) and Yutaka Watanuki (Japan)

Invited Speaker:
Martin Renner (Tern Again Consulting, USA)

Marine birds and mammals (MBMs) are highly mobile, yet relatively easy to observe to define their spatial distributions. They consume large amounts of prey and are susceptible to changes in marine food web structure, productivity, and to a variety of anthropogenic impacts. Therefore, MBMs are highly visible sentinels of ecosystem health and its change. To incorporate these roles and characteristics of MBMs into ecosystem-based management and meet objectives of FUTURE, the PICES MBM Advisory Panel (AP-MBM) has proposed to focus on MBM spatial ecology and conservation from 2012-2014. Over the past several decades, a variety of research programs have collected observations of MBMs throughout the North Pacific using tracking studies and vessel-based surveys. Some of these data have been compiled into large databases, while others remain to be integrated in a more complete coverage of the PICES region. The workshop will devise a strategy to compile, integrate, and analyze these various data sets. Specifically, the workshop will determine the analytical approaches to integrate datasets, methods to spatially interpolate data, environmental data to include in spatial modeling, and spatial selection criteria to conduct regional analyses. Regional case studies will be used to test applications and resolve data integration issues. Workshop invitees and participants will include data holders and spatial analysis experts. Once data are compiled and integrated, the overall objectives will be to: (1) synthesize distribution data of MBMs and assess changes over time; (2) examine physical and biological factors that correspond to high use "hot spots"; (3) map and provide information on important ecological areas in the PICES regions. This workshop is an important first step to compiling and integrating these massive datasets. Results of the workshop and subsequent activities will be published as a PICES scientific report at the end of AP-MBM 3-year focus period.

Friday, October 11 (09:00-18:00)

Datasets

09:00 ***Introduction by Convenor: Robert Suryan***
Overview and discussion of goals of workshop

09:15 (cancelled) **Gary S. Drew and John F. Piatt**
The North Pacific Pelagic Seabird Database (NPPSD) Version 2: Expanding spatial and temporal ranges and identifying data gaps (W3-9201)

09:30 **Tracee O. Geernaert**
Trends in seabird occurrence on Pacific halibut assessment surveys (2002-2012) (W3-9206)

09:45 **Lisa T. Ballance, Jay P. Barlow and Trevor W. Joyce**
At sea marine mammal, seabird, and ecosystem assessment surveys in the eastern Pacific: An overview of Southwest Fisheries Science Center's 23-year time series (W3-9203)

10:00 (cancelled) **Alexandre Zerbini, Phillip Clapham, Marilyn Dahlheim, John Durban, Nancy Friday, Brad Hanson, Rod Hobbs, Sally Mizroch, Sue Moore, Amy Kennedy, Brenda Rone, Paul Wade and Janice Waite**
An overview of vessel-based cetacean surveys and satellite telemetry studies conducted by the National Marine Mammal Laboratory in the North Pacific Ocean, the Bering Sea and adjacent waters

10:15 ***Coffee/Tea Break***

10:45 *Discussion: Data gaps, accessibility, and needs*

Applications

11:15 **Tsutomu Tamura, Kenji Konishi, Koji Matsuoka and Takashi Hakamada**
Geographical and temporal distribution of common minke, sei and Bryde's whales in the western North Pacific in relation to prey availability (W3-8938)

11:30 **Sara M. Maxwell, Elliott L. Hazen, Steven J. Bograd, Benjamin S. Halpern, Greg A. Breed, Barry Nickel, Nicole M. Teutschel, Larry B. Crowder, Scott Benson, Peter H. Dutton, Helen Bailey, Michelle A. , Carey E. Kuhn, Michael J. Weise, Bruce Mate, Scott A. Shaffer, Jason L. Hassrick, Robert W. Henry, Ladd Irvine, Birgitte I. McDonald, Patrick W. Robinson, Barbara A. Block and Daniel P. Costa**
Understanding spatial overlap of human impacts and marine predator distributions (W3-9167)

11:45 **Hiroko Sasaki, Hiroto Murase, Koji Matsuoka, Yoko Mitani and Sei-Ichi Saitoh**
Seasonal shift of Bryde's and sei whale habitat in the western North Pacific (W3-9035)

12:00 **D.F. Bertram, Dave Mackas, D.W. Welch, W.S. Boyd, J.L. Ryder and A. Hedd**
Interannual variation in zooplankton prey distribution determines marine breeding distributions of Cassin's Auklet in the proposed Scott Islands National Marine Wildlife Area in Canada (W3-9193)

12:15 ***Lunch***

13:30 *Discussion*
How would integrated datasets be used and who/what would benefit from these

Integration

14:00 **Martin Renner (Invited)**
Combining tracking and transect data - Issues and possible solutions (W3-9208)

14:30 **Yutaka Watanuki, Bungo Nishizawa, Takashi Yamamoto, Elizabeth Labunski, Kathy Kuletz, Catherine Meathrel and R.A. Phillips**
Distribution of short-tailed shearwaters in the northern North Pacific: A comparison between geolocator-based tracking of individuals and boat-based surveys (W3-9210)

14:45 **Jarrod A. Santora, Josh Adams, Bill Henry, K. David Hyrenbach, Jim T. Harvey and David G. Ainley**
Comparative habitat use and spatial overlap of sooty shearwaters using shipboard surveys and satellite-tracking (W3-9211)

15:00 **Helen Bailey, Steven J. Bograd, Elliott L. Hazen, Bruce Mate, Ladd Irvine, Daniel M. Palacios, Karin A. Forney and Evan Howell**
Whale Watch: Integrating blue whale satellite telemetry and oceanographic data to develop habitat models for conservation management (W3-9132)

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

15:45 *Discussion and Simulations*
Integrating tracking and survey data. Synthesis and next steps (to be continued Saturday afternoon, if needed)

18:00 *Workshop Ends*

W3 Workshop, Oral presentations

October 11, 09:15 (W3-9201)

The North Pacific Pelagic Seabird Database (NPPSD) Version 2: Expanding spatial and temporal ranges and identifying data gaps

Gary S. Drew and John F. **Piatt**

U.S. Geological Survey, Alaska Science Center, 4210 University Dr., Anchorage, AK, 99508, USA. E-mail: jpiatt@usgs.gov

Long-term data on the pelagic distribution and abundance of seabirds are critical for understanding the basic ecology of marine birds and assessing effects of environmental change and human activities. The broad scale at which marine birds interact with their environment and the high cost of conducting at-sea surveys have impeded our understanding of factors that affect habitat use by these top predators. To address these issues, we consolidated at-sea survey data collected in the North Pacific during the past four decades by investigators associated mainly with university and government organizations into the North Pacific Pelagic Seabird Database (NPPSD). The current iteration of the database, version 2.0, includes a large increase in the number of samples and associated environmental data, and a new structural design that increases efficiency of use. Version 2.0 of the NPPSD contains 370,571 samples (transects) collected between 1973 and 2012, comprising a total sampled area of 282,034 km^2. In total the database contains observations of 17,331,611 seabirds and 241,531 marine mammals. Despite this large sample, there remain numerous data gaps for the North Pacific, including areas of limited or no sampling, areas sampled only seasonally, and areas lacking temporal replication.

October 11, 09:30 (W3-9206)

Trends in seabird occurrence on Pacific halibut assessment surveys (2002-2012)

Tracee O. **Geernaert**

International Pacific Halibut Commission, 300-2320 West Commodore Way, Seattle, WA, 98199, USA. E-mail: tracee@iphc.int

A total of 13,741 seabird occurrence observations representing over 640,000 individual birds have been collected during International Pacific Halibut Commission (IPHC) stock assessment surveys since 2002 from the west coast of Washington, Oregon, British Columbia (B.C.), southeast Alaska (inside and outside waters), the central and western Gulf of Alaska, Aleutian Islands, and the southeastern Bering Sea shelf The number of stations recording bird counts ranged annually from a low of 1,218 to a high of 1,284. Start dates for each year's survey ranged from May 25 to June 7 and the end dates from August 27 to September 14, with the bulk of observations from June through August.

The northern fulmar (*Fulmarusglacialis*) was most common, making up 72% of the sightings. Glaucous-winged gulls (*Larusglaucescens*) made up nine percent of the overall sightings, with black-footed albatrosses (*Phoebastrianigripes*) and fork-tailed storm petrels (*Oceanodromafurcata*) representing seven and two percent, respectively. Black-footed albatross (*P. nigripes*) were more common in Washington and Oregon and northward into the Gulf of Alaska, whereas Laysan albatross (*P. immutabilis)* were seen in greatest numbers in the central and western Aleutian Islands. A total of 221 endangered short-tailed albatross (*P. albatrus)* were sighted in the central Gulf of Alaska and regions westward, more often in July and August than in June.

Because of the large geographic scope and consistent spatial pattern of the surveys, these data are helpful to scientists studying populations of threatened and endangered birds commonly seen during our surveys.

October 11, 09:45 (W3-9203)

At sea marine mammal, seabird, and ecosystem assessment surveys in the eastern Pacific: An overview of Southwest Fisheries Science Center's 23-year time series

Lisa T. Ballance[1,2], Jay P. Barlow[1,2] and Trevor W. **Joyce**[2]

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The Marine Mammal and Turtle Division of the NOAA/NMFS Southwest Fisheries Science Center, in collaboration with the Pacific Islands and Northwest Fisheries Science centers, has collected extensive data on seabirds, marine mammals, mid trophic-level fishes and invertebrates, and physical and biological oceanography in oceanic ecosystems of the eastern Pacific since 1986. These data have been collected using standard methods (line and strip transect for mammals and seabirds, respectively) aboard NOAA research vessels in the eastern tropical Pacific, California Current, Hawaiian Archipelago Exclusive Economic Zone (EEZ), and certain US Pacific Island EEZs, and represent 10s of thousands of sightings in oceanic ecosystems that comprise millions of square km of open ocean. These datasets overlap with and complement many other at-sea and tracking datasets in the same regions (collected by programs such as California Cooperative Oceanic Fisheries Investigations, US Geological Survey, Equatorial Pacific Ocean Climate Studies, and Tagging of Pacific Predators, to name a few). This spatial and temporal overlap presents a remarkable range of opportunities to integrate detailed, individual-based biologging records of ambit, movement patterns, and inferred feeding behaviors with population-level descriptions of distribution, density, and foraging behaviors, and in-situ oceanographic measurements, in order to obtain a more comprehensive view of the at-sea ecology of these species.

October 11, 10:00 (full abstract on p. 203)

An overview of vessel-based cetacean surveys and satellite telemetry studies conducted by the National Marine Mammal Laboratory in the North Pacific Ocean, the Bering Sea and adjacent waters

Alexandre **Zerbini**, Phillip Clapham, Marilyn Dahlheim, John Durban, Nancy Friday, Brad Hanson, Rod Hobbs, Sally Mizroch, Sue Moore, Amy Kennedy, Brenda Rone, Paul Wade and Janice Waite

National Marine Mammal Laboratory, Alaska Fisheries Science Center, NOAA Fisheries, 7600 Sand Point Way NE, Seattle, WA, 98115, USA

October 11, 11:15 (W3-8938)

Geographical and temporal distribution of common minke, sei and Bryde's whales in the western North Pacific in relation to prey availability

Tsutomu **Tamura**, Kenji Konishi, Koji Matsuoka and Takashi Hakamada

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Minke (*Balaenoptera acutorostrata*), sei (*B. borealis*) and Bryde's (*B. edeni*) whales are common whale species in the western North Pacific. Distribution of these species in this area in summer depends on the availability of prey species, which in turn depend on the changing oceanographic conditions. The purpose of this study is to investigate the seasonal and yearly change in distribution of these whale species in relation to prey availability. For this purpose we examined sighting and stomach contents data of these three species collected during the Second Phase of the Japanese Whale Research Program under Special Permit in the western North Pacific (JARPN II) from May to September during 2000-2012. The study was conducted in the area from the Pacific coast of Japan to 170°E longitude, and between 35°N and 50°N latitude. Our results suggested seasonal and annual changes in the distribution of minke, sei and Bryde's whales which were explained by the availability of prey species in the research area.

October 11, 11:30 (W3-9167)

Understanding spatial overlap of human impacts and marine predator distributions

Sara M. Maxwell[1,2,3,4], Elliott L. **Hazen**[4,5,6], Steven J. Bograd[5], Benjamin S. Halpern[7,8], Greg A. Breed[9], Barry Nickel[10], Nicole M. Teutschel[11], Larry B. Crowder[3], Scott Benson[12], Peter H. Dutton[13], Helen Bailey[14], Michelle A. Kappes[11,15], Carey E. Kuhn[16], Michael J. Weise[17], Bruce Mate[18], Scott A. Shaffer[19], Jason L. Hassrick[11], Robert W. Henry[6], Ladd Irvine[18], Birgitte I. McDonald[19], Patrick W. Robinson[11], Barbara A. Block[3,4] and Daniel P. Costa[11]

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19 Department of Biological Sciences, San Jose State University, San Jose, CA, 95192-0100, USA
Center for Marine Biotechnology and Biomedicine, Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA, 92093, USA

Stressors associated with human activities interact in complex ways to impact marine ecosystems, yet we lack spatially explicit assessments of cumulative effects on ecologically and economically key components such as marine predators. We developed a metric of cumulative utilization and impact (CUI) on marine predators by combining electronic tracking data of eight protected predator species (n=685 individuals) in the California Current Ecosystem with 24 anthropogenic stressors. We show significant variation in CUI with some of the highest impacts within US National Marine Sanctuaries. High variation in underlying species and cumulative impact distributions means that neither alone is sufficient for effective spatial management. Instead, comprehensive management approaches accounting for both cumulative human impacts and tradeoffs among multiple stressors must be applied in planning the use of marine resources.

October 11, 11:45 (W3-9035)

Seasonal shift of Bryde's and sei whale habitat in the western North Pacific

Hiroko **Sasaki**[1], Hiroto Murase[2], Koji Matsuoka[3], Yoko Mitani[4] and Sei-Ichi Saitoh[1]

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Rorquals utilize the western North Pacific as foraging area and migration corridor in summer. Seasonal shift of their habitat is likely linked with change in oceanographic conditions. However, quantitative knowledge on such shifts is sparse. This study aims to clarify rorqual habitat in the western North Pacific in summer (May–August) using sightings and oceanographic data. The sighting survey for Bryde's and sei whales was conducted from 2002 through 2007, as a part of the second phase of Japanese Whale Research Program under Special Permit in the northwestern Pacific (JARPN II). The data were aggregated in 0.25° latitude-longitude grids. Generalized additive

model (GAM) with a binomial error distribution was used to detect relationships with ecological indicators. Potential ecological indicators included in the GAM analysis were sea surface temperature (SST), water depth, and chlorophyll *a* concentration, sea surface height anomaly, eddy kinetic energy derived from satellite remote sensing data. SST was identified as the most important variable in predicting habitat for both species. The predicted spatial distribution suggested that there is little habitat available for either species in May, but potential habitat gradually expands as the season progresses. In August, potential habitat was clearly separated by species along a latitudinal gradient, with Bryde's whale showing a more southern distribution and sei whale a more northern distribution. This kind of exercise can be applied to investigations of the effects of future climate change on potential habitat of these whales using the outputs of climate models as covariates.

October 11, 12:00 (W3-9193)

Interannual variation in zooplankton prey distribution determines marine breeding distributions of Cassin's Auklet in the proposed Scott Islands National Marine Wildlife Area in Canada

D.F. **Bertram**, Dave Mackas, D.W. Welch, W.S. Boyd, J.L. Ryder and A. Hedd

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To investigate the causal basis for patterns of seabird feeding distributions we couple fisheries oceanography, radio telemetry and colony based research. We examine the marine distributions of breeding Cassin's Auklet (*Ptychoramphusaleuticus*) from the world's largest colony in the Scott Islands, B.C., Canada, using aerial telemetry in 1999, 2000 and 2001. Concurrently, zooplankton was sampled at 16 stations along a cross shelf transect in the vicinity of the seabird colony. In years when key prey populations of copepods, *Neocalanuscristatus* were abundant at deep water stations the majority of the seabirds were concentrated SW of the colony 40-75 km offshore, parallel to, but well off (35-50 km) the shelf break in deep water (1500m-2000m). The ongoing time series of zooplankton samples from 1999-2012 allows us to investigate the frequency of years where *N. cristatus* were abundant at deep water stations and thus to report on the predictability of these foraging hot spots for planktivorous seabirds. Our results have contributed to the reserve design of the proposed Scott Islands National Marine Wildlife Area, the first of its kind in Canada.

October 11 (W3-9044) - CANCELLED

Approaches for identifying multi-species hot-spots from electronic tracking and vessel-based sightings data

Ian **Jonsen**

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State-space modeling approaches are increasingly being developed and applied to analyze animal tracking data. These state-of-the-art time-series tools can be used to infer spatio-temporal behavioural patterns hidden within error-prone tracking data and to combine information across multiple species and data types. Drawing on examples from recent publications, I will illustrate how these tools can be used to infer species' distributions and multi-species hot-spots from electronic tracking data. Distributional patterns obtained from tracking data can be combined with sightings data, provided uncertainties in the spatial data are adequately characterized.

October 11, 14:00 (W3-9208) **(full abstract on p. 202)**

Combining tracking and transect data - Issues and possible solutions

Martin **Renner**

Tern Again Consulting, 388 E Bayview Ave., Homer, AK, USA. E-mail: mrenner@gmx.com

October 11, 14:30 (W3-9210)

Distribution of short-tailed shearwaters in the northern North Pacific: A comparison between geolocator-based tracking of individuals and boat-based surveys

Yutaka **Watanuki**[1], Bungo Nishizawa[1], Takashi Yamamoto[2], Elizabeth Labunski[3], Kathy Kuletz[3], Catherine Meathrel[4] and R.A. Phillips[5]

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To obtain information useful for defining Marine Protected Areas, increasing efforts has been focused on identify in gecologically or biologically significant areas. To find these areas in the offshore waters, distributions of seabirds and marine mammals have often been measured by boat-based survey and GPS or geolocatortracking of individuals. Further, to characterize these hot spots and predict their changes with climate, habitat modeling has been conducted using these two types of data. However, intrinsic and technical constraints on these two approaches have not been discussed in detail. We tracked year-round movement of short-tailed shearwaters (*Puffinustenuirostris*) breeding in Tasmania during 2009-2011and conducted boat-based surveys in the Bering and Chukchi seas in autumn of 2012 and summer of 2013. We will summarize these observations in the northern North Pacific where the shearwaters spend their non-breeding period and hence have no constraints of breeding (returning to the colony, *etc.*) and characterize the marine habitats used by this species from these two data sets.

October 11, 14:45 (W3-9211)

Comparative habitat use and spatial overlap of sooty shearwaters using shipboard surveys and satellite-tracking

Jarrod A. **Santora**[1*], Josh Adams[2], Bill Henry[3], K. David Hyrenbach[4], Jim T. Harvey[5] and David G. Ainley[6]

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There is need for integrating shipboard observations of seabirds with telemetry data collected from individual seabirds to better understand behavioral, functional, and numerical responses to environmental variability and to evaluate risks posed to seabirds at sea from various human activities. However, methodological differences of shipboard surveys (density at sea) compared with tracking individuals (utilization distributions) creates difficulties for integrating estimates of seabird distribution into one unified variable that reflects an accurate probability distribution of seabirds. For this workshop, we present a spatially and temporally concise data set on long-term density and satellite-tracking of sooty shearwaters (*Puffinus griseus*) off central California and discuss the benefits and limitations for integrating these disparate data. We propose that integration of these data sets requires the following steps: (1) merge data on a common grid resolution, (2) identify high density locations/high usage areas and measure dispersion, (3) compare habitat use relative to geospatial environmental features (*e.g.*, bathymetry, distance to isobath), and (4) combination of density at sea and tracking data into a standardized variable of spatio-temporal intensity.

October 11, 14:00 (W3-9208)

Combining tracking and transect data - Issues and possible solutions

Martin **Renner**

Tern Again Consulting, 388 E Bayview Ave., Homer, AK, USA. E-mail: mrenner@gmx.com

Individuals carrying a tracking device and survey data along transects provide information on distribution and habitat use. Both approaches have their strengths and weaknesses: tracking data are not limited to a small survey area and sometimes cover the entire year. Transect data, on the other hand, cover all individuals using the surveyed location, not just those from a select few colonies, yielding actual densities. Combining these two sources of information would be valuable, but is not trivial for anything but occurrence. The different mechanisms by which these two data sets are collected, preclude modeling both data sets within the same model. Combining parameter estimates from two independent models may be possible, but may not improve predictive power, given that both datasets already contain a large number of samples. I will explore the idea to of using tracking data of colonial species as one of many independent variables when modeling transect data. I substitute a scaled 1/distance function for colonies without tracking data. I will illustrate this approach with seabird data from the Pribilof Islands.

October 11, 15:00 (W3-9132)

Whale Watch: Integrating blue whale satellite telemetry and oceanographic data to develop habitat models for conservation management

Helen Bailey[1], Steven J. **Bograd**[2], Elliott L. Hazen[2], Bruce Mate[3], Ladd Irvine[3], Daniel M. Palacios[2], Karin A. Forney[4] and Evan Howell[5]

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5 NOAA Pacific Islands Fisheries Science Center, Ecosystems and Oceanography Division, Honolulu, HI, 96822, USA

Management of highly migratory species requires spatially explicit information on their distribution and abundance, and how this varies over time. Satellite telemetry provides time-series information on individual movements, but these "presence-only" data have generally been ranked lower on management's data hierarchy than density estimates, which have mainly been derived from survey observations. Here, we demonstrate the development of density estimates from satellite telemetry of endangered blue whales, and the increased utility of telemetry data for marine conservation and management. A state-space model was applied to 104 blue whale satellite tracks from1994 to 2008 to account for errors in the locations. We output daily positions and integrated these with remotely sensed environmental data as a proxy for habitat preference and prey availability. We created "absence" points using a correlated random walk to sample the environment where whales could have gone at the same temporal and spatial scales as the tag data. A generalized additive mixed model was applied to determine the probability of occurrence, and then scaled by the population abundance to estimate absolute densities. These densities were comparable to those derived from survey modeled densities. Using tag data, we can provide year-round density estimates and modeled ecological relationships that are critical to understand seasonal changes in habitat and will allow management to more accurately examine the overlap with potentially harmful human activities. Our approach could be applied to other protected populations and species for which telemetry data is available, and further inform policies to reduce human impacts.

October 11, 10:00

An overview of vessel-based cetacean surveys and satellite telemetry studies conducted by the National Marine Mammal Laboratory in the North Pacific Ocean, the Bering Sea and adjacent waters

Alexandre **Zerbini**, Phillip Clapham, Marilyn Dahlheim, John Durban, Nancy Friday, Brad Hanson, Rod Hobbs, Sally Mizroch, Sue Moore, Amy Kennedy, Brenda Rone, Paul Wade and Janice Waite

National Marine Mammal Laboratory, Alaska Fisheries Science Center, NOAA Fisheries, 7600 Sand Point Way NE, Seattle, WA, 98115, USA

The National Marine Mammal Laboratory (NMML) has developed dedicated vessel line transect surveys since the late 1970's in Alaskan waters including Southeast Alaska, the Gulf of Alaska, the Aleutian Islands, and the Bering Sea. The majority of these cruises were conducted in relatively coastal waters over the continental shelf in the summer months. While the goals of these surveys have varied, they contributed to building a rich dataset on the distribution and abundance of multiple cetacean species. Since the early 1990s, surveys have totaled nearly 80,000 km of on-effort track line, with a total of over 13,700 sightings of 14 cetaceans identified to species level. Telemetry studies were initiated more recently and focused primarily on humpback (Bering Sea [n=8] and Kodiak [n=6]), right whales (Bering Sea [n=6]), killer whales (Bering Sea [n=4], Aleutian Islands [n=13] and Southeast Alaska [n=12]) and belugas (Cook Inlet [n=14], Bristol Bay [n=27]). Integrating telemetry and sighting data may contribute to better describe distribution and habitat of cetacean species in the North Pacific. The goal of this presentation is to provide an overview of NMML's existing datasets in order to identify which components can contribute to develop analytical approaches to integrate sighting and satellite-based location data.

W4 TCODE Workshop
Tools, approaches and challenges for accessing and integrating distributed datasets

Co-sponsored by IODE

Co-Convenors: Lynn deWitt (USA) and Toru Suzuki (Japan)

Invited Speakers:
Roy Mendelssohn (NOAA/NMFS/SWFSC, USA)
Rich Signell (Woods Hole Science Center, USA)

Most of PICES' data sharing activities have been on the server side: gathering and standardizing metadata and developing a web portal based on GeoNetwork software. These tools aim to provide web browser access to data. The tools are useful because distributed data require the efficiencies of machine to machine access to data that are distributed across multiple sites. However, users may prefer to access data using their particular client of choice. It may be a browser, but it might also include anything from shell scripts to python or java programs to application extensions or libraries that allow direct access to the data from within the user's favourite application. This workshop will examine new and existing client-side solutions that are working to make the use of distributed data services simple and invisible to the user. Live demonstrations are encouraged.

Friday, October 11 (09:00-18:00)

09:00	***Introduction by Convenors***
09:05	**Lynn deWitt on behalf of Roy Mendelssohn (Invited)** Integrating web-service based environmental and biological data into client applications (W4-8915)
09:50 (remotely)	**Richard P. Signell (Invited)** Better tools to search, access and analyze ocean data (W4-9163)
10:35	***Coffee/Tea Break***
11:00	**Kelly Knee, Kyle Wilcox, Cheryl Morse, Roy Mendelssohn and Cara Wilson** Client-side tools for utilization of data services (W4-9129)
11:45	**Vadim Burago, Andrey Golik, Rimma Kravtchenko, Larisa Matyushenko, Georgiy Moiseenko, Olga Vasik and Igor Shevchenko** Providing ice characteristics of the Northwest Pacific marginal seas (W4-9209)
12:30	***Lunch***
14:00	**Danelle Cline, Kevin Gomes, Duane Edgington, Micheal Godin, Thom Maughan, Mike McCann, Tom O'Reilly, Fred Bahr, Francisco Chavez, Monique Messie, Jnaneshwar Das and Kanna Rajan** ODSS: A Decision Support System (DSS) for ocean exploration (W4-9209)
14:45	*Demonstration and Discussion*
15:30	***Coffee/Tea Break***
15:50	*Demonstration and Discussion*
18:00	*Workshop Ends*

W4 Workshop Oral Presentations

October 11, 09:05 (W4-8915)

Integrating web-service based environmental and biological data into client applications

Lynn deWitt on behalf of Roy **Mendelssohn**

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There have been many meetings about services for providing integrated access to distributed environmental and biological data, but little on the client side. For the data services to be useful, they must be transparent to the user, and integrate directly into the normal work flow of the user. That is, the services should be able to be accessed directly in the users' applications of choice. In this talk, I give a highly opinionated and biased overview and examples of such integration in applications such as Matlab, R, python, ArcGIS and others. Most of the talk will be live demonstrations.

October 11, 09:50 (W4-9163)

Better tools to search, access and analyze ocean data

Richard P. **Signell**

U.S. Geological Survey, Woods Hole, MA, 02543, USA. E-Mail: rsignell@usgs.gov

Ocean scientists are producers and consumers of vast and varied data, and spend significant effort on tasks that could be eliminated by better tools. In the last several years, standardization led by the US Integrated Ocean Observing System Program to use OPeNDAP for delivery of gridded data (*e.g.* model fields, remote sensing) and OGC Sensor Observation Services (SOS) for delivery of in situ data (*e.g.* time series sensors, profilers, ADCPs, drifters, gliders) has resulted in significant advancements, making it easier to deliver, find, access and analyze data. Data brokers such as Unidata's THREDDS Data Server and NOAA ERD's ERDDAP have played an important role in making much more data accessible using software commonly used in the oceanographic community. Examples of searching, accessing, analyzing and visualizing in situ data as well as data from both curvilinear and unstructured grid model output in Python, Matlab and R will be presented, with workflows captured using the IPython Notebook.

October 11, 11:45 (W4-9129)

Client-side tools for utilization of data services

Kelly **Knee**[1], Kyle Wilcox[1], Cheryl Morse[1], Roy Mendelssohn[2] and Cara Wilson[2]

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The use of data services for distribution of large environmental science datasets such as satellite-derived data, sea surface radar, in-situ observations, and meteorological and oceanographic models is increasingly prevalent. The Environmental Data Connector (EDC) was developed for NOAA (SWFSC/ERD) to facilitate access to scientific data from client-side analysis and visualization packages. The EDC allows users to connect directly from analysis packages such as ArcMap, Matlab, R, and Excel to THREDDS, ERDDAP, and SOS services, simplifying their use within applications.

The EDC allows users to connect, browse, and search data services and catalogs to find datasets of interest. After selecting a dataset, the interface allows users to filter large amounts of data in space, time and by variable. The EDC downloads the selected data in NetCDF format, where it is automatically converted to a format compatible with the client side application for further analysis. For example, EDC for ArcGIS automatically converts gridded data to raster datasets and tabular data such as in-situ observations to point feature classes. The data is assigned a spatial reference, loaded into the map, and made available for animation. Customizations have been made to the ESRI temporal data handling capabilities to allow ArcMap to manage non-uniform time steps and allow

on-the-fly creation of time-series plots. This presentation will discuss implementation of EDC, demonstrate access to several NOAA data servers and discuss the challenges of handling disparate data sets, non-uniform time-steps, and syncing datasets with a wide range of temporal resolutions, such as acoustic telemetry and climate data.

October 11, 14:00 (W4-9209)

Providing ice characteristics of the Northwest Pacific marginal seas

Vadim Burago[1], Andrey Golik[2,3], Rimma Kravtchenko[1], Larisa Matyushenko[1], Georgiy Moiseenko[4], Olga Vasik[1,2] and Igor **Shevchenko**[1,2]

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Using various imagery sources, analysts from the U.S. National Ice Center (NIC) construct, among others, the Weekly/Bi-Weekly Ice Analysis Products for the Arctic in the shape format. The data set represents a unique, relatively homogeneous series of observations of the ice concentration, form, and stage of development, for the period since 1996. The shape files are available in particular for the Bering Sea, the Sea of Okhotsk, and the Japan/East Sea which are of the most interest to researchers from fisheries and academic institutions in Russia. However, for some reason, the boundaries of seas adopted by scientific communities or individual researchers may differ from those used by NIC analysts. Moreover, sometimes ice data are analyzed for only specific subregions, *e.g.*, when evaluating the ice cover in a one degree band of latitude that stretches from the coast to the shelf break. The NIC shape files can be processed with different software tools and ice data for any geographic area can be extracted with a sequence of commands. In this talk, we will describe value-added data and services available on the website with URL: http://ice.tinro.ru where several archives with primary and automatically processed georeferenced data from NIC along with derived characteristics of the seasonal ice for some Arctic marginal seas are posted. The content and services can be accessed by various applications. With an additional functionality, this site may become a node in the network of information suppliers for periodically publishing/updating the future web-based editions of the North Pacific Ecosystem Status Report.

October 11, 14:00 (W4-9209)

ODSS: A Decision Support System (DSS) for ocean exploration

Danelle **Cline**[1], Kevin Gomes[1], Duane Edgington[1], Micheal Godin[1], Thom Maughan[1], Mike McCann[1], Tom O'Reilly[1], Fred Bahr[1], Francisco Chavez[1], Monique Messie[1], Jnaneshwar Das[2] and Kanna Rajan[1]

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MBARI has designed, built, tested and fielded a decision support system, which provides a platform for situational awareness, planning, observation, archiving and data analysis. While still in development, our interdisciplinary team of computer scientists, engineers, biologists and oceanographers has made extensive use of our system in at-sea experiments since 2010. The novelty of our work lies in the targeted domain, its evolving functionalities that closely tracks how ocean scientists are seeing the evolution of their own work practice, and its actual use by engineers, scientists and marine operations personnel. We describe the architectural elements and lessons learned over the more than two years use of the system.

W6 MEQ Workshop
Economic Impacts of harmful algal blooms on fisheries and aquaculture

Co-Convenors: Chang-Hoon Kim (Korea) and Vera Trainer (USA)

Invited Speaker:
Daniel Huppert (University of Washington, USA)

Harmful algal blooms (HABs) have adverse economic and social impacts on the aquaculture industry, human health, coastal economies, and wild fisheries. HABs have prompted routine closures of both commercial and recreational shellfish harvesting as well as contributing to the death of aquaculture finfish resulting in financial losses in coastal communities. But the economic impacts generated by these events extend far beyond the industry itself. Obtaining more realistic estimates of HAB economic impacts, and the costs of preventing and managing them, calls for an integrated assessment approach that comprises the following: the economic impact of HABs on the aquaculture industry, the secondary integrated industries, and consumers, on both local and regional scales; some valuation of the costs and benefits of taking any recognized steps to lessen the HAB problem (*e.g.*, reducing coastal pollution and other human-related activities); and weighing the costs and benefits of enhanced monitoring and surveillance that potentially reduces the magnitude of the impacts (*e.g.*, by limiting shellfish harvesting closure windows or alteration in the timing of finfish harvesting). This workshop comprises 2 parts, with the first being a presentation of what is known about the economic and social impacts of HABs in the eastern and western Pacific, by both HAB researchers and invited speakers who can inform on cutting edge approaches and methodologies for assessment of HAB and other marine economic impacts (*e.g.*, oil spills). In Part 2 participants will identify specific steps for developing improved and more comprehensive economic impact assessments of HABs on fisheries and aquaculture in the North Pacific.

Friday, October 11 (09:00-12:30)

09:00	***Introduction by Convenors***
09:05	**Karen Dyson and Daniel D. Huppert (Invited)** Regional economic impacts of razor clam beach closures due to Harmful Algal Blooms (HABs) on the Pacific coast of Washington (W6-8917)
09:35	**Takafumi Yoshida and Hiroshi Ono** Economic impacts of Harmful Algal Blooms in the NOWPAP region (W6-9105)
09:55	**Nicola Haigh and Svetlana Esenkulova** Economic losses to the British Columbia salmon aquaculture industry due to Harmful Algal Blooms 2009–2012 (W6-9019)
10:15	**Hao Guo, Dewen Ding and Chunjiang Guan** The economic cost of Harmful Algal Blooms in China from 2008-2012 (W6-9028)
10:30	***Coffee/Tea Break***
10:50 (cancelled)	**Charles G. Trick** Re-evaluating the economic metrics of HAB events (W6-9100)
11:10 (cancelled)	**Leif E. Anderson and Mark L. Plummer** Effects of HAB and pollution closures on the recreational use values of shellfish harvesters in Puget Sound (W6-9092)
11:25 (cancelled)	**Changkyu Lee, Youngtae Park and Taegyu Park** HAB mitigation by yellow clay in Korean waters (W6-8965)

11:40 **Shigeru Itakura and Ichiro Imai**
Economic impacts of Harmful Algal Blooms on fisheries and aquaculture in the western Japan – An overview of interannual variability and interspecies comparison (W6-9049)

11:55 **Meg Chadsey, Vera L. Trainer and Thomas Leschine**
Cooperation of science and management for Harmful Algal Blooms: Domoic acid and the Washington Coast razor clam fishery (W6-9016)

12:10 *Discussion and Summary*

12:30 *Workshop Ends*

W6 POSTER

W6-P1 **Ji A Park, HyeongKyu Kwon, HanSoeb Yang and Seok Jin Oh**
Utilization of different nitrogen sources by the toxic dinoflagellates, *Alexandriumtamarense and Alexandriumcatenella*, isolated from Masan Bay, Korea

W6 Oral Presentations

October 11, 09:05 (W6-8917)

Regional economic impacts of razor clam beach closures due to Harmful Algal Blooms (HABs) on the Pacific coast of Washington

Karen Dyson and Daniel D. **Huppert**

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Since 1991 the razor clam fishery has had a positive impact on the coastal economies of Grays Harbor and Pacific counties in Washington State. The fishery has been occasionally closed due to harmful algal blooms (HABs). These events reduce or eliminate recreational clam-related visitor spending. A local economic input-output model is modified to include recreationists' spending, and then to estimate the economic impacts of these closures. To estimate visitor expenditure patterns, questionnaires were distributed in April of 2008 to an on-site sample of clammers at four beaches on Washington's Pacific coast: Mocrocks, Copalis, Twin Harbors, and Long Beach. Based upon 240 responses, average expenditure per party ranged from $268.77 at Mocrocks beach to $412.67 at Long Beach. Overall expenditures for the 2007–2008 season were estimated at $24.4 million. To estimate negative impacts, expected visitor expenditures are adjusted to account for visitors' stated intentions when razorclamming is unavailable. For example, some may shift their time or location of fishing in response to partial closure. For a full year closure of all four beaches, the estimated negative economic impact is a loss of 339 full-time equivalent jobs and $10.6 million of labor income in the two counties. Further, impacts were calculated for beach closures ranging from a single (2–5 days) season opening to a full year for individual beaches and combinations of beaches.

October 11, 09:35 (W6-9105)

Economic impacts of Harmful Algal Blooms in the NOWPAP region

Takafumi **Yoshida** and Hiroshi Ono

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The NOWPAP region has faced serious problems due to the frequent occurrence of Harmful Algal Blooms (HABs). This is due to increased nutrient inputs from land associated with economic development, and an increase in agricultural production in surrounding countries. Even though the number of HABs has decreased in recent years, due to the establishment of sewage plants and appropriate treatment of discharged water, HABs occur every year in the region. HABs cause damage to aquaculture and fisheries that are highly active in the region and face increasing demand. In 1999, approximately USD 7 million of fishery damage was recorded in Imari Bay, Kyushu, Japan. Even greater economic losses were recorded in Korea in 1995 and 2003, worth approximately USD95 million and USD19 million, respectively. During 2008 to 2010, total amount of fishery damage by *Chattonella antiqua* in Yatsushiro Sea reached 8.4 billion yen (about USD86 million). In China, from 2008, massive green macroalgae (*Ulva prolifera*) blooms occurred in the Yellow Sea and the East China Sea. The removal and treatment of such a large volume of *U. prolifera* cost more than USD100 million. To prevent and reduce such economic damage, NOWPAP member states, including China, Japan, Korea and Russia, implement various kinds of measures, such as early detection, constant monitoring *etc.*. In my presentation, the latest situation of the member states and estimated economic effect by countermeasures will be introduced.

October 11, 09:55 (W6-9019)

Economic losses to the British Columbia salmon aquaculture industry due to Harmful Algal Blooms 2009–2012

Nicola **Haigh** and Svetlana Esenkulova

Harmful Algae Monitoring Program, Vancouver Island University, 900 Fifth St., Nanaimo, BC, V9S 5S5, Canada. E-mail: Nicky.Haigh@viu.ca

Harmful algal blooms (HABs) have been the largest cause of mortality to British Columbia (BC) aquacultured salmon since the beginning of the industry in Western Canada in the 1970s. In 2009–2012 direct losses of farm salmon due to HABs totalled more than CAD$10 million. Additiona lcosts of HABs include production loss due to withholding of salmon feeding during blooms, and bloom mitigation supplies which may amount to more than CAD$1 million per year per company. Harmful algae species directly implicated in farm salmon mortalities in BC include *Heterosigma akashiwo, Chaetoceros concavicornis, Chaetoceros convolutus, Cochlodinium fulvescens, Chattonella* sp., *Dictyocha speculum,* and *Chrysochromulina* sp. Monitoring of HABs at salmon farms is done on-site, and since 1999 by the Harmful Algae Monitoring Program (HAMP) which analyzes weekly phytoplankton samples from up to 27 west coast farm sites. Management of HABs at farm sites is done by mitigation strategies including barrier curtains and upwelling of deep water, and timing of stock introduction and harvest based on historical HAB timing information from HAMP and farm data.

October 11, 10:15 (W6-9028)

The economic cost of Harmful Algal Blooms in China from 2008-2012

Hao **Guo**[1,2], Dewen Ding[1] and Chunjiang Guan[2]

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There are more than 330 cases of red tides in China from 2008 to 2012, encompassing a total area of 52,777 km^2 with an economic cost of nearly 458 million yuan ($75 million USD). Surveys have shown that the southeast coastal area of China is important fishery area where red tides occur frequently and cause enormous economic losses. The main seasons of annual events are May and June. The dominant red-tide species are *Karenia mikimotoi*, *Skeletonema costatum*, *Noctiluca scintillans, and Prorocentrum donghaiense.* The major fish-killing organisms are *Karenia mikimotoi*, *Cochlodinium geminatum* and *Prorocentrum donghaiense.*

October 11, 10:50 (W6-9100)

Re-evaluating the economic metrics of HAB events

Charles G. **Trick**

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"To tell the story we need data - To sell the story we need the right metric."

HAB events, by definition, are large-scale growth or accumulation of phytoplankton that result in negative or harmful impacts. While scientists are highly skilled at defining the species and the possible mechanisms of damage, it is usually by implication that the consequences of these HAB events are reported. The impacts are often expressed as a negative economic loss. In general, the economic assessment is a difficult one and one that can be misleading. Difficult or mis-leading explanations do not translate well to the public and can place managers or public policy advocates in a difficult position. Using the adage, 'no data is better than poor data', I will discuss the need for proper metrics on the effect of HABs on society. By using different metrics from ecosystem services, social, economic, recreational and human health approaches to the cost of environment changes; broader views of the economic consequences of HAB events will be presented.

October 11, 11:10 (W6-9092)

Effects of HAB and pollution closures on the recreational use values of shellfish harvesters in Puget Sound

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Recreational shellfish harvesters in Puget Sound face a wide variety of spatial and temporal closures for water quality, including HABs and pollution. We used a survey to collect data on the preferences and behavior of licensed shellfish harvesters. The survey was tested using a series of focus groups and one-on-one interviews with shellfish harvesters around Puget Sound. Contingent behavior questions provide data on the number of trips that would be taken conditional on a range of spatial and temporal closures observed in past seasons. These questions provide the basis for estimating recreational demand models that will allow us to estimate the potential loss in economic value associated with HAB and pollution closures of varying extent at shellfish harvest sites.

October 11, 11:25 (W6-8965)

HAB mitigation by yellow clay in Korean waters

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Cochlodinium polykrikoides blooms have caused severe fisheries damage since the 1990s in Korea. Yellow clay, mainly composed of montmorillonite, has been used to control *C. polykrikoides* blooms since 1996.The spreading of suspended clay particle, estimated using a theoretical model, showed that suspended clay could be transported by tidal currents as far as 11.2, 0.84, 0.09 and 0.04km^2, corresponding to the 10, 35, 50 and 100mm clay particle sizes, respectively. The theoretical height of clay sedimentation at the target site over the past 8 years is estimated at 1.6-4.0mm in the outer area and 40-80mm nearer to the culture farm. It was assumed that frequent typhoons might play a significant role in resuspension and transport of clay settled in those areas. The impact of yellow clay on fisheries animals was assessed in the laboratory, showing that accumulation of clay in the gills and viscera of mussel (*Mytilus galloprovincialis*), oyster (*Crassostrea gigas*) and abalone (*Haliotis discus*) increased rapidly over time. The visceral cavity of shellfish became filled with clay within 2 h of exposure. Depuration of accumulated clay from shellfish was evident as complete discharge of clay from their visceral cavities from 30min to 6h after their removal from clay suspensions. The effect of yellow clay on oxygen consumption rate (OCR) in black rockfish, *Sebastes schlegelii*, showed that the OCR in the low clay suspension (0.05 and 0.25%, w/w) was normal compared to the control. In contrast, the OCR in the high clay suspension (1.25 and 6%, w/w) was abnormal and did not return to the control level, indicating that high clay suspensions (≥1.16%, w/w) might cause negative effects in the black rockfish. Given that field application of yellow clay in Korea is generally <0.04% (V/V), clay mitigation measures for the control harmful algal blooms (HABs) likely do not impact Korean rockfish if the clay is dispersed at low concentrations (≤0.25%).

October 11, 11:40 (W6-9049)

Economic impacts of Harmful Algal Blooms on fisheries and aquaculture in the western Japan – An overview of interannual variability and interspecies comparison

Shigeru **Itakura**[1] and Ichiro Imai[2]

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In Japanese coastal waters, fish kills caused by HABs have mainly occurred in the western part of Japan, such as the Seto Inland Sea and the Kyushu coasts. Since 1970s, the Fisheries Agency of Japan has been gathering data on HABs in two areas - the Seto Inland Sea since 1970, and the Kyushu coast since 1979 - and has published annual reports. These reports contain detailed statistics on the number of HAB events and the amount of economic losses attributed to each causative species. Guided by these reports, this talk will make interannual and interspecies

(causative species) comparisons of the economic impacts of HABs on fisheries and aquaculture in western Japan. In the Seto Inland Sea, the most harmful species causing severe economic losses are *Chattonella* (*C. antiqua*/*marina*/*ovata*), followed by *Karenia mikimotoi*. For example, *Chattonella* caused 7.1 billion JPY (ca. 73 million USD) of economic losses in Harima-Nada in 1972, and *K. mikimotoi* caused approximately 1.3 billion JPY of economic losses in Bungo-Suido in 2012. On the Kyushu coast, *K. mikimotoi* and *Cochlodinium polykrikoides* are the major harmful species, although *Chattonella* has begun to cause severe economic losses in recent years (5.4 billion JPY in Yatsushiro Sea in 2010). This talk will also detail unrecognized financial losses in coastal communities and some proposed countermeasures to mitigate these economic losses.

October 11, 11:55 (W6-9016)

Cooperation of science and management for Harmful Algal Blooms: Domoic acid and the Washington Coast razor clam fishery

Meg **Chadsey**[1], Vera L. Trainer[2] and Thomas Leschine[3]

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Harmful algal blooms (HABs) appear to be increasing in frequency and intensity worldwide. Coastal economies suffer significant income losses when fisheries or beaches are closed to protect human health and subsistence fishing communities are at risk. Despite these hardships, managers must often conservatively close harvests across a wide area or for long periods, because they lack scientific information that would allow them to predict HAB events. The outer coast of Washington State has experienced several closures of the razor clam (*Siliqua patula*) fishery starting in 1991, due to domoic acid (DA) contamination caused by toxic blooms of the diatom *Pseudo-nitzschia*. Improved science-based management was needed to minimize the impact of DA on this fishery and the coastal communities that relied on it for income, tourism, and subsistence. The Olympic Region Harmful Algal Bloom (ORHAB) Partnership, comprised of state and tribal managers, scientists, and local stakeholders, evolved in response to this need; it has been successful in its mission. We examined ORHAB through the lens of the Institutional Analysis and Development framework, in order to identify key factors contributing to its success, and their relevance to other ORHAB-like institutions in the Pacific Northwest and elsewhere.

W6 POSTER

W6-P1

Utilization of different nitrogen sources by the toxic dinoflagellates, *Alexandriumtamarense* and *Alexandriumcatenella,* isolated from Masan Bay, Korea

Ji A Park, HyeongKyu Kwon, HanSoeb Yang and Seok Jin **Oh**

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In Korea, the problem of paralytic shellfish poisoning (PSP) in the spring, induced by toxic dinoflagellates, including *Alexandriumtamarense* and *Alexandriumcatenella,* is almost an annual event. The purpose of this study was to evaluate the physiological characteristics and dominance strategy of *Alexandriumtamarense* and *Alexandriumcatenella* under DIN (dissolved inorganic nitrogen) conditions through field observations in Masan Bay, Korea and in laboratory experiments. In the field observations, *Alexandrium* spp. were observed from April to July, and accounted for about 60% of the dinoflagellates observed from May to June. During these periods, the N:P ratio was less than 16, suggesting that nitrogen was the factor limiting the growth of phytoplankton. However, dissolved organic nitrogen (DON) accounted for approximately 70% of dissolved total nitrogen (DTN). In the experiment testing DON utilization, *A. tamarense* and *A. catenella* were able to grow using DON (*i.e.* urea and amino acids) as well as DIN (*i.e*. nitrate and ammonium). The growth of the two species with urea and amino acids corresponded to 90% and 60%, respectively, of the growth with nitrate. Therefore, the utilization of DON by *A. tamarense* and *A. catenella* may be an important survival strategy influencing their dominance under DIN-limited conditions in areas such as Masan Bay.

HAB-S Meeting

Day 1, Friday, October 11 (14:00-18:00)

14:00 ***Introduction by Convenors: Shigeru Itakura and Vera Trainer***
Welcome, goals of HAB Section meeting, review of terms of reference

Country Reports (2012-13) and HAE-DAT (year 2009) reports

14:15 **Changkyu Lee**
Korea

14:30 **Vera L. Trainer**
U.S.A.

14:45 **Shigeru Itakura**
Japan

15:00 **Ruixiang Li and Mingyuan Zhu**
China: HAB in coastal water of China in 2012 (HAB-S-9037)

15:15 **Charles Trick**
Canada

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

16:00 **Tatiana Orlova and Tatiana Morozova**
Russia

16:15 **Henrik Enevoldsen and Vera Trainer**
The joint Harmful Algal Bloom Programme and International Oceanographic Data and Information Exchange Harmful Algae Information System: An update and country maps

16:30 **Mark Wells**
Report on ICES Meeting and Joint Workshop on HABs and Climate

16:45 **Charles Trick and Vera Trainer**
Report on New MAFF project, Marine Ecosystem Health and Human Well Being

17:00 **Mark Wells**
Review of Workshop, The contrasting cases of HABs in the eastern and western Pacific in 2007 and 2011

17:30 ALL Discussion about Sessions and Workshops for 2014

17:45 ALL Assignments for the evening

18:00 *Meeting Ends*

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

09:00 ***Introduction by Convenors: Shigeru Itakura and Vera Trainer***
Welcome and review of previous day

09:15 **Tatiana Yu. Orlova, I.V. Stonik , P.A. Popkova, Tatiana V. Morozova , Vera L. Trainer, L. Moore and B.-T.L. Eberhart**
Diarrhetic shellfish toxins in Primorye, Russian Federation (HAB-S-8937)

09:45 **Joo-Hwan Kim, Bum Soo Park, Jin Ho Kim, Pengbin Wang, Jae-Hyung Joo and Myung-Soo Han**
Improvement of previous qPCR methods for the quantification of *Heterosigmaakashiwo* cysts (HAB-S-9074)

10:00 **Satoshi Nagai, Shigehiko Miyamoto, Koji Takahashi and Jun Tomono**
Easy detection of multiple HAB species by nucleic acid chromatography (HAB-S-9098)

10:15 **Ichiro Imai, Hiroshi Shimada and Shigeru Itakura**
Prediction of toxic algal bloom occurrences and adaptation of scallop aquaculture industry to blooms for minimizing economic losses in Hokkaido, Japan (HAB-S-9112)

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

11:00 **Vera Pospelova**
Spatial distribution and identification of resting cysts of *Cochlodinium polykrikoides* in surface sediments from the aquaculture sites of southern South Korea (HAB-S-9139)

11:15 ALL HOT Topics – short discussions of hot topics or novel, interesting findings

12:15 ALL Final discussion of Proposals for the Future and Review of assignments

12:30 *Meeting Ends*

HAB Section Meeting POSTERS

HAB-S-P1 **Svetlana Esenkulova, Christopher M. Pearce, Nicola Haigh and Laurie J. Keddy**
Isolation and culture of harmful algal species affecting aquaculture on the west coast of Canada

HAB-S-P2 **Parandavar Hossein, Sung-Kyun Kim, Byung-Kwon Kim, Kyeong-Hun Kim and Chang-Hoon Kim**
Water quality improvement by the polychaete rock worm *Marphysasanguinea* (Montagu) in the integrated culture with olive flounder

HAB Section Meeting, Oral Presentation, Day 1

October 11, 15:00 (HAB-S-9037)

HAB in coastal water of China in 2012

Ruixiang Li and Mingyuan **Zhu**

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There are 73 HAB events in the coastal water of China in 2012. Among them, 38 events were detected in the East China Sea, 16 in the South China Sea, 11 in the Yellow Sea and 8 in the Bohai Sea. Twenty HAB events resulted in economic losses. The main causative species included *Kareniamikimotoi, Skeletonemacostatum, Prorocentrumdonghaienseand Aureococcusanophagefferens*. May and June were the months with the most frequent HABs. The most devastating events were *Karenia*-related HABs in the coastal waters of the Fujian Province from May 18 to June 8, which caused massive abalone deaths and also *Aureococcus*-related HABs in the coastal water of Qinhuangdao City, Bohai Sea. A green tide occurred in the southwest Yellow Sea from March to August 2012 with a total affected area of 19610 km^2. On June 13, 2012, the largest coverage area of 267 km^2 green tide was observed.

HAB Section Meeting, Oral Presentations, Day 2

October 12, 09:15 (HAB-S-8937)

Diarrhetic shellfish toxins in Primorye, Russian Federation

Tatiana Yu. **Orlova**[1], I.V. Stonik[1] , P.A. Popkova[1], Tatiana V. Morozova[1] , Vera L. Trainer[2], L. Moore [2] and B.-T.L. Eberhart[2]

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The rapidly expanding mariculture and recreational zones along the coast of Primorye demonstrates the necessity of monitoring for toxin producing algae and seafood contamination by phycotoxins, especially for diarrhetic shellfish toxins (DSTs). Routine monitoring of phytoplankton carried out since 1997 showed that the species of the genus *Dinophysis* which are known as producers of DSTs is common and abundant in the coastal waters of Primorye. Concentration of *Dinophysis* spp. in the summer-autumn period can exceed the reportedly harmful level at which many countries prohibit production and marketing of shellfish, as their use may be associated with diarrhetic shellfish poisoning (DSP). Virtually nothing was known of the nature of DSP toxicity and causative organisms on the east coast of Russia. This study presents the first data on DSTs in coastal waters of Primorye. The seasonal occurrence of DSTs in mussels *Crenomytilus grayanus* (digestive glands) was correlated with the presence of *Dinophysis* spp. in coastal water in July and November. The analysis of DSTs in mussels from various areas of Primorye showed that DSTs exceeds the U.S. and E.U. regulatory limit of 16 µg/100 g at almost all sites with the maximum concentration of 56.3 µg/100 g. Moreover, the first data of qualitative analysis of DSTs showed that the primary toxin isomer in shellfish and plankton samples in Primorye is dinophysistoxin-1 (DTX-1; 94-100%), followed by OA (0-6%) with *D. acuminata* as the primary *Dinophysis* species. Other lipophilic toxins in shellfish were pectenotoxin-2 (PTX-2), yessotoxin (YTX), and azaspiracid-2 (AZA-2).

October 12, 09:45 (HAB-S-9074)

Improvement of previous qPCR methods for the quantification of *Heterosigmaakashiwo* cysts

Joo-Hwan **Kim**, Bum Soo Park, Jin Ho Kim, Pengbin Wang, Jae-Hyung Joo and Myung-Soo Han

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The identification and quantification of *H. akashiwo* cysts in sediments using light microscopy are difficult due to their small size and morphology that is indistinguishable from many other cells. Here, a qPCR assay for accurate cyst identification quantification has been developed. However, past qPCR assays for *H. akashiwo* cysts have not considered the difference in gene copy number between vegetative cells and cysts. Moreover, qPCR assays for *H. akashiwo* cyst quantification have shown some interference with DNA debris in the sediment. To obtain a higher accuracy of the qPCR assay, we compared gene copy number of both cysts and vegetative cells, demonstrating that gene copies in cysts were half that in vegetative cells. This result suggested that the standard curve must be specific to *H. akashiwo* cysts. The qPCR assay analyzing Ct value and the log of cyst number showed a significant linear relationship ($R^2 \geq 0.99$, slope=-4.89).To remove DNA debris from the sediment, we developed an effective method using DNA elution in a low ionic strength solution. A total of 18 sediment samples were used to quantify *H. akashiwo* cysts using the qPCR assay with and without removal of DNA debris. Using a regression analysis and comparison with a direct counting method, the qPCR method showed a higher correlation when using the DNA debris treatment (R^2=0.72, slope=1.07, $P<0.001$) than the non-treatment (R^2=0.60, slope=3.20, $P<0.001$). These results suggest that this improved qPCR method will be a powerful tool for the accurate quantification of *H. akashiwo* cysts.

October 12, 10:00 (HAB-S-9098)

Easy detection of multiple HAB species by nucleic acid chromatography

Satoshi **Nagai**[1], Shigehiko Miyamoto[2], Koji Takahashi[2] and Jun Tomono[2]

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Of the 5,000 species of extant marine phytoplankton, approximately 300 species can form red tides or cause shellfish poisoning, and the distribution of these species is extending all over the world. Monitoring of harmful algal bloom (HAB) species has been hitherto conducted by morphologically-based microscopic observations. However, as many species lack distinctive characteristics, inadequate information on which to base identification may lead to misidentification and result in an inaccurate estimation of the abundance. Therefore, molecular diagnostic techniques such as real-time qPCR, DNA micro array, and/or multiplex-PCR assay have been developed to accurately identify HAB species. Kaneka Corporation, Japan has developed a novel molecular diagnostic method utilizing nucleic acid chromatography (Kaneka DNA chromatography chip), *i.e.* a capture DNA probe is solid-phased on a strip. PCR amplification is conducted using primer pairs added to two different tags for visualization with colloidal gold and for capture by the solid phase DNA probe. After PCR amplification of the target regions, one drop of PCR amplicon (5μL) was sufficient to successfully detect the target species within 5 min. This DNA chromatography chip will be widely applicable to many targets through the use of different sequence capture probes. This technology was applied to the species-specific detection of HAB species. The successful development of two different multiple-PCR assays that enabled the specific detection of 5 species in the genus *Alexandrium* and 6 noxious red tide causative species such as *Chattonella*, indicate that this method is one of the most convenient, reliable and rapid molecular tools for HAB monitoring.

October 12, 10:15 (HAB-S-9112)

Prediction of toxic algal bloom occurrences and adaptation of scallop aquaculture industry to blooms for minimizing economic losses in Hokkaido, Japan

Ichiro **Imai**[1], Hiroshi Shimada[2] and Shigeru Itakura[3]

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Scallop (*Mizuhopecten yessoensis*) aquaculture is a big fisheries industry in Japan, especially in northern areas such as Hokkaido and Tohoku. Production is about 500 thousands tons with a value reaching about 84 billion JPY (about 840 million USD). More than 60% of the total production (landing) and amounts were produced in Hokkaido, mainly in the Okhotsk Sea and Funka Bay. Both areas have long histories of economic impacts due to paralytic shellfish poisoning (PSP) and diarrhetic shellfish poisoning (DSP). In the Okhotsk Sea, occurrences of toxin contamination by PSP recently have been predicted on the basis of the movement of the warm Soya Current. This current prevents the transport of toxic dinoflagellate, *Alexandrium tamarense,* by the water mass of Okhotsk Sea to the coastal towns of northern Hokkaido such as Monbetsu and Abashiri. In Funka Bay, in the southwestern part of Hokkaido, the scallop culturing industry has adapted to the frequent incidence of toxic dinoflagellate blooms that cause DSP and PSP, which usually occur in May and following summer season. Scallops are harvested for fresh consumption and processing such as boiling and freezing every year from December to April. This modified harvesting approach has been achieved through the development of new culturing technology together with specific scheduling of harvest. This was necessitated, in part, by the severe fisheries damage in 1980s with heavy PSP contamination that stopped all bivalve shipments. Adaptation is thought to be one effective way for mitigating the impacts of toxic blooms on the bivalve aquaculture industry in the coastal sea.

October 12, 11:00 (HAB-S-9139)

Spatial distribution and identification of resting cysts of *Cochlodinium polykrikoides* in surface sediments from the aquaculture sites of southern South Korea

Vera **Pospelova**

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Palynological identification of resting cysts of the ichthyotoxic species *Cochlodinium polykrikoides* has been addressed in several publications. Matsuoka and Fukuyo (2000) illustrated cysts as being ovoidal with brownish fin-like projections. Subsequently, Kim *et al.* (2007) made a dedicated study of the *C. polykrikoides* life cycle in Korean coastal waters, and identified another morphotype as a haline round cyst with folding on one side. These were first identified in the lab, but similar cysts were also found in sediments. Given the importance of *C. polykrikoides*, it is essential to investigate the spatial distribution of these two cyst morphotypes in Korean coastal waters. In this work (Pospelova and Kim, 2010, *Marine Micropaleontology*), we performed a comprehensive study of dinoflagellate cyst assemblages along with geochemistry data from surface sediment samples collected at multiple locations separated by small spatial scales in the coastal area of Tongyeong and Gosung, South Korea.

Using cyst assemblages as a signal of nutrient enrichment, we determined the most eutrophic sites in the studied estuarine systems of Southern Korea. The distribution of dinoflagellate cysts on small spatial scales correlates with available environmental and sedimentary data. We identified the correct morphotype of cysts of C. *polykrikoides*. Cysts of C. *polykrikoides* were not found in Buk Bay, and were otherwise recorded in most of the studied sites in low proportions, except in Gosung Bay where they contribute up to 41% of the cyst assemblage. This is in agreement with previously observed blooms of C. *polykrikoides* in Gosung Bay.

HAB Section Meeting POSTERS

HAB-S-P1

Isolation and culture of harmful algal species affecting aquaculture on the west coast of Canada

Svetlana **Esenkulova**[1], Christopher M. Pearce[2], Nicola Haigh[1] and Laurie J. Keddy[2]

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Harmful algal blooms (HABs) are one of the most significant risks for the British Columbia (BC) finfish and shellfish aquaculture industries. The Harmful Algae Monitoring Program (HAMP) has been monitoring phytoplankton at salmon farms since 1999. Phytoplankton quantification and identification are based solely on light-microscope analysis of water samples, a technique that is not always sufficient for identifying certain harmful algae to species level. To improve our knowledge of HABs, starting in 2012, HAMP has been involved in a two-year collaborative research project to isolate and culture various species of harmful algae collected from finfish and shellfish aquaculture sites around BC, with the goal of identifying all samples to species level using a variety of techniques (*i.e.* light microscopy, electron microscopy, genetics). This research is being funded by the Aquaculture Collaborative Research and Development Program (ACRDP) of Fisheries and Oceans Canada (DFO) and industry. Here we present the results of isolation and culturing of harmful algae from BC coastal waters in 2013. Twenty aquaculture sites were monitored weekly from April to November with more frequent samples collected during blooms. Successful isolations so far include at least eight cultures of *Heterosigmaakashiwo* (from different geographical locations), *Pseudo-nitzschia* sp., *Protoceratiumreticulatum*, and *Chrysochromulina* sp. Future work will make use of genomics to identify physiological processes in shellfish that are affected by their exposure to harmful algal species.

HAB-S-P2

Water quality improvement by the polychaete rock worm *Marphysasanguinea* (Montagu) in the integrated culture with olive flounder

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Aquaculture is growing rapidly all over the world and the increasing number of fish culture industries has begun to create serious environmental problems due to the impact caused by fish farming wastes. Based on the information on great potential of the polychaete worms for bioremediation and the successful seed production of the polychaete rock worm *Marphysasanguinea* at Fisheries Science and Technology Center, PKNU, three trials have been conducted to test the water quality improvement and growth performance in the rock worm settlement tanks receiving wastes from olive flounder rearing tanks, in the integrated culture systems with flow-through and semi-recirculation. In comparison between culture systems, the pure production of the worm was 1.5 times higher in flow-through system than in semi-recirculating system. Different effects on the removal efficiency were appeared both in culture systems and among treatments. In flow-through system, the highest removal efficiency showed in TN (56%) in G2 (0.6~1.5g/initial weight), TP (59%) in G1(<0.5g), TSS (86%) in G2, and COD (30%) in G3 (1.6~2.5g). In semi-recirculating system, the highest removal efficiency was in TN (63%) in G2, TP (53%) in G3, TSS (80%) in G3, and COD (21%) in G2.These results suggest that the rock worm, *M. sanguinea,* is an excellent candidate for integrated aquaculture and nutrient recycling, including the removal of organic wastes in land-based systems.

W7 MEQ Workshop
Traditional seafoods of coastal aboriginal communities in the North Pacific: Insight into food, social and ceremonial uses at Snuneymux'w First Nation in Nanaimo, British Columbia

Co-Convenors: Peter Ross (Canada) and local community members

Seafoods are integral part of the nutritional, social and cultural fabric of many aboriginal communities inhabiting coastal regions of the North Pacific Ocean. The Snuneymux'w First Nation in Nanaimo, BC, is home to 1,200 residents who have relied heavily on seafoods for thousands of years. Despite now living in an urban environment with ready access to supermarket foods, it has been recently estimated that the average individual from this aboriginal community consumes 12 to 15 times as much seafood as the average Canadian. Much of this is harvested locally by native fishers. Community members routinely express concerns about the quality and quantity of their local seafoods. It is becoming increasingly evident that the availability of nutritious and uncontaminated seafoods is important for food, social and ceremonial purposes in this other coastal communities in BC. This workshop will bring together local members of the Snuneymux'w First Nation and PICES participants, and provide an invaluable opportunity for sharing, learning and teaching about the importance of traditional seafoods to this aboriginal community. The workshop will involve discussions on science and traditional ecological knowledge. This workshop is open to any participant attending the 2013 PICES Annual Meeting, but a maximum capacity is set at 45 persons. The workshop will be of interest to persons working on issues of marine stewardship, marine resource management, seafoods, and local cultures. Local practices, culture and traditions of First Nations will be showcased at this workshop, with additional input from resource persons from other communities. The workshop will feature:

- cultural welcome and prayer from representative of the Chief-in-Council, Snuneymux'w First Nation;
- song and drum opening from local community members;
- teachings from local community elders on marine resource management and sustainable harvesting;
- discussions on the role of traditional ecological knowledge (TEK) in a science-driven world (a panel of elders and scientists will be invited to prepare 4 x 15 minute talks, followed by discussions);
- a tour of the local seashore south of Nanaimo where practical demonstrations will take place on techniques to harvest seaweeds, shellfish and other seafoods;
- preparation of lunch foods using traditional aboriginal cooking techniques including a pit-cook and bentwood box; lunch and snacks comprising locally and seasonally-available foods as prawns, oysters, sea urchins, salmon, halibut, and a variety of crops and plants.

The workshop is open to any participant of PICES-2013, but a maximum capacity is set at 45 persons. It is expected that approximately 1/3 of the day will be indoors at the Vancouver Island University First Nations Shq'aqpthut ('Gathering Place'; http://www.viu.ca/gatheringplace/gallery.aspx), and 2/3 outdoors (shoreline and cooking area). Participants should bring suitable walking/hiking shoes, warm clothing and raingear to prepare for seasonal weather in coastal temperate British Columbia (16ºC, with possible rain).

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BEST-BSIERP	NPRB/NSF Bering Sea Project http://bsierp.nprb.org/
CeNCOOS	The Central and Northern California Ocean Observing System www.cencoos.org/
ESSAS	Ecosystem Studies of Sub-Arctic Seas www.imr.no/essas
EVOSTC	Exxon Valdez Oil Spill Trustee Council http://www.evostc.state.ak.us/
GESAMP	Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection www.gesamp.org/
ICES	International Council for the Exploration of the Sea www.ices.dk/indexfla.asp
IMBER	Integrated Marine Biogeochemistry and Ecosystem Research www.imber.info/
IOC	Intergovernmental Oceanographic Commission of UNESCO http://ioc-unesco.org
IOCCP	International Ocean Carbon Coordination Project www.ioccp.org/
IODE	IOC International Oceanographic Data and Information Exchange www.iode.org/
ISC	International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean http://isc.ac.affrc.go.jp
IWC	International Whaling Commission http://iwcoffice.org/
NANOOS	Northwest Association of Networked Ocean Observing Systems www.nanoos.org/
NEAR-GOOS	North-East Asian Regional GOOS program http://near-goos.coi.gov.cn/

NOWPAP	Action Plan for the Protection, Management and Development of the Marine and Coastal Environment of the Northwest Pacific Region www.nowpap.org/
NPAFC	North Pacific Anadromous Fish Commission www.npafc.org
NPFMC	North Pacific Fishery Management Council www.fakr.noaa.gov/npfmc
NPRB	North Pacific Research Board www.nprb.org/
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SAHFOS	Sir Alister Hardy Foundation for Ocean Science www.sahfos.ac.uk/
SCCOOS	Southern California Coastal Ocean Observing System www.sccoos.org/
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WESTPAC	IOC Sub-Commission for the Western Pacific www.unescobkk.org/westpac/about-us/ioc-westpac/ioc-westpac/

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Artioli, Yuri 63
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Aseeva, Nadezhda L. 149
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Awaji, Toshiyuki 140, 141, 148, 176
Aydin, Kerim 110, 184

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Bae, Ho Jin 146
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Bahr, Fred 208
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Blinov, Yuriy G. 32
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Boyarova, Margarita D. 31, 32
Boyd, W.S. 200
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Branch, Trevor A. 112, 138, 139
Brandt, Stephen B. 87
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Brodeur, Richard D. 92, 143, 151, 158
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Brown, Robin 160
Budyansky, Maksim 159
Bugaev, Victor F. 135
Bundy, Alida 9, 85
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Burkanov, Vladimir N. 23
Buszowski, Joe 181
Butenschon, Momme 63
Butorin, Dmitriy A. 28
Byamba, Bolorchimeg 14

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Callendar, Wendy 64
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Chai, Fei 40
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Chang, Kyung-Il 99, 164, 167

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Chen, Yun-Long 145
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Chiba, Sanae 17, 69, 102
Childers, John 143, 151
Child, Tom 175
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Choi, Jung Hwa 70
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Choi, Kwang-Sik 31
Choi, Minkyu 29
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Chulchekov, Denis 163
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Clapham, Phillip 203
Clasen, Jessica 53
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Cline, Danelle 208
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Connors, Brendan M. 136
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Couture, Jennifer 100
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Crego-Prieto, V. 176
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Curchitser, Enrique 40, 110, 189

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Daewel, Ute 63
Dahlheim, Marilyn 203
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Daisuke, Ambe 159
Dangerfield, Neil 26
Danielson, Seth 189
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Ding, Dewen 212
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Dulvy, Nick 182
Dunne, John 64
Durban, John 203
Dutch, Maggie 43
Dutton, Peter H. 199
Dyson, Karen 211

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Edgington, Duane 208
Edwards, Andrew M. 44, 174
Edwards, Christopher 40
Emmett, Robert L. 138
Endoh, Yuki 103
Enyo, Kazutaka 45
Esenkulova, Svetlana 212, 220
Essington, Timothy E. 138, 139
Evans, Wiley 39, 45
Exarchopoulos, Dionysios Raitsos 43

F

Fach, Bettina 63
Fadely, Brian S. 23
Fain, Isaak 64
Fan, Jingfeng 26, 29
Farley, Edward V. Jr. 109, 136
Fayman, Pavel A. 166
Fedewa, Erin J. 130
Feinberg, Leah R. 121
Feist, Blake E. 90, 92
Fiechter, Jerome 40
Field, John C. 54, 123
Fisher, Jennifer L. 19, 69, 183, 190
Flostrand, Linnea 142
Foley, David G. 129
Foley, Melissa M. 84
Ford, Michael J. 92
Foreman, Michael 64
Forney, Karin A. 92, 202
Forrest, Robyn E. 111

Fotherby, Hannah 90
Fox, Peter 8
Frank, David C. 18
Fraser, Dave 101
Freshwater, Cameron 135
Friday, Nancy 203
Friedenberg, Laura 43
Fritz, Lowell 101
Fu, Caihong 86
Fu, Mingzhu 90
Fukuchi, Shin-Ichi 25
Funamoto, Tetsuichiro 143

G

Galbraith, Moira 26, 120, 128, 142
Gao, Hui 33, 157
Gao, Shan 41, 184
Gao, Zhong-yong 39
García-Reyes, Marisol 10, 17, 18, 64, 76
Garcia-Vazquez, E. 176
Gauthier, Stephane 142
Geernaert, Tracee O. 197
Gerhardinger, Leopoldo C. 8
Glaser, Marion 8
Godbout, Lyse 147
Godin, Micheal 208
Goebel, Nicole 40
Golik, Andrey 208
Golovashchenko, Ekaterina V. 54
Golubeva, Elena 165
Gomes, Kevin 208
Gomez-Fernandez, Mario 157
Goñi, Miguel A. 37
Gorin, Igor 164
Goryachev, Vladimir 159
Grant, Sue C.H. 12
Greenlaw, Charles F. 125
Gregr, Edward J. 9
Greiner, Thomas A. 88
Griffin, Daniel 18
Gritsay, Elena V. 144
Guan, Chunjiang 29, 212
Guerry, Anne 51
Gulenko, Timofei 164
Guo, Hao 212
Guo, Xianghui 38
Guo, Xinyu 173
Gurney-Smith, Helen J. 82

H

Ha, Sung Yong 25
Haigh, Nicola 212, 220
Haigh, Rowan 44
Hakamada, Takashi 198
Hales, Burke 45
Halpern, Benjamin S. 84, 199
Haltuch, Melissa A. 138, 139
Han, Gi Myung 25, 28
Han, Myung-Soo 218
Hanson, Brad 203
Harle, James 63
Harms, John H. 100
Harris, Katherine 45
Harrison, Cheryl S. 108, 190
Harvey, Jim T. 201
Hassrick, Jason L. 199
Hastings, Alan 107
Hay, Doug 88
Hazen, Elliott L. 199, 202
He, Jianhua 158
Hebert, Kyle 88
Hedd, A. 200
Hedstrom, Katherine 189
Heintz, Ron A. 109
Helmuth, Brian 7
Henry, Bill 201
Henry, Robert W. 199
Herman, David 23
Hermann, Albert J. 110, 191
Herrmann, Bethellee 43
Hertz, Eric 137
Hidaka, Kiyotaka 191
Higley, Kathryn 157, 158
Hilborn, Ray 54, 112
Hipfner, Mark 123
Hirawake, Toru 147, 148
Hirota, Yuichi 191
Hobbs, Rod 203
Hodes, Vanessa 142
Holland-Bartels, Leslie 155
Hollmén, Tuula E. 14
Hollowed, Anne B. 112, 138, 139
Holsman, Kirstin K. 87, 110
Holt, Carrie A. 10, 44, 147
Holt, Jason 63
Hong, Hyun-Ki 31
Hong, Sang Hee 25, 28
Hossein, Parandavar 220
Houle, Jennifer 85
Howard, Kathrine 12
Howell, Evan 183, 202
Hsieh, Chih-hao 141
Hsieh, Hung-Yen 127
Huang, Ling 55
Huang, Liuyi 95
Huebert, Klaus B. 182
Hufnagl, Marc 88
Hunt, Brian P.V. 119
Huo, Chuanlin 33, 157
Huppert, Daniel D. 211
Hurst, Thomas P. 130
Hwang, Dong-Woon 29
Hwang, Kangseok 70
Hyrenbach, K. David 201
Hyun, Bonggil 128

I

Ianelli, Jim 110
Ianson, Debby 44
Ichikawa, Tadafumi 69, 102, 191
Idris, Mohd Hanafi 27
Igarashi, Hiromichi 140, 148, 176
Ihara, Yu 147
Iida, Yosuke 45
Iiyama, Masaaki 176
Ikenaka, Yoshinori 24
Imai, Ichiro 118, 119, 126, 213, 219
Irvine, James 147
Irvine, Ladd 199, 202
Isada, Tomonori 129
Ishihara, Taiki 168
Ishii, Chihiro 24
Ishii, Masao 45, 46
Ishikawa, Yoichi 129, 140, 141, 148, 169, 176
Ishimatsu, Atsushi 44
Ishimura, Gakushi 14
Ishiyama, Hiromu 118
Ishizuka, Mayumi 24
Isoda, Yutaka 13
Itakura, Shigeru 213, 219
Ito, Kento 14
Ito, Motohiro 24
Ito, Shin-ichi 13, 70, 103, 107, 159

J

Jang, Chan Joo 63, 66, 67, 73, 74
Jang, Mi 28
Jang, Min-Chul 128
Jang, Pung-Guk 128
Jayaraman, R. 57
Jeon, Chanhyung 164, 165
Jeong, Hee-Dong 47
Jiayi, Zhao 33
Ji, Xuanliang 41, 184
Jin, Xianshi 56, 145
Jing, Wenping 38
Jinkun, Yang 76
Joh, Youngji 67
Johan, Ismail 27
Johannessen, Sophia 42
Johnson, Penny 85
Johnson, Stewart C. 82
Jonsen, Ian 200
Joo, Jae-Hyung 218
Joyce, Trevor W. 125, 198
Ju, Se-Jong 120, 122
Juanes, Francis 101, 135, 137, 149, 176, 177
Jung, Chun Yong 63
Jung, Hae Kun 72
Justice, Matthew 83

K

Kaeriyama, Hideki 159
Kaeriyama, Masahide 93
Kaga, Shinnosuke 103
Kakehi, Shigeho 13, 70, 103, 159, 191
Kamachi, Masafumi 140, 148, 176
Kamal, Abu Hena Mustafa 27
Kameda, Takahiko 191
Kanaya, Gen 25
Kang, Chang-Keun 31, 70, 72, 75
Kang, Dong-Jin 38, 46, 47
Kang, Hyung-Ku 118
Kang, Jung-Hoon 30
Kaplunenko, Dmitry 75, 159, 164
Kappel, Carrie V. 84
Kappes, Michelle A. 129, 199
Kasai, Hiromi 70
Kato, Yoshiki 176
Katugin, Oleg N. 130
Kawamura, Hiroshi 13
Keddy, Laurie J. 220
Keister, Julie E. 43
Kennedy, Amy 203
Keshav, Nisha 27
Key, Robert M. 46
Keyzers, Mya 43
Khristoforova, Nadezhda K. 31, 32
Kikuchi, Takashi 124
Kiku, Denis P. 24
Kilduff, Patrick 107
Kim, Ah Reum 146
Kim, Byung-Kwon 220
Kim, Chang-Hoon 220
Kim, Cheol-Ho 63, 73, 74
Kim, Dong Guk 168
Kim, Jae-Yeon 38, 47
Kim, Jin Ho 218
Kim, Jong-Bin 151
Kim, Joo-Hwan 218
Kim, Ki-Wan 99
Kim, Kyeong-Hun 220
Kim, Kyung-Ryul 38, 46, 47
Kim, Kyung-Su 89
Kim, Minwoo 74
Kim, Nam Sook 25
Kim, PilSoo 150
Kim, Pyoung-Joong 29
Kim, Sen Tok 20
Kim, Sook-Yang 29
Kim, Suam 89
Kim, Sung-Kyun 220
Kim, Young Ho 164
King, Stephanie 83
Kimball, Jennifer 82
Kishi, Michio J. 19, 56, 107, 119, 129
Kitajima, Satoshi 191
Kitamura, Minoru 124

Kivva, Kirill 163, 177
Klain, Sarah 51
Knee, Kelly 207
Ko, Ah-Ra 120, 122
Ko, Chul Min 63, 66
Kodama, Masashi 159
Koeppen, Will 12
Kojima, Atsushi 45
Komatsu, Kosei 66
Konishi, Kenji 198
Konishi, Yoshinobu 145
Kosaka, Rosemary 54
Koslow, J. Anthony 73, 100
Kosugi, Naohiro 45, 46
Kotenev, Boris 72
Kovekovdova, Lidia T. 24
Koyamada, Koji 148
Koyama, Jiro 160
Kravtchenko, Rimma 208
Krembs, Christopher 43
Kreus, Markus 182
Krishnan, M. 57
Krovnin, Andrei 72
Kruse, Gordon H. 110
Kuhn, Carey E. 199
Kuletz, Kathy 201
Kulik, Vladimir V. 86
Kuroda, Hiroshi 70, 159
Kusaka, Akira 70
Kusunoki, Takayuki 102
Kutsukake, Hiroshi 159
Kuwae, Tomohiro 24
Kuzin, Viktor 165
Kwak, Jung Hyun 70
Kwon, HyeongKyu 214
Kwon, Jung-no 178
Kwon, Minho 67
Kwon, Oh-Youn 30

L

Labunski, Elizabeth 201
Ladychenko, Svetlana 164
Lapointe, Mike 111
Lara-Lopez, Ana 73
Lawrence, Suzanne 8
Lee, Changkyu 213
Lee, Chung Il 70, 72, 75
Lee, Hae Won 70
Lee, In-Seok 29
Lee, Jae Bong 150, 151
Lee, Jae-Hak 164
Lee, Kyung-Jae 167
Lee, Kyun-Woo 30
Lee, Sangjin 28
Lee, Sang-Uk 99
Lee, S. Todd 52
Lee, Sunkil 151
Lee, Tongsup 38
Lee, Tonsup 47
Lee, Woo-Jin 128
Leon, Sheila Mae Santander-De 160
Leschine, Thomas 214
Lessard, Evelyn 71
Levin, Phillip S. 85, 90, 92
Levine, Jordan 53
Lew, Daniel K. 52
Liang, Zhenlin 95
Liapidevskii, Valeriy 37
Limpanont, Yanin 31
Lin, Fengao 29
Li, Ruixiang 90, 217
Li, Yuhong 40
Litz, Marisa N.C. 122, 138
Litzow, Michael 17
Liu, Chunsheng 146
Liu, Guimei 41, 184
Liu, Jie 95
Liu, Jinwen 38
Liu, Kon-Kee 41
Liu, Yang 147
Lluch-Cota, Salvador 187
Lo, Wen-Tseng 127
Lobanov, Vyacheslav 37, 159, 164
Logerwell, Elizabeth 101
Long, Yu 173
Lu, Zihao 33
Luchin, Vladimir A. 175
Lukyanova, Olga N. 31, 32
Lynam, Chris 85

M

MacDonald, Bronwyn L. 12
MacDonald, Patricia 55
Macdonald, Robie 42, 193
Mach, Megan E. 84
Mackas, Dave 142, 200
Maeda, Hiroto 160
Mahon, Robin 8
Maki, Hideaki 25
Makino, Mitsutaku 8
Makoto, Kanamori 147
Malick, Michael 17
Maloy, Carol 43
Mangel, Marc 109
Mantua, Nathan 138
Mantua, Nathan J. 139
Markel, Russell 53
Marks, Corina I. 84
Martell, Steven J.D. 111
Martin, Michael H. 99
Martone, Rebecca G. 53, 84
Masson, Diane 42, 64, 94
Masuda, Shuhei 141
Mate, Bruce 199, 202
Mathis, Jeremy T. 39
Matsuno, Kohei 119, 126

Matsuoka, Koji 148, 198, 199
Matyushenko, Larisa 208
Maughan, Thom 208
Maxwell, Sara M. 199
Mazumder, Asit 137
McAllister, Murdoch K. 111
McCann, Mike 208
McDonald, Birgitte I. 199
McFarlane, Gordon 142
McKinnell, Skip 81, 111
McLaskey, Anna 43
McMillan, Olivia 177
McQuatters-Gollop, Abigail 43
Mcubbing, Don 147
Meathrel, Catherine 201
Mecum, Bryce 12
Melnychuk, Michael C. 54
Mendelssohn, Roy 207
Merryfield, William 67
Messie, Monique 208
Michielsens, Catherine J.G. 111
Midorikawa, Takashi 45
Miller, Jessica A. 122, 130, 138
Miller, Lisa 46
Miller, Rebecca R. 54
Min, Hong Sik 164
Minami, Kenji 117
Ming, Hongxia 26
Minobe, Shoshiro 192
Mitani, Yoko 124, 199
Miura, Kazuki 25
Miwa, Takeshi 56
Miyamoto, Shigehiko 218
Miyashita, Kazushi 117, 124, 143
Mizroch, Sally 203
Mohanthy, A. 27
Moiseenko, Georgiy 178, 208
Moon, Chang-Ho 128
Moon, Cho-Rong 46
Moore, L. 217
Moore, Sue 203
Morimoto, Haruyuki 191
Morita, Yuka 117
Morozova, Tatiana V. 217
Morrison, John 64
Morse, Cheryl 207
Moury, George 72
Moyano, Marta 88
Mueter, Franz 189
Mundy, Phillip R. 12
Murakami, Hiroshi 102
Murase, Hiroto 199
Murata, Akihiko 46
Murray, Cathryn Clarke 84
Murray, Grant 52, 55

N

Na, Guangshui 33, 157
Nadtochy, Victoria 192
Nagai, Satoshi 218
Nagasawa, Toru 56
Nakada, Satoshi 129, 148
Nakagami, Masayasu 107
Nakano, Hiroki 14
Nakano, Toshiya 45
Nakaoka, Masahiro 117
Nakaoka, Shin-ichiro 74
Nakata, Kisaburo 89
Nakayama, Shouta M.M. 24
Napp, Jeffrey M. 125
Natsuike, Masafumi 119
Navrotsky, Vadim 37
Neate, Holly E. 44
Nelson, Richard 160
Nelson, R. John 119
Nemcek, Nina 117
Neville, Delvan 157, 158
Newland, Eric J. 12
Nickel, Barry 199
Nishikawa, Haruka 141
Nishimura, Osamu 25
Nishino, Shigeto 124
Nishiuchi, Kou 191
Nishizawa, Bungo 201
Nojiri, Yukihiro 74
Noro, Tadahide 160
Novikov, Roman N. 173
Nuñal, Sharon N. 160

O

O, Miriam 84
O'Hara, Todd M. 23
O'Neill, Sandra 23
O'Reilly, Tom 208
Oh, Seok Jin 214
Oh, Yuri 66
Oh, Chul-Woong 146
Ohman, Mark D. 73, 187
Ohno, Sosuke 70
Okazaki, Ryotaro 58
Oken, Kiva L. 139
Okey, Thomas A. 83
Okunishi, Takeshi 70
Okuno, Akira 168
Onishi, Hiroji 118
Ono, Hiroshi 211
Ono, Tsuneo 74, 159
Orlov, Alexei M. 173, 174
Orlova, Tatiana Yu. 217
Ortiz, Ivonne 184
Otsuki, Mayuko 124
Overland, James E. 11

P

Palacios, Daniel M. 129, 202
Pan, Minling 53
Panigrahi, S.N. 27
Parada, Carolina 189
Park, Bum Soo 218
Park, Hyun Je 70
Park, Jae-Hun 164, 165
Park, Ji A 214
Park, Taegyu 213
Park, Taewook 67, 73
Park, Young Gyu 46
Park, Young-Gyu 164, 165
Park, Youngtae 213
Parken, Chuck 137
Pätsch, Johannes 182
Patterson, Michele 55
Pavlova, Elena 37
Pearce, Christopher M. 220
Pearcy, William G. 143, 151
Peck, Myron A. 88, 182
Pelenev, Dmitry V. 174
Peña, Angelica 65, 117
Perry, Laurelyn 122
Perry, R. Ian 1, 91, 94
Peterson, Jay O. 19
Peterson, William T. 18, 19, 69, 121, 122, 190
Petrik, Colleen M. 189
Phillips, A. Jason 143, 151
Phillips, R.A. 201
Piatt, John F. 94, 197
Pinchuk, Alexei 71
Pizarro, Oscar 42
Platov, Gennady 165
Plummer, Mark L. 213
Polovina, Jeffrey 183
Pomerleau, Corinne 119
Ponomarev, Vladimir I. 166
Popkova, P.A. 217
Popov, Oleg 164
Porter, Amelia A. 175
Pörtner, Hans-O. 11, 190
Pospelova, Vera 68, 219
Prants, Sergei 159
Prins, Micha 83
Punt, Andre E. 112
Pushpadas, Dhanya 63

Q

Qi, Qing-hua 167
Qin, Yuxue 93
Qiu, Shengrao 56

R

Raatikainen, Lisa 43
Rachkov, Vladimir 192
Rahman, SM M. 75
Rajan, Kanna 208
Ramirez, Nadin 42
Ramshaw, Brock 53
Rastyagaeva, Nadezhda A. 150
Ray, Subhash 55
Rea, Lorrie D. 23
Renner, Heather 94
Renner, Martin 202
Rice, Stanley D. 155
Richar, Jonathan I. 110
Rivkin, David 156
Robert, Marie 160
Robinson, James P.W. 174
Robinson, Patrick W. 199
Roca, A. 176
Rone, Brenda 203
Rooper, Christopher N. 99
Ross, Peter 26
Ross, Peter S. 175
Rountre, Rodney A. 101
Ruedig, Elizabeth 157
Ruggerone, Gregory T. 136
Ryder, J.L. 200
Rykaczewski, Ryan R. 10, 18, 64, 76

S

Sackmann, Brandon 43
Saitoh, Sei-Ichi 129, 140, 147, 148, 176, 199
Saito, Rui 118, 126
Sakai, Mitsuo 141, 176
Sakurai, Yasunori 58
Salihoglu, Baris 63
Salomon, Anne 182
Samhouri, Jameal F. 85, 90, 91, 92
Sampson, David B. 108
Sanderson, Dan S. 82
Santora, Jarrod A. 54, 121, 123, 201
Sarkar, S.K. 27
Sarmiento, Jorge L. 181
Sasaki, Hiroko 148, 199
Sasaki, Hisao 25
Sasaki, Yuji 141
Sasano, Daisuke 45, 46
Sassa, Chiyuki 142, 145
Sastri, Akash 119
Satpathy, K.K. 27
Satterfield, Terre 51
Scherbinin, Pavel 164
Schmidt, Stephanie N. 12
Schoeman, David S. 10, 17
Schroeder, Isaac D. 18, 123
Schrum, Corinna 63
Schuttenberg, Heidi 8

Schweigert, Jake 88, 142
Sea, Seong Bong 165
Segerson, Kathleen 55
Seitoh, Masaki 176
Seito, Masaki 13, 140, 148
Selkoe, Kimberly A. 84
Sellinger, Cynthia 87
Semenova, Tatiana N. 58
Seo, Seong Bong 164
Sergeev, Aleksandr 159, 164
Sethi, Suresh A. 14
Shaffer, Scott A. 129, 199
Shannon, Lynne 85
Shan, Xiu-Juan 56, 145
Shao, Huamei 117
Shaw, C. Tracy 121, 122
Shcherbakov, Ilya A. 31
Sheer, Mindi 90
Shelton, A. Ole 90
Sherr, Barry 71
Sherr, Evelyn 71
Shevchenko, Igor 178, 208
Shevtsov, Gennadyi A. 130
Shim, JeongHee 47, 89, 178
Shim, Won Joon 25, 28, 30
Shimada, Hiroshi 126, 219
Shimizu, Shota 168
Shimizu, Yugo 70
Shimizu, Yuichi 93
Shin, Chang-Woong 165, 168
Shin, Ho-Jeong 67
Shin, Kyoungsoon 128
Shin, Yunne-Jai 85, 86
Shlyk, Natalia 159
Short, Charlie 83
Shuangquan, Wu 76
Siegel, David A. 108, 190
Signell, Richard P. 207
Sim, Boram 46
Simokon, Mikhail V. 24
Singh, Gerald G. 53, 84
Smith, Joanna 83
Smith, John N. 160
Solomin, Andrey I. 54
Son, Young Baek 68
Song, Bome 118
Song, Qingyang 166
Song, Young Kyoung 28
Sonoki, Shiori 117
Sorokin, Yury D. 71
Spear, Adam 125
Spencer, Paul D. 138, 139
Sremba, Angela L. 122
Stabeno, Phyllis J. 125
Stachura, Megan M. 139
Stahle, David W. 18
Stawitz, Christine C. 138
Steenbeek, Jeroen 181
Stepanenko, Mikhail A. 144
Stepanova, Victoriia I. 65
Stepanov, Dmitry V. 65, 175
Stock, Charles A. 64, 181
Stone, Brian 12
Stonik, I.V. 217
Stormer, David G. 137, 149, 177
Sugisaki, Hiroya 17, 69, 102, 191
Sun, Heng 39
Sun, Peng 95
Sun, Peng-Fei 145
Surma, Szymon 124
Suyama, Satoshi 107
Suzuki, Toru 45, 46
Sydeman, William J. 10, 17, 18, 64, 76, 94, 121, 123
Szuwalski, Cody S. 112

T

Tadokoro, Kazuaki 191
Takahara, Hideo 140
Takahashi, Koji 218
Takahashi, Motomistu 91
Takahashi, Motomitsu 91, 142
Takasuka, Akinori 191
Takatani, Yusuke 45, 46
Takayama, Go 140
Takeuchi, Kazuhiro 13, 159
Tamaru, Osamu 140
Tamura, Tsutomu 198
Tanaka, Kazushi 103
Tanaka, Nobuyuki 25
Tanaka, Yusuke 169
Tang, Yanli 95
Taylor, F.J. 176
Tchaplinski, Peter 147
Teel, David J. 138
Terui, Takeshi 107, 119
Teutschel, Nicole M. 199
Thapa, Madhu 174
Thompson, Sarah Ann 10, 17, 94
Thomson, Catherine A. 82
Thomson, Cindy 54
Thorsteinson, Lyman 155
Tian, Yongjun 93, 141
Tikhomirova, Evgeniya A. 175
Timothy, David 193
Ting, Yu 76
Tischchenko, Pavel 38
Tomono, Jun 218
Torgunova, Nadezhda 177
Toyoda, Takahiro 141
Trainer, Vera L. 214, 217
Trathan, Philip N. 24
Trebilco, Rowan 182
Tremblay, Yann 129
Treshcheva, Natalia 159
Trick, Charles G. 212
Trudel, Marc 13, 123, 135, 137, 147

Trusenkova, Olga 75
Tsukamoto, Youichi 142, 145
Tsygankov, Vasiliy Yu. 31, 32
Tu, Chen-Yi 141
Tucker, Strahan 123, 137
Tyler, Ellen 12
Tyupeleev, Peter A. 31

U

Ueno, Hiromichi 19, 118, 167
Ustinova, Elena I. 71
Usui, Norihisa 140, 148, 176

V

Valdes, J. Luis 8
Varlamov, Sergey 164
Vasik, Olga 208
Velez, Laure 85
Vert-Pre, Katyana A. 112
Voronin, Aleksandr 164
Vousden, David 8

W

Wade, Paul 203
Wagawa, Taku 13, 70, 103
Waite, Janice 203
Wakamatsu, Tsuyoshi 169
Wakelin, Sarah 63
Wakita, Masahide 46
Waldbusser, George 45
Walden, John 55
Wall, Carrie C. 101
Wallace, Colin 123
Walters, Carl J. 111, 181
Wang, Guizhi 38
Wang, Hongjie 38
Wang, Hui 41
Wang, Jun 56
Wang, Muyin 11
Wang, Pengbin 218
Wang, Yunzhong 56
Wang, Zhen 33
Wang, Zongling 90
Watanabe, Eiji 19
Watanabe, Tatsuro 168
Watanabe, Toshihiro 140
Watanuki, Yutaka 24, 201
Watson, James R. 181
Weise, Michael J. 199
Welch, D.W. 200
Wells, Brian K. 123
West, James 23
White, J. Wilson 107
Whitney, Frank A. 74, 193
Wiener, Allison R. 18, 76
Wilcox, Kyle 207
Wilkins, Mark E. 99
Williams, Bill 160
Williams, Dee 156
Williams, Greg D. 85, 90
Williams, Ivor D. 174
Williams, William J. 119
Wilson, Cara 207
Wilson, Lorna 136
Winans, Amanda 43
Woodworth-Jefcoats, Phoebe 183
Wu, Men 158
Wu, Qiang 145

X

Xia, Tao 51

Y

Yagi, Hiroshi 159
Yamaguchi, Atsushi 118, 119, 126
Yamaguchi, Hisashi 102
Yamamoto, Takashi 24, 201
Yamane, Lauren 107
Yamanome, Takeshi 103
Yamashita, Ai 24
Yang, E.J. 122
Yang, HanSoeb 214
Yao, Ziwei 33, 157
Yarosh, Nadezhda V. 135
Yasuda, Ichiro 118
Yasunaka, Sayaka 74
Ye, Guanqiong 95
Yi, Woo Yul 118
Yin, Rui 44
Ylitalo, Gina 23
Yongjiu, Xu 102
Yoo, Sinjae 66, 68
Yoon, Jong-Hwan 164, 166
Yoon, Joo-Eun 68
Yoon, Seokjin 19, 56, 107, 129
Yoon, Seung-Tae 164
Yoshida, Takafumi 211
Yoshida, Tooru 13
Yoshikawa, Takeshi 160
Yoshiki, Tomoko M. 69, 102
Yotsukura, Norishige 117
Young, Oran 8
Yu, Huaming 166
Yu, Shwu-Feng 127
Yu, Tao 158
Yu, Wen 158
Yu, Yang 95

Z

Zador, Stephani 87
Zavolokin, Alexander V. 127
Zeno, Ramona L. 121
Zerbini, Alexandre 203
Zhan, Liyang 40
Zhang, Jiexia 40
Zhang, Jinlun 71
Zhang, Jun-pen 163
Zhang, Wanru 33
Zhang, Xun 148
Zhang, Yusheng 158
Zhao, Fenfang 95
Zhao, Zhenliang 56
Zhigang, Gao 76
Zhu, Mingyuan 90, 91, 217
Zhu, Xiao-Hua 173
Zondervan, Ruben 8
Zuenko, Yury 192
Zuev, Mikhail A. 130, 144