2nd International Symposium

Effects of Climate Change on the World's Oceans

May 13 – 20, 2012
Yeosu, Korea

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Abstracts for oral presentations are sorted first by date 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.

Welcome

We are honored to welcome you to the Second International Symposium on "*Effects of Climate Change on the World's Oceans*" that intends to become a major and regular event for the oceanography and climate change scientific communities. In May 2008, we met in Gijón (Spain), and this time the Symposium takes place in Yeosu, Korea where the International Exposition Yeosu Korea 2012 on the Living Ocean and Coast (Expo-2012) is being held. No other venue could be more appropriate.

Expo-2012 is calling for good practices in a sustainable ocean and coasts, and this reminds us that good practices and greening the economy must be scientifically and politically driven. In fact, the debate on climate change relies heavily on science, and this science has to be adequately transmitted to policy makers. While the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (2007) lacked specificity on the impacts of climate change on ocean ecosystems, the emerging Fifth Assessment Report (2014) will have two chapters dedicated to marine ecosystems. This is a great opportunity for researchers, but put an immense responsibility on them, and requires impartial, objective and excellent science. The issues related to climate change are moving up the political agenda, but we are still far from achieving a global commitment to reduce the emissions of greenhouse gases. The debate on climate change needs input from science as one of the essential elements, and symposia like this one are crucial to consolidate and share our understanding and knowledge.

This symposium aims to review recent achievements in climate change research in ocean and marine ecosystems, and to identify future requirements and steps. Our speakers include key players in different facets of this large and complex issue, and they represent views from academia to policy covering a variety of temporal and spatial scales and geographical locations.

We would like to thank the Secretariats of the convening organizations PICES, IOC and ICES, and especially the Local Organizing Committee for their efforts that ranged from trivial preparations to fundraising for this event. They have worked hard to ensure that all arrangements for the large number of theme sessions and workshops will run smoothly at the Symposium, This Symposium gathers together more than 350 participants from approximately 40 countries, and confirms the breadth, richness and vitality of scientific interests of the Asian community which is represented by about 150 experts.

We want to thank all the institutions for the trust they placed in us when we asked for support for this symposium. Without their commitment and decisive support, our aims would have been impossible to achieve. Our sincere thanks and congratulations must also go to the Scientific Steering Committee for their work in mobilizing a wide representation of scientific teams attending the meeting.

Not only will this Symposium give us an opportunity to discuss our ongoing research, progress and plans, it will also give us a chance to deliberate on the institutional challenges that we face in our various responsibilities and capacities. We are sure that all of you will have a scientifically productive meeting and that you will also enjoy the Expo and the social events, sights, foods, and hospitality of Korea.

Luis Valdés, Alexander Bychkov, Adolf Kellermann, Suam Kim, Hiroaki Saito and Svein Sundby
Symposium convenors and coordinators

Symposium Organizers

Symposium Convenors

Suam Kim (Local Convenor)
Pukyong National University, Republic of Korea)

Hiroaki Saito (PICES)
Fisheries Research Agency, Japan)

Svein Sundby (ICES)
Institute of Marine Research, Norway)

Luis Valdés (IOC-UNESCO)
IOC Ocean Science Section, United Nations

Symposium Coordinators

Alexander Bychkov (PICES)
Adolf Kellermann (ICES)
Luis Valdés (IOC-UNESCO)

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Korea Ocean Research and Development Institute

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Ilana Wainer
University of Sao Paulo, Brazil

Sinjae Yoo (IMBER)
Korea Ocean Research and Development Institute, Korea

Primary International Sponsors

ICES
International Council for the Exploration of the Sea

IOC
Intergovernmental Oceanographic Commission of UNESCO

PICES
North Pacific Marine Science Organization

Symposium Local Organizers

KOC
Korea Oceanographic Commission

KORDI
Korea Ocean Research and Development Institute

Co-sponsoring Organizations

Expo-2012 Yeosu Korea

MLTM
Ministry of Land, Transport and Maritime Affairs

Fisheries and Oceans Canada

EAST-1
Korean East Asian Seas Time Series Research Project

FAO
Food and Agriculture Organization of the United Nations

GOOS
Global Ocean Observing System

IMAS
Institute for Marine and Antarctic Studies, Australia

IMBER
Integrated Marine Biogeochemical Ecosystem Research

IPHC
International Pacific Halibut Commission

KMA
Korea Meteorological Administration

NASA
National Aeronautics and Space Administration

NFRDI
National Fisheries Research and Development Institute, Korea

NOAA
U.S. National Oceanographic and Atmospheric Administration

NPAFC
North Pacific Anadromous Fish Commission

NPRB
North Pacific Research Board

Seoul National University OCCAPA (Ocean Climate Change: Analysis, Projection, Adaptation) project

PKNU
Pukyong National University

PNU
Pusan National University

SCOR
Scientific Committee on Oceanic Research

UNEP
United Nations Environment Programme

WCRP
World Climate Research Programme

Yeosu City

Notes for Guidance

Registration

The registration desk will be located at the Expo Promotion Center (p. XVII) from May 12 (p.m.) to May 20.

Location for the Sessions and Workshops

All sessions and workshops will be convened at the Expo Hall (#13, p. XVI). The Theater (p. XIV) will be used for opening and closing ceremonies and for all plenary sessions. The Conference Rooms C1, C2, B1 and B2 (pp. XIV-XV) will be used for parallel sessions/workshops.

W2 (May 13 only) will be held at the Notos Room of the MVL Hotel (#25, p. XVII).

Presentations

In order to allow the sessions to run smoothly, and in fairness to other speakers, all presentations are expected to adhere strictly to the time allocated. All authors should designate at least 3 minutes for questions.

Authors can download their presentations straight to the computers where the session/workshop will be held.

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

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

Posters

Posters will be on display in the Conference Rooms C3 and C4 (p. XIV) during the entire Symposium, from May 14-20. Two evening poster sessions (with appetizers and drinks) will be held from 18:30-20:30 on May 16 and May 17, when poster presenters are expected to be available to answer questions.

Social activities

All participants are invited to attend the Welcome Reception to be held from 18:30-21:00, on May 15, in the Ballroom of the Korea Pavilion (#5, p. XVI), and the Symposium Dinner to be held from 19:00-22:00, on May 18, in the Ballroom of the MVL Hotel (#25, p. XVII).

For the Convention Center floor maps and building locations please refer to pp. XIV-XVII.

Symposium Timetable

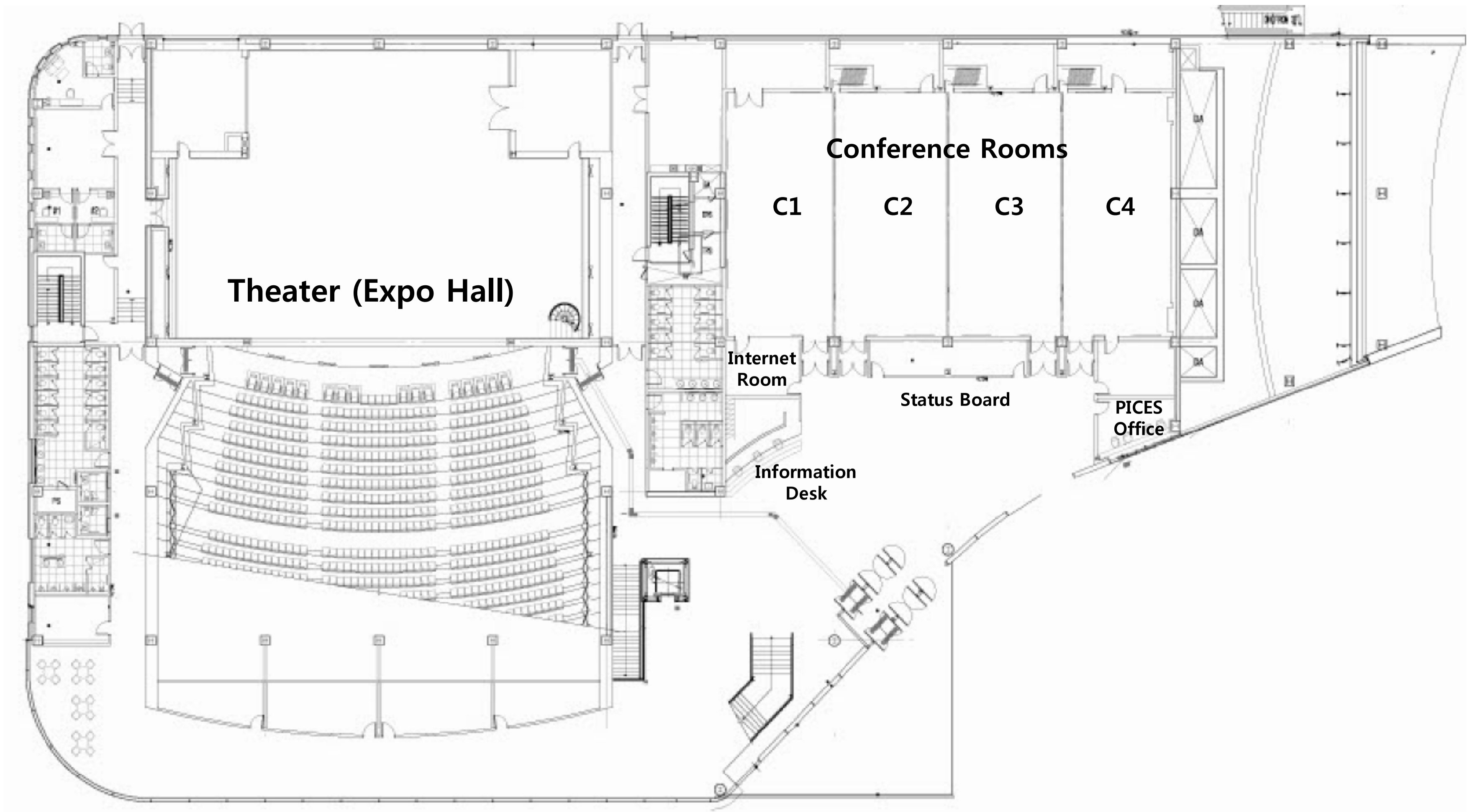
Sunday, May 13				
09:00 17:30	W2 Workshop (day 1)			
Monday, May 14				
09:00	W2 Workshop (day 2)	W3 Workshop	W4 Workshop	W5 Workshop
12:30	Lunch			
14:00	W2 Workshop	W3 Workshop	W4 Workshop	
Tuesday, May 15				
10:00	**Opening Ceremony**			
10:45	**Day 1 Plenary Session** Kenneth Drinkwater (S1) Ann Bucklin (S5) Núria Marbà (S7)			
12:30	Lunch			
14:00 18:00	Session 1 (day 1)	Session 5	Session 7	
18:30 21:00	**Welcome Reception**			
Wednesday, May 16				
09:00 10:40	**Day 2 Plenary Session** Anthony Charles (General Plenary) Manuel Barange (S4) Pedro Monteiro (S2)			
11:00	Session 1 (day 2)	Session 4 (day 1)	Session 2	
12:30	Lunch			
14:00	Session 1	Session 4	Session 2	
18:30 20:30	**Poster Session / Reception**			
Thursday, May 17				
09:00 10:40	**Day 3 Plenary Session** Peter Brewer (General Plenary) Lothar Stramma (S8) Takafumi Hirata (S3)			
11:00	Session 3 (day 1)	Session 4 (day 2)	Session 8	
12:30	Lunch			
14:00	Session 3	Session 4	Session 8	
18:30 20:30	**Poster Session / Reception**			
Friday, May 18				
09:00 10:40	**Day 4 Plenary Session** Ichiro Yasuda (General Plenary) Kyung-Ryul Kim (General Plenary) Jeffrey Dambacher (S9)			
11:00	Session 3 (day 2)	Session 4 (day 3)	Session 9	
13:00	Free afternoon / Sightseeing	(14:00-18:00) CCME Meeting	(14:00-18:00) Workshop 1	
19:00 22:00	**Symposium Dinner**			

<table>
<tr><th colspan="4">Saturday, May 19</th></tr>
<tr><td>09:00
10:40</td><td colspan="3">Day 5 Plenary Session
Peter Lemke (General Plenary)
Hugh Possingham (S6)
Benjamin McNeil (S10)</td></tr>
<tr><td>11:00</td><td>Session 10</td><td>Session 4 (day 4)</td><td>Session 6</td></tr>
<tr><td>13:00</td><td colspan="3">Lunch</td></tr>
<tr><td>14:30</td><td colspan="3">Closing Plenary Session
Keith Alverson and Martin Visbeck (General Plenary)
Corinne Le Quere (summary)</td></tr>
<tr><td>15:40
16:30</td><td colspan="3">Closing Ceremony</td></tr>
<tr><th colspan="4">Sunday, May 20</th></tr>
<tr><td>09:30</td><td>Workshop 6</td><td colspan="2">Workshop 7</td></tr>
<tr><td>12:30</td><td colspan="3">Lunch</td></tr>
<tr><td>14:00
17:30</td><td>Workshop 6</td><td colspan="2">Workshop 7</td></tr>
</table>

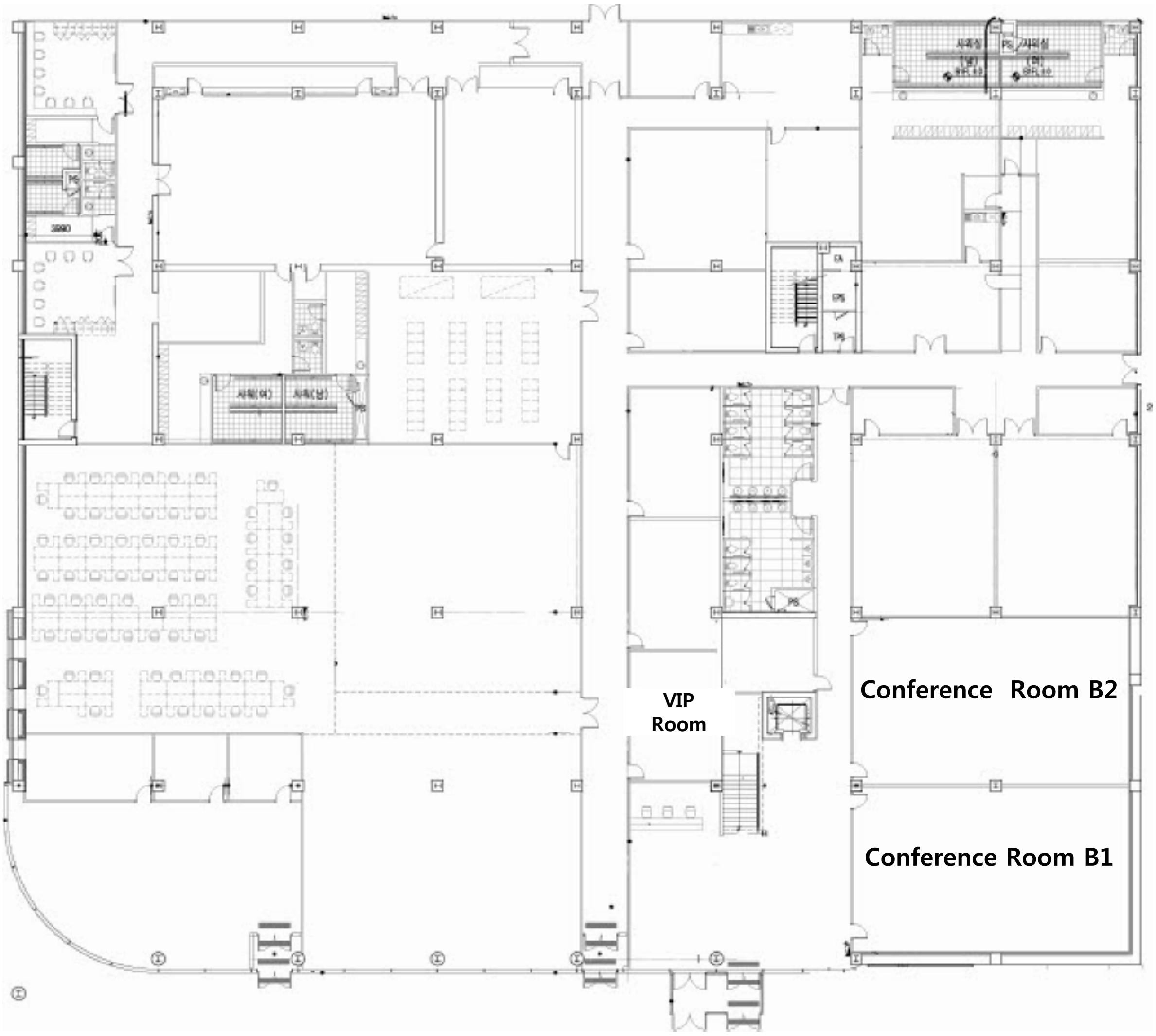
List of Sessions and Workshops

S1	Climate variability versus anthropogenic impacts; analysing their separate and combined effects on long-term physical, biogeochemical and ecological patterns
S2	Systematic, sustained and integrated global ocean observations
S3	Projections of climate change impacts on marine ecosystems and their uncertainty
S4	Climate change effects on living marine resources: From physics to fish, marine mammals, and seabirds, to fishermen and fishery-dependent communities
S5	From genes to ecosystems: Genetic and physiological responses to climate change
S6	Marine spatial planning and risk management in the context of climate change: The living ocean and coast under changing climate
S7	Coastal and low-lying areas
S8	Trend and impacts of de-oxygenation in oceanic and coastal ecosystems
S9	Marine tipping points in the earth system
S10	Changes in the marine carbon cycle
W1	Ocean observation: Strategic framework
W2	Climate change projections for marine ecosystems: Best practice, limitations and interpretation
W3	Coastal Blue Carbon: Mitigation opportunities and vulnerability to change
W4	Effects of climate change on advective fluxes in high latitude regions
W5	Public perception of climate change
W6	Climate change and range shifts in the ocean: Detection, prediction and adaptation
W7	Beyond dispersion: integrating individual-based models for bioenergetics and behavior with biophysical transport models to predict influences of climate change on recruitment processes in marine species
GP	General Poster Session
CCME	Joint ICES/PICES Expert Group on Climate Change Effects on Marine Ecosystems

First Floor of the Expo Hall



Basement of the Expo Hall



EXPO SITE

EXPO 2012
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Yeosu Expo Station
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Yeony Bridge
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Press Center
Shuttle Bus Stop
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Disabled Parking

The Big-O

Expo Digital Gallery(EDG)

Theme Pavilion

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Marine Forest
MVL Hotel
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Suny Bridge
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Promotion Center
Tour Bus Stop
A
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Airport Limousine Bus Stop
1 The Big-O
2 Expo Digital Gallery (EDG)
3 Sky Tower
4 Theme Pavilion
5 Korea Pavilion
6 Marine Life Pavilion (Aquarium)
7 Climate & Environment Pavilion
8 Marine Civilization & City Pavilion
9 Marine Industry & Technology Pavilion
10 International Pavilion
11 Local Governments Pavilion
12 International Organizations Pavilion, BIE Pavilion, Korea Shipping & Ports Pavilion, DSME Marine Robot Pavilion
13 Expo Hall (Convention Center)
14 Expo Plaza
15 Hyundai Motor Group Pavilion
16 SAMSUNG Pavilion
17 SK Telecom Pavilion
18 LG Pavilion
19 GS Caltex Energy Field
20 LOTTE Pavilion
21 POSCO Pavilion
22 Energy Park
23 Fisheries Experience Zone (Coastal)
23-1 Fisheries Experience Zone (Deep Sea)
24 Ferry / Cruise Terminal
25 Yeosu MVL Hotel
26 Expo Town
M Main Gate
A Gate 1 (Odong-do Is.)
B Gate 2 (Cruise Terminal)
C Gate 3 (KTX Station)
D Gate 4 (Expo Town)
V VIP Gate
P Promotion Center

Korea Pavilion

Sky Tower

Schedules
Oral Presentations

Sunday, May 13 - W2

Workshop 2 (W2) - Day 1

Climate change projections for marine ecosystems: Best practice, limitations and interpretations

Co-Convenors:
Enrique Curchitser (Rutgers University, USA)
Icarus Allen (Plymouth Marine Laboratory, UK)

Invited Speakers:
William Cheung (Fisheries Centre, UBC, Canada)
Villy Christensen (University of British Columbia, Canada)
Jason Holt (National Oceanographic Centre, UK)
Charles Stock (Geophysical Fluid Dynamics Laboratory, USA)

This 2-day workshop aims to assemble scientists interested in making and interpreting projections of ecosystem responses to future climate change. The goal is to describe different approaches to modeling the impacts of climate variability on marine ecosystems, their ability to support sustainable harvesting and to highlight the strengths and limitations of the different approaches. We seek models that address both global and regional ecosystems and are particularly interested in presentations covering a range of models from statistical to mechanistic approaches including mass-balance (ECOPATH), size-based, minimalist, individual-based (IBMs) and end-to-end (E2E) models. Emphasis will be placed on models that examine trophic interactions as well as approaches that link biogeochemical processes with higher trophic level production. Presentations that discuss advantages and limitations of particular approaches and discuss the quantification of uncertainty in climate forced simulations are encouraged.

Sunday, May 13, Day 1 (9:00-17:00)

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

09:10 **Villy Christensen**
Nereus: Predicting the Future Ocean (W2-7989), Invited

09:50 **Jason Holt, James Harle, Sarah Wakelin, Momme Butenschön, Yuri Artioli, Icarus Allen, Jason Lowe and Jonathan Tinker**
Exploring the drivers of climate change impacts on shelf and coastal marine ecosystems: Consequences for downscaling experiment design (W2-8126), Invited

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

11:00 **Charles A. Stock, Michael A. Alexander, Nicholas A. Bond, Keith Brander, William W.L. Cheung, Enrique N. Curchitser, Thomas L. Delworth, John P. Dunne, Stephen M. Griffies, Melissa A. Haltuch, Jonathan A. Hare, Anne B. Hollowed, Patrick Lehodey, Simon A. Levin, Jason S. Link, Kenneth A. Rose, Ryan R. Rykaczewski, Jorge L. Sarmiento, Ronald J. Stouffer, Franklin B. Schwing, Gabriel A. Vecchi and Francisco E. Werner**
On the use of IPCC-class models to assess the impact of climate on living marine resources (W2-8141), Invited

11:40 **William W.L. Cheung, Jose Fernandes, Thomas L. Frölicher, Jorge L. Sarmiento, U. Rashid Sumaila and Daniel P. Pauly**
Modelling large scale effects of global change on marine ecosystems and fisheries (W2-8243), Invited

12:20 ***Lunch***

14:00 **Corinna Schrum, Bjørn Ådlandsvik, Richard Bellerby, Ute Daewel, Trond Kristensen and Dhanya Pushpadas**
Dynamic downscaling to marine ecosystems (W2-8293)

14:30 **Fei Chai, Yi Xu, Kenneth A. Rose and Francisco P. Chavez**
Modeling Peru upwelling ecosystem dynamics: From physics to anchovy (W2-8046)

15:00 **Enrique N. Curchitser, Kenneth A. Rose, Kate Hedstrom, Jerome Fiechter, Miguel Bernal, Shin-ichi Ito, Alan Haynie and Francisco E. Werner**
Development of a climate-to-fish-to-fishers model: Implementation in the Eastern Pacific sardine and anchovy system (W2-8315)

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

16:00 Discussion

17:00 Workshop Ends

Monday, May 14 - W2

Workshop 2 (W2) - Day 2

Climate change projections for marine ecosystems: Best practice, limitations and interpretations

Co-Convenors:
Enrique Curchitser (Rutgers University, USA)
Icarus Allen (Plymouth Marine Laboratory, UK)

Invited Speakers:
William Cheung (Fisheries Centre, UBC, Canada)
Villy Christensen (University of British Columbia, Canada)
Jason Holt (National Oceanographic Centre, UK)
Charles Stock (Geophysical Fluid Dynamics Laboratory, USA)

This 2-day workshop aims to assemble scientists interested in making and interpreting projections of ecosystem responses to future climate change. The goal is to describe different approaches to modeling the impacts of climate variability on marine ecosystems, their ability to support sustainable harvesting and to highlight the strengths and limitations of the different approaches. We seek models that address both global and regional ecosystems and are particularly interested in presentations covering a range of models from statistical to mechanistic approaches including mass-balance (ECOPATH), size-based, minimalist, individual-based (IBMs) and end-to-end (E2E) models. Emphasis will be placed on models that examine trophic interactions as well as approaches that link biogeochemical processes with higher trophic level production. Presentations that discuss advantages and limitations of particular approaches and discuss the quantification of uncertainty in climate forced simulations are encouraged.

Monday, May 14, Day 2 (9:00-17:30)

09:00	Discussion
10:30	***Coffee/Tea Break***
11:00	Discussion
12:30	***Lunch***
14:00	Discussion
15:30	***Coffee/Tea Break***
16:00	Discussion
17:30	Workshop Ends

Monday, May 14 - W3

Workshop 3 (W3)

Coastal Blue Carbon: Mitigation opportunities and vulnerability to change

Co-Convenors:
Ik Kyo Chung (PNU, Korea)
Gabriel Grimsditch (UNEP)
Jerker Tamelander (UNEP)

Invited Speaker:
Núria Marbà (Mediterranean Institute for Advanced Studies, CSIC-UIB, Spain)

Blue Carbon is a relatively recent concept in finding nature-based solutions to climate change. It recognizes the role that coastal ecosystems can play in climate change mitigation as well as adaptation, as these ecosystems (in particular mangroves, intertidal marshes, seaweed beds and seagrass beds) hold vast CO_2 reservoirs. In fact, the rates of carbon sequestration and storage in coastal ecosystems are comparable to and often higher than those rates in carbon-rich terrestrial ecosystems such as tropical rainforests or peatlands. Given the recent heightened interest in coastal Blue Carbon, the science surrounding the concept is advancing rapidly; especially concerning our understanding of how coastal ecosystems sequester and store carbon, where the 'hotspots' for coastal Blue Carbon are, how rapidly the ecosystems are being lost or modified because of anthropogenic disturbances and climatic changes, and the releases of carbon that follow ecosystem loss of modification. Although our understanding of these crucial questions is improving, there are still large gaps in our knowledge and our scientific understanding of these processes and how to manage them.

The objectives of this 1-day workshop are to: a) synthesize the current status of scientific knowledge of the role that coastal ecosystems play in climate change mitigation, and to identify how this knowledge can support management strategies and policy decisions; b) identify the major gaps in knowledge concerning coastal Blue Carbon that still need to be addressed; c) analyze the major threats to coastal Blue Carbon and how different damaging anthropogenic practices as well as climate change are responsible for causing greenhouse gas emissions from these ecosystems, as well as eroding the various ecosystem services provided; d) provide Blue Carbon science-based policy recommendations for the management of coastal carbon sinks; e) raise awareness of successful coastal Blue Carbon case studies around the world; and f) explore possibilities for Blue Carbon policy, science and pilot projects in the region of East Asia and set out a plan of action for Blue Carbon in the region of East Asia.

The outcomes of the workshop are expected to be: (1) a white paper/workshop report, providing a synthesis of current status of scientific knowledge on coastal Blue Carbon, identification of major gaps in knowledge, successful Blue Carbon case studies, and management strategies that protect and enhance these carbon stocks, including an analysis of threats and damaging activities to coastal Blue Carbon and how they are responsible for greenhouse gas emissions; and (2) a plan of action for Blue Carbon in the region of East Asia, outlining research needs, policy gaps and possible pilot projects.

Monday, May 14 (9:00-17:30)

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

09:10 **Carlos M. Duarte and Núria <u>Marbà</u>**
Vegetated coastal habitats as intense carbon sinks: Understanding and using Blue Carbon strategies (W3-8052), Invited

09:50 **Gabriel <u>Grimsditch</u>**
The UNEP Blue Carbon Initiative (W3-8311)

10:10 **Stephen <u>Crooks</u>**
Predicting the response of coastal marshes and mangroves to sea level rise and human impacts: State of science and information needs (W3-8316)

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

11:00 **Gail L. <u>Chmura</u> and Dante Torio**
Assessing the permanence of Blue Carbon sinks with rising sea levels (W3-8318)

11:20 **Gabriel Grimsditch, Gordon <u>Ajonina</u> and James Kairo**
Mangroves and carbon in West and Central Africa (W3-8320)

11:40 **Guanghui (George) <u>Lin</u>, Hui Chen, Weizhi Lu, Shengchang Yang, Hao Wu, Q. Li and Dai Jia**
Effects of tidal regimes, mariculture and restoration on carbon pools and fluxes in subtropical mangrove ecosystems of China: Implications for blue carbon managements (W3-8322)

12:00 **Ik Kyo <u>Chung</u>, Jung Hyun Oak, Kwang Seok Park, Jong Ahm Shin, Jong Gyu Kim and Jin Ae Lee**
Kelp forest/seaweed bed as mitigation and adaptation measure: Korean project overview (W3-8160)

12:20 Questions

12:30 ***Lunch***

14:00 Round Table Panel Discussion

15:00 Open Discussion

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

16:00 Open Discussion

17:30 Workshop Ends

Monday, May 14 - W4

Workshop 4 (W4)

Effects of climate change on advective fluxes in high latitude regions

Co-Convenors:
Ken Drinkwater (Institute of marine Research, Norway)
George Hunt (University of Washington, USA)
Eugene Murphy (British Antarctic Survey, UK)
Jinping Zhao (Ocean University of China, PR China)

This 1-day workshop, sponsored by ESSAS (Ecosystem Studies of Subarctic Seas) and ICED (Integrating Climate and Ecosystem Dynamics in the Southern Ocean), will briefly review the advection of water masses within and between polar and sub-polar regions and their driving mechanisms. It will also review the role of advection on the ecology of these high latitude regions, including heat and nutrient fluxes as well as the advection of flora and fauna. The major objective of the workshop, however, is to develop likely scenarios of these advective fluxes under climate change. Comparative studies of the responses in the Arctic and Antarctic regions are also of interest. To achieve these objectives we plan to bring together atmospheric scientists, climatologists, biogeochemists, physical and biological oceanographers, ecologists, and fisheries scientists who will use a combination of conceptual, statistical and numerical models studies. The workshop will also receive input from the ESSAS-sponsored Theme Session on "Arctic-Subarctic Interaction" to be held at the Ocean Sciences Meeting in Salt Lake City in February 2012 and the ICED Sentinel meeting on "Southern Ocean Ecosystem Change and Future Projections" to be held in Hobart in early May 2012. The workshop consists of a few focused invited talks with significant discussion time to address the main topic, the expected future high latitude circulation patterns and their ecological effects.

The primary outcomes of the workshop aim to be: (1) a paper on the future physical, chemical and biological fluxes in high latitude regions under climate change; (2) identification of the gaps in our knowledge about these advective processes and development of recommendations for future research to address these gaps; and (3) discussions on the formation of a Working Group under IMBER (Integrated Marine Biogeochemistry and Ecosystem Research) to compare the structure and function of sub-polar and polar ecosystems for the Arctic and Antarctic.

Monday, May 14 (9:00-17:30)

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

09:10 **Kenneth F. Drinkwater, George Hunt Jr., Eugene Murphy and Jinping Zhao**
Climate change and its impacts: Comparisons between the polar and subpolar regions of the Arctic and Antarctic (W4-8119-a)

09:30 **Eileen E. Hofmann, Kenneth F. Drinkwater, George Hunt Jr., Eugene Murphy and Jinping Zhao**
Climate change and its impacts: Comparisons between the polar and subpolar regions of the Arctic and Antarctic (W4-8119-b)

09:50 **Kenneth F. Drinkwater, George Hunt Jr., Eugene Murphy and Jinping Zhao**
Climate change and its impacts: Comparisons between the polar and subpolar regions of the Arctic and Antarctic (W4-8119-c)

10:10 **Kenneth F. Drinkwater, George Hunt Jr., Eugene Murphy and Jinping Zhao**
Climate change and its impacts: Comparisons between the polar and subpolar regions of the Arctic and Antarctic (W4-8119-d)

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

11:00 **Eileen E. Hofmann, Kenneth F. Drinkwater, George Hunt Jr., Eugene Murphy and Jinping Zhao**
Climate change and its impacts: Comparisons between the polar and subpolar regions of the Arctic and Antarctic (W4-8119-e)

11:20 **Sei-Ichi Saitoh, Kenneth F. Drinkwater, George Hunt Jr., Eugene Murphy and Jinping Zhao**
Climate change and its impacts: Comparisons between the polar and subpolar regions of the Arctic and Antarctic (W4-8119-f)

Toru Hirawake, Katsuhito Shinmyo, Shintaro Takao, Amane Fujiwara and Sei-Ichi Saitoh
Interannual changes in primary productivity and sea surface temperature in the polar oceans (W4-8248)

11:55 **Carin Ashjian, Kenneth F. Drinkwater, George Hunt Jr., Eugene Murphy and Jinping Zhao**
Climate change and its impacts: Comparisons between the polar and subpolar regions of the Arctic and Antarctic (W4-8119-g)

Rosamma Stephen, P. Jasmine and N.V. Madhu
Copepods in Austral summer in Sub-Antarctic region of western Indian Ocean: A synthesis of 1964 and 2004 observations (W4-8146)

12:30 ***Lunch***

13:30 **Kenneth F. Drinkwater, George Hunt Jr., Eugene Murphy and Jinping Zhao**
Climate change and its impacts: Comparisons between the polar and subpolar regions of the Arctic and Antarctic (W4-8119-h)

13:50 **William Cheung, Kenneth F. Drinkwater, George Hunt Jr., Eugene Murphy and Jinping Zhao**
Climate change and its impacts: Comparisons between the polar and subpolar regions of the Arctic and Antarctic (W4-8119-i)

14:10 **Kenneth F. Drinkwater, George Hunt Jr., Eugene Murphy and Jinping Zhao**
Climate change and its impacts: Comparisons between the polar and subpolar regions of the Arctic and Antarctic (W4-8119-j)

14:30 **Nina Karnovsky, Kenneth F. Drinkwater, George Hunt Jr., Eugene Murphy and Jinping Zhao**
Climate change and its impacts: Comparisons between the polar and subpolar regions of the Arctic and Antarctic (W4-8119-k)

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

15:50 **Carin Ashjian, Eugene Murphy, Kenneth F. Drinkwater, George Hunt Jr., Eugene Murphy and Jinping Zhao**
Climate change and its impacts: Comparisons between the polar and subpolar regions of the Arctic and Antarctic (W4-8119-i)

16:30 Discussion

17:30 Workshop Ends

Monday, May 14 - W5

Workshop 5 (W5)

Public perception of climate change

Co-Convenors:
Dohoon Kim (National Fisheries Research & Development Institute, Korea)
Katja Philippart (Royal NIOZ, The Netherlands)

Invited Speakers:
Paul Buckley (Centre for Environment, Fisheries and Aquaculture Science (CEFAS), UK)
Mitsutaku Makino (Fisheries Research Agency, Japan)

Despite extensive research programs including considerable outreach efforts focusing specifically on climate change in the marine environment, very little of this research has reached public consciousness, and the level of public awareness of such issues is still relatively low. The reasons for this limited uptake are unclear, and in particular it is not known whether the lack of public awareness is primarily a consequence of limited media attention in marine science or climate change issues, whether it reflects limited efforts by the research community (or funding agencies) to communicate or publicize their results, or whether it reflects a general lack of understanding among the public of scientific and technical issues.

During this 0.5-day workshop, we will explore the effectiveness of different approaches for promoting the climate change messages to a wider audience. We will discuss trends and developments in the scope of outreach activities, for example the recent inclusion of social networking websites (*e.g.*, Facebook and Twitter), among the arsenal of tools used by research projects. Most importantly, we will address the ways in which scientific information on the effects of climate change on the world's oceans could be presented in such a way as to create engagement, in addition to merely to increase public knowledge.

The outcome of the workshop is expected to be a compilation of recommendations with regard to outreach programs and communicating with the public, stakeholders and policy makers, ranging from suggestions of particular tools and techniques that have proven useful or effective elsewhere, to recommendations regarding project strategy, planning and cost-effectiveness (taking into account the regional variation in possibilities and limitations of outreach). Based on the outcomes of the workshop, we will submit a joint manuscript to the special issue of the ICES Journal of Marine Science.

Monday, May 14 (9:00-12:30)

09:00	***Introduction by Convenors***
09:10	**Paul J. Buckley and John K. Pinnegar** Outcomes of the first pan-European poll on public perception of marine climate change impacts (W5-8138), Invited
09:40	**Tae-Goun Kim and Daniel R. Petrolia** Public perceptions of wetland restoration benefits in Louisiana (W5-8064)
10:10	***Coffee/Tea Break***
10:40	**Mitsutaku Makino** Outreach and adaptation strategy for climate change; Japanese examples (W5-8181), Invited
11:10	Round table discussion on effectiveness of different approaches for promoting the climate change messages to a wider audience

12:10 Wrap up by Convenors:

- First compilation of recommendations
- Road book for joint publication

12:30 Workshop Ends

Tuesday, May 15 - Plenary

Plenary Session

10:00	Opening Ceremony
10:45	**Kenneth F. Drinkwater** Ecosystem responses to climate variability and anthropogenic-induced changes (S1 Plenary-8118)
11:20	**Ann Bucklin, Ebru Unal and Paola G. Batta-Lona** From transcriptomes to bugs: Using 'omics to understand climate responses of marine zooplankton (S5 Plenary-7988)
11:55	**Carlos M. Duarte and Núria Marbà** The potential of coastal ecosystems to help mitigate climate change impacts (S7 Plenary-8004)
12:30	Plenary Session Ends

Tuesday, May 15 - S1

Session 1 (S1), Day 1

Climate variability versus anthropogenic impacts; analysing their separate and combined effects on long-term physical, biogeochemical and ecological patterns

Co-Convenors:
Sanae Chiba (JAMSTEC, Japan)
Nicholas A. Bond (JISAO, University of Washington, USA)

Invited Speakers:
Nathan Bindoff (University of Tasmania, Australia)
Shin-ichi Uye (Hiroshima University, Japan)

There is a strong scientific consensus that human-induced global warming is occurring, with this signal having been detected even into the deep ocean. The effects of climate change are not restricted to just temperature, but also have been observed in water properties such as pH and oxygen concentrations. The world's oceans will continue to be influenced by natural variability over a range of temporal and spatial scales, which can obscure anthropogenic effects. The confounding effects of intrinsic fluctuations in the physical forcing can be especially challenging to sort out for marine ecosystems, due to the complexity of the interactions controlling the biogeochemistry of the ocean. But that challenge needs to be met in order to be able to predict probable shifts and trends in the structure and function of marine ecosystems, and to carry out effective mitigation. This session consists of papers on topics related to disentangling natural variability from anthropogenic climate change with respect to marine ecosystems. We expect papers featuring a variety of approaches, and lively discussions of their relative merits and limitations.

Tuesday, May 15, Day 1 (14:00-18:05)

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

14:05 **Shin-ichi Uye**
Jellyfish blooms as consequences of human perturbed environment and ecosystems (S1-7975), Invited

14:35 **Sanae Chiba, Tomoko Yoshiki, Kosei Sasaoka, Hiroya Sugisaki, Tsuneo Ono and Sonia Batten**
Lower trophic level linkage and cool-warm cycle based on the North Pacific CPR survey 2001-2009: An implication for the future warming ocean (S1-8225)

14:55 **Antonio Bode, M. Teresa Álvarez-Ossorio, A. Miranda and Manuel Ruiz-Villarreal**
Shifts between gelatinous and crustacean plankton in a coastal upwelling region (S1-7963)

15:15 **Ting-Chun Kuo, Janet Nye, Franz J. Mueter, Nicholas K. Dulvy and Chih-hao Hsieh**
Environmental sensitivity of latitudinal shifts in marine fishes depends on latitude and fishing effects (S1-7982)

15:35 **Dave Checkley, Julie Jones, Shoshiro Minobe, Yoshioki Oozeki, Ryan R. Rykaczewski, Carl D. van der Lingen, Nadine Moroff and Anja Kreiner**
Long-term fluctuations of sardine populations in relation to dominant modes of high-latitude climate variability (S1-8254)

15:55 ***Coffee/Tea Break***

16:20	**Roksana Jahan and Joong Ki Choi** Estuarine phytoplankton responses to climate change: Gyeonggi Bay long-term surveys (S1-7970)
16:40	**Christian Möllmann, Justus van Beusekom, Rabea Diekmann, Jens Floeter and Axel Temming** Climate and anthropogenic effects on structure and functioning of the North Sea ecosystem (S1-8145)
17:00	**Stefano Ciavatta, Claudia Halsband-Lenk, Claire Widdicombe, Steve Coombs, Davis Sims and Tim Smyth** Impact of climate events on trophic dynamics in coastal ecosystems (S1-8142)
17:20	**Jonne Kotta, Velda Lauringson and Arno Põllumäe** Effects of eutrophication and climate change on the benthic and pelagic environments in the brackish Baltic Sea: What are their consequences to the water quality assessment? (S1-8037)
17:40	**Aiko Tachibana, Hideaki Nomura and Takashi Ishimaru** Long-term variation of the copepod community structure in Tokyo Bay, Japan (S1-8252)
18:00	Discussion
18:05	Session ends

Tuesday, May 15 - S5

Session 5 (S5)

From genes to ecosystems: Genetic and physiological responses to climate change

Co-Convenors:
Julie Hall (National Institute of Water and Atmospheric Research, New Zealand)
Coleen Moloney (University of Cape Town, South Africa)

Invited Speaker:
Carl van der Lingen (Department of Agriculture, Forestry and Fisheries, South Africa)

Individual organisms experience the effects of climate change directly. Their responses are governed by genotype, phenotype, physiology and behaviour. The responses by individuals ultimately influence the impacts of climate change on individuals, populations, communities and ecosystems. This session aims to understand and explore the rich variety of genetic and physiological responses to climate change, and to assess the progress we have made in predicting the presence, extent and persistence of the impacts of these responses at the level of the ecosystem.

Tuesday, May 15 (14:00-18:05)

14:00	***Introduction by Convenors***
14:05	**Carl D. van der Lingen and Coleen L. Moloney** From ecosystems to genes: Climate change effects on Benguela sardine (S5-8006), Invited
14:35	**Jennifer Sunday, Amanda E. Bates and Nicholas K. Dulvy** Marine species' latitudinal distributions conform better to their thermal tolerance than terrestrial species: Implications for range shifts (S5-8240)
14:55	**Sam Dupont and Mike Thorndyke** Ocean acidification – The quest for unifying principles (S5-8031)
15:15	**Thomas Wernberg** Latitude and aptitude: The influence of climatic stress on the distribution, performance and function of seaweeds (S5-8297)
15:35	**Alexandra H. Campbell, Ezequiel M. Marzinelli, Tamsin A. Peters, Rebecca Neumann and Peter D. Steinberg** Climate-mediated diseases affecting habitat-forming seaweeds: Complex environmental effects on hosts and pathogens (S5-8214)
15:55	***Coffee/Tea Break***
16:20	**Rui Yin, Kyoung-Seon Lee, Guining Wang, Haruko Kurihara and Atsushi Ishimatsu** Climate changes (ocean acidification and warming) may impact the reproduction of the sea urchin *Hemicentrotus pulcherrimus* (S5-7999)
16:40	**Maarten Boersma, Arne M. Malzahn, Stefanie Schnell and Katherina L. Schoo** Food web effects of ocean acidification: Why is an increase in CO_2 availability important? (S5-8287)
17:00	**Atsushi Ishimatsu, Awantha Dissanayake, So Kawaguchi, Robert King, Haruko Kurihara, Akio Ishida and Masahide Wakita** Antarctic krill in a high CO_2 Southern Ocean: Potential impacts on early development and adult growth (S5-7998)

17:20	**Piero Calosi, Sedercor Melatunan, Simon Rundle and Steve Widdicombe** Latitudinal variation in the vulnerability to elevated temperature and CO_2 in a marine gastropod (S5-8309)
17:40	**Amanda E. Bates, Simon Morley, Koh Siang Tan and Chien-Houng Lai** Behaviour, thermal safety margins, environmental variability, and species-specific vulnerability to climate change (S5-8236)
18:00	Discussion
18:05	Session ends

Tuesday, May 15 - S7

Session 7 (S7)

Coastal and low-lying areas

Co-Convenors:
Iñigo Losada (University of Cantabria, Spain)
Poh Poh Wong (University of Adelaide, Australia)

Invited Speaker:
Poh Poh Wong (University of Adelaide, Australia)

Scientific evidence has been presented during the last decades that the coasts and low-lying areas, especially deltas, are experiencing the adverse consequences of the hazards related to climate change. Saltmarshes, coral reefs, mangroves and other relevant ecosystems are and will be suffering degradation affecting seriously their sustainability and the services they provide. Besides, coastal human settlements are highly vulnerable to climate change, especially to extreme events. The combination of sea level rise with the alteration of sea surface temperature, storm surges, waves, run-off/precipitation and acidification are some of the relevant elements to be considered. Besides, external stressors mostly originated by increasing human-pressure such as land-use, hydrological changes in catchments, groundwater extraction or reduced sediment supply exacerbate the impact of climate change. Erosion, flooding, saltwater intrusion, ecosystem deterioration and migration or increasing valuable human assets at risk are some of the immediate impacts requiring further research and immediate action. Contributions to this session may help to clarify and quantify the drivers of climate change impacts in coastal areas, from the evidence to projections as well as those considering the impacts and adaptation options for natural and human coastal systems.

Tuesday, May 15 (14:00-17:45)

14:00	***Introduction by Convenors***
14:05	**Poh Poh Wong** Large-scale modular mangrove planting – Adaptation to sea-level rise (S7-8228), Invited
14:35	**Andy Steven, Russ Babcock, Geoff Carlin, Nagur Cherukeru, Phillip Ford, Felipe Gusmao, Gary Fry and Kadija Oubelkheir** Biogeochemical properties and ecological consequences of the 2011 floods in Moreton Bay, Queensland (S7-8253)
14:55	**Guize Liu, Jingfeng Fan and Kuishuang Shao** The impact of climate changes on coastal wetland ecosystem (S7-8015)
15:15	**Shailendra Mandal, Kamini Sinha and Manoj Kumar** Effects of climate change on Indian Oceans: Concepts, approaches and applications of Integrated Coastal Zone Management in planning and management of Indian coastal zone of India (S7-8282)
15:35	**So-Min Cheong** Coastal adaptation (S7-8221)
15:55	***Coffee/Tea Break***
16:20	**Michael Dagg and Brian Roberts** Marsh derived DOC and CO_2 production in the coastal ocean of the northern Gulf of Mexico (S7-7960)

16:40 **Sergey Aleksandrov**
Impact of climate change on algae blooms and eutrophication in the lagoon ecosystems of the Baltic Sea (S7-8063)

17:00 **Evangeline Magdaong, Hiroya Yamano and Masahiko Fujii**
Development of a large-scale, long-term coral cover database in the Philippines (S7-8217)

17:20 **Guillem Chust, Aitor Albaina, Aizkorri Aranburu, Ángel Borja, Onno E. Diekmann, Andone Estonba, Javier Franco, Joxe M. Garmendia, Mikel Iriondo, Fernando Rendo, J. Germán Rodríguez, Otsanda Ruiz-Larrañaga, Iñigo Muxika and Mireia Valle**
Estuarine connectivity: Assessing species vulnerability to global change (S7-7985)

17:40 Discussion

17:45 Session ends

Wednesday, May 16 - Plenary

Plenary Session

09:00	**Anthony Charles** Social, economic and governance impacts of climate change on fisheries (General Plenary-8011)
09:35	**Manuel Barange, Gorka Merino, Icarus Allen, Jason Holt, James Harle, Simon Jennings, Julia Blanchard and Eddie Allison** Quantifying the impacts of climate change on marine shelf ecosystems and their resources: Feeding the world in 2050 (S4 Plenary-8127)
10:10	**Pedro M.S. Monteiro and Christopher Sabine** Global Ocean Carbon Observations: Decadal challenges in addressing and understanding global climate and ocean ecosystem change (S2 Plenary-8312)
10:45	Plenary Session Ends

Wednesday, May 16 - S1

Session 1 (S1), Day 2

Climate variability versus anthropogenic impacts; analysing their separate and combined effects on long-term physical, biogeochemical and ecological patterns

Co-Convenors:
Sanae Chiba (JAMSTEC, Japan)
Nicholas A. Bond (JISAO, University of Washington, USA)

Invited Speakers:
Nathan Bindoff (University of Tasmania, Australia)
Shin-ichi Uye (Hiroshima University, Japan)

There is a strong scientific consensus that human-induced global warming is occurring, with this signal having been detected even into the deep ocean. The effects of climate change are not restricted to just temperature, but also have been observed in water properties such as pH and oxygen concentrations. The world's oceans will continue to be influenced by natural variability over a range of temporal and spatial scales, which can obscure anthropogenic effects. The confounding effects of intrinsic fluctuations in the physical forcing can be especially challenging to sort out for marine ecosystems, due to the complexity of the interactions controlling the biogeochemistry of the ocean. But that challenge needs to be met in order to be able to predict probable shifts and trends in the structure and function of marine ecosystems, and to carry out effective mitigation. This session consists of papers on topics related to disentangling natural variability from anthropogenic climate change with respect to marine ecosystems. We expect papers featuring a variety of approaches, and lively discussions of their relative merits and limitations.

Wednesday, May 16, Day 2 (11:00-16:45)

11:00	***Introduction by Convenors***
11:05	**Nathaniel L. Bindoff, Paul Halloran, Oliver Andrews, Corinne Le Quéré, Catia Domingues and Helen E. Phillips** Are the observed pattern changes of ocean heat, salinity and oxygen man made? (S1-8209), Invited
11:35	**Nicholas A. Bond, Muyin Wang and Phyllis J. Stabeno** Which climate change signals in the North Pacific are liable to emerge sooner and stronger? (S1-7991)
11:55	**Olga Trusenkova** Regional patterns of interannual sea level variability: Case of the Japan/East Sea (S1-7954)
12:15	**Svetlana P. Shkorba, Vladimir I. Ponomarev, Elena V. Dmitrieva and Lubov N. Kuimova** Long wave of interdecadal oscillation in moderate latitude of the Asian Pacific (S1-8014)
12:35	***Lunch***
14:00	**Joji Ishizaka, Yongjiu Xu, Hisashi Yamaguchi and Eko Siswanto** Influence of Changjiang discharge, resuspension of sediment and eutrophication to chlorophyll variability in the Yellow Sea and East China Sea: Results from new satellite data set (S1-8045)

14:20	**Yun Ho Kang, Se-Jong Ju, Kyoung-Soon Shin, Sang-Duk Choi, Kyeong-Ho Han and Ho-Seop Yoon** Simulating ecosystem response to climate change, thermal waste discharge and reclamation in a highly industrialized bay (S1-8034)
14:40	**Jong-Yeon Park, Jong-Seong Kug and Young-Gyu Park** Bio-physical interaction in the tropical Pacific (S1-8005)
15:00	**Alexander Demidov, Eugene Krayushkin, Nina Kalshnikova and Sergey Chereshnyuk** Water mass structure in the South Atlantic and its decadal variability (S1-8036)
15:20	**James R. Christian** Detection of anthropogenic influences on ocean biogeochemistry (S1-8295)
15:40	***Coffee/Tea Break***
16:00*	**Svetlana Pakhomova, Elena Vinogradova, Evgeny Yakushev, Andrey Zatsepin, Valery Chasovnikov and Oleg I. Podymov** *Presented by Evgeny Yakushev on behalf of Svetlana Pakhomova* Black Sea biogeochemical regime recent decades variability: The role of climatic and anthropogenic forcing (S1-8051)
16:20	**Fabricio V. Branco, Bruno Biazeto, Ricardo de Camargo, Ilana Wainer, Jose Edson, Daniel Moita, Bruno Ferrero, Pedro P. Lopes, Tiago Bomventi, Christiano Campos, Marcelo Andrioni and Andre L.T. Mendes** South Atlantic wave climate under climate change impacts (S1-8230)
16:40	Discussion
16:45	Session ends

Wednesday, May 16 - S2

Session 2 (S2)

Systematic, sustained and integrated global ocean observations

Co-Convenors:
Keith Alverson (UNEP, Division of Environmental Policy Implementation)
Dong-Young Lee (Korea Ocean Research and Development Institute, Korea)

Invited Speakers:
Hee-Dong Jeong (National Fisheries Research and Development Institute, Korea)
Eric Lindstrom (National Aeronautics and Space Administration, USA)

Over the past two decades a sustained ocean observations for climate have evolved from a patchwork of research efforts to a sustained Global Ocean Observing System. A network of satellites and *in situ* platforms are monitoring essential climate variables in service of research needs and societal benefits. Reporting to the parties of the UN Framework Convention on Climate Change ensures the adequacy of the system for purposes largely associated with detection and attribution of anthropogenic climate change. This session seeks to build on these past successes, but with an eye to the future of sustained ocean monitoring. In particular, focusing on sustained ocean observations is required in support of climate change adaptation measures and biogeochemical variables. Prioritization and assessment of climate change adaptation measures will call for very different monitoring strategies than have been designed for detection and attribution. At the same time, monitoring non-climatic targets, including for example acidification, biodiversity changes and ecosystem shifts, will require that new variables are integrated with the existing system. The session is based on a broad range of presentations on ocean monitoring, including both past results and future strategies.

Wednesday, May 16 (11:00-18:15)

11:00 ***Introduction by Convenors***

11:05 **Eric Lindstrom, John Gunn, Albert Fischer, Candyce Clark and Andrea McCurdy**
Presented by Andrea McCurdy and Candyce Clark on behalf of Eric Lindstrom
The framework for ocean observing: Best practices for the global observing system (S2-8279), Invited

11:35 **Sung Yong Kim, E.J. Terrill, B.D. Cornuelle, B. Jones, L. Washburn, M.A. Moline, J.D. Paduan, N. Garfield, J.L. Largier, G. Crawford and P.M. Kosro**
Sustained observations of mesoscale and submesoscale surface circulation off the U.S. West Coast (S2-7935)

11:55 **William T. Peterson, Jay Peterson, Cheryl Morgan and Jennifer Fisher**
Tracking ecosystem change in the northern California Current: A role for long term ship-board observations (S2-8180)

12:15 **Che Sun and Lin Zhang**
Interannual variability of the Antarctic Circumpolar Current strength based on merged altimeter data (S2-8047)

12:35 ***Lunch***

14:00 **Hee Dong Jeong, Sang Woo Kim, Yong Kyu Choi, Jeong Min Shim and Kee Young Kwon**
Global ocean observing and monitoring activities: Focus on the North East Asian Region (S2-8299), Invited

14:30 **Toshihiko Nagai**
History and present situation of Japanese coastal wave and tsunami monitoring system (NOWPHAS) (S2-7997)

14:50 **Huaming Yu, Qingyang Song and Xueen Chen**
Analyses on the tidal characteristics of the China Sea from the satellite altimetry data (S2-8025)

15:10 **Jae-Hyoung Park, Kyung-Il Chang, Young-Tae Son, Hee-Mang Park, Ki-Wan Kim and Joo-Hyung Ryu**
A long-term coastal ocean buoy station in the East/Japan Sea: Past, present, future (S2-8067)

15:30 **Yu-Hwan Ahn, Joo-Hyung Ryu, Young-Je Park and Seongick Cho**
Geostationary Ocean Color Imager for the North East Asian waters: Overview and ocean application***s*** (S2-8083)

15:50 **J.S. Park, J.R. Li, J.Y. Jin, D.Y. Lee, K.S. Lee, S.G. Hyun and E. Hayte**
Integrated coastal monitoring system through combination of *in situ* monitoring, satellite remote sensing and 3-D numerical models (S2-8140)

16:10 ***Coffee/Tea Break***

16:30 **Igor Burago, Georgy Moiseenko, Olga Vasik and Igor Shevchenko**
Federating metadata collections on monitoring of the North Pacific (S2-7942)

16:50 **So Kawaguchi, Mitsuo Fukuchi, Andrew Constable and Anthony J. Press**
Assessment of climate change impacts on marine ecosystems in East Antarctica: Outcomes of a research collaboration between Australia and Japan (S2-8020)

17:10 **Rosamma Stephen and R. Radhika**
Decadal changes in pelagic copepod distribution in the EEZ -west coast of India (S2-8076)

17:30 **Marie-Fanny Racault, Trevor Platt, Shubha Sathyendranath, Ertugrul Agirbas and Victor Martinez Vicente**
Integration of ecological indicators with the global network of ocean observations (S2-8129)

17:50 **Sei-Ichi Saitoh, Toru Hirawake, I. Nyoman Radiarta, Tomonori Isada, Robinson Mugo, Fumihiro Takahashi, Ichiro Imai, Yasuhiro Sakurai, Michio J. Kishi, Masaaki Wada, Toshiyuki Awaji and Yoichi Ishikawa**
Development of integrated coastal fisheries information system for sustainable fisheries in southern Hokkaido, Japan (S2-8267)

18:10 Discussion

18:15 Session Ends

Wednesday, May 16 - S4

Session 4 (S4), Day 1

Climate change effects on living marine resources: From physics to fish, marine mammals, and seabirds, to fishermen and fishery-dependent communities

Co-Convenors:
Miguel Bernal (Instituto Español de Oceanografía, Spain)
Keith Criddle (University of Alaska Fairbanks, USA)
Anne Hollowed (Alaska Fisheries Science Center, NOAA-Fisheries, USA)

Invited Speaker:
Shin-ichi Ito (Tohoku National Fisheries Research Institute, Japan)

Climate change is likely to affect the biological components of marine ecosystem at various spatial and temporal scales, and will have different effects at species, population and ecosystem levels. This session covers climate-induced changes in the medium to high trophic levels of the marine ecosystem biological components, including fish, mammals, seabirds and humans. Changes in those communities expected to be analysed in the session include shifts in distribution of species, changes in fish reproduction and productivity, migratory routes, changes in the productivity of littoral habitat (*e.g.*, estuaries, marshes), changes in freshwater habitat for anadromous species, and loss in marine biodiversity. Mechanisms of individual, population and ecosystem – including humans - responses to climate change, such as marine populations acclimation and adaptation; resilience of fishery management systems; resilience of fishery dependent communities (including modern and subsistence-dependent economies) effects on management of transboundary stocks; interactions of climate and harvesting impacts on fish populations, will also be dealt with.

Wednesday, May 16, Day 1 (11:00-18:05)

11:00 ***Introduction by Convenors***

11:05 **Shin-ichi Ito, Takeshi Okunishi and Mitsutaku Makino**
Climate induced fluctuation of Japanese sardine, its influence on marine ecosystem and human being (S4-8265), Invited

11:35 **William J. Sydeman, Sarah Ann Thompson, J. Anthony Koslow, Ralf Goericke, Marisol Garcia-Reyes and Mark D. Ohman**
Climate change impacts on the pelagic ecosystem off southern California: Comparisons of trends and variability within and between trophic levels (S4-8176)

11:50 **Elvira S. Poloczanska, Christopher J. Brown, William J. Sydeman, Wolfgang Kiessling, Pippa J. Moore, Keith Brander, John F. Bruno, Lauren Buckley, Michael T. Burrows, Carlos M. Duarte, Benjamin S. Halpern, Johnna Holding, Carrie V. Kappel, Mary I. O'Connor, John M. Pandolfi, Camille Parmesan, David S. Schoeman, Franklin B. Schwing, Sarah Ann Thompson and Anthony J. Richardson**
Climate change imprint on marine life from long-term observations (S4-8306)

12:05 **Gennady Matishov, Denis Moiseev, Olga Lyubina, Aleksandr Zhichkin, Sergey Dzhenyuk, Oleg Karamushko and Elena Frolova**
Climate and cyclic hydrobiological changes in the Barents Sea in the 20th and 21st centuries (S4-7968)

12:20 **Jürgen Alheit, Kenneth F. Drinkwater and Janet Nye**
Impact of Atlantic Multi-decadal Oscillation on marine ecosystems (S4-8147)

12:35 ***Lunch***

14:00 **Camilla S. Landa**
Geographical distribution and abundance of North East Arctic (NEA) haddock (Melanogrammus aeglefinus) in a changing climate (S4-8207)

14:15	**George Hunt Jr., Harald Loeng, Anne B. Hollowed, Franz J. Mueter and Kenneth F. Drinkwater** To migrate or not? When may we expect groundfish species to move poleward? (S4-7949)
14:30	**Phyllis J. Stabeno, Ed Farley, Nancy Kachel, Sue Moore, Calvin Mordy, Jeffrey M. Napp, James E. Overland, Alexei I. Pinchuk and Michael F. Sigler** Climate-mediated processes on the northern and southern shelves of the eastern Bering Sea and some implications for the ecosystem (S4-8135)
14:45	**Vicky W.Y. Lam, William W.L. Cheung and U. Rashid Sumaila** Climate change, ocean acidification and the fish and fisheries of the Arctic (S4-8233)
15:00	**Oleg Titov** Water exchange in the southern Barents Sea: Indirect integral characteristics and impact on the abundance of NEA cod (S4-7996)
15:15	**Paul D. Spencer, Nicholas A. Bond, Anne B. Hollowed and Franz J. Mueter** Projected spatial distributions for eastern Bering Sea arrowtooth flounder under simulated climate scenarios, with implications for predation (S4-8060)
15:30*	**Andrea Piñones, Eileen E. Hofmann, Kendra L. Daly, Michael S. Dinniman and John M. Klinck** *Presented by Eileen E. Hofmann on behalf of Andrea Piñones* Effects of circulation and climate change on early life stages of Antarctic krill (S4-8153)
15:45 *Cancelled*	**Daniel P. Costa** The potential effects of climate change on southern ocean top predators (S4-8305)
16:00	***Coffee/Tea Break***
16:20	**Robinson Mugo, Sei-Ichi Saitoh, Akira Nihira, Tadaaki Kuroyama, Shuhei Masuda, Toshiyuki Awaji, Takahiro Toyoda, Hiromichi Igarashi and Yoichi Ishikawa** Potential impact of global warming on skipjack tuna (*Katsuwonus pelamis*) habitat in the western North Pacific (S4-8269)
16:35	**Jeffrey J. Polovina, Phoebe Woodworth, Julia Blanchard and John P. Dunne** Use of a size-based ecosystem model driven by a climate model to project the consequences of climate change on fish abundance and catches in the North Pacific Ocean (S4-7958)
16:50	**Nan-Jay Su, Chi-Lu Sun, André E. Punt and Su-Zan Yeh** Potential impacts of climate change on the habitat of striped marlin (*Kajikia audax*) in the North Pacific Ocean (S4-8017)
17:05	**Jung Jin Kim, Cheol-Ho Kim, Hong Sik Min, Chan Joo Jang, William T. Stockhousen and Suam Kim** Predicted ecological characteristics of common squid (*Todarodes pacificus*) larvae inferred by various climate models under IPCC SRES A1B Scenarios (S4-8257)
17:20	**Yongjun Tian, Kazuya Nashida and Hideo Sakaji** Synchrony in the abundance trends of spear squid *Loligo bleekeri* in the Japan Sea and Pacific Ocean with special reference to the latitudinal differences in response to the climate regime shift (S4-7956)
17:35	**David Costalago and Isabel Palomera** Vulnerability of small pelagic fish populations in non-upwelling areas under climate change (S4-7986)
17:50	**Priscilla Licandro, Delphine Nicolas, Sébastien Rochette and Mark Dickey-Collas** Linking the impact environmental changes on clupeoid fish through the zooplankton: The example of North Sea herring (S4-8027)
18:05	Session Ends

Thursday, May 17 - Plenary

Plenary Session

09:00	**Peter G. Brewer** Deep-Sea gas exchange rates: The diffusive boundary layer link between fish, changing chemistry and climate (General Plenary-7946)
09:35	**Lothar Stramma** On the expansion of oxygen minimum zones, trends in dissolved oxygen and its impact on the tropical Pacific Ocean (S8 Plenary-7959)
10:10	**Yasuhiro Yamanaka and Takafumi Hirata** Developing marine ecosystem model to improve future projection (S3 Plenary)
10:45	Plenary Session Ends

Thursday, May 17 - S3

Session 3 (S3), Day 1

Projections of climate change impacts on marine ecosystems and their uncertainty

Co-Convenors:
Kyung-Il Chang (Seoul National University, Korea)
Corinna Schrum (University of Bergen, Norway)

Invited Speakers:
Noel Keenlyside (Geophysical Institute, University of Bergen, Norway)
Markus Meier (Sveriges Meteorologiska och Hydrologiska Institut, Sweden)
Ryan Rykaczewski (Princeton University, USA)

Within the last decades increasing scientific evidence indicates that climate change is occurring and impacting the functioning and structuring of regional marine ecosystems on various scales in various ways. Politicians and environmental and fisheries managers increasingly demand answers from scientist to assess regional impacts and future changes and risks for regional marine ecosystems and marine resources. Consequently, scientific efforts have been undertaken recently to develop tools and dynamically consistent methods to assess the regional climate change impacts to the marine ecosystems. These projections typically build on future climate change scenarios from Global Climate Models (GCMs) and involve model chains with modelling tools for various regional parts of the marine ecosystems, such as coupled physical-biological models for the lower trophic levels, IBMs (individual based models) for fish larvae, multi-species or end-to-end models. Such projections involve a number of practical and conceptual challenges and are subject to uncertainties that arise from the baseline global climate projections and downstream modelling tools.

This session consists of papers on various aspects related to climate change projections for global and regional marine physical, biogeochemical and ecological systems, such as contributions related to: (i) projected changes, risks and potential chances, (ii) various downscaling methods (bias corrections, delta change) and their impacts on dynamic consistency of the projections and (iii) uncertainties in projections and error propagation through the model chain. We are seeking a lively and open discussion about potentials and limitations of climate change projections and downscaling to marine ecosystems.

Thursday, May 17, Day 1 (11:00-18:05)

11:00	***Introduction by Convenors***
11:05	**Ryan R. Rykaczewski, John P. Dunne, Charles A. Stock, James R. Watson and Jorge L. Sarmiento** Connectivity between basin-scale and local processes influences regional ecosystem responses to increases in upper-ocean stratification (S3-8159), Invited
11:35	**Jason Holt, Momme Butenschön, Sarah Wakelin, Yuri Artioli, Icarus Allen, James Harle, Jason Lowe and Jonathan Tinker** Climate change impacts on shelf and coastal marine ecosystems: Contrasting ocean-shelf exchange, stratification, and temperature effects on the northwest European shelf (S3-8272)
11:55	**Dhanya Pushpadas, Corinna Schrum and Ute Daewel** Climate change impacts on the North and Baltic Sea ecosystems: An assessment based on IPCC AR4 and AR5 models (S3-8162)

12:15 **Corinna Schrum, Bjørn Ådlandsvik, Richard Bellerby, Ute Daewel, Trond Kristensen and Dhanya Pushpadas**
Dynamic downscaling to marine ecosystems (S3-8292)

12:35 ***Lunch***

14:00 **Noel Keenlyside**
Near-term climate prediction: New opportunities and challenges (S3-8124), Invited

14:30 **Charles A. Stock, John P. Dunne and Jasmin John**
Augmenting earth system models to capture global-scale energy flows through the planktonic food web to fish (S3-8157)

14:50 **Yang-Ki Cho, Gwang-Ho Seo, Byoung-Ju Choi and Kwang-Yul Kim**
Development of a regional ocean climate model for the northwest Pacific marginal seas (S3-8245)

15:10 **Ute Daewel, Corinna Schrum and Dhanya Pushpadas**
Impact of climate changes on North Sea Atlantic cod (*Gadus morhua*) larval survival: A modeling study (S3-8131)

15:30 **Enrique N. Curchitser, Kenneth A. Rose, Kate Hedstrom, Jerome Fiechter, Miguel Bernal, Shin-ichi Ito, Alan Haynie and Francisco E. Werner**
Development of a climate-to-fish-to-fishers model: Implementation in the eastern Pacific Sardine and Anchovy system (S3-8314)

15:50 ***Coffee/Tea Break***

16:10 **H.E. Markus Meier, Helén C. Andersson, Kari Eilola, Bo G. Gustafsson, Ivan Kuznetsov, Bärbel Müller-Karulis, Thomas Neuman and Oleg P. Savchuk**
Hypoxia in future climates: A model ensemble study for the Baltic Sea (S3-8001), Invited

16:40 **Manal M. Sabrah and Azza A. El-Ganainy**
Relationship between coral reef degradation and overexploitation of coral reef fishes in El-Tur region, Egyptian Red Sea coast (S3-8264)

17:00 **Jose Fernandes, William Cheung, Simon Jennings and Alastair Grant**
Projecting distribution changes in marine fishes and invertebrates by integrating trophic interactions (S3-7944)

17:20 **Pavel A. Salyuk and Oleg A. Bukin**
Interactions between regional climate-forming factors and phytoplankton communities in the north-western Pacific (S3-8111)

17:40 **Hyunwoo Lee, Ki-Tae Park, Kitack Lee, Hae Jin Jeong and Yeong Du Yoo**
Prey-dependent retention of dimethylsulfoniopropionate by mixotrophic dinoflagellates (S3-8117)

18:00 Discussion

18:05 Session Ends

Thursday, May 17 - S4

Session 4 (S4), Day 2

Climate change effects on living marine resources: From physics to fish, marine mammals, and seabirds, to fishermen and fishery-dependent communities

Co-Convenors:
Miguel Bernal (Instituto Español de Oceanografía, Spain)
Keith Criddle (University of Alaska Fairbanks, USA)
Anne Hollowed (Alaska Fisheries Science Center, NOAA-Fisheries, USA)

Invited Speaker:
Shin-ichi Ito (Tohoku National Fisheries Research Institute, Japan)

Climate change is likely to affect the biological components of marine ecosystem at various spatial and temporal scales, and will have different effects at species, population and ecosystem levels. This session covers climate-induced changes in the medium to high trophic levels of the marine ecosystem biological components, including fish, mammals, seabirds and humans. Changes in those communities expected to be analysed in the session include shifts in distribution of species, changes in fish reproduction and productivity, migratory routes, changes in the productivity of littoral habitat (*e.g.*, estuaries, marshes), changes in freshwater habitat for anadromous species, and loss in marine biodiversity. Mechanisms of individual, population and ecosystem – including humans - responses to climate change, such as marine populations acclimation and adaptation; resilience of fishery management systems; resilience of fishery dependent communities (including modern and subsistence-dependent economies) effects on management of transboundary stocks; interactions of climate and harvesting impacts on fish populations, will also be dealt with.

Thursday, May 17, Day 2 (11:00-18:15)

11:00 ***Introduction by Convenors***

11:05 **William W.L. Cheung, Jorge L. Sarmiento, John P. Dunne, Thomas L. Frölicher, Vicky W.Y. Lam, M.L. Deng Palomares, Reg Watson and Daniel P. Pauly**
Shrinking of fishes exacerbates impacts of global ocean changes on marine ecosystems (S4-8242)

11:20 **Adriana Vergés, Fiona Tomas, Emma Cebrian, Zafer Kizilkaya, Enric Sala and Enric Ballesteros**
Invasion of tropical herbivores into a temperate system results in devastating phase-shift mediated by the loss of canopy algae (S4-7990)

11:35 **Dawit Yemane, Toufiek Samaai and Steve P. Kirkman**
Assessing changes in distribution and range size of demersal fish species in the Benguela Current Large Marine Ecosystem in relation to long-term change in the environment (S4-8055)

11:50 **Arno Põllumäe and Lennart Lennuk**
Is the abundance of invasive cladoceran *Cercopagis pengoi* controlled by blooms of moon jelly *Aurelia aurita* in northern Baltic Sea? (S4-8032)

12:05 **Malin L. Pinsky, Michael Fogarty, Boris Worm, Jorge L. Sarmiento and Simon A. Levin**
How predictable are species distribution shifts? Testing ecological hypotheses against four decades of observations (S4-8071)

12:20 ***Lunch***

14:00 **Sukgeun Jung and Ilsu Choi**
Latitudinal shifts in catch distribution of fisheries species in Korean waters during the past 30 years in relation to climate change (S4-8224)

14:15 **Warren Potts and Warwick H.H. Sauer**
Transboundary climate induced distributional changes in an important recreational west African fish species – consequences and adaptation (S4-7957)

14:30 **Steve P. Kirkman, Dawit Yemane, John Kathena, Sam Mafwila, Sylvia N'siangango, Toufiek Samaai and Larvika Singh**
Identifying and characterizing of demersal biodiversity hotspots in the Benguela Current large marine ecosystem: Its relevance in the light of global changes (S4-8088)

14:45 **Dan Smale, Thomas Wernberg, Tim Langlois and Gary Kendrick**
Impact of a 'marine heat wave' on seaweed, coral and fish assemblages in a global biodiversity hotspot (S4-7995)

15:00 **John K. Pinnegar, Will J.F. Le Quesne and Silvana N.R. Birchenough**
Ocean acidification and the possible loss of echinoderms: How will commercial fish and fisheries be affected? (S4-8058)

15:15 **Daniel Small, Piero Calosi, John Spicer, Dominic Boothroyd and Steve Widdicombe**
Synergistic impacts of climate change drivers on the developmental ecophysiology, growth and survival of the European lobster, *Homarus gammarus* (S4-8310)

15:30 **C. Tracy Shaw, Leah R. Feinberg and William T. Peterson**
Effects of climate variability on the euphausiids *Euphausia pacifica* and *Thysanoessa spinifera* in the coastal upwelling zone off the Oregon Coast, USA (S4-8178)

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

16:00 **Alan Haynie and Lisa Pfeiffer**
Climate change and fisher behavior in the Bering Sea pollock trawl and Pacific cod longline fisheries (S4-8231)

16:15 **Anthony Charles**
Climate change impacts and adaptation in the real world of coastal communities (S4-8074)

16:30 **Kuo-Wei Lan and Ming-An Lee**
Effects of climate variability on the distribution and fishing conditions of yellowfin tuna (*Thunnus albacares*) in the Indian Ocean (S4-8022)

16:45 **Renae C. Tobin, Ann Penny, Andrew J. Tobin, Stephen Sutton and Nadine Marshall**
Stop, change or move: Practical adaptation of commercial fishers to spatial changes in fish abundance due to extreme weather events (S4-7977)

17:00 **Edward JK. Patterson**
Climate change impacts on coastal resources and dependent livelihood in Tamil Nadu, Southeastern India (S4-7947)

17:15 **Sibananda Senapati and Vijaya Gupta**
Dying fisheries in a changing environment: A study on livelihood strategies of fishery communities in Mumbai (S4-8189)

17:30 **Caroline Brown and Nicole M. Braem**
Observations of climate change and subsistence harvests in Emmonak, Alaska (S4-8168)

17:45 **SM Sharifuzzaman**
The effect of climate change on shrimp aquaculture, Bangladesh (S4-8134)

18:00 **Francisca George, Dominic O. Odulate and Adekunle Idowu**
Climate change effects and adaptation strategies in a Nigerian coastal agro-ecological zone (S4-7969)

18:15 Session Ends

Thursday, May 17 - S8

Session 8 (S8)

Trend and impacts of de-oxygenation in oceanic and coastal ecosystems

Co-Convenors:
Frank Whitney (Canada)
Evgeniy Yakushev (Norwegian Institute for Water Research, Norway/Russia)

Invited Speakers:
Steven Bograd (Southwest Fisheries Science Center, NOAA-Fisheries, USA)
Felix Janssen (Max-Planck Institute for Marine Microbiology, Germany)

Modifications to ocean circulation due to global warming are being observed broadly throughout our oceans. Surface warming of our planet reduces oxygen solubility in seawater, increases mixed layer buoyancy and reduces ice formation in important ventilation areas. All of these processes lead to a reduction in oxygen transport to the interior waters of major ocean basins and coastal seas. As a transition zone between the continents and the ocean, coastal waters are natural susceptibility to oxygen-deficiency and anoxia due to both the input of low density coastal water and topographic restrictions which can increase the residence time of bottom waters.

Oxygen depletion inevitably leads to biological impacts ranging from altered microbial activity (*e.g.*, enhanced de-nitrification, N_2O production or sulfate reduction) to whole community displacements (loss of fisheries, invasions of displaced species into new habitat) which are poorly understood. As well, oxygen losses in the interior ocean are accompanied by increased acidity as carbon dioxide levels rise. These two trends may have synergistic impacts on biota. Contributions across these diverse topics, as well as on expansions of coastal dead zones caused by non-climate related change, are included in this session.

Thursday, May 17 (11:00-18:00)

11:00	***Introduction by Convenors***
11:05	**Felix Janssen, Christoph Waldmann, Antje Boetius and the HYPOX project team** Oxygen observation activities within the FP7 EU-project HYPOX: A step towards hypoxia monitoring in a rapidly changing world (S8-8094), Invited
11:35	**Evgeniy Yakushev** Oxygen depletion events in the European Seas: Observations and modelling (S8-8043)
11:55	**Oleg I. Podymov** Recent decadal changes of the northeastern Black Sea anoxic boundary position and interannual nutrient dynamics (S8-8167)
12:15	**Pavel Tishchenko, Vyacheslav B. Lobanov, Tatyana Mikhajlik, Pavel Semkin, Alexander Sergeev, Petr Tishchenko and Vladimir Zvalinsky** *Presented by Vyacheslav Lobanov on behalf of Pavel Tishchenko* Seasonal hypoxia of Amurskiy Bay (Japan/East Sea) (S8-8084)
12:35	***Lunch***
14:00	**Young Jae Ro, Baek Jin Kim, Kwang Young Jung and Kwang Soon Park** Two case studies for hypoxia in Korean coastal waters (S8-8193)
14:20	**Meng Xia** The effect of climate change on a Gulf estuary plume and its hypoxia variation (S8-7927)

14:40 **Dmitry D. Kaplunenko, Vyacheslav B. Lobanov, Pavel Tishchenko and Maria A. Shvetsova**
Vertical structure of dissolved oxygen and nitrate *in situ* profiles in the North-East Asian Marginal Seas (S8-8246)

15:00 **Jinhui Wang and Yanqin Wu**
The historical status and impacts of hypoxia in Changjiang estuary (S8-8044)

15:20 **K. Allison Smith, John P. Dunne, Brendan R. Carter, and Jorge L. Sarmiento**
Predicting future habitat changes above oxygen minimum zones (S8-8175)

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

16:00 **Frank A. Whitney, Steven J. Bograd and Tsuneo Ono**
Implications of subsurface nutrient increases in the subarctic Pacific Ocean (S8-8010), Invited

16:30 **Frank A. Whitney, Vaughn Barrie, Kim Conway and Bill Crawford**
Oxygen sinks and sources along the coast of British Columbia, Canada (S8-7974)

16:50 **John A. Barth, Stephen D. Pierce and Francis Chan**
Hypoxia over the continental shelf in the Northeast Pacific ocean (S8-8069)

17:10 **J. Anthony Koslow, Peter Davison, Ana Lara-Lopez, Amanda Netburn and Noelle Bowlin**
The influence of declining oxygen concentrations and mesopelagic fish biomass on ecosystem structure and carbon export in the California Current (S8-8173)

17:30 **Anand Gnanadesikan, Daniele Bianchi, Irina Marinov, Jaime Palter and Marie-Aude Pradal**
Understanding the connection between ocean circulation and open-ocean oxygen levels (S8-8218)

17:50 Discussion

18:00 Session Ends

Friday, May 18 - Plenary

Plenary Session

9:00	**Ichiro Yasuda** Interactions between fisheries production, planktonic ecosystems, physical oceanographic processes and climate change (General Plenary-8072)
9:35	**Kyung-Ryul Kim** Recent Advances in studies for East Sea (Sea of Japan), a miniature test ocean for global changes (General Plenary-8307)
10:10	**Jeffrey M. Dambacher** The role of positive feedback in structuring alternative ecosystem states (S9 Plenary-7966)
10:45	Plenary Session Ends

Friday, May 18 - S3

Session 3 (S3), Day 2

Projections of climate change impacts on marine ecosystems and their uncertainty

Co-Convenors:
Kyung-Il Chang (Seoul National University, Korea)
Corinna Schrum (University of Bergen, Norway)

Invited Speakers:
Noel Keenlyside (Geophysical Institute, University of Bergen, Norway)
Markus Meier (Sveriges Meteorologiska och Hydrologiska Institut, Sweden)
Ryan Rykaczewski (Princeton University, USA)

Within the last decades increasing scientific evidence indicates that climate change is occurring and impacting the functioning and structuring of regional marine ecosystems on various scales in various ways. Politicians and environmental and fisheries managers increasingly demand answers from scientist to assess regional impacts and future changes and risks for regional marine ecosystems and marine resources. Consequently, scientific efforts have been undertaken recently to develop tools and dynamically consistent methods to assess the regional climate change impacts to the marine ecosystems. These projections typically build on future climate change scenarios from Global Climate Models (GCMs) and involve model chains with modelling tools for various regional parts of the marine ecosystems, such as coupled physical-biological models for the lower trophic levels, IBMs (individual based models) for fish larvae, multi-species or end-to-end models. Such projections involve a number of practical and conceptual challenges and are subject to uncertainties that arise from the baseline global climate projections and downstream modelling tools.

This session consists of papers on various aspects related to climate change projections for global and regional marine physical, biogeochemical and ecological systems, such as contributions related to: (i) projected changes, risks and potential chances, (ii) various downscaling methods (bias corrections, delta change) and their impacts on dynamic consistency of the projections and (iii) uncertainties in projections and error propagation through the model chain. We are seeking a lively and open discussion about potentials and limitations of climate change projections and downscaling to marine ecosystems.

Friday, May 18, Day 2 (11:00-13:05)

11:00 ***Introduction by Convenors***

11:05 **Cody Szuwalski and André E. Punt**
Reaching management goals under a changing climate: A management strategy evaluation of snow crab (*Chionoecetes opilio*) fishery in the eastern Bering Sea (S3-7945)

11:25 **Yun Ho Kang, Se-Jong Ju, Kyoung-Soon Shin, Young-Gyu Park, Sang-Duk Choi, Kyeong-Ho Han and Ho-Seop Yoon**
Predicting climate change-induced fishery shrink through bottom-up control around the southern waters of Korea by using a flow trophic model (S3-8033)

11:45 **James R. Watson, Charles A. Stock, Ryan R. Rykaczewski and Jorge L. Sarmiento**
Quantifying the distribution and dynamics of forage fish by using a size-based ecosystem model (S3-8158)

12:05 **Tomohiro Yasuda, Yusuke Tanaka, Junichi Ninomiya, Sota Nakajo, Nobuhito Mori and Hajime Mase**
Hindcast and historical assessment of Cyclone Tomas and climate change impact analysis on tropical cyclones in the South Pacific (S3-8259)

12:25 **Yang Liu, Sei-Ichi Saitoh, I. Nyoman Radiarta and Toru Hirawake**
Impact of climate change on the development of marine aquaculture: A case study on the Japanese scallop in Dalian, China, using satellite remote sensing and Geographic Information Systems-based models (S3-8132)

12:45 **Tore Johannessen and Tron Frede Tingstad**
Do phytoplankton, bacteria, and heterotrophic nanoflagellates gain competitive advantages by sacrificing parts of their clonal populations in favour of receiving resources for continuous growth? (S3-7984)

13:05 Session Ends

Friday, May 18 - S4

Session 4 (S4), Day 3

Climate change effects on living marine resources: From physics to fish, marine mammals, and seabirds, to fishermen and fishery-dependent communities

Co-Convenors:
Miguel Bernal (Instituto Español de Oceanografía, Spain)
Keith Criddle (University of Alaska Fairbanks, USA)
Anne Hollowed (Alaska Fisheries Science Center, NOAA-Fisheries, USA)

Invited Speaker:
Shin-ichi Ito (Tohoku National Fisheries Research Institute, Japan)

Climate change is likely to affect the biological components of marine ecosystem at various spatial and temporal scales, and will have different effects at species, population and ecosystem levels. This session covers climate-induced changes in the medium to high trophic levels of the marine ecosystem biological components, including fish, mammals, seabirds and humans. Changes in those communities expected to be analysed in the session include shifts in distribution of species, changes in fish reproduction and productivity, migratory routes, changes in the productivity of littoral habitat (*e.g.*, estuaries, marshes), changes in freshwater habitat for anadromous species, and loss in marine biodiversity. Mechanisms of individual, population and ecosystem – including humans - responses to climate change, such as marine populations acclimation and adaptation; resilience of fishery management systems; resilience of fishery dependent communities (including modern and subsistence-dependent economies) effects on management of transboundary stocks; interactions of climate and harvesting impacts on fish populations, will also be dealt with.

Friday, May 18, Day 3 (11:00-12:45)

11:00	***Introduction by Convenors***
11:05*	**Akihiko Yatsu, Sanae Chiba, Yasuhiro Yamanaka, Shin-ichi Ito, Yugo Shimizu, Masahide Kaeriyama and Yoshiro Watanabe** *Presented by Shin-ichi Ito on behalf of Akihiko Yatsu* Climate forcing and the Kuroshio/Oyashio ecosystem (S4-7980)
11:20	**Myron A. Peck, Marc Hufnagl, Klaus Huebert, Markus Kreus and Johannes Pätsch** Will climate-driven warming uncouple marine food webs? Projections from biophysical, size-based modeling (S4-8150)
11:35	**Jong Hee Lee, Jae Bong Lee, Chang Ik Zhang and Suam Kim** Ecosystem-based risk assessing the Korean major fisheries under climate change (S4-8100)
11:50	**Mbog Dieudonné Marius** Impacts of climate change on waterbirds, mammals, fish and fishermen in coastal systems: The case of mangroves, coral reefs and coastal lagoons in the sub-region of the Congo Basin in Central Africa (S4-8232)
12:05	**Ivonne Ortiz, Kerim Aydin and Al Hermann** *Presented by Nicholas Bond on behalf of Ivonne Ortiz* From climate to fisheries: Performance of a 40-year hindcast for the Eastern Bering Sea (S4-8009)
12:20	**Jennifer Howard and Roger Griffis** Impacts of climate change on U.S. oceans and marine resources: Technical input to the 2013 U.S. National Climate Assessment (S4-8049)
12:35	Session Summary
12:45	Session Ends

Friday, May 18 - S9

Session 9 (S9)

Marine tipping points in the earth system

Co-Convenors:
Gretta Pecl (University of Tasmania, Australia)
Martin Visbeck (IFM-GEOMAR, Germany)

Invited Speakers:
Mike Litzow (University of Tasmania, Australia)
Jacob Schewe (Potsdam Institute for Climate Impact Research, Germany)

The ocean plays a central role in the regional and global climate system. Its circulation, temperature and salinity patterns, nutrient distributions and chemical composition are mainly influenced by changes in the atmosphere and fluxes from the land. This ocean state provides the basis for the marine ecosystem, which itself has several complex interdependencies. From complex system theory we know that many systems tend to respond in an almost linear fashion to changes in the forcing. However, at some point a critical value can be reached, and the system responds with a dramatic switch-like behavior into a new stable state, having passed a critical tipping point. Evidence for tipping points in nature is often generated only after the consequences of a major shift become obvious. Predicting the existence and effects of tipping points on ocean state or ecosystem function are major, and likely increasing, challenges for both scientists and resource managers. This session aims to provide an overview of some of the known tipping points in the marine system and invites contributions to elaborate on our mechanistic understanding of these or provide evidence or a strong theoretical basis for new tipping points. Disciplines to be covered range from ocean circulation dynamics, sea ice formation, de-oxygenation, through to dramatic shifts in ecosystem structure and function, and beyond.

Friday, May 18 (11:00-13:05)

11:00 ***Introduction by Convenors***

11:05 **Jacob Schewe and Anders Levermann**
Rapid transitions in the horizontal ocean circulation (S9-8188), Invited

11:35 **Michael A. Litzow, Franz J. Mueter and Dan Urban**
Rising variance as a leading indicator of tipping points in marine ecosystems: A test using Alaskan crustacean data (S9-8113), Invited

12:00 **Elena I. Ustinova and Yury D. Sorokin**
Tipping points: Shifts in climatic variables or their relationships? Examples for the Far-Eastern Seas (S9-8184)

12:15 **Christian Möllmann, Justus van Beusekom, Rabea Diekmann, Jens Floeter and Axel Temming**
Multi-level oscillating trophodynamic control causes regime shifts in large marine ecosystem (S9-8149)

12:30 **Hongjun Li, Qing Yang and Jingfeng Fan**
Long-term responses of zooplankton in northern Yellow Sea of China: Implications of climate change (S9-7994)

12:45 **Hans-Juergen Hirche, Michael Karcher and Ksenia N. Kosobokova**
The future of Arctic zooplankton: Interplay between advection, life history traits and trophodynamics (S9-8271)

13:00 **Yury Zuenko**
Resonance effect of spawning match with spring bloom for some fish species in the Japan/East Sea (S9-8073)

13:05 Session Ends

Friday, May 18 - W1

Workshop 1 (W1)

Ocean observation: Strategic framework

Co-Convenors:
David Checkley (Scripps Institution of Oceanography, USA)
Candyce Clark (Climate Project Office, NOAA, USA)

The ocean observation workshop is to address the new multidisciplinary requirements (both climate and non-climate) being placed on the marine observing community. The primary objective of the workshop is to begin consideration of the approaches needed to move these new multidisciplinary and diverse observing requirements forward into the next decade. Particular attention will be to follow up on the discussions at the symposium theme session on "Systematic, sustained and integrated global ocean observations" that are directed at how to integrate new biogeochemical, biodiversity and ecosystem shifts observations into a sustained observing system integrated with established monitoring systems. The Framework for Ocean Observing document will serve as the foundation for these exchanges. A panel of several scientists with diverse expertise is selected to prepare short presentations and then lead the audience in discussion. An intense effort to incorporate early career scientists into the workshop is essential to ensure that a cadre of future observationalists is available.

Friday, May 18 (14:00-18:00)

14:00	***Introduction by Convenors David Checkley and Candyce Clark***
14:20	**Graham Hosie, Sonia Batten, Sanae Chiba and The GACS Board of Governance** Initiation of a Global Alliance of Continuous Plankton Recorder Surveys (GACS) (W1-8091)
14:35	Convening of Panel with remarks by other panel members (Eric Lindstrom, Pedro Monteiro, and Hee-Dong Jeong)
15:00	Discussion
16:00	***Coffee/Tea Break***
16:30	Reconvene
18:00	Workshop Ends

Saturday, May 19 - Plenary

Plenary Session

09:00	**Peter Lemke** Climate change in high-latitude oceans (General Plenary-8286)
09:35	**Hugh P. Possingham, Maria Beger, Alex Maufroy, Eddie Game, Matt Watts, Lissa Barr, Carissa Klein, Viv Tulloch, Azusa Makino, Hedley Grantham, Lucy Robinson, Christopher J. Brown, Kerrie Wilson, Eve McDonald-Madden, Eric Treml, Stuart Kininmonth and Takuya Iwamura** Marine spatial planning and risk management in the context of climate change (S6 Plenary-8239)
10:10	**Benjamin McNeil** Nature *vs* Nurture: The importance of understanding the oceans natural carbon cycle in the context of anthropogenic change (S10 Plenary-8319)
10:45	Break

Saturday, May 19 - S4

Session 4 (S4), Day 4

Climate change effects on living marine resources: From physics to fish, marine mammals, and seabirds, to fishermen and fishery-dependent communities

Co-Convenors:
Miguel Bernal (Instituto Español de Oceanografía, Spain)
Keith Criddle (University of Alaska Fairbanks, USA)
Anne Hollowed (Alaska Fisheries Science Center, NOAA-Fisheries, USA)

Invited Speaker:
Shin-ichi Ito (Tohoku National Fisheries Research Institute, Japan)

Climate change is likely to affect the biological components of marine ecosystem at various spatial and temporal scales, and will have different effects at species, population and ecosystem levels. This session covers climate-induced changes in the medium to high trophic levels of the marine ecosystem biological components, including fish, mammals, seabirds and humans. Changes in those communities expected to be analysed in the session include shifts in distribution of species, changes in fish reproduction and productivity, migratory routes, changes in the productivity of littoral habitat (*e.g.*, estuaries, marshes), changes in freshwater habitat for anadromous species, and loss in marine biodiversity. Mechanisms of individual, population and ecosystem – including humans - responses to climate change, such as marine populations acclimation and adaptation; resilience of fishery management systems; resilience of fishery dependent communities (including modern and subsistence-dependent economies) effects on management of transboundary stocks; interactions of climate and harvesting impacts on fish populations, will also be dealt with.

Saturday, May 19, Day 4 (11:00-13:05)

11:00 *Introduction by Convenors*

11:05 **Susa Niiranen, Johanna Yletyinen, Maciej T. Tomczak, Olle Hjerne and Thorsten Blenckner**
Could fishery management be used to mitigate the climate change effects on marine ecosystem function? (S4-8089)

11:20 **Melissa A. Haltuch, Nicholas A. Bond, Ian J. Stewart and Michael J. Schirippa**
Projecting U.S. west coast sablefish recruitment under global climate change scenarios (S4-8223)

11:35 **Jörn O. Schmidt, Massimiliano Cardinale, Piotr Margonski, Martin Quaas, Valerio Bartolino and Rüdiger Voss**
Optimal harvest of Baltic Sea herring under environmental change (S4-8285)

11:50 **Yi-Jay Chang, Chi-Lu Sun, Yong Chen and Su-Zan Yeh**
Modelling of the effects of climate change on population dynamics of the Taitung spiny lobster, *Panulirus penicillatus*, fishery (S4-8039)

12:05 **Z. Teresa A'mar and Martin W. Dorn**
Management strategy evaluation for the Gulf of Alaska walleye pollock (*Theragra chalcogramma*) fishery: How persistent are the environmental-recruitment links? (S4-8062)

12:20 **Huijie Xue, Stephen Cousins, Lewis S. Incze, Richard Wahle and Andrew C. Thomas**
Connectivity of Lobster Populations in the Gulf of Maine (S4-7973)

12:35	**Anne B. Hollowed, Enrique N. Curchitser and Charles A. Stock** Modeling fish and shellfish responses to climate change: Trade-offs in model complexity (S4-8144)
12:50	Session Summary
13:05	Session Ends

Saturday, May 19 - S6

Session 6 (S6)

Marine spatial planning and risk management in the context of climate change: The living ocean and coast under changing climate

Co-Convenors:
Adriaan Rijnsdorp (IMARES, The Netherlands)
Christian Möllmann (University of Hamburg, Germany)

Invited Speaker:
John K. Pinnegar (Centre for Environment, Fisheries and Aquaculture Science, Lowestoft Laboratory, UK)

Climate change will impact marine ecosystems and their habitats in various ways. Effects will include changed distribution and productivity of marine organisms, connectivity and adaptability of populations as well as overall biodiversity. The different climate-induced changes will have implications for the spatial management of our living resources and marine ecosystems. Especially migratory fish stocks move between management units leading to conflicts between resource users. Hence their dynamics will become more uncertain under climate change, and conservation objectives have to be re-defined or adapted. This session aims to discuss how climate change may affect the human activities on the sea and explore how society can adapt its policies and uses of the marine ecosystem.

Saturday, May 19 (11:00-13:05)

11:00	***Introduction by Convenors***
11:05	**John K. Pinnegar, Stephen R. Dye and Miranda Jones** Marine Protected Areas (MPAs) and climate change – Will the organisms we are trying to protect, still be there in 100 years time? (S6-8057), Invited
11:35	**Gretta T. Pecl, Jemina Stuart-Smith, Dianne Bray, Karen Edyvane, Stewart D. Frusher, Gary Jackson, Natalie Moltschaniwskyj, Melissa Nursey-Bray, Keith Rowling and Peter Walsh** Redmap: An online database and mapping resource for observational marine species data – Marine monitoring, community engagement and collaborative research effort (S6-8120)
11:55	**Thomas A. Okey, Hussein Alidina and Selina Agbayani** A preliminary climate change vulnerability assessment of Canada's Pacific Marine Ecosystems (S6-8301)
12:15	**See-Whan Kang and Ki-Cheon Jun** An overview of impacts and adaptation measures of climate change on seaports (S6-8250)
12:35	**Felipe Briceño, Stewart D. Frusher, Caleb Gardner, Rafael León, Sean R. Tracey, Jeffrey M. Dambacher and Gretta T. Pecl** Exploring the effect of environment and fishing pressure on a key prey/predator interaction: Signals from an 'early warning' fishery within a global hotspot region (S6-8080)
12:55	**David Vousden, Magnus Ngoile and Warwick H.H. Sauer** Building a regional alliance for sustainable science and governance in the Western Indian Ocean large marine ecosystems (S6-7964)
13:15	Session ends

Saturday, May 19 - S10

Session 10 (S10)

Changes in the marine carbon cycle

Co-Convenors:
James Christian (Department of Fisheries and Oceans, Canada)
Kitack Lee (POSTECH, Korea)

Invited Speaker:
Dr. Masao Ishii (Meteorological Research Institute, Japan)

The carbon cycle is the primary mechanism by which ocean processes determine future atmospheric CO_2 concentration and associated climate changes. Ocean acidification affects all marine biota and future ocean carbon fluxes and ocean-atmosphere CO_2 exchange. This session includes presentations on the ocean carbon cycle, its interactions with the biogeochemical cycles of nitrogen and other nutrient elements, and ocean acidification. Processes of interest are ocean-atmosphere exchange, fluxes across the pycnocline, interactions of CO_2 with the carbon cycle that determine the future course of ocean acidification and ocean CO_2 concentration, and acidification impacts on biota.

Saturday, May 19 (11:00-14:00)

11:00 ***Introduction by Convenors***

11:05 **Masao Ishii, Takashi Midorikawa, Daisuke Sasano, Naohiro Kosugi, Toshiya Nakano and Hisayuki Y. Inoue**
An overview of the ocean CO_2 increase in the western North Pacific subtropical and tropical zones (S10-8179), Invited

11:35 **Pedro M.S. Monteiro and Christopher Sabine**
Global Ocean Carbon Observations: Decadal challenges in addressing and understanding global climate and ocean ecosystem change (S10-8312)

11:55 **Samar Khatiwala, Toste Tanhua, Christopher Sabine and Richard A. Feely**
Ocean acidification over the industrial era constrained from tracer observations (S10-8177)

12:15 **Jae-Yeon Kim, Dong-Jin Kang, Tongsup Lee and Kyung-Ryul Kim**
Decadal trend of carbon dioxide and ocean acidification in the surface water of the Ulleung Basin, the East/Japan Sea (S10-8098)

12:35 **Naoki Yoshie, Naoki Fujii, Xinyu Guo, Tomohiro Komorita and Atsuhiko Isobe**
Nutrient and phytoplankton responses to the intrusion of oceanic warm water in the western Seto Inland Sea, Japan (S10-8097)

12:55 **Kyung-Su Kim JeongHee Shim and Suam Kim**
Effect of elevated carbon dioxide in seawater on the early life history of olive flounder, *Paralichthys olivaceus* (S10-8206)

13:15 **Olubunmi Ayoola Nubi**
Influence of equatorial upwelling on biological productivity in the eastern equatorial Atlantic (S10-7965)

13:35 **Tae-Wook Kim, Raymond G. Najjar and Kitack Lee**
Enhanced phytoplankton production in the US east coast due to precipitation containing nitrate (S10-8104)

13:55 Discussion

14:00 Session Ends

Saturday, May 19 - Closing

Closing Plenary Session

14:30	**Keith Alverson and Martin Visbeck** Climate change: Mitigation and adaptation policy (General Plenary-8186)
15:05	**Corinne Le Quere** Summary
15:40	Closing Plenary Session Ends

Sunday, May 20 - W6

Workshop 6 (W6)

Climate change and range shifts in the ocean: Detection, prediction and adaptation

Co-Convenors:
Amanda Bates (University of Tasmania, Australia)
Gretta Pecl (University of Tasmania, Australia)
Stewart Frusher (University of Tasmania, Australia)
Alistair Hobday (CSIRO Marine and Atmospheric Research, Australia)
Warwick Sauer (Rhodes University, South Africa)
David Vousden (UNDP GEF Agulhas and Somali Currents Large Marine Ecosystems Project, South Africa)
Thomas Wernberg (University of Western Australia, Australia)

Invited Speakers:
Alistair Hobday (CSIRO Marine and Atmospheric Research, Australia)
Warwick Sauer (Rhodes University, South Africa)
Thomas Wernberg (University of Western Australia, Australia)

Climate change driven changes in the phenology, distribution and abundance of marine species are being reported around the globe. Distributional changes are the most commonly reported, sometimes involving shifts of 100's of km. Changes in exploited species may subsequently affect the utilization of marine resources, with ramifications that range from fishers' profitability and livelihoods to food security, poverty and social cohesion. Despite this importance, there are currently limitations to the detection and prediction of range shifts. Overcoming these is critical for policy adaptation to manage shifting marine resources in order to enhance food security.

Ocean warming "hotspots", or regions where ocean temperatures are rising most rapidly represent an opportunity to quickly advance our understanding of factors limiting detection of range shifts and to formulate predictions of future changes. We aim to develop of an inter-disciplinary team representing ocean "hotspots" from around the globe to identify knowledge gaps in the detection and prediction of range shifts at different temporal and spatial scales. Adaptation responses to the predicted changes should be robust to uncertainty in both detection and prediction, and shared experience is critical to minimize independent adaptation failures. We also target to identify and further develop effective mechanisms for translating scientific information into active management guidelines and policy for adaptive governance that can respond to ecosystem variation.

The main objective of this 1-day workshop is to lay the groundwork to develop contextually relevant response strategies to ensure sustainable resource use, management and food security by addressing the following three themes:

1. *Detection*: methods to quantify climate driven range extensions and contractions at different time scales;
2. *Prediction*: biological responses in ocean warming "hotspots" that can advance our understanding of likely changes both at hotspots and in a wider set of regions;
3. *Adaptation*: marine resource management, policy and governance responses to species range shifts for present and into the future, and at different spatial scales.

The main outcome of the workshop are expected to be: (1) a conceptual model of mechanisms, consequences and feedbacks involved in species range shifts, outlining critical links between detection, prediction and adaptation (this model will be developed into a publication for a high profile journal such as Nature Climate Change), (2) a workshop report, and (3) a summary article in PICES Press. The outputs from the workshop will be featured on Marine Hotspots website (www.marinehotspots.org).

Sunday, May 20 (09:00-17:30)

09:00	***Introduction by Convenors***
09:10	Participants introduction
09:20	**Thomas Wernberg, Amanda E. Bates, Gretta T. Pecl, Alistair Hobday and Dan Smale** Climate change and range shifts in the ocean, Theme 1: DetectionDetecting species distribution shifts with climate warming to inform adaptation (W6-8108), Invited
09:55	**Alistair Hobday, Gretta T. Pecl, Amanda E. Bates and Jennifer Sunday** Climate change and range shifts in the ocean, Theme 2: PredictionPredicting species' distribution shifts with climate warming: The role of monitoring and modelling in adaptation (W6-8109), Invited
10:30	***Coffee/Tea Break***
11:00	**Warwick H.H. Sauer, Stewart D. Frusher, David Vousden and Renae C. Tobin** Climate change and range shifts in the ocean, Theme 3: Adaptation to species distribution shifts with climate warming: Marine resource management, policy and governance responses for present and into the future (W6-8110), Invited
11:35	Workshop objectives and structure Break-out session 1
12:30	***Lunch***
14:00	Break-out session 2
15:30	***Coffee/Tea Break***
16:00	Full group discussion Action itemization
17:30	Workshop Ends

Sunday, May 20 - W7

Workshop 7 (W7)

Beyond dispersion: Integrating individual-based models for bioenergetics and behavior with biophysical transport models to predict influences of climate change on recruitment processes in marine species

Co-Convenors:
William T. Stockhausen (Alaska Fisheries Science Center, NOAA-Fisheries, USA)
Sukyung Kang (National Fisheries Research and Development Institute, Korea)
Carolina Parada (INPESCA, Chile)

Invited Speakers:
Shin-ichi Ito (Tohoku National Fisheries Research Institute, Japan)
Myron Peck (Institute for Hydrobiology and Fisheries Science, Hamburg, Germany)

Future climate change is expected to influence the abundance and distribution of marine fish species in complex ways, including changes in the local environmental characteristics and transport pathways experienced by early life stages that are typically pelagic, such as eggs and larvae. To date, numerous coupled biophysical models have been developed to study the influence of oceanographic transport patterns on dispersion of early life stages and recruitment variability in marine fish species. In many of these models, advective oceanographic processes are hypothesized to be the main determinant of recruitment variability; simulated individuals in the models are regarded primarily as passive particles or drifters and "success" is judged by the relative number of simulated particles that end up being advected to suitable juvenile nursery grounds. While these models represent an important step in our ability to understand and predict the effects of climate change on recruitment, they ignore important effects (temperature/salinity stress, food availability, etc.) on growth and survival associated with the environmental conditions encountered by the (simulated) individuals along their drift trajectories. While individual-based bioenergetic models can be used to address the impact of local environmental variation on the growth and survival of eggs and larvae, few bioenergetics models have been targeted toward early marine life stages, few coupled biophysical models incorporate bioenergetic considerations, and fewer still have been used to address the potential impact of climate change on marine species.

The objectives of this 1-day workshop are to: (1) stimulate the integration of bioenergetic considerations within coupled biophysical modes by bringing together researchers with expertise in bioenergetic models for early marine life stages and researchers with expertise in coupled biophysical models to facilitate cross-discipline communication; and (2) discuss state-of-the-art techniques and develop guidelines and "best practices" for incorporating individual-based bioenergetics models within existing or future coupled biophysical models to improve the biological realism associated with these latter models.

Anticipated products from the workshop include a workshop report and a white paper on best practices toward integrating bioenergetics considerations into individual-based coupled biophysical models.

Sunday, May 20 (09:00-17:30)

09:00	***Introduction by Convenors***
09:10	**Myron A. <u>Peck</u>, Klaus Huebert, Marc Hufnagl and Joel K. Llopiz** Integrating marine fish physiology, behaviour and physical constraints into early life stage biophysical IBMs: Recent advances and future challenges (W7-8148), Invited
09:40	**Shin-ichi <u>Ito</u> and Takeshi Okunishi** Beyond dispersion: How to model migration of Japanese sardine (*Sardinops melanostictus*) in the western North Pacific (W7-8266), Invited

10:10 **Carolina Parada, Javier Porobic and Sebastián I. Vásquez**
Understanding climate change through the coupling of bioenergetic and biophysical models: A review of the state-of the art, constraints and challenges (W7-8290)

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

11:10 **Jung Jin Kim, William T. Stockhousen, Yang-Ki Cho, Chang Sin Kim and Suam Kim**
Influence of ontogenetic vertical migration on transport processes of common squid (*Todarodes pacificus*) larvae in the East China Sea using a coupled behavioral-physical model (W7-8258)

11:40 **Sukgeun Jung, Ig-Chan Pang, Joon Ho Lee and Ilsu Choi**
Spatially-explicit, individual-based model for Pacific anchovy in Korean waters (W7-8035)

12:00 **Min-Jung Kim, Seok-Hyun Youn, Jin Yeong Kim and Chul-Woong Oh**
Diet of anchovy *Engraulis japonicus* in the southern coastal waters of Korea (W7-8256)

12:20 **Iskhaq Iskandar, Hideharu Sasaki, Yoshikazu Sasai, Yukio Masumoto and Keisuke Mizuno**
Eddy-induced chlorophyll bloom in the southeastern tropical Indian Ocean during Indian Ocean Dipole event (W7-8199)

12:40 ***Lunch***

14:00 **Sylvain Bonhommeau, Philippe Verley, Gwendoline Andres, Jean-Marc Fromentin, Anne Elise Nieblas and Christophe Lett**
Coupling a particle-tracking model (Ichthyop) and a bio-energetic model (Dynamic Energy Budget theory) to estimate Atlantic bluefin tuna larval survival in the Mediterranean Sea (W7-8185)

14:20 Questions and answers for presenters

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

16:00 Roundtable Discussion

17:30 Workshop Ends

Schedules
Poster Presentations

S1 Posters

Climate variability versus anthropogenic impacts; analysing their separate and combined effects on long-term physical, biogeochemical and ecological patterns

S1-P1 **Sommart Niemnil, Marc Naeije and Itthi Trisirisatayawong**
Sea surface height variability in the Gulf of Thailand and South China Sea using altimetry data

S1-P2 **Keun-Hyung Choi, Young-Bak Son and Hyung-Ku Kang**
Recent collapse of the copepods in the northern East China Sea: Effects of Three Gorges Dam?

S1-P3 **Vladimir I. Ponomarev, Elena V. Dmitrieva, Vera A. Petrova, Svetlana P. Shkorba, Lubov N. Kuimova and Pavel P. Sherstyankin**
Multiple scale climate variability in the Asian Pacific: Teleconnections and anthropogenic effect

S1-P4 **Viktoria Platonova**
Changes of extreme events in regional climate simulations for Russian Far East

S1-P5 **Sang Heon Lee, SeungHyun Son, Jae-Hyun Lim, Jae-Hoon Noh and Jae-Il Kwon**
Satellite observations of decadal changes in the Japan/East Sea phytoplankton chlorophyll-*a* concentration

S1-P6 **Roksana Jahan and Joong Ki Choi**
Interdecadal variations in phytoplankton communities associated with rapid regional climate change in the Gyeonggi Bay

S2 Posters

Systematic, sustained and integrated global ocean observations

S2-P1	**Qingyang Song and Huaming Yu** Tidal information of Chinese Seas from altimetric data
S2-P2	**Artem Sarafanov, Anastasia Falina, Herlé Mercier, Alexey Sokov, Pascale Lherminier, Claire Gourcuff, Sergey Gladyshev, Fabienne Gaillard and Nathalie Daniault** Present-day state of the gyre/overturning circulation at the northern periphery of the Atlantic Ocean: An estimate based on repeat hydrographic measurements and satellite altimetry data
S2-P3	**K. Maneesha and Y. Sadhuram** Importance of stratification, upper ocean heat content and eddies in the genesis and intensification of storms over Bay of Bengal
S2-P4	**Nadezda M. Vakulskaya** Analysis of spatio-temporal distributions of ice characteristics in the Bering Sea
S2-P5** *Moved to Oral*	**Che Sun and Lin Zhang** Interannual variability of the Antarctic Circumpolar Current strength based on merged altimeter data
S2-P6 *Cancelled*	**Dmitry K. Staritsyn and Polina V. Lobanova** Features of spatial and temporal sea level variability in the Japan and Okhotsk Seas based on satellite altimeter data
S2-P7	**Hak-Soo Lim, Chang S. Kim, Kwang-Soon Park and Insik Chun** Operational oceanographic system for the coastal waters of Korea using ROMS
S2-P8	**Igor E. Stepochkin and Pavel A. Salyuk** Estimation of phytoplankton communities' state from satellite ocean color scanners
S2-P9	**Hyoung Chul Shin, Hyoungsul La and Sung-Ho Kang** Sea ice records and some limited ocean measurements from a small Antarctic coastal embayment; Trends and implications
S2-P10	**Roksana Jahan, Hyu Chang Choi, Young Seuk Park, Young Cheol Park, Ji Ho Seo and Joong Ki Choi** Implementation of Self-Organizing Maps (SOM) to analyses of environmental parameters and phytoplankton biomass in a macrotidal estuary and artificial lake
S2-P11	**Oleg A. Bukin, Pavel A. Salyuk and Igor E. Stepochkin** Reproduction efficiency of dissolved organic matter by phytoplankton cells as the indicator of climate changes influence on the phytoplankton communities' state
S2-P12	**Vladimir A. Krikun, Konstantin S. Kluger and Pavel A. Salyuk** Analysis of the relationships between chlorophyll *a* and dissolved organic matter (DOM) concentrations depending on type of the DOM

S3 Posters

Projections of climate change impacts on marine ecosystems and their uncertainty

S3-P1 **Aleksey Bobrikov and Shmirko Konstantin**
The role of atmospheric aerosol in temperature field formation in the Primorsky region

S3-P2 **Oleg A. Bukin, Yuri N. Kulchin and Andrey N. Pavlov**
Complex investigation of basic climate-forcing factors in the northwest part of the Pacific Ocean

S3-P3 **Konstantin A. Shmirko and Oleg A. Bukin**
The impact of climate-forcing factors of the north-western Pacific on radiative budget

S3-P4 **Byung Ho Choi, Jin-Hee Yuk and Byung Il Min**
Effects of global warming on the oceanic systems of the northwest Pacific Ocean (S3-8195)

S3-P5 **Inkweon Bang and Kwang-Yul Kim**
Climate change in the northwest Pacific as seen in the SRES A1B simulations of AR4 models

S3-P6** *Moved to Oral* **Tomohiro Yasuda, Yusuke Tanaka, Junichi Ninomiya, Sota Nakajo, Nobuhito Mori and Hajime Mase**
Hindcast and historical assessment of Cyclone Tomas and climate change impact analysis on tropical cyclones in the South Pacific

S3-P7* **Mari S. Myksvoll, Anne D. Sandvik, Lars Asplin and Svein Sundby**
Presented by Svein Sundby on behalf of Mari S. Myksvoll
Impacts of variations in river runoff on coastal cod subpopulations

S3-P8 **Shiro Nishikawa, Yoichi Ishikawa, Shuhei Masuda, Hiromichi Igarashi, Yoshihisa Hiyoshi, Yuji Sasaki, Haruka Nishikawa, Takashi Mochizuki, Shigeki Hosoda, Kanako Sato and Toshiyuki Awaji**
Development of a global 4D-VAR data assimilation and forecast system focusing on climate variability in the North Pacific and use of Argo profiling data: Experiment of 2010–2011

S3-P9 **Sei-Ichi Saitoh, I. Nyoman Radiarta, Yang Liu and Toru Hirawake**
Potential impact of climate variability on Japanese scallop aquaculture in southern Hokkaido, Japan

S4 Posters

Climate change effects on living marine resources: From physics to fish, marine mammals, and seabirds, to fishermen and fishery-dependent communities

S4-P1 **Md. Kawser Ahmed and Shamima Sultana**
Impacts of climate change on the coastal fisheries resources of Bangladesh

S4-P2* **Andrés H. Arias, Carla V. Spetter, Rubén H. Freije and Jorge E. Marcovecchio**
30 years of oceanographic monitoring at the south Atlantic: Highlights of climate change

S4-P3 **Jabeur Chédia**
Role of sea surface temperature and rainfall in the fluctuation of production and abundance of the stock of the common octopus in the East of Tunisia

S4-P4 **S. Kalei Shotwell, Igor M. Belkin and Dana H. Hanselman**
In the path of the polar front: Extracting environmental time series from a large scale oceanographic feature with application to the Alaska sablefish stock assessment

S4-P5 **Wen-Tseng Lo, Hung-Yen Hsieh and Shwu-Feng Yu**
Comparison of siphonophore assemblages under the influence of two different monsoon seasons in the Taiwan Strait, western North Pacific

S4-P6 **Hideaki Kidokoro**
What was the major factor causing the change in the migration pattern of Japanese common squid *Todarodes pacificus* associated with the 1989 regime shift?

S4-P7 **Chang Ik Zhang, Jong Hee Lee, Anne B. Hollowed, Chan Joo Jang and Jae Bong Lee**
An IFRAME approach for estimating exploitable biomass of fish stocks changing climate

S4-P8 **Yeong Gong and Young Sang Suh**
Climate change and fluctuations of pelagic fish populations in the Far-East region

S4-P9* **Alexander V. Zavolokin**
Presented by Elena I. Ustinova on behalf of Alexander V. Zavolokin
Variations in abundance, body size, age, and growth of chum salmon in relation to climate changes and density-dependent interactions

S4-P10 **Hyunju Seo, Sukyung Kang, Yu-xue Qin, Kohei Matsuda and Masahide Kaeriyama**
Long-term variation in the relative abundance and body size of Pacific Salmon, *Oncorhynchus* species

S4-P11 **Dawit Yemane, Janet Coetzee, Carl D. van der Lingen and Nandipha Twatwa**
Modelling the distribution of small pelagic fish species in the Southern Benguela using remotely-sensed data

S4-P12 **Dawit Yemane, Nandipha Twatwa and Janet Coetzee**
The performance of multiple species distribution models in replicating the distribution of small pelagic fish in the Southern Benguela

S4-P13 **Juan P. Zwolinski and David A. Demer**
Fish story repeats itself

S4-P14 **Grace Aroella-Jarvie and Thomas A. Okey**
Expert survey of climate change and marine life: Gulf of California to the Beaufort Sea

S4-P15 **Ming-An Lee, Pei-Yuan Wang, Mu-Tun Tzeng, Yi Chang and Kuo-Wei Lan**
Effects of long-term environment variability on the gray mullet (*Mugil cephalus* L.) abundance in the Taiwan Strait

S4-P16 **Nina Karnovsky, Zachary Brown, Jorg Welcker, Ann Harding, Wojciech Walkusz, Slawomir Kwasniewski, David Grémillet and Alexander Kitaysky**
Arctic auks, advection and oscillations: The impact of climate change on planktivores of the Greenland Sea

S4-P17 **Steve P. Kirkman, Dawit Yemane, W. Herman Oosthuizen, Mike A. Meÿer, Deon Kotze, H. Skrypzeck, F. Vaz Velho and L.G. Underhill**
Going the wrong way? Changes in distribution of the cape fur seal *arctocephalus pusillus pusillus* (southern Africa, 1972-2009)

S4-P18 **Jae Bong Lee, Young Shil Kang, Peter-John Hulson, Chang Ik Zhang, Dong Woo Lee, Yang Jae Im and Hee Yong Kim**
Climate forcing and the Yellow Sea/East China Sea ecosystem

S4-P19 **Chen-Te Tseng, Chi-Lu Sun, Su-Zan Yeh, Shih-Chin Chen, Don-Chung Liu and Wei-Cheng Su**
Influence of oceanographic variability on the spatio-temporal distributions of Pacific saury (*Cololabis saira*)

S4-P20 **Suchana Chavanich, Voranop Viyakarn and Daiki Nomura**
Effect of climate change on feeding preference of Antarctic fish

S4-P21 **Yi-Jay Chang, Chi-Lu Sun, Yong Chen, Su-Zan Yeh and Gerard Dinardo**
Modelling the impacts of environmental variation on the habitat of swordfish, *Xiphias gladius*, in the North Atlantic Ocean

S4-P22 **John G. Ramirez, Gina M. Puentes and Francisco J. Reyes**
A link between the phase-shift Niño-Niña phenomenon and faunistic composition of small scale fisheries in the Colombian Caribbean

S4-P23 **Caroline Brown, Nicole M. Braem, Catherine Moncrieff and Lauren Sill**
Natural indicators and climate change in Emmonak, Alaska

S4-P24 **Nam-Il Won, Kawamura Tomohiko, Hideki Takami and Yoshiro Watanabe**
Climate effects on marine benthic organisms: A case study of an abalone *Haliotis discus hannai* on the Pacific coast of northern Japan

S4-P25 **Andhika Prima Prasetyo, Zhaohui Yin, Hanggar Prasetyo Kadarisman, Setiya Tri Haryuni and Puput Fitri Rachmawati**
Time-lag and EOF analysis for study of environment impact to Purse Seine fisheries in Java Sea

S4-P26 **Haruka Nishikawa, Toshiyuki Awaji, Yoichi Ishikawa, Masafumi Kamachi, Hiromichi Igarashi, Shuhei Masuda, Toshimasa Doi, Shiro Nishikawa, Yoshihisa Hiyoshi, Yuji Sasaki, Takashi Mochizuki, Hiroshi Ishizaki, Yoshikazu Sasai, Hideharu Sasaki, Mitsuo Sakai, Yoshiki Kato and Shin-ichi Sato**
Impact of environmental variability in the Kuroshio Extension on neon flying squid stock

S4-P27 **Heeyong Kim, Dae Hyun Kim and Hak Jin Hwang**
Effect of Siberian High and global warming on the catch fluctuation of pacific cod, *Gadus macrocephalus*, in the Yellow Sea

S4-P28 **Liviu-Daniel Galatchi**
Impacts of climate change on the Black Sea marine and coastal environment

S4-P29 *Cancelled* **Daniel P. Costa, Patrick W. Robinson, Daniel E. Crocker, Louis A. Huckstadt, Samantha E. Simmons, Chandra Goetsch, Kimberly T. Goetz, Jennifer Maresh and Sarah H. Peterson**
Foraging behavior of a widely ranging meso-pelagic top predator, the northern elephant seal

S4-P30 *Cancelled* **Chandra Goetsch, Patrick W. Robinson, Sarah H. Peterson, Greg A. Breed, Sara M. Maxwell, Melinda A. Fowler, Nicole M. Teutschel, Samantha E. Simmons, Daniel E. Crocker and Daniel P. Costa**
The changing face of El Niño: The influence of a strong central pacific El Niño on the foraging behavior of northern elephant seals

S5 Posters

From genes to ecosystems: Genetic and physiological responses to climate change

S5-P1	**Ying Cui, Ying Wu and Jing Zhang** Trophic strategy of biota in a tropical estuarine ecosystem indicated by fatty acid composition
S5-P2	**Guo Ying Du, Yuxiang Mao and Ik Kyo Chung** Responses of intertidal microphytobenthos community to environmental factors
S5-P3	**YoonSeok Choi, PyoungJoong Kim, KwangJae Park, JaeHee Song, SangOk Chung, SangPil Yoon and KyoungHo An** The effect of geochemical characteristics and climate change on the growth of cultured clams at Taean tidal flat on the west coast of Korea
S5-P4	**Jee Eun Lee, Sang-Rae Lee, Jung Hyun Oak, Jin Ae Lee and Ik Kyo Chung** Dynamic feature of eukaryotic plankton biodiversity in the Nakdong River system, Korea
S5-P5	**Ju-Hyoung Kim, Eun Ju Kang, Kwang Young Kim and Kitack Lee** Impact of ocean acidification on five species of macroalgae
S5-P6	**David I. Kline, Lida Teneva, Kenneth Schneider, Thomas Miard, Aaron Chai, Malcolm Marker, Jack Silverman, Ken Caldeira, Brad Opdyke, Rob Dunbar, B. Greg Mitchell, Sophie Dove and Ove Hoegh-Guldberg** A 6-month *in situ* ocean acidification experiment at Heron Island
S5-P7	**Ah-Ra Ko, Se-Jong Ju, Moonkoo Kim, Seok-Gwan Choi and Kyung-Hoon Shin** Developing a biochemical index to track physiological adaptations of cetaceans to environmental changes
S5-P8	**Se-Joo Kim and Se-Jong Ju** Gene expression of cytochrome P450 in *Euplotes crassus* (Ciliophora, Hypotrichida) under conditions of ocean acidification: Lab trial
S5-P9	**Jennifer Sunday, Amanda E. Bates and Nicholas K. Dulvy** Marine species' latitudinal distributions conform better to their thermal tolerance than terrestrial species: Implications for range shifts
S5-P10	**Jin Yeong Kim, HaeYoung Moon Lee, Mun-Seong Choi and Sungchul C. Bai** Evaluation of fatty acids as trophic indicators for the anchovy population in the southern coastal waters of Korea

S6 Posters

Marine spatial planning and risk management in the context of climate change: The living ocean and coast under changing climate

S6-P1	**Alexandra Temnykh, Victor Melnikov, Yuriy Tokarev and Mikhail Silakov** State of plankton community of the Zernov's Phyllophora Field (Black Sea) in 2010-2011
S6-P2 *Cancelled*	**Vaughan Ituk** Responses to climate change: Past, present, and future
S6-P3*	**Vitaly I. Sychev and Dmitri A. Petrenko** *Presented by Dmitri A. Petrenko on behalf of Vitaly I. Sychev* Spaceborne investigation of the long-term variations of primary productivity and sea ice conditions in the Arctic Basin

S7 Posters

Coastal and low-lying areas

S7-P1	**Md. Kawser Ahmed and Shamima Sultana** Adaptation strategies in coping with the impacts of global climate change on the coastal environment and resources of Bangladesh
S7-P2*	**Hyun-Min Eom, KiRyong Kang, Sang Boom Ryoo and Yong Hee Lee** *Co-Authors are not participating in the Symposium* A numerical simulation of storm surge and coastal inundation under the future climate condition
S7-P3*	**Maksim Gulin, Kateryna Ivanova, Vitaly Timofeev and Mikhail Kovalenko** *Presented by Kateryna Ivanova on behalf of Maksim Gulin* Black Sea hot-spot environments and ecosystems: Future of deltas and riverbeds flooded by sea

S8 Posters

Trend and impacts of de-oxygenation in oceanic and coastal ecosystems

S8-P1* **Svetlana Pakhomova, Evgeny Yakushev, Hans Fredrik Veiteberg Braaten, Jens Skei and Kai Sørenson**
Presented by Evgeny Yakushev on behalf of Svetlana Pakhomova
Oxygen intrusions into anoxic fjords: Positive and negative effects

S8-P2** *Moved to Oral* **Pavel Tishchenko, Vyacheslav B. Lobanov, Tatyana Mikhajlik, Pavel Semkin, Alexander Sergeev, Petr Tishchenko and Vladimir Zvalinsky**
Presented by Vyacheslav Lobanov on behalf of Pavel Tishchenko
Seasonal hypoxia of Amurskiy Bay (Japan/East Sea)

S8-P3 **Daisuke Sasano, Masao Ishii, Takashi Midorikawa, Yusuke Takatani, Toshiya Nakano, Takayuki Tokieda and Hitomi Kamiya**
Oxygen decrease in the western Pacific along 165°E

S8-P4 **Mi Jin Kim, Se-Jong Ju, Chan Min Yoo and Jung-Ho Hyun**
Understanding the role of bacteria in the oxygen minimum zone (OMZ) in the carbon cycle

S8-P5 **Kateryna Ivanova, Maksim Gulin and Vitaly Timofeev**
Black Sea Holocene gas seeps as hot-spot environments with opposing natural properties: Zoobenthos high-activity and strong hypoxia coupled by H_2S contamination

S9 Posters

Marine tipping points in the earth system

S9-P1 **Marcos Llope, Thorsten Blenckner, Christian Möllmann, Michele Casini and Nils Chr. Stenseth**
The Baltic Sea regime shift, can it flip back?

S9-P2 **Olga Trusenkova and Dmitry D. Kaplunenko**
East-west regime shifts in the Japan/East Sea

S9-P3 **Dawit Yemane, Yohannes Itembu, Steve P. Kirkman, Bjorn Axelsen and Toufiek Samaai**
Investigation of common temporal trends in the major demersal fish populations in the Benguela Current Large Marine Ecosystem, 1985-2010

S9-P4 **Jin-Soo Kim, Kwang-Yul Kim and Sang-Wook Yeh**
El Niño change associated with subsurface ocean in greenhouse gas forcing scenarios

S10 Posters

Changes in the marine carbon cycle

S10-P1 **Dmitri A. Petrenko, E. Zabolotskih, D. Pozdnyakov and Vitaly I. Sychev**
Quantitative estimation of an annual inorganic carbon production in the Arctic Ocean by coccolithophore during 1998-2010 from synergistic remote sensing data

S10-P2* **Pavel Tishchenko, Galina Pavlova and Elena Shkirnikova**
Presented by Vyacheslav Lobanov on behalf of Pavel Tishchenko
Total alkalinity and calcium of the Japan/East Sea

S10-P3 **L.K. Sahu, S. Lal and S. Venkataramani**
Change in oceanic emissions of light alkenes due to monsoon circulations over northern Indian Ocean

S10-P4 **Yeon Jee Suh, Sangmin Hyun and Chan Hong Park**
Preliminary study on sedimentary organic matter variations in the East/Japan Sea

S10-P5 **Sangmin Hyun and Irino Tomohisa**
Paleoclimate and paleoceanographic variations based on foraminiferal isotope study in shelf sediment of the East/Japan Sea, Korea

General Session (GP) Posters

GP-P1 **Vladimir V. Plotnikov and Evgeniy M. Semenova**
Change of seasonal rhythms of ice processes by the Peter the Great Bay (Japan Sea) in the second half of the 20th - beginning of the 21st centuries

GP-P2 **Victoriia Saklakova and Pavel A. Salyuk**
Influence of Asian dust storms on the state of phytoplankton communities

GP-P3 **Keunyong Kim, Byung Ju Gong, Ju-Hyoung Kim and Kwang Young Kim**
The fate of floating macroalgal bloom in Yellow Sea during late July of 2011

GP-P4 **Olga Skaberda, Lubov Vasilevskaya and Viktoria Platonova**
Investigation of interactions between temperature and precipitation on Kamchatka Peninsula

GP-P5 Cancelled **Mª Luz Fernández de Puelles, Laura Vicente and Valle Macias**
Summer and winter zooplankton abundance and biodiversity in two oligotrophic areas of the Central Western Mediterranean Sea

GP-P6 **Dominic O. Odulate, Waheed O. Abdul and Yemi Akegbejo-Samsons**
Influence of ocean water quality on diversity of marine fauna resources in the Gulf of Guinea, off Ogun State Southwest Nigeria

GP-P7 **Gyung-Soo Park**
Preliminary plans of marine biodome for the studies of climate change and ecosystem management in Korea

GP-P8 **Alexander Turra, Ângelo F. Bernardino, A. Cecília Z. Amaral, Flavio A.S. Berchez, Joel C. Creed, Margareth S. Copertino, Ricardo Coutinho and Yara Schaeffer-Novelli**
Evaluating the effect of climate changes on marine biodiversity: The ReBentos (Network for Monitoring Coastal Benthic Habitats) initiative in Brazil

GP-P9* **Talgat R. Kilmatov**
The model of catastrophe theory to apply to the possible climatic trends

GP-P10 **Irina A. Golik and Pavel A. Salyuk**
Analysis of tropical cyclones influence on phytoplankton communities in the North-western Pacific in 2002-2011 on the basis of satellite ocean color data

GP-P11 **Gwang-Ho Seo, Yang-Ki Cho and Byoung-Ju Choi**
Seasonal and inter-annual variation of volume and heat transport in the Northwest Pacific marginal seas based on high resolution regional reanalysis

GP-P12 **Mi Hee Chung, Seok-Hyun Youn and Minjung Kim**
Temporal and spatial variation of phytoplankton communities in the Nakdong River, estuary and coastal areas

GP-P13* **Hyun-Ki Hong, Hyun-Sil Kang, Hee-Do Jeung, Hee-Jung Lee, Arumi Park and Kwang-Sik Choi**
Effect of air exposure on hemocyte parameters of abalone *Sulculus diversicolor supertexta* from Jeju Island, Republic of Korea

GP-P14* **Hyun-Sil Kang, Jee-Yeon Lee, Hyun-Ki Hong, Young-Ok Kim and Kwang-Sik Choi**
Molecular diagnostics of the ovarian parasite *Marteilioides chungmuensis* in wild Pacific oysters *Crassostrea gigas* on the south coast of Korea

GP-P15* **Mostafizur Rahman Mondol, Hyun-Ki Hong, Areumi Park, Heung-Sik Park, Won Joon Shim and Kwang-Sik Choi**
Impacts of *Hebei Spirit* oil spill on wild Pacific oyster, *Crassostrea gigas*, two years after the accident in Taean, Korea

W2 Posters

Climate change projections for marine ecosystems: Best practice, limitations and interpretations

W2-P1 **Alexey V. Golikov, Rushan M. Sabirov, Pavel A. Lubin and Lis L. Jørgensen**
Changes in Structure of Teuthocenosis (Cephalopoda) of the Arctic due to climatic changes of the last decades

W6 Posters

Climate change and range shifts in the ocean: Detection, prediction and adaptation

W6-P1 **Alexandra H. Campbell, Ezequiel M. Marzinelli, Tamsin A. Peters, Rebecca Neumann and Peter D. Steinberg**
Climate-mediated diseases affecting habitat-forming seaweeds: Complex environmental effects on hosts and pathogens

W6-P2 **Sukgeun Jung and Ilsu Choi**
Latitudinal shifts in catch distribution of fisheries species in Korean waters during the past 30 years in relation to climate change

W6-P3 **John K. Pinnegar, Georg H. Engelhard and Tina Kerby**
Range shifts in the North Sea: Why is life so complicated?

W6-P4 **Hans-Juergen Hirche, Michael Karcher and Ksenia N. Kosobokova**
The future of Arctic zooplankton: Interplay between advection, life history traits and trophodynamics

W6-P5 **Corinne Pomerleau, Gesche Winkler, Akash R. Sastri, R. John Nelson, Svein Vagle, Véronique Lesage and Steven H. Ferguson**
Spatial patterns in zooplankton communities across the eastern Canadian sub-Arctic and Arctic waters: Insights from stable carbon (δ13C) and nitrogen (δ15N) isotope ratios

W6-P6 **Edmo J.D. Campos**
Changes in the South Atlantic-Indian Ocean super-gyre due to poleward shift of the southern hemisphere westerlies

W6-P7 **Paul R. Lyon**
Risk-based approach to manage the impacts of climate change on Canada’s aquatic resources

W6-P8 **Amina H. Khan, ElisabethLevac and Gail L. Chmura**
Potential impact of global warming on ranges of commercial fish species in the Northwest Atlantic

Abstracts
Oral Presentations

Plenary Session Presentations

May 15

May 15, 10:45

Ecosystem responses to climate variability and anthropogenic-induced changes

Kenneth F. **Drinkwater**

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Marine ecosystems respond both to natural climate variability and to anthropogenic-induced changes. Examples of ecological responses to the combined effects of climate variability and climate change will be provided from both the Pacific and Atlantic subarctic seas with emphasis on elaborating, where possible, the mechanisms linking climate and the observed changes in the ecosystem. How the responses vary as a function of frequency will also be described. In recent years many of the climate changes and their resultant ecosystem responses have been attributed to global climate change. These attributions will be explored including reviewing the recommendations of the IPCC on how to determine if climate changes are anthropogenic-induced or not. Perhaps a more important challenge is separating out the ecosystem responses to other anthropogenic changes such as ocean acidification, fishing, pollution, *etc.* from those caused by climate. These challenges and what needs to be done to address these issues will also be discussed.

May 15, 11:20

From transcriptomes to bugs: Using 'omics to understand climate responses of marine zooplankton

Ann **Bucklin**, Ebru Unal and Paola G. Batta-Lona

Department of Marine Sciences, University of Connecticut, Groton, CT, 06340, USA. E-mail: ann.bucklin@uconn.edu

An important frontier of climate change research is the development and use of molecular genetic, genomic, transcriptomic, and proteomic approaches to detect, quantify, and understand the responses of individual organisms to climate and climate variability. Studies of comparative physiology of marine organisms now employ a variety of 'omic approaches to understand cellular (metabolic) stress responses associated with warming, acidification, low-oxygen, food availability, and related stressors. We have used a species-specific candidate gene microarray or 'DNA chip' with probes for potential biomarker genes of climate-induced stress to examine gene expression patterns of the copepod *Calanus finmarchicus* in the Gulf of Maine (NW Atlantic). We found up-regulation of genes associated with active behaviors (cellular homeostasis, olfactory learning and memory, response to oxidative stress) in surface females; genes associated with cell cycle functions and biosynthesis were upregulated in deep females; and genes related to development, sex differentiation and mating behavior were upregulated in juveniles. We are using whole-transcriptome shotgun sequencing (RNA-seq) of the Southern Ocean salp, *Salpa thompsoni*, to identify molecular processes underlying the salp's complex life history and population dynamics in relation to extreme and variable environmental conditions and the pelagic ecosystem. These powerful analytical – but reductionist – 'omic approaches must be balanced by analytical, statistical, and interpretative methodologies that lead to understanding of responses of organisms – and thus populations, species, and ecosystems – to climate and climate change.

May 15, 11:55

The potential of coastal ecosystems to help mitigate climate change impacts

Carlos M. Duarte and Núria **Marbà**

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Climate change will affect coastal areas through multiple impacts including erosion and flooding of coastal areas through the combined effects of increased sea level and storm surges, changes in species composition due to warming, and decline of calcifying organisms due to ocean acidification. In combination, these impacts may generate economic losses large enough as to defy the capacity of even the wealthiest nations to face them. While the international community continues to work to mitigate climate change, actions to mitigate its impacts need be adopted locally. Here I review the potentials for an intelligent use of coastal ecosystems to mitigate climate change and the associated impacts and identify the key elements of coastal ecosystem able to strengthen their resistance and resilience against climate change.

May 16

May 16, 9:00

Social, economic and governance impacts of climate change on fisheries

Anthony **Charles**

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Climate change will have a wide range of impacts on fisheries, other human uses of marine systems, and the coastal communities that depend on the ocean for sustainable livelihoods. From a social perspective, there is a focus on assessing the vulnerability to climate change of marine resource users, coastal households and communities, and enhancing their adaptive capacity both to reduce those vulnerabilities and to cope with change as it occurs. From an economic point of view, climate change impacts imply a set of benefits and costs, with associated 'winners' and 'losers' (*e.g.*, among neighbouring communities or competing economic sectors), all of which is likely to be compounded by interactions with economic change processes, notably globalization and large-scale technological change. Finally, a governance lens leads to consideration of policy measures and decision making in the face of climate change – what institutional arrangements are needed, what policies need changing, and who will make the decisions, at the relevant spatial and temporal scales? Addressing such considerations may require a re-designing of governance systems to make them more robust, adaptive, participatory and precautionary. This presentation focuses on fishery systems, providing a review of the current state of knowledge on social and economic impacts of climate change, with illustrations from a variety of locations globally, and an exploration of the governance and policy directions needed to meet upcoming challenges.

May 16, 9:35

Quantifying the impacts of climate change on marine shelf ecosystems and their resources: Feeding the world in 2050

Manuel **Barange**, Gorka Merino, Icarus Allen, Jason Holt, James Harle, Simon Jennings, Julia Blanchard and Eddie Allison

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The urgency to estimate the impacts of climate change on marine production has been elevated since the release of the 4th IPCC assessment report. The development of climate models has provided increasingly realistic simulations of changes in physical ocean properties and on the biochemistry of the global ocean based on particular carbon emission scenarios. However, the impacts of climate change on marine ecological processes and their fish resources are much less understood. Despite recent attempts to project catch potential changes from bioclimate envelope models (Cheung *et al.* 2010, 2011), the spatial resolution of the underling ecosystem models cannot capture processes in coastal and shelf regions or the complex and often compensatory ecological interactions leading to changes in potential catch changes. Here we use a climate change model driven by emissions scenario SRES A1B, coupled to high-resolution physical-biological models of the shelf seas of almost 70 countries from 28 Large Marine Ecosystems (LME), to obtain size-based estimates of marine ecosystem production changes by 2050. These estimates are used to project potential for fish production, both for direct human consumption and for animal feeds (fishmeal). In the second part of the presentation we use human population size estimates from United Nations prospects, fishmeal and fish oil price estimations from published economic scenarios, and projections of the technological development of aquaculture feed technology, to investigate the feasibility of sustaining current and increased *per capita* fish consumption rates in 2050, both globally, and in a number of national case studies.

May 16, 10:10

Global Ocean Carbon Observations: Decadal challenges in addressing and understanding global climate and ocean ecosystem change

Pedro M.S. **Monteiro**[1] and Christopher Sabine[2]

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The ocean presently takes up 2.4±0.5 $GtCy^{-1}$ of anthropogenic emissions of CO_2, approximately 24% of the total emissions (Le Queré *et al.*, 2009; PersCom 2011). However, three key challenges frame shape of a future global observations plan: evidence that the ocean uptake of anthropogenic CO_2 may be weakening, the long term trends in the balance of ocean – atmosphere fluxes of natural CO_2 and the net effects of these changes in ocean acidification. While the former two have strong implications for global emissions reductions under the UNFCCC, the latter one has similarly important implications for the long term viability of ecosystem services delivered by both the coastal and deep ocean (Scholes *et al.*, 2009; Doney *et al.*, 2009a,b; Feely *et al.*,). Long term sustained ocean carbon observations have two key challenges in the 21st century:

Firstly, placing a robust constraint on the interannual trends in the ocean sink of CO_2 (Monteiro *et al.*, 2010; Gruber *et al.*, 2010). This is necessary in order to evaluate the effectiveness of global emissions reductions and reliable attribution of the interannual changes in the global carbon budget. Global ocean observations approach this challenge along two avenues: ocean - atmosphere CO_2 flux assessments initially based on underway observations on ships of opportunity and ocean storage assessments based on repeat line hydrography (Takahashi *et al.*, 2009; Sabine and Tanhua, 2010). These are linked through inversion models and provide constraints for each other. The challenge in here is to provide annual assessments at a level of uncertainty of 10% but also diagnose the changing ocean capacity to take up anthropogenic CO_2 and alter its natural CO_2 fluxes. Despite strong advances in observational technology, this is unlikely to be achieved through observations alone and development of empirical methodologies such as neural networks and model data assimilation are envisaged as necessary steps to this goal.

Secondly, is the global advance of ocean acidification in both coastal and deep ocean systems. Ocean acidification will have implications for both ecosystem structure and function as it will directly impact the thermodynamics

of calcification as well the broader physiology through more complex interactions with oxygen and temperature (Portner and Farrell, 2008). Other less clear but potentially important implications include changes in carbon – nutrient stoichiometry. Different parts of the ocean have varying vulnerabilities to OA depending on the mean or intraseasonal ratios of DIC and Alkalinity. The observational challenge for OA is not just to measure the changing carbonate chemistry but also to integrate the ancillary variables that are necessary to understand and predict the ecosystem responses.

There are important synergies in coordinating observations across both climate and ecosystem concerns and data management, especially quality control, plays a key role as demonstrated by SOCAT and CARINA/PACIFICA initiatives.

May 17

May 17, 9:00

Deep-Sea gas exchange rates: The diffusive boundary layer link between fish, changing chemistry and climate

Peter G. **Brewer**

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Ocean warming will reduce O_2 concentrations and at the hypoxic limit for a given species this can pose challenges to marine life. The limit is traditionally reported as simple O_2 concentration with no T, P, or flow rate dependency, yet it is a dynamic gas exchange problem for the animal analogous to familiar gas exchange processes at the sea surface. It depends on diffusive boundary layer transport at animal gas exchange surfaces. This defines the supply side ability of the ocean to match the demand side of an animal. Defining this allow us to visualize, map, comprehend and predict the impact of changing physical properties of the ocean on aerobic life. We can define three quantities: 1) the minimal free stream oxygen concentration Cf for support of a given oxygen demand rate 2) the maximal oxygen uptake rate Emax associated with a particular oceanic environment, and 3) the flow velocity offset Δu100 needed to physically compensate for given ocean warming and deoxygenation scenarios. T and P dependencies of diffusion and partial pressure create zones of greatest physical constriction on the diffusive transport in the boundary layer typically at around 1000 m depth, coinciding with O_2 minimum zones. There ocean warming and deoxygenation have a clear negative effect for aerobic life. In some shallow, warm waters positive O_2 effects occur. However, for the vast cold deep water regions the net effect of ocean warming and deoxygenation is negative for marine life. Higher CO_2 levels also have a negative but smaller effect.

May 17, 9:35

On the expansion of oxygen minimum zones, trends in dissolved oxygen and its impact on the tropical Pacific Ocean

Lothar **Stramma**

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Subsurface low oxygen layers often called oxygen minimum zones (OMZ) exist in all tropical ocean basins, the most enhanced one in the eastern Pacific Ocean. OMZ's represent the largest contiguous of naturally occurring region of hypoxia in the world's oceans. Numerical model runs predicted and observations confirmed changes in dissolved oxygen (DO), which are likely influenced by global warming. Tropical and subtropical DO decreases in most Pacific regions, however some regions exist where DO increases. DO trends are a combination of long-term trends combined with decadal and short-term changes. Processes involved are climate-change related ocean warming, variations in the supply paths of oxygen-rich water via zonal near-equatorial current bands, changes in the expansion and speed of the subtropical gyres, Pacific Decadal Oscillation (PDO) and El Niño events. The expanding OMZ's interact with natural or eutrophication-induced hypoxic shelf areas and impact pelagic and shelf ecosystem and fishery. Based on modeling studies, it is expected that Pacific DO decrease will continue in the future. Should past trends in observed oxygen differences continue into the future, shifts in animal distribution and changes in ecosystem structure could accelerate.

May 17, 10:10

Developing marine ecosystem model to improve future projection

Yamanaka Yasuiro and Takafumi **Hirata**

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Model evaluations of inter-decadal variability in the past serve as a validation of the models to be used to project impacts of future climate change. Using NEMURO ((North pacific Ecosystem Model for Understanding Regional Oceanography) developed by PICES model task team, we conducted historical simulations in recent 50 years (*e.g.*, NEMURO special issue in *Ecological modeling* in 1997). As a next version, we have developed new model, MEM (Marine Ecosystem Model with optimal nutrient uptake) based on NEMURO that integrates the iron cycle, optimum nutrient uptake kinetics and particle sinking processes. These improvements, especially including iron cycle, lead model performance to a better representation of inter-annual variability of phytoplankton as well as climatological distributions of nutrients and Chlorophyll-a in the High Nutrient Low Chlorophyll-a (HNLC) regions. Recently, we conduct ensemble of future projections, seven runs, from present to 2030 using MEM. Future projection by NEMURO (*e.g.*, Hashioka *et al.*, 2009) showed decreases in annually averaged biomass of both diatoms and other small phytoplankton groups with global warming in HNLC regions due to decrease in nutrient supply from subsurface water, although biomass peak of spring bloom in HNLC regions slightly increase because improvement of temperature condition prevails against decrease in surface nutrients. However, future projection by MEM shows increase in annually averaged biomass of other small phytoplankton groups in spite of decrease in diatoms'. This simulation result is consistent with the observation (*e.g.*, Ishida *et al.*, 2009). Above story demonstrate better understanding of dynamics lead to better future projection.

May 18

May 18, 9:00

Interactions between fisheries production, planktonic ecosystems, physical oceanographic processes and climate change

Ichiro **Yasuda**

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Focusing on the drastic stock variations of Japanese sardine (*Sardinops melanostictus*), long-term ecosystem variations in the northwestern Pacific and interactions among physical, biogeochemical and fish are overviewed. Recruitment of the Japanese sardine are recently found to be correlated with physical environments near the Kuroshio jet along the larval transport routes from spawning grounds to the Kuroshio Extension. Particularly, the most likely environment that impacts on recruitment is the variability in winter mixed layer depth and spring phytoplankton density on the northern side of the Kuroshio jet, where the Kuroshio transports large amount of nutrients in subsurface and locally enhanced vertical mixing continuously pumps nutrients up into the biologically active layer. The long-term variability of the Kuroshio jet is controlled by local atmospheric cooling and basin-wide inter-decadal scale climate-related wind variability, in which the bi-decadal ocean and climate variability is related to 18.6-year period tidal cycle. Evidences of impacts from the18.6-year period vertical mixing variability around the Kuril Straits and other areas with strong tidal mixing are found in various parts of the North Pacific and climate. Vertical mixing processes, their impacts and long-term climate variability are the keys for forecasting and understanding ocean ecosystem variability.

May 18, 9:35

Recent Advances in studies for East Sea (Sea of Japan), a miniature test ocean for global changes

Kyung-Ryul **Kim**

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Recent studies clearly show that oceans are undergoing many changes. A Japan-Korea-Russia International research program, named CREAMS(Circulation Research for East Asian Marginal Seas), started in 1993, have confirmed the existence of most dramatic changes in the East Sea (Japan Sea): warming and dramatic decrease of DO(dissolved oxygen) in deep waters during the last 50 years. The analysis of DO profiles, in particular, strongly suggests that these changes are due to changes in conveyor belt system from bottom water formation in the past to intermediate water formation at the present time.

This shift in the deep water formation system has a remarkable resemblance to the changes anticipated in the world ocean circulation system associated with global warming in the coming century. We believe that the East Sea whose turnover time for the conveyor-belt system is less than 100 years, may serve as a miniature test ocean providing a clue for global changes in the future, meriting careful time-series studies to understand the effects of global changes on the ocean.

For more than 6 years, The East Sea has become a forum for international cooperation related for climate change researches under PICES approved a CREAMS/PICES program, EAST(East Asian Sea Time-series)-I, promoting international cooperation over East Sea, especially among Japan, Korea and Russia. As one of the successful outcomes, EAST-II program for promoting international cooperation over Yellow Sea and East China is under active discussion. Some results obtained during this program and a new direction of this international endeavor will be further discussed.

May 18, 10:10

The role of positive feedback in structuring alternative ecosystem states

Jeffrey M. **Dambacher**

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Demonstrating and predicting the existence of alternative ecosystem states remains a daunting task. Analyses have generally proceeded through post hoc descriptions of well known case studies, or through conceptual or pictorial models illustrating the transition as a shift between basins of attraction. Whereas formal analytical approaches offer insight into possible underlying mechanisms, and thus the hope of a predictive framework, they have so far been restricted to systems with only a few species. A central tenet of all these approaches is that positive feedback is involved in the formation of alternative states, and in both empirical and theoretical literature, it has been recognized as a necessary but not sufficient condition. Beyond this recognition, however, there remains a need for an analytical framework that provides insight into how system feedback forms and maintains alternative states in large complex ecosystems, and the means to make testable predictions of perturbation response, and formulate management interventions. We address this need through an analysis of how the structure of an ecological system (*i.e.*, graphical network of population variables, or vertices, and the signs of their interactions, or links) determines its feedback properties and, qualitatively, its response to a perturbation. Here our goal will be to distinguish, a priori, whether or not an ecosystem is prone to exhibit alternative states, and if so, then to reveal the characteristics of those states in terms of how variables respond to a perturbation, and finally, identification of key subsystems and critical underlying relationships.

May 19

May 19, 9:00

Climate change in high-latitude oceans

Peter **Lemke**

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High latitudes have received attention recently because of significant changes in the atmosphere, sea ice, and ocean, and on land, especially in the Arctic. The surface air temperature in the Arctic has increased about twice as fast as the global air temperature. The Arctic sea-ice extent in summer has decreased by 35% since 1979, and the sea-ice thickness during late summer has declined in the Central Arctic by about 40% since 1958. A warming has also been observed at depth in the Arctic Ocean and the Southern Ocean. But there is no trend observed in the Antarctic sea ice. Both, the Greenland and Antarctic ice sheets are losing mass, and the sea level is rising. These observed trends are in agreement with warming scenarios performed with coupled climate models, which indicate an amplified response in high latitudes to increased greenhouse gas concentrations. But details of the complex interaction between atmosphere, sea ice and ocean, and the impacts on the ecosystem and the human society are still only marginally understood.

May 19, 9:35

Marine spatial planning and risk management in the context of climate change

Hugh P. **Possingham**, Maria Beger, Alex Maufroy, Eddie Game, Matt Watts, Lissa Barr, Carissa Klein, Viv Tulloch, Azusa Makino, Hedley Grantham, Lucy Robinson, Christopher J. Brown, Kerrie Wilson, Eve McDonald-Madden, Eric Treml, Stuart Kininmonth and Takuya Iwamura

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Almost all countries have committed to dedicating systems of marine protected areas that cover at least 10% of their exclusive economic zones. Most of these countries use systematic conservation planning tools, such as Marxan http://www.uq.edu.au/marxan, to develop those plans. Marxan solves the problem of securing, in marine reserves, a user-specified fraction (*e.g.* 10%) of every kind of conservation feature (habitat, species or process) for the minimum impact on other users (for example: fisheries, mining, transport). In this talk we will discuss new developments in systematic conservation planning that facilitate the incorporation of risk and uncertainty, with a particular emphasis on climate change. There are two ways of treating risk in conservation planning – avoid placing marine reserves in risky places, or place marine reserves in places where better management can best ameliorate impacts – both are relevant to climate change risk adaptation. In marine systems, we also need to account for issues of connectivity and dynamics - well-connected marine systems may be able to recover faster than poorly connected systems. Our ability (and inability) to incorporate such issues in marine conservation plans is discussed using examples from the Great Barrier Reef and the Coral Triangle. Marine conservation planning typically ignores many ecological processes, which is our greatest challenge in the future.

May 19, 10:10

Nature *vs* Nurture: The importance of understanding the oceans natural carbon cycle in the context of anthropogenic change

Benjamin **McNeil**

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The oceans carbon cycle has undergone immense change since the industrial revolution; both its capacity to absorb anthropogenic CO_2 is changing along with its chemical composition (pH and carbonate), leading to ocean acidification. Our ability to monitor, detect and understand these changes has rapidly advanced over the past 20 years, in conjunction with a growing global data-collection program. Our large-scale understanding of how the oceans role modulates atmospheric CO_2 has advanced, however our understanding of how natural cycles can either amplify or suppress future anthropogenic CO_2 changes is still uncertain. Our future carbon understanding, from the regional scale to ocean acidification impacts are wholly dependent on a good understanding of the oceans natural cycling, dynamics and variability. Without this understanding, our knowledge of a changing ocean carbon biosphere will always be limited. Here, by reviewing recent advances in ocean carbon cycle research, I make an emphasis to show how natural carbon cycling significantly alters our understanding of anthropogenic carbon change. I also discuss how we as carbon cycle researchers can get more understanding from seemingly inevitable sub-optimal data-sets and discuss some key areas where greater emphasis is needed in the future.

May 19, 14:30

Climate change: Mitigation and adaptation policy

Keith **Alverson and Martin Visbeck**

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According to "The Emissions Gap Report" report released by UNEP at the 2011 Conference of the Parties to the UNFCCC in Durban, limiting global warming to 2 degrees C above preindustrial levels would require that atmospheric greenhouse gas levels peak no later than 2020, requiring immediate and substantial reductions. At the same meeting, the parties instead agreed to a path of increasing emissions, with a possibility of reductions starting in 2020, and thus a peak in atmospheric concentrations, long thereafter. Because efforts to mitigate global warming have failed, adaptation to the impacts of this warming is now an urgent priority.

Climate Change Adaptation is a process, including understanding regional modes of climate variability, impacts of that variability on the environment, and societal vulnerabilities. Global climate change impacts both ecosystems and human livelihoods. The extent of these impacts is influenced by the regional expression of climatic forcing and the degree of vulnerability of natural and human systems. Unlike climate change mitigation efforts, which are for the most part multilateral and focused on global targets such as average temperature and greenhouse gas concentrations, adaptation measures are inherently local. Adaptation measures must respond to regional climate patterns including drought, sea level rise and extreme events. Because past regional climate variability has included dramatic and rapid changes, natural ecosystems and traditional societies have well established resilience measures. Thus, UNEP's ecosystem based adaptation (EbA) approach is grounded in management of ecosystems, and the local communities that depend on them, as a means to reduce vulnerability to climate change. An important component of Ecosystem based Adaptation is developing a research and economic case for where the approach works best, and when it is cost effective. The Ecosystem-Based approach provides multiple benefits additional to building resilience to climate change, including preserving biodiversity and sustaining ecosystem services. Sustaining ecosystems as part of an overall adaptation strategy can help communities minimize the negative impacts and benefit from the positive effects of climate variability and change.

This presentation will showcase examples of using the ecosystem based approach, focus on adaptation to sea level rise specifically.

S1 Oral Presentations (Day 1)

May 15, 14:05 (S1-7975), Invited

Jellyfish blooms as consequences of human perturbed environment and ecosystems

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Jellyfish populations are increasing globally, particularly in waters under significant human impact such as the East Asian seas, where problematic blooms of scyphozoan jellyfish, such as *Aurelia aurita* s.l. and *Nemopilema nomurai*, have regularly occurred. Since the life cycle of scyphozoans is primarily comprised of both a planktonic sexual medusa phase and a benthic asexual polyp phase, reproduction in the latter is a main cause of the medusa population outbreaks. *A. aurita* polyps are opportunistic, exploiting different reproductive modes (*e.g.* by budding and podocyst formation) depending on environmental conditions, so that medusae of this species tend to bloom constantly in coastal waters with strong human-perturbation (*e.g.* warming, eutrophication, deoxygenation, marine construction, loss of biodiversity). Whilst *N. nomurai* polyps reproduce only by means of podocyst production, and medusae bloomed intermittently (once per *ca.* 40 years) for most of the 20th century, but became almost annual since 2002, except for 2008, 2010 and 2011. Podocysts of *N. nomurai*, being capable of dormancy for at least 5.5 years, are induced to excyst into active polyps by exposure to extreme environmental conditions (*e.g.* high temperature, low salinity, low DO and burial in organic-rich silt). Recent frequent blooms of this species might be attributed to favorable environmental conditions conducive to such outbreaks that have prevailed in Chinese coastal waters, a seeding and nursery ground. In addition, the behavior of benthic podocysts (*e.g.* maintaining dormancy or mass excystment into polyps) would also determine whether the medusa population would lead to a bloom or non-bloom year.

May 15, 14:35 (S1-8225)

Lower trophic level linkage and cool-warm cycle based on the North Pacific CPR survey 2001-2009: An implication for the future warming ocean

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This presents the lower trophic level linkage and climatic forcing in the western subarctic North Pacific using satellite Chl-*a* data and zooplankton samples taken by the North Pacific CPR survey 2001-2009. We divided study area into sub-regions, the East region, off Kamchatka (43-55°N, 155-170°E), and the West region, off Northeast Japan (40-50°N, 142-155°E), based on the difference in physical properties. Phytoplankton abundance temporarily varied in a different manner between the East and West. Phytoplankton bloom generally started earlier in the West, where yearly bloom timing was determined by spring SST anomaly, which was dominated by the PDO signal; early (late) in warm (cool) years with negative (positive) PDO. In the East spring SST anomaly was roughly out of phase with that in the West, but correlations among bloom timing, spring SST and PDO were less clear. Developmental timing of one of the dominant copepods species, *Eucalanus bungii* was earlier in the West, and its interannual variation corresponded to phytoplankton phenology, suggesting the dependency of *E. bungii*'s development on phytoplankton availability. Contrarily, interannual variation in developmental timing and growth rate of three *Neocalanus* species did not differ between the West and East despite of the distinctive difference in phytoplankton availability and SST anomaly. Large-scale environmental condition within a mixed layer rather than the regional near-surface condition might be responsible for *Neocalanus* development. These results implied that species-specific response of zooplankton to environmental perturbation should be considered for prediction of the lower trophic level production in the future warming ocean.

May 15, 14:55 (S1-7963)

Shifts between gelatinous and crustacean plankton in a coastal upwelling region

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Marine zooplankton communities can be characterized according to two basic types: those dominated by crustaceans and those dominated by organisms with gelatinous bodies. Crustaceans (basically copepods) are generally the most abundant in all situations while large accumulations of gelatinous plankton are found occasionally in most seas. Gelatinous organisms include both medusae (predators) and tunicates (herbivores) and may potentially affect plankton structure by direct removal of copepods or by modifying phytoplankton availability. Changes in gelatinous plankton have been related to climate variability in various regions. In this study the variability in the dominance of copepods versus gelatinous plankton is analysed using monthly time-series and related to changes in climatic and oceanographic conditions in the upwelling region of NW Spain. Seasonality was generally the main component of variability in all groups, both in the coast and in the nearby ocean but no common long term trend was found. Copepods increased in coastal waters since early 1990s and gelatinous plankton increased in the ocean since 1948. Different trends were found for gelatinous plankton in two coastal sites, characterised by increases in either medusae or tunicates. In all series multiyear periods of relative dominance of gelatinous versus copepod plankton were evident. In general copepod periods were observed in positive phases of the main modes of regional climatic variability and high upwelling intensity. Conversely gelatinous periods occurred during negative climatic phases and low upwelling. Environmental factors appear to influence the ratio between copepods and gelatinous zooplankton through a larger effect of the environment on copepods.

May 15, 15:15 (S1-7982)

Environmental sensitivity of latitudinal shifts in marine fishes depends on latitude and fishing effects

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Although a great amount of effort has been invested in investigating synergistic effects of fishing and climate, quantitative understandings of their interactions remain elusive. The difficulty arises because different fish species have different life history traits and live in different environments and therefore are expected to respond to human impacts and climate changes in different ways. In this study, we carried out a meta-analysis using data from the east and west coast of US, North Sea, and Bearing Sea to investigate to what extent the distributional shift of marine fishes was determined by environmental changes and whether fishing plays a role, after accounting for life history variation. We tested the hypotheses: 1) Due to the evolved less moving ability of trophic species, the fishes in the high latitudes may have stronger responsive rates than those living in low latitudes. However, because of high latitude species' broader thermal tolerance, the species in high latitudes are less sensitive to climate than the fishes in low latitudes. 2) The exploited species are more sensitive but with smaller response rates to climate than unexploited species, owing to their undermined population structures caused by fishing. We found that fishes' sensitivity generally decreases but response rate increases with their body size (and associated life history traits); however, the pattern is not clear. Species in the west coast of the US, which is the lowest latitude region, show the smallest sensitivity than the other regions. In addition, exploited species in low latitude have higher sensitivity and northern-ward shifting rate than unexploited species, partially supported our second hypothesis. Interestingly, this phenomenon became weaker or even reverses in high latitude regions, showing that the effect of fishing on species response to warming decreased with increasing latitude. While most species moved pole-ward, some species shifted equator-ward, and unexploited species had a higher southward shifting rate. Our findings suggest that marine fishes responded to global warming in a complex way.

May 15, 15:35 (S1-8254)

Long-term fluctuations of sardine populations in relation to dominant modes of high-latitude climate variability

Dave **Checkley**[1], Julie Jones[2], Shoshiro Minobe[3], Yoshioki Oozeki[4], Ryan R. Rykaczewski[5], Carl D. van der Lingen[6], Nadine Moroff[7] and Anja Kreiner[7]

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Sardine (*Sardinops* spp.) populations occur at mid-latitudes, fluctuate greatly on the scale of decades, and at times support some of the world's largest fisheries. Here we investigate relationships between fluctuations in population size of Japanese sardine (JS, *Sardinops melanostictus*) and northern and southern Benguela sardine (NBS, SBS; *Sardinops sagax*) to the North Eurasian Index (NEI) and Southern Annular Mode Index (SAMI), respectively. NEI is a measure of sea level pressure over northern Siberia. SAMI is a measure of the pressure difference between mid- and high-latitudes in the Southern Hemisphere and thus the circumpolar westerly flow. We compare unfiltered and low-pass (5 and 10 years) filtered December-February NEI and SAMI to indices of sardine populations. Recruitment of JS is positively correlated with unfiltered DJF NEI for 1976-2010. Biomass of SBS is positively correlated with unfiltered and filtered DJF SAMI for 1950-2010. Biomass of NBS is positively correlated with filtered but not unfiltered DJF SAMI, with a 4-y lag, for 1952-1985. NBS has not recovered in recent decades, despite a trend to positive SAMI, possibly due to a change in pelagic ecosystem structure and functioning there. NEI and SAMI covary. The results above are preliminary and results after further consideration of autocorrelation will be presented. The fluctuations of sardine in all regions appear due to a combination of fishing and climate at mid- to high-latitudes. Climate change may affect high latitudes disproportionately. Our results have implications for the effects of climate variability and change on sardine populations in both hemispheres.

May 15, 16:20 (S1-7970)

Estuarine phytoplankton responses to climate change: Gyeonggi Bay long-term surveys

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Although global warming (~0.2°C decade^{-1}) is responsible for a strong decline (~1% year^{-1}) in oceanic phytoplankton biomass by thermal stratification, estuarine phytoplankton response to climate change remains enigmatic. Evaluation of a 50-year climatic data set (1960-2010), a 12-year data set of nutrients (1997-2008), a 10-year data set of phytoplankton biomass and species composition (2001-2010) in the macrotidal (>10m), Gyeonggi Bay shows an increase of dinoflagellates and decrease of diatoms, which accordingly coincided with the increasing air temperature (+1.36°C), sea surface temperature (+0.47°C), nitrate concentrations and decreased wind speed pattern (-1.12 ms^{-1}). Phytoplankton biomass showed bimodal seasonal cycles with winter and summer maxima and hence a dramatic change compared to single spring blooms in 1980's. GB's winter blooming (>30.29 µg Chl l^{-1}) mechanisms are related to low temperature (r= -0.25), precipitation (r= -0.19), river flows (r= -0.20), high wind speed (r= 0.34) and resuspension. Note that, the causes of a shift in the winter dominant species from tychopelagic (*Paralia sulcata*) to pelagic diatom (*Thalassiosira nordenskioeldii*) during the last three decades are still undiscovered. GB's summer bloom (>21 µg Chl l^{-1}) potential in response to nitrification is mediated by irradiance (r= 0.25) and river flows. Shifts in the dominant summer bloom groups (diatom to dinoflagellates) might be due to silica limitation. We conclude that interannual variability of estuarine phytoplankton biomass has been linked to climatic oscillation and eutrophication but their synergistic effects on dominant winter-summer blooming species are quite complex, with significant implications for biogeochemical processes and ecosystem functions in estuaries.

May 15, 16:40 (S1-8145)

Climate and anthropogenic effects on structure and functioning of the North Sea ecosystem

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The North Sea ecosystem is one of the most productive shelf ecosystems in the world ocean, which suffers from intensive anthropogenic activities such as cultural eutrophication and overfishing. Additionally a strong warming of the sea water has been observed which is frequently related to decadal variability in atmospheric forcing due to the North Atlantic Oscillation (NAO). Recently the importance of multidecadal climate forcing represented by the Atlantic Multidecadal Oscillation (AMO) is strongly discussed. Despite many studies on the single effects of the various external drivers on the North Sea ecosystem have been published, integrative investigation covering all trophic levels and multiple external drivers are rare. Using time-series on four trophic levels, *i.e.* phytoplankton, zooplankton, planktivorous and piscivorous fish, covering > four decades (1963-2007) we test the effects of (i) decadal and multidecadal climate variability as well as their interaction, (ii) fishing pressure and (iii) nutrient concentrations on North Sea ecosystem structure and function. Our study which applies Generalized Additive Modelling (GAMs) demonstrates that multidecadal climate effects alternate between negative and positive throughout the trophic cascade. Climate effects are amplified by fishing pressure and nutrient input.

May 15, 17:00 (S1-8142)

Impact of climate events on trophic dynamics in coastal ecosystems

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Changes in the climate and anthropogenic forcings can impact the dynamic of the trophic components of marine ecosystems, influencing their status and productivity. These effects can be investigated through the analysis of time series collected by long-term monitoring stations. In this work, we investigated the changes in the trend and relationships among the trophic components of the English Channel (UK), in relation to changes in climate forcings. Long-term time series of phytoplankton and upper trophic taxa sampled at the Western Channel Observatory were decomposed by using Dynamic Harmonic Regression (DHR) models, coupled with a Kalman filtering algorithm. The results show that changes in physical forcings (*e.g.* sea surface temperature and wind intensity) impacted the community composition and the abundance of indicator taxa (*e.g.* calanoids). Correlation analysis among the long term components of the time series indicated changes in the trophic relationship between primary and secondary producers. This work points out that climate events can induce fast changes in the trophic relationships in marine food-webs, with potential impacts on fish abundance.

May 15, 17:20 (S1-8037)

Effects of eutrophication and climate change on the benthic and pelagic environments in the brackish Baltic Sea: What are their consequences to the water quality assessment?

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There is currently a critical knowledge gap in how eutrophication and climate variables impact the dynamics of marine ecosystems. Based on long-term monitoring data we quantified the separate and combined impacts of nutrient loading, temperature, salinity, and wind conditions on benthic invertebrates and zooplankton inhabiting the brackish Baltic Sea. In the Gulf of Riga changes in benthic invertebrate communities were largely explained by climate variables whereas in the Gulf of Finland the variability was mainly due to local nutrient loading, and gulf scale climate variables. In both gulfs, however, zooplankton species were equally affected by eutrophication and climate variables. Similarly, we found similar contributions of climate and eutrophication on the variability of the water quality index used in the study area. The relative importance of climate variables on the index performance increased with sediment coarseness and coastal slope values. The relative contribution of eutrophication to index variability did not change across the pressure gradient. Thus, the results indicate that water quality assessments may easily become misinterpreted. Climate and hydrographic factors can only be accounted for if there is complete knowledge of the various sources of variability.

May 15, 17:40 (S1-8252)

Long-term variation of the copepod community structure in Tokyo Bay, Japan

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Long-term variation of copepod community structure in the Tokyo Bay (35° 25′N, 139° 48′E) was investigated using zooplankton samples collected by NORPAC net (mouth diameter: 45 cm, mesh size: 330 µm) during 1981-2004. The total copepod abundance gradually declined with short term fluctuation. Cluster analysis based on similarities in copepod composition among samples revealed clear seasonal groups (Groups A, B, C and D). Group A appeared in winter-spring, characterized by cold water species such as *Centropages abdominalis* and *Acartia omorii*. Group B and C occurred in summer and fall, respectively. *A. omorii* and *Pseudodiaptomus marinus* dominated in the former and *Paracalanus parvus* and *Temora turbinata* in the latter. Group D appeared mainly in December, but sporadically in various months. We found that the timing of shifts between groups and terms of the occurrence for each group changed in 1989/90 and 1999/00. The timing from Group A to B changed from July to May and extended occurrence of Group B appeared after 1990. In 2000s, terms for Group A and B became shorter and that for Group C longer. *C. abdominalis* and *A. omorii* lay resting eggs in high water temperature. The annual variation of timing both cool-down in winter and warm-up in spring could affect long-term variation of copepod community structure in Tokyo Bay. Environmental factors which affected the occurrence of other major species will be discussed in the presentation.

S1 Oral Presentations (Day 2)

May 16, 11:05 (S1-8209), Invited

Are the observed pattern changes of ocean heat, salinity and oxygen man made?

Nathaniel L. **Bindoff**[1,2,3], Paul Halloran[4], Oliver Andrews[5], Corinne Le Quéré[5], Catia Domingues[2,3] and Helen E. Phillips[1]

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Projections of climate change indicate increased precipitation in the equatorial region and at high latitudes and decreased precipitation in the subtropics, a general increase in ocean stratification and enhanced heat uptake in the polar regions. We use the available oceanographic temperature, salinity and oxygen data and CMIP3 or CMIP5 simulations for the period 1970 to 2005. Globally we find increased salinities in the mid-latitudes and decreased salinities in the polar surface waters and salinity minimum (~700m deep). These salinity changes imply about a 1% decrease in the precipitation-minus-evaporation over the mid-latitudes oceans and a 5% increase in the precipitation-minus-evaporation in the Southern Ocean since 1970. These new and independent ocean derived estimates of changes in precipitation-minus-evaporation extend the growing evidence for an acceleration of the Earth's water cycle. An analysis of oxygen changes throughout the global ocean shows a coherent decrease in zonal averages at almost all latitudes above 1500m, particularly in the shallow oxygen minimum zones and in the Polar Oceans. These changes are most simply explained by biological consumption resulting from reduced renewal rates. Examination of the internal variability of the CMIP3 and CMIP5 models from control simulations for these climate indices shows that some of the observed trends exceed internal variability of the earth system at the 90% confidence level. Most of the large scale spatial pattern and temporal changes in the simulations of these three climate indices can be attributed to a combination the rising greenhouse gases, increases in tropospheric aerosols and volcanic eruptions, with greenhouse gases the largest contributor.

May 16, 11:35 (S1-7991)

Which climate change signals in the North Pacific are liable to emerge sooner and stronger?

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The North Pacific atmosphere-ocean system is subject to considerable variability on decadal time scales. These variations serve to obscure systematic trends in association with climate change. The relative magnitude of the "noise" in the North Pacific climate system is a function of location and parameter. The present study characterizes this noise using historical reconstructions based on atmospheric and oceanic reanalyses. The "signal" associated with climate change through roughly 2050 is assessed using output from IPCC-class global climate models. An ensemble model approach is employed to estimate projected decadal means and overall trends. Maps of signal to noise ratios for a variety of air-sea interaction (*e.g.*, winds) and upper-ocean variables (*e.g.*, mixed layer depth and stratification) are used to reveal where systematic alterations are liable to occur sooner versus later. This information should be useful towards anticipating the relative timing and strength of the responses of North Pacific marine populations in future decades. It may also help guide the design of observing strategies, in particular effective sentinels for climate change related to North Pacific ecosystems.

May 16, 11:55 (S1-7954)

Regional patterns of interannual sea level variability: Case of the Japan/East Sea

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Altimetric measurements from satellites reveal an increasing trend in mean sea level, that has strengthened recently. However, regional trends are far from uniform due to different factors affecting sea level. In particular, the hydrographic regime in the Japan/East Sea is strongly influenced by transport through the straits and the same can be expected for the sea level and dynamic/energetic characteristics derived from it. To study this variability, AVISO ¼°-gridded weekly sea level anomalies (SLA) for the period from October 1992 through October 2009 are used, eddy kinetic energy (EKE) is computed from SLA, and multivariate analysis of SLA and EKE is performed. Interannual (low-pass filtered) SLA yield the leading mode of simultaneous quasi-biennial oscillations over the entire Japan/East Sea. Their strength is closely correlated to low-frequency spatially averaged EKE; both reveal oscillatory rather than trend-like behavior and tend to follow interannual transport variations in the Korea/Tsushima Strait. Strong seasonal oscillations of meridional sea level gradient result in variations of the mean currents, strengthening during the warm season by October and weakening during the cold season by March. Mean EKE and a leading mode of its variability are characterized by the same seasonal signal, both being highest in October through November and lowest in February through April. This temporal behavior and spatial pattern of the leading EKE mode imply an important contribution of shear instability to EKE generation. However, no counterparts of either SLA gradient mode or EKE instability mode emerge on interannual time scales.

May 16, 12:15 (S1-8014)

Long wave of interdecadal oscillation in moderate latitude of the Asian Pacific

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The main goal of our study is to reveal and compare the oscillations of interdecadal (20-30 years) and quasi-semi-centennial time scales in the Asian-Pacific subarctic zone and North Asian central continental area. Time series of Ice extent in the Japan Sea (1960-2009) and ice thickness in the Baykal Lake (1869-2010) are used as indicators of regional climate variability in the large scale subarctic marginal area and continental South Siberia region. We also use time series of Hadley SST, Okhotsk Sea Ice Extent and surface atmospheric pressure fields. The quasi-semi-centennial climate oscillation in the subarctic Japan Sea area and Lake Baikal ice thickness, as compared to the NE Pacific region, has a reversed phase relative to the 50-70 year climatic oscillation over the North Pacific and North America (Minobe, 1997). There are also interdecadal oscillations in JES ice extent and Lake Baikal ice thickness. Cold anomalies in the JES subarctic area in one decadal/ multidecadal period or similar anomalies in the Lake Baikal region during the next decadal/multidecadal period are associated with cold northern wind outbreaks in the corresponding longitude zone. The zonal alternation of the inversed anomalies and remote links between the Pacific SSTA, Japan Sea Ice Extent, and Lake Baikal ice thickness are conditioned by teleconnections between anomalies in the Arctic, North Asia, North America, and different Pacific regions.

May 16, 14:00 (S1-8045)

Influence of Changjiang discharge, resuspension of sediment and eutrophication to chlorophyll variability in the Yellow Sea and East China Sea: Results from new satellite data set

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It has been known that the Yellow Sea and East China Sea receive a great deal of nutrient loading. There are some indications of ecosystem changes in these areas including extensive red tides, blooms of giant jellyfish and green tides. However, the details of these changes have not been well described. Phytoplankton is a base of the trophic level and the trophic level responding directly to eutrophication, and ocean color remote sensing is a useful tool to understand changes over large areas. On the other hand, the accuracy of ocean color remote sensing is uncertain in turbid water. We developed a new ocean color remote sensing data set for a 15 year period in the Yellow Sea and East China Sea. The data set showed spring bloom in the large area of Yellow Sea and East China Sea after the decrease of winter resuspension of bottom sediment, and summer increase of chlorophyll *a* at the mouth of Changjiang River to Jeju Island. Variability of the summer increase was well corresponded to variability of Changjiang discharge. In the Yellow Sea, direct influence of the Changjiang discharge is less, and long term increase of chlorophyll *a* was persistent. The data set is based on an empirical method but it is still useful towards understanding anthropogenic and climate induced ecosystem variability and changes.

May 16, 14:20 (S1-8034)

Simulating ecosystem response to climate change, thermal waste discharge and reclamation in a highly industrialized bay

Yun Ho **Kang**[1], Se-Jong Ju[2], Kyoung-Soon Shin[2], Sang-Duk Choi[3], Kyeong-Ho Han[3] and Ho-Seop Yoon[3]

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Gwangyang Bay is located on the southern coast of Korea. It has experienced significant changes due to the development of large petroleum, chemical and iron industries and an international container port. Environmental impacts exerted on the bay's ecosystem include a rise in water temperature, reclamation and dredging projects, pollutant release and a decline in river runoff. In this study a trophic flow model, EwE, is applied to assess how water temperature rise and reclamation perturbs the bay ecosystem in a quantitative manner. Sea temperature has increased steadily during 1965 to 2007 due both to global climate change and local anthropogenic inputs. The bay has thermal discharge of 1.5 M m^3/d from 6 power plants with ΔT of 7°C. Thermal dispersion was simulated using 3D EFDC model, yielding distribution of temperature increase. In addition, reclamation has shrunk the bay's area by 30% over the period of 1973 to 2004. The EwE model was run for 30 years, with sea temperature and reclamation, respectively, represented by phytoplankton productivity based on laboratory experiments of growth curve under a temperature range between 10 to 30°C, and a habitat area with shallow water dwelling organisms of bivalve and benthic algae. The model results were compared with and without the anthropogenic forcing.

May 16, 14:40 (S1-8005)

Bio-physical interaction in the tropical Pacific

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Variability of marine phytoplankton associated with El Niño-Southern Oscillation (ENSO) and potential biological feedbacks onto ENSO are investigated using coupled ocean model experiments forced by realistic surface wind from 1951 to 2010. The model used in this study is the MOM4 Oceanic GCM coupled to a biogeochemical model, called TOPAZ (Tracers in the Ocean with Allometric Zooplankton). In general, the MOM4-TOPAZ model simulates well the major features of phytoplankton variability associated with ENSO, which is consistent with the observational findings. Through comparisons between the interactive MOM4-TOPAZ experiment and ocean-only experiments with the various prescribed chlorophyll concentrations, the potential impact of phytoplankton on ENSO is also evaluated. From the set of the experiments, we found that chlorophyll generally plays a role in increasing the mean SST and decreasing subsurface temperature by altering an extent of penetration of solar radiation. Nevertheless, as the chlorophyll concentration increases, the equatorial Pacific SST is decreased due to the enhanced upwelling of the cooled sub-surface water with shoaling of mixed layer. In these experiments, the presence of chlorophyll generally intensifies the ENSO amplitude by changing the ocean basic state. On the other hand, interactive chlorophyll associated with ENSO tends to reduce the ENSO amplitude. Therefore, chlorophyll has competing effects in terms of its contribution to SST variance in the equatorial Pacific.

May 16, 15:00 (S1-8171) - Cancelled

Implications of anthropogenic nutrient enrichment and climate induced stratification for the Black Sea ecosystem

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A coupled 3-D hydrodynamic-ecosystem model of the Black Sea has been developed in order to investigate the implications of anthropogenic effects versus specific climatic drivers on the Black Sea pelagic ecosystem. The Black Sea is under the strong influence of human induced nutrient enrichment through the inflow of biogenic elements via river discharge. Although the influence of nutrient enrichment has been studied, the relative influence of climate change on the Black Sea ecosystem is not investigated. The model results revealed a gradual reduction in the mixed-layer depth during 1972-2001. Mixed-layer depths and water column structures derived from CTD casts collected during individual years throughout the simulation compare well with the model results, supporting this conclusion. Shallowing of the mixed-layer reflects an increase in the surface buoyancy input, the net heat flux from the atmosphere into the water has increased while evaporation minus precipitation has declined over this period, resulting in warmer and fresher surface waters. Both model simulations and observations revealed a reduction in nitrate availability at the base of the euphotic zone, associated with the increased water column stability. As nitrate is a limiting nutrient for phytoplankton growth in the Black Sea, primary production is expected to mirror nitrate availability. Due to the top down control of the Black Sea pelagic food web by gelatinous species, however, phytoplankton concentrations do not exhibit a simple relationship with water column structure or nutrient availability. Model results suggest a positive feedback of reduced grazing pressure on phytoplankton during warm years due to increased grazing control on zooplankton by gelatinous species (*i.e. Mnemiopsis leidyi*).

May 16, 15:00 (S1-8036)

Water mass structure in the South Atlantic and its decadal variability

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The main target of this work is to determine South Atlantic water mass structure and its long-term variability. The main characteristic of this study is the analysis of newest data on oceanography sections collected over the last decade since 2000 year. Those data were collected thanks to the International program CLIVAR and the Russian program "Meridian plus", which were compared with archive data (Meteor, IGY). South Atlantic water mass boundaries were established by maxima of vertical gradients of temperature and salinity. A new classification of North Atlantic Deep Water (NADW) components was created. There are several concepts concerning NADW structure. In classical work [Wust, 1935] it was shown that the layer of NADW was divided into three components (upper, middle and lower NADW). According to another classification [Rhein *et al.*, 1995] which is based on the analysis of CFC distribution, NADW structure was divided into a shallow upper water (SUNADW), a layer from the Labrador Sea and two lower layers, the old and the overflowing (LNADW-old, OLNADW). There is no common accepted opinion about the origin of the NADW components. In this research the layer structure of NADW was found as consisting of four layers, although those significantly differ from the above mentioned concepts. It was specified the origin of NADW components and determined their distribution in the South Atlantic Ocean. The variability of the thermohaline characteristics are usually based on results of the numerical modeling and often are not connected with the real objects of the investigation, the water mass. In the present work average characteristics of water masses were detected using repeat transect measurements. According to this approach it was possible to reveal the trends of thermohaline characteristics changes in deep and bottom water mass layers. Volume mean values were calculated for the whole water parcels as well as for its cores. For Antarctic Bottom Water (AABW) it was established that AABW also penetrates into the Eastern Basin through Vernadsky and Doldrums fracture zones, besides the traditional Romanche, Vema and Chain fracture zones. Penetration is also possible through Strakhov, Sierra-Leone, Fifteen Twenty and Kane fracture zones. From key sites of AABW distribution, long time series of temperature and salinity were constructed and analyzed in terms of their variations and trends.

May 16, 15:20 (S1-8295)

Detection of anthropogenic influences on ocean biogeochemistry

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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. Direct effects of carbon dioxide such as shoaling of the calcite and aragonite saturation horizons are prominent among these, but biological processes can also show secular trends, in some cases as early as the 1960s. These trends are not usually detectable with localized ocean time series of less than 20-30 years even in regions where they are strongest. In some regions natural interdecadal variability is large, and statistically significant secular trends can occur at specific locations over periods as long as 30 years that do not represent longer term trends. 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.

May 16, 16:00 (S1-8051)

Black Sea biogeochemical regime recent decades variability: The role of climatic and anthropogenic forcing

Svetlana **Pakhomova**[1], Elena Vinogradova[1], Evgeny Yakushev[2], Andrey Zatsepin[1], Valery Chasovnikov[3] and Oleg I. Podymov[3]

Presented by Evgeny Yakushev on behalf of Svetlana Pakhomova

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In the present paper, we summarize recent assessments of the latest decade changes of oxygen and nutrients (phosphate, total inorganic nitrogen, and silica) in the oxic layer of the Black Sea and of characteristics of the oxic/anoxic interface and discuss the role of the climatic and anthropogenic forcing. The variability of dissolved oxygen in the surface layer was found mostly forced by the climatic factor, whereas the variability of nutrients was connected to anthropogenic land-based discharge. DO concentration in the surface layer and in the Cold Intermediate Layer decreased in warm periods and increased in cold periods, which was well related to variations in the NAO climate index. The biogeochemical regime of the Black Sea oxygenated upper layer has notably changed since the warm winter of 1999, after which the DO concentration in the CIL decreased by 20% with negligible changes in concentrations in the surface layer. This is evidence that the CIL waters were not fully replenished during the winters of the last decade. It was demonstrated that the Black Sea hydrogen sulfide boundary oscillated in the density field with an amplitude of σ_θ=0.05-0.20 kg m^{-3} (up to 20 m) depending on the oxygen variability in CIL and, thus, on climate factor only. The interannual and decadal shifts of the sulfide boundary position could change the volume of the oxic layer, where the Black Sea living organisms dwell, by up to 10%. No connection between nutrients and oxygen dynamics was traced which possibly indicates the absence of intensive eutrophication during the last decades.

May 16, 16:20 (S1-8230)

South Atlantic wave climate under climate change impacts

Fabricio V. **Branco**[1,2], Bruno Biazeto[2], Ricardo de Camargo[2], Ilana Wainer[1], Jose Edson[1], Daniel Moita[1], Bruno Ferrero[1], Pedro P. Lopes[2], Tiago Bomventi[1], Christiano Campos[3], Marcelo Andrioni[3] and Andre L.T. Mendes[3]

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For many years several researchers have been trying to understand the impact of global climate change in its various aspects: air, soil, water, health, economy, human occupation risk areas, *etc*. Even after much effort, the level of knowledge is still incomplete, especially relative to regional impacts of global warming due to increased concentration of greenhouse gases and its relation to the physical mechanisms in the oceans. The goal of this work is to obtain regional climate projections for the South Atlantic Ocean in order to understand the regional wave climate, and how it is affected by different emission scenarios of greenhouse gases in the atmosphere. This is ongoing team work and is inserted into a large project funded by Brazil's Petrobras Oil Company. Evaluating the regional impacts of Climate Change in the ocean involves specific goals comprising regional atmospheric modeling, ocean circulation and wave modeling. Research strategy involves the choice of the best climate model projection for the South Atlantic, creation of a database to validate the numerical simulations for the twentieth century, regional atmospheric downscaling between 2011 and 2040 and the wave climate simulations to obtain future projections. The chosen wave model is WAVEWATCH III v.3.14, running with two nested grids: global (1X1) and regional (0.2X0.2). The global implementations are forced with NCEP Reanalysis (20th century) and with IPCC models (projections). The regional implementations are forced with the results of the regional atmospheric model (BRAMS) downscaling that were forced with the same NCEP Reanalysis and the IPCC projections.

S2 Oral Presentations

May 16, 11:05 (S2-8279), Invited

The framework for ocean observing: Best practices for the global observing system

Eric **Lindstrom**[1], John Gunn[2], Albert Fischer[3], Candyce Clark[4] and Andrea McCurdy[5]
Presented by Andrea McCurdy and Candyce Clark on behalf of Eric Lindstrom

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"The Framework for Ocean Observing" is fully described at http://www.oceanobs09.net. The Framework is being utilized as a tool to reform and further develop the Global Ocean Observing System (GOOS). It provides a system-level view of best practices for setting requirements, coordinating observation networks, and delivering information products for sustained global ocean observing to address scientific and societal issues. The Framework brings together a suite of ideas to re-energize development of global ocean observing infrastructure. It embraces a key theme of OceanObs'09 to broaden sustained global ocean observing across ocean science disciplines. It suggests appeal to international conventions beyond the United Nations Framework Convention on Climate Change. The concept of communication across the system in terms of "Essential Ocean Variables," is modeled after Essential Climate Variables used in the Global Climate Observing System. The Framework articulates development of subsystems in terms of "readiness" using assessment of feasibility and fitness-for-purpose in order to embrace emerging research to empower sustained ocean observing.

May 16, 11:35 (S2-7935)

Sustained observations of mesoscale and submesoscale surface circulation off the U.S. West Coast

Sung Yong **Kim**, E.J. Terrill, B.D. Cornuelle, B. Jones, L. Washburn, M.A. Moline, J.D. Paduan, N. Garfield, J.L. Largier, G. Crawford and P.M. Kosro

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With collaborated research efforts in the regional coastal ocean observing systems off the U.S. West Coast (USWC), the nearly completed high - frequency radar (HFR) network provides an unprecedented capability to monitor and understand coastal ocean dynamics and phenomenology through hourly surface current measurements at up to 1 km resolution. The dynamics of the surface currents off the USWC are governed by tides, winds, Coriolis force, low-frequency pressure gradients (less than 0.4 cycles per day (cpd)), and nonlinear interactions of those forces. Alongshore surface currents show poleward propagating signals with phase speeds of O(10) and O(100 to 300) km/day and time scales of 2 to 3 weeks. The signals with slow phase speed are only observed in southern California. It is hypothesized that they are scattered and reflected by shoreline curvature and bathymetry change and do not penetrate north of Point Conception. The seasonal transition of alongshore surface circulation forced by upwelling - favorable winds and their relaxation is captured in fine detail. Submesoscale eddies, identified using flow geometry, have Rossby numbers of 0.1 to 3, diameters in the range of 10 to 60 km, and persistence for 2 to 12 days. The HFR surface currents resolve coastal surface ocean variability continuously across scales from submesoscale to mesoscale (O(1) km to O(1000) km). Their spectra decay with k^{-2} at high wave number (less than 100 km) in agreement with theoretical submesoscale spectra below the observational limits of present - day satellite altimeters.

May 16, 11:55 (S2-8180)

Tracking ecosystem change in the northern California Current: A role for long term ship-board observations

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

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We sample the hydrography and plankton off Newport OR on a fortnightly basis, a sea-going program now in its 17th year. We visit 7 stations from nearshore to just beyond the continental shelf (42 km offshore) and take water column profiles of temperature, salinity, and oxygen and collect samples of zooplankton with plankton nets. The value of this work, particularly the data on copepod species composition and community structure, has increased greatly due to the recent finding that these variables are highly correlated with survival of Columbia River salmon (coho and Chinook). Furthermore, we have learned that copepod biodiversity and community structure are correlated with the Pacific Decadal Oscillation: when the PDO is negative, cold salty waters from the Gulf of Alaska feed the northern California Current (NCC) and transport large, lipid-rich copepods to the shelf waters; when positive, a greater proportion of the NCC is fed by warm fresh waters from offshore, which bring small, oceanic lipid-poor copepods to the coast. Thus the basin-scale variations in winds that drive the PDO result in changes in transport that in turn control local food chain structure and salmon survival. This result is an example of the power of integrating data streams from moored ocean sensors (SST), satellites (altimetry) and shipboard sampling (zooplankton species) to improve fisheries management. Scenarios of future climate-driven ecosystem change will need to consider the role played by the PDO and variations in source waters (and the copepods contained therein) which feed the northern California Current.

May 16, 12:15 (S2-8275)

Abyssal currents in the Drake Passage

Roman Yu. **Tarakanov**

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Throughout 2000s the expedition studies of Institute of Oceanology RAS were concentrated in the Drake Passage. Seven sections across the passage (from shelf to shelf) and one survey in the central part of the passage were made. The CTD- (Conductivity-Temperature-Depth) and LADCP (Lowered Acoustic Doppler Profiler) measurements were performed at each station in the entire water column. Analyses of these data showed that the character of abyssal currents over the whole region of the Drake Passage is much more complex than previously thought. In particular, the measured transport of water in the layer 0.2°C<THETA<0.9°C (which is usually attributed to the very lower of eastward extending circumpolar waters) across aforementioned sections was near zero. The high intensity of water exchange (separate components of the flow just to the east or west only) in this layer and the flow structure on the sections suggest the presence densely packed (quasi-steady and unsteady) eddies in the abyss of the Drake Passage. These results, taking into account near-isopycnal character of water mass spreading, exclude the specified layer out from circumpolar circulation. This leads to some revision of the role of the Southern Ocean in the climate of the World Ocean.

May 16, 14:00 (S2-8299), Invited

Global ocean observing and monitoring activities: Focus on the North East Asian Region

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The northeast Asia regional sea is a marginal sea in the northwestern corner of the Pacific Ocean surrounded by Korea, Japan, China and Russia. The coastal zone and continental shelf waters have traditionally provided much of food, energy, minerals and other raw materials to the development of the region. Trade, industrialization, migration and urbanization associated with high levels of economic growth in many parts of the region are likely to add to the environmental pressure on the coastal zone and adjacent seas. Many commercial fish stocks are overexploited. Industrial waste continues to find its way into the region. Pollution of rivers and coastal waters from urban and industrial wastes further contributed to the deterioration of coastal waters and habitats.

There is an urgent need for a coherent and integrated approach to face up to these threats and conserve marine environment. Although long-term oceanographic survey will not necessarily take away the coastal hazards or curb the environmental degradation trends, it will offer countries the information necessary to better prepare for the future. In this presentation, we would like to review the status of the long-term oceanographic survey conducted by north east Asian countries (*i.e.* China, Japan, Korea, Russian Federation) and discuss its' development and implementation of international cooperation. Oceanographic observations in the North East Asia Region may be enhanced through the latest developments in technology (*in situ* monitoring, remote sensing, modelling, data management) and maximized through better operational co-ordination.

May 16, 14:30 (S2-7997)

History and present situation of Japanese coastal wave and tsunami monitoring system (NOWPHAS)

Toshihiko **Nagai**

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History and present situation of Japanese coastal wave monitoring system named as NOWPHAS (Nationwide Ocean Wave information network for Ports and HArborS) is introduced in this paper. NOWPHAS has been established and operated since 1970 by the Ports and Harbors Bureau of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) and its associated agencies including the Port and Airport Research Institute (PARI). Observed data of waves, including low frequency tides and tsunamis, have been recorded at seabed installed Doppler-typed Wave Directional Meter (DWDM) and deep-sea GPS buoy stations.

Both system provides that tsunami can be measured in the accuracy of several centimetres. Especially in recent years, MLIT has been promoting a national project of establishing GPS buoys along the Japanese coast. The real-time tsunami data of 11th March 2011 Tohoku-Oki earthquake tsunami was observed by these GPS buoys. The Japan Meteorological Agency utilized the data to update the tsunami early warning before land communication was destroyed. And, the complete tsunami wave form was obtained by using backup power supply at the land base.

However, failure of the communication network on land left a problem for the system to be solved in the future. In order to solve this problem, for example, it may be necessary to use a satellite communication. Robust system against power failure is essential for earthquake and tsunami disaster prevention.

May 16, 14:50 (S2-8025)

Analyses on the tidal characteristics of the China Sea from the satellite altimetry data

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This paper analyzes the tidal characteristics of the Bohai Sea, the Yellow Sea, the East China Sea and the South China Sea by using altimetry data over 19 years from the TOPEX/POSEIDON and then after the orbital transfer of 2002, the JASON 1 and JASON 2 satellites. Harmonic constants of 68 tidal constituents are calculated at net points in the study area before and after the orbital transfer by interpolating the two groups of data to the reference track. The two groups of cotidal charts for five tidal constituents M2, S2, O1, K1 and Sa are used to compared with each other and the results of other researchers in detail, which proves that the charts more precise in the deep water and open oceans than those along costal areas; also, they conform better in amplitudes than in phase-lags. This may be attributable to the selection of the net points. The results also indicate the sea surface height variability in past twenty years to some extent. Compared with the results from numerical models and field observed *in situ* data, the average absolute error of the observed harmonic constants for amplitudes and phase-lags are more accurate than Peiliang (2000) but less accurate than Guohong (2004).

May 16, 15:10 (S2-8067)

A long-term coastal ocean buoy station in the East/Japan Sea: Past, present, future

Jae-Hyoung Park[1], Kyung-Il **Chang**[1], Young-Tae Son[1], Hee-Mang Park[1], Ki-Wan Kim[2] and Joo-Hyung Ryu[3]

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An ocean buoy station ESROB (East Sea Real-time Ocean Buoy) has been in operation on a real-time basis in the southwestern East/Japan Sea since 1999. It is located about 8 km off the east coast of Korea at a depth of 130 m. The ESROB carries meteorological sensors to measure air temperature, humidity, air pressure, and wind. It is also equipped with CTD sensors at 5 depth levels (2 m, 20 m, 40 m, 60 m, 130 m) and a downward-looking acoustic current meter to measure current profiles at every 4m depth interval. Multiple scale oceanic processes have been identified from temporally highly-resolved buoy data such as the response of coastal water to the passage of typhoon, occurrence of anomalous coastal upwelling together with long-term climate variability of coastal water properties. Recently, biogeochemical sensors have been added to ESROB to monitor dissolved oxygen, chlorophyll concentration, and turbidity. Also added were short- and longwave radiometers to calculate surface heat flux. Results from those newly installed sensors will be presented together with *in situ* calibration of biogeochemical sensors. Future plan with ESROB includes an installation of irradiance sensors for optical measurement to calibrate GOCI (Geostationary Ocean Color Imager) product, and $p\mathrm{CO}_2$ sensors.

May 16, 15:30 (S2-8083)

Geostationary Ocean Color Imager for the North East Asian waters: Overview and ocean applications

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The first Geostationary Ocean Color Imager (GOCI) is a new concept of ocean color sensor designed to provide hourly images to observe the ocean environment changes in the North-East Asian Seas. GOCI takes the hourly images in the fixed coverage (2,500km × 2,500km) at 500m × 500m spatial resolution with full spectral coverage (8 channels, similar SeaWiFS). GOCI has been operating since July 2010 and collected over 5100 scenes. In this presentation, we give an overview of GOCI operation, sensor radiometric calibration, and the validation of level-2 products. We also show some results of GOCI images monitoring in Korean and China coastal waters.

May 16, 15:50 (S2-8140)

Integrated coastal monitoring system through combination of *in situ* monitoring, satellite remote sensing and 3-D numerical models

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Gyeonggi Bay, South Korea is characterized with large tidal range about 8 meters, inflow of Han River, mud and sand mixed sediment environment, which make coastal environmental parameters vary rapidly with time and space. The monitoring of the detailed 3-D features of rapidly varying environmental parameters is a challenge using modern technologies of *in situ* un-manned monitoring of vertical profiles, Geo-stationary satellite remote sensing and 3-D numerical models.

Korea Ocean Development and Research Institute (KORDI) had developed an Intelligent Buoy System (INBUS) that automatically measures the vertical profiles of more than 10 parameters including temperature, salinity, suspended sediment concentration, Chlorophyll *etc.* every half an hour. The surface layer data of this INBUS System are used in the calibration of the satellite remote sensing data from high spatial resolution (500 × 500 m), time interval (8 times per day) Korean Communication, Ocean and Meteorological Satellite (COMS) which was launched with first Geo-stationary Ocean Color Image sensor (GOCI) in June 2010. Combination of the *in situ* data from INBUS system with Geo-stationary Ocean Color Image Sensor satellite remote sensing allows us to produce accurate mapping of 2-D surface data set to cover all the area of Gyeonggi Bay.

Three dimensional numerical models are used to expend the 2-D surface information into full three dimensional information to cover the entire layer of the Bay as well as in producing 3-D data for the case when the satellite remote sensing data are not available due to bad weather condition. EFDC (Environmental Fluid Dynamic) model for mud-sand mixed bed and Delft 3D model are used in simulation of suspended sediment concentration.

Details of application of modern technologies in monitoring rapidly varying 3-D coastal environmental parameters through combination of *in situ*, satellite remote sensing and 3-D numerical model will be introduce.

May 16, 16:30 (S2-7942)

Federating metadata collections on monitoring of the North Pacific

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PICES is an intergovernmental scientific organization that was established to promote and coordinate marine research in the northern North Pacific and adjacent seas. One of the PICES mission's component is to promote the exchange of data, information and services related to marine scientific research. In order to accomplish this objective, the PICES Technical Committee on Data Exchange (TCODE) initiated a metadata federation project. Metadata is considered as a description of essential characteristics of data ('data about data') that eventually lead to data files themselves or to entry points for corresponding data services. The metadata records are to be created, posted, edited, maintained and made spatially searchable for particular groups of the end-users on the Internet. The goal of the project is to implement a one-stop web utility for preparing and searching metadata on marine ecosystems of the North Pacific. Initially, the project was based on the FGDC metadata format and the NSDI Clearinghouse Network. Then, an instance of GeoNetwork opensource was installed on a rented server as the PICES TCODE geospatial portal. Not only members of the PICES expert groups but all interested in sharing geo-referenced data, information and services related to the North Pacific may register and run their own metadata collections on the portal, or may contribute to the existing categories. One more option is chosen by TINRO-Center (Russia) that runs its own GeoNetwork server and allows metadata harvesting. Our talk will address different aspects of sharing data, information and services on ocean monitoring using the implementation of the PICES metadata federation project as an example.

S2

May 16, 16:50 (S2-8020)

Assessment of climate change impacts on marine ecosystems in East Antarctica: Outcomes of a research collaboration between Australia and Japan

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Long-term monitoring sites which are currently used to conduct comprehensive marine ecosystem observations in the Southern Ocean are all located in the Southwest Atlantic (LTER, US-AMLR). Similar ecosystem monitoring sites are lacking in other areas of the Antarctic. This makes it very difficult to make statements about change in Antarctic and Southern Ocean ecosystems overall, particularly when environmental trends and rates of change differ between areas around the Antarctic continent. Australia and Japan both have permanent stations in East Antarctica, making continuous observations of many variables, and both nations have executed successful large scale snapshots surveys of ecosystem in a region which encompass more than a quarter of the Antarctic coast line. Recently Australia and Japan completed a 2-year project to assemble a common Antarctic database on zooplankton, krill, and other components of the ecosystem (physical parameters inclusive), and undertook preliminary analyses of trends and decadal change. In this talk I will summarise the main points and findings presented at the final workshop held in Hobart in early 2011. I will also talk about the gaps in existing observation networks, and a series of recommendations from the project for future collaborative research in the Indian Ocean sector of the Southern Ocean. These outcome will contribute to the international multidisciplinary program "Southern Ocean Sentinel" which aims to provide early warning of climate change impacts on marine ecosystems, and to further our current achievements to fulfil the gaps of our knowledge on Southern Ocean ecosystems structure, function and change.

May 16, 17:10 (S2-8076)

Decadal changes in pelagic copepod distribution in the EEZ -west coast of India

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The alteration in the species composition of pelagic copepods of the Indian Ocean due to global warming has not been addressed so far. A study of copepods collected along the west coast of India during 1998-2006 under the program "Marine Research on Living Resources (MR-LR)" showed considerable variation from the previous studies. The zooplankton collections of the International Indian Ocean Expedition, IIOE (1960-1965) and the subsequent samples taken during the oceanograhic investigations of the National Institute of Oceanography till 1995 showed species of *Eucalanidae* and *Paracalanidae* as the dominant herbivores. In recent years the percentage composition of these copepods has decreased. In the present study significant increase in carnivores namely species of *Euchaetiidae*, *Candaciidae*, *Oithonidae*, *Corycaidae* and *Oncaeiidae* was observed. *Temora turbinata*, the swarming herbivorous copepod associated with coastal upwelling showed a diminishing trend. Increase of SST (0.5°C) has been observed in the Arabian Sea during this period. The frequency of harmful algal blooms was also on the increase. A marked decline in major pelagic fishes that feed on zooplankton was also reported from the west coast. The match-mismatch concept between phytoplankton production and herbivores and planktivorous fishes may be attributed to this. The impact of climate change over the past 5 decades has in these biological changes. The environmental properties during the present study are compared with those recorded during the IIOE.

May 16, 17:30 (S2-8129)

Integration of ecological indicators with the global network of ocean observations

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Historical plankton data have been sampled across the oceans for more than a century at diverse spatial resolution and frequency. Here, we examine the global network of ocean observations in context of its relevance and practicality to retrieve ecological indicators. Indicators are essential metrics to monitor objectively, effectively and comprehensively responses of pelagic ecosystems to climate drivers. Two broad streams of ocean observations are identified: visible spectral radiometry and *in situ* measurements. Integration of ecological indicators with these streams of observations is typically illustrated in two original cases studies: 1. Long-term changes in phytoplankton phenology in the North Atlantic from *in situ* Continuous Plankton Recorder surveys and visible spectral radiometry and 2. Temporal changes in phytoplankton biomass and size fractions across the Atlantic Ocean from *in situ* Atlantic Meridional Transect expeditions and visible spectral radiometry. Representativeness, comparativeness, potential for synergic use and complementarities of these streams of observations are assessed specifically in terms of coverage, resolution, cost-efficiency, availability to the scientific community, and range of variables measured. Practical, analytical, and numerical obstacles to the integration of ecological indicators are discussed. Based on the experience so far, minimum requirements in the data are outlined and recommendations for future observations are provided.

May 16, 17:50 (S2-8267)

Development of integrated coastal fisheries information system for sustainable fisheries in southern Hokkaido, Japan

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Oceanography is moving toward the construction of operational observing systems in coastal regions. This issue is of global interest for sustainable use of fisheries and aquaculture resources. In particular, satellite remote sensing and marine-GIS for fisheries and aquaculture has been developing rapidly, and an operational use is required for sustainable development and management. We started "Hakodate Marine Bio Industrial-Cluster Project" in the Regional Innovation Cluster Program (Global Type) from 2009 supported by the Grant-in-Aid for University and Society Collaboration from the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan. Through this project, we develop an integrated coastal fisheries information system that combines satellite remote sensing, observations from a buoy network, 4-D VAR data assimilation system, ecosystem modeling, and marine-GIS spatial modeling to delineate the potential fishing zone for coastal squid fisheries, and to predict suitable sites for scallop and kelp aquaculture in southern Hokkaido coastal region, Japan. New challenges in the field of fisheries information systems now include developing systems capable of analyzing the marine environment in 3D, prediction and validation of oceanographic parameters, and dissemination of new information products to the user community in real or near-real time. We will present the overview of this on-going project.

S3 Oral Presentations (Day 1)

May 17, 11:05 (S3-8159), Invited

Connectivity between basin-scale and local processes influences regional ecosystem responses to increases in upper-ocean stratification

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Increased vertical stratification of the upper-ocean is a projected consequence of atmospheric warming during the 21st century. In response, the depth of wintertime mixing and the supply of subsurface nutrients to the euphotic zone are hypothesized to decrease, reducing new primary production. We show that modeled ecosystem responses to global warming support this conventional view over much of the subtropical North Pacific. However, ecosystem responses at the regional scale are more nuanced. In some areas, remote changes that affect the ventilation and biogeochemical properties of subsurface waters may be more influential than the local exchange between the surface layer and the ocean interior, and nutrient supply to the euphotic zone from depth may increase as a result of greater stratification of the upper ocean. Through use of Earth system models developed at the NOAA Geophysical Fluid Dynamics Laboratory, we explore the mechanisms that control projected nutrient, pH, and oxygen changes at different spatial scales in the North Pacific and describe a projected increased gradient in new primary production between eutrophic and oligotrophic ecosystems. We also investigate the uncertainty of our results with respect to mesoscale oceanographic features that are not represented in current global models, consider the implications of our findings to the future structure of marine food webs, and highlight the ecological processes that act to obfuscate the conversion of modeled physical changes to future fisheries production and the methods through which these challenges may be overcome.

May 17, 11:35 (S3-8272)

Climate change impacts on shelf and coastal marine ecosystems: Contrasting ocean-shelf exchange, stratification, and temperature effects on the northwest European shelf

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Coastal and shelf seas are susceptible to climate change impacts through a variety of contrasting drivers of larger-scale atmospheric, oceanic, and terrestrial change. These can affect shelf sea ecosystems through temperature effects on physiological rates, changes to stratification and mixing, and hence the timing of blooms, and through diffusive/advective nutrient transport on time scales ranging from the spring-neap pumping of nutrients to the decadal flushing of shelf seas from the open ocean. Here, we consider a series of numerical experiments with the POLCOMS-ERSEM coupled hydrodynamic ecosystem models forced by IPCC AR4 simulations, building on the work of Holt *et al.* (2012; *Biogeosciences*, 9, 97–117). We investigate the relative importance of changes in ocean-shelf exchange, temperature, and stratification in determining the impacts of future climate change on marine ecosystems in this region, focusing on the modeled primary production. The experiments demonstrate that increased oceanic stratification substantially reduces the open-ocean surface nutrient concentrations, which in turn reduces the nutrients advected on-shelf (on a 5–10-year time scale) and consequently the on-shelf primary production. However, these effects are mitigated by increased recycling through warming effects and lengthened growing season on-shelf. Regions less influenced by ocean-shelf exchange show a modest increase in primary production. The results are considered in the context of the model's ability to reproduce seasonal mean observed data from the WODC.

May 17, 11:55 (S3-8162)

Climate change impacts on the North and Baltic Sea ecosystems: An assessment based on IPCC AR4 and AR5 models

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Utilizing results from global climate models (GCMs) to force regional shelf ocean models provides a tool to assess the impacts of climate change on shelf seas. However, the application is not straightforward because the resolution of GCMs is usually too coarse to sufficiently resolve shelf sea systems, and different GCMs can exhibit large discrepancies specifically on a regional scale.

In this study, projected climate change data from both IPCC AR4 and AR5 GCMs were applied to force a 3D-coupled biophysical model, ECOSMO, adapted to the North and Baltic Sea system. We present results from a 30-year hindcast simulation (1970–1999) as a baseline and compared these to future (2070–2099) climate projection that uses a delta change approach according to the respective GCM outcome. The use of different GCMs allows us not only to compare present ecosystem dynamics to future projections but also to assess the discrepancies among different GCMs and AR4 and AR5 simulations and how important these discrepancies are when simulating ecosystem dynamics on a regional scale. Additionally, we will investigate the distinct influence of oceanic and atmospheric changes on primary production of the North and Baltic Seas by performing sensitivity studies based on each GCM with a special emphasis on impacts of boundary and initial conditions. Here, the focus is not only on physical, but also on biochemical variables, such as nutrients.

May 17, 12:15 (S3-8292)

Dynamic downscaling to marine ecosystems

Corinna **Schrum**[1], Bjørn Ådlandsvik[2], Richard Bellerby[1,3], Ute Daewel[1], Trond Kristensen[2] and Dhanya Pushpadas[1]

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Dynamic downscaling of climate change impacts to marine ecosystems has received increasing attention in the last years. Downscaling experiments have been performed for many marine ecosystems, and climate change projections have been formulated for different trophic levels. We will synthesize downscaling experiments for regional and shelf seas in the eastern North Atlantic with the focus on nutrients and biogeochemistry, lower trophic levels, and larvae fish. Our key study areas are the North, Baltic, and Barents Seas. We aim to identify robust climate change impact projections and their driving mechanisms, and if possible provide uncertainty estimates derived from ensemble simulations. We will relate them to internal variability and direct anthropogenic driver impacts.

May 17, 14:00 (S3-8124), Invited

Near-term climate prediction: New opportunities and challenges

Noel **Keenlyside**

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There is currently much excitement in near-term or decadal prediction, with a large effort being made in support of the upcoming IPCC AR5. Decadal prediction aims to close the gap between centennial-scale climate projections and shorter seasonal predictions to deliver more skillful predictions of near-term regional climate change. This presentation will discuss the feasibility of this prediction system.

First, I will outline the basis for making decadal prediction, and summarize the skill of the current prediction systems. The extra-tropical North Atlantic is one area where models agree that upper ocean circulation and heat content, and sea surface temperature can be predicted with skill up to 10 years in advance. This skill results from the initialization of the ocean and exceeds that of radiative forced changes. The ability to predict oceanic changes in this region could have major implications for the management of marine resources. Apart from the North Atlantic, there are also some indications of predictive skill in the Pacific, and these will also be discussed.

Second, despite promising early results, large uncertainties exist that limit prediction skill. To illustrate this, I will present examples for the North Atlantic on intermodel differences in simulated variability, and the response to external forcing. The accuracy of the initial conditions is also a problem.

Third, I will highlight an area where important progress is being made: ocean-atmosphere coupling and the role of the stratosphere. Whether better resolving stratosphere-troposphere coupling can enhance predictability in the North Atlantic sector will be discussed.

May 17, 14:30 (S3-8157)

Augmenting earth system models to capture global-scale energy flows through the planktonic food web to fish

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Most global biogeochemical models emphasize the resolution of broad-scale biogeochemical cycles. This emphasis often results in coarsely resolved planktonic food web dynamics that limit 1) the mechanistic resolution of biogeochemical processes, and 2) the utility of these models for assessing climate impacts on marine resources. In particular, capturing global-scale patterns of energy flow through the planktonic food web is essential to the development of models that can explain large-scale patterns in fisheries productivity and how they may change in the future. We have augmented the planktonic food web dynamics of the biogeochemical component of the NOAA/GFDL's earth system model to resolve broad-scale patterns in the flow of energy through the planktonic food web. Additions to the 1.0 version of this model, called COBALT (Carbon, Ocean Biogeochemistry, and Lower Trophics), include 3 zooplankton groups with flexible feeding behaviors, explicit bacteria and improved resolution of microbial processes, and expanded bioenergetics formulations. COBALT is validated against observed and independently estimated patterns in the energy flow through bacteria, microzooplankton, small and large phytoplankton, and mesozooplankton, and shown to capture basin-scale, emergent patterns in these quantities. Aspects of the model formulation that are critical to matching these patterns will be discussed.

May 17, 14:50 (S3-8245)

Development of a regional ocean climate model for the northwest Pacific marginal seas

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The northwest Pacific (NWP) marginal seas are characterized by complex circulation and large variability, yet they are small enough for ensemble simulations to be economically feasible. A global climate model with a relatively coarse resolution often results in the isolation of the marginal seas from the neighboring open ocean basins or unreasonably large or small transport in the straits. Exchange of mass and heat between the semi-enclosed marginal seas and the neighboring open ocean is extremely important in simulating climate changes in the marginal seas by accurately accounting the mass and heat transports through the straits. Typically, global climate model results are downscaled to produce appropriate forcing and boundary conditions for higher-resolution regional ocean models. In this study, a different approach is adopted for climate change simulations with our NWP regional ocean model.

The NWP regional model covers the domain from 18°N to 49°N and from 118°E to 155°E. It includes the East China Sea, the Yellow Sea, the East/Japan Sea, and the northwestern part of the Pacific Ocean. The nominal resolution of the model is 0.1° in the horizontal direction, and 20 vertical sigma levels are used. A climate change signal in space and time is derived from the MIROC high-resolution model run under the A1B scenario with cyclostationary empirical orthogonal function (CSEOF) analysis. This temporally varying signal is downscaled and added to the original surface forcing and the open boundary conditions to produce water temperature, salinity, and ocean currents up to the year 2100. The model starts from the initial data obtained from assimilated ocean state with observational data. The simulation results from the NWP regional model are compared with the global climate model (MIROC) results. To understand regional climate change, consistent and realistic ocean climate projections are needed with regional ocean models. A reasonable climate projection from this study suggests that the new approach is a physically consistent and efficient way of producing accurate regional climate projections without being contaminated significantly by strong natural variability in the global climate models.

May 17, 15:10 (S3-8131)

Impact of climate changes on North Sea Atlantic cod (*Gadus morhua*) larval survival: A modeling study

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We examined the potential survival and growth of the early life stages of Atlantic cod (*Gadus morhua*) in response to changes in physical forcing and lower trophic level dynamics of the North Sea ecosystem. Previous studies on the impacts of climate change on cod survival in the North Sea indicated a close correlation with temperature changes; however, climate variability might influence the vital rates of cod early life stages in many different ways. This could be directly through temperature, but also indirectly through, *e.g.*, transport processes, food availability, or predation.

To disentangle the impact of different processes potentially influencing the vital rates of cod early life stages, we developed and used a three-dimensional (3d) interlinked model system that included the 3d ecosystem model (ECOSMO) as well as a physiologically based individual based model (IBM). Here, we present results from a long-term hindcast and compare these to a set sensitivity runs that account for changes in transport, temperature, and food availability independent of each other. Additionally, we will present results from future projections for cod larval survival in the North Sea based on initially performed model runs with the ecosystem model ECOSMO. The model was forced by downscaled results from several state-of-the-art IPCC AR5 general circulation models. Based on our results and existing literature, we want to specifically discuss the feasibility of future projections for fish population dynamics on one hand, and the specific applicability of our model approach for this purpose on the other.

May 17, 15:30 (S3-8314)

Development of a climate-to-fish-to-fishers model: Implementation in the eastern Pacific Sardine and Anchovy system

Enrique N. **Curchitser**[1], Kenneth A. Rose[2], Kate Hedstrom[3], Jerome Fiechter[4], Miguel Bernal[5], Shin-ichi Ito[6], Alan Haynie[7] and Francisco E. Werner[8]

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An ecosystem approach to understanding large-scale patterns in exploited systems caused by both climate change and human activity increasingly relies on the use of numerical models. In the past, physical, lower and higher trophic level models were developed, tested, and implemented independently of each other. Recently, the advances in physics and biology have created the needed pieces for a comprehensive (end-to-end) ecosystem model, including humans as a dynamical component. The challenge is to integrate all the components, and examples of fully-coupled end-to-end models are relatively rare. This is partly due to the perception that blending separate yet complex sub-models is impractical because of demanding computational requirements and partly due to the respective communities working independently. In this presentation, we present our progress to date on the development of an end-to-end model modeling framework within the widely-used ROMS (Regional Ocean Modeling System) circulation model. The NEMURO Nutrient-Phytoplankton-Zooplankton (NPZ) submodel provides the lower trophic level dynamics, and a multi-species individual-based submodel simulates fish population and community dynamics, including fishing fleets as one of the predator species. All of these models exist in various forms, but the individual sub-models have never been harmonized together into one integrated analysis tool useful for synthesis, integration, and prediction. This model framework was designed to investigate the effects of climate and fishing on marine ecosystems within one model that includes dynamical feedbacks among the different systems. We will present results of a test-bed application developed to study the low-frequency fluctuations of sardine and anchovy.

May 17, 16:10 (S3-8001), Invited

Hypoxia in future climates: A model ensemble study for the Baltic Sea

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By using an ensemble of coupled physical-biogeochemical models driven with regionalized data from global climate simulations, we are able to quantify the influence of changing climate on oxygen conditions in one of the many coastal seas (the Baltic Sea) that worldwide experience eutrophication and expanding hypoxic zones. We show, by applying various nutrient load scenarios, that under the impact of warming climate, hypoxic and anoxic areas will very likely increase or at best only slightly decrease (in case of optimistic nutrient load reductions) compared with present conditions, regardless of the used global model and climate scenario. The projected decreased oxygen concentrations are caused by (1) enlarged nutrient loads due to increased runoff, (2) reduced oxygen flux from the atmosphere to the ocean due to increased temperature, and (3) intensified internal nutrient cycling. In future climate, a similar expansion of hypoxia as projected for the Baltic Sea can also be expected for other coastal oceans worldwide.

S3-Day1

May 17, 16:40 (S3-8264)

Relationship between coral reef degradation and overexploitation of coral reef fishes in El-Tur region, Egyptian Red Sea coast

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The Red Sea is characterized by a unique diversity of fish and invertebrate, as well as the presence of one of the world's most beautiful coral reef ecosystems. Coral reef fisheries resources are a vital source of food and are valuable economic sources. *Lethrinus nebulosus* is the most economically important species in the Red Sea and adjacent areas. This study provides further scientific information on the status of coral reef fisheries and the impacts of fishing on this species and on coral reef habitats. Age, growth, mortality, and feeding behavior of *L. nebulosus* caught by artisanal fisheries were evaluated. The estimated life span was 10 years on fish otolith reading. The Von Bertalanffy growth parameters were $L_{\infty} = 81.6$, $K = 0.161$ year^{-1}, and $t = 0.472$ year^{-1}. The total, natural, and fishing mortality rates were $Z = 0.722$, $M = 0.237$, and $F = 0.485$, respectively. The exploitation ratio was estimated as $E = 0.67$. Analysis of the stomach contents indicated that *L. nebulosus* is a heavily carnivorous fish, feeding mainly on crustaceans, 40.5% (shrimps and crabs); fish, 23.3%; echinoderms, 19.50% (*Acanthaster* spp.); and mollusks, 12.0%. Cephalopods, coelenterates, and unidentifiable matters make up 4.70% of the food items. The abundance of food items according to length groups showed that small fish ≤25.0 cm, crustaceans are the major food items. Crustaceans, fishes, and mollusks are recorded in fish with lengths of ≤40.0 cm, whereas in those with lengths ≥50.0 cm and older, sea stars and sea urchin are the dominant food items. The results indicated that *L. nebulosus* in the Red Sea is exposed to heavy overexploitation, particularly large individuals that feed only on sea stars and sea urchins. As a result of overfishing, the predators of sea stars decreased, which led to the overspreading of *Acanthaster* species that exhibit a feeding behavior that attacks coral polyps, affecting the health of the coral reefs. These results suggest that the depletion of functionally important consumer species by overexploitation can indirectly influence the coral reef ecosystem structure.

May 17, 17:00 (S3-7944)

Projecting distribution changes in marine fishes and invertebrates by integrating trophic interactions

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Climate change is affecting the distribution and abundance of fishes and invertebrates in the world ocean. Previous modelling studies have focused on examining the effects of changes in ocean conditions at the species level; however, the implications for trophic interactions have not been addressed. However, changes in distribution are expected to affect interactions between species. In this study, we propose a framework that integrates the species-based Dynamic Bioclimate Envelope model with the size spectrum-based approach.

This model considers competition between species for limited resources and predator-prey interactions through the size-spectrum theory when predicting species' change in population dynamics, distribution, and abundance under scenarios of climate change. This model addresses a major gap in conventional species distribution modelling approaches, thus, providing a valuable tool for developing more realistic scenarios of future marine ecosystems under climate change.

May 17, 17:20 (S3-8111)

Interactions between regional climate-forming factors and phytoplankton communities in the north-western Pacific

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Phytoplankton communities are one of the main climate-forming factors. They produce approximately half of the atmosphere's oxygen and draw nearly as much CO_2 as all land plants do. Phytoplankton form the base of the oceans' food chain and are a basic synthesizer of dissolved organic matter in the oceans. In the north-western Pacific region, several regional climate-forming factors have a direct and indirect influence on the state of phytoplankton communities; for example, Asian dust events, tropical cyclones, and volcanic eruptions Conversely, phytoplankton communities utilize CO_2, which is one of the main greenhouse gases, and produce biological aerosol. Thus, phytoplankton communities have an influence on radiative active components and on the earth's radiative balance. This can also be equally applied to interactions between phytoplankton communities and other climate-forming factors.

Investigations on the influence of Asian dust events, volcanic eruptions, and tropical cyclones on phytoplankton communities in the north-western Pacific are presented in the report. Local events analysis and general analysis for the whole region were performed for the working period with the ocean color scanners SeaWiFS, MODIS-Aqua, and GOCI. The main difficulties of using only satellite data are discussed. Estimations of the influence of each climate-forming factor considered on the state of phytoplankton communities are presented. Possible mechanisms of interrelations are given.

May 17, 17:40 (S3-8117)

Prey-dependent retention of dimethylsulfoniopropionate by mixotrophic dinoflagellates

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The formation of dimethylsulfide (DMS) in the oceans has received considerable attention because atmospheric DMS may partly counteract global warming. The main precursor of DMS is dimethylsulfoniopropionate (DMSP), a compatible solute synthesized by various groups of marine algae. The unique characteristics of dinoflagellates indicate that they are potentially important in the dynamics of oceanic DMSP and DMS. We investigated the retention of DMSP in phototrophic dinoflagellates arising from mixotrophy by estimating the cellular content of DMSP in *Karlodinium veneficum* (mixotrophic growth) fed for 7–10 days on either DMSP-rich *Amphidinium carterae* (phototrophic growth only) or DMSP-poor *Teleaulax* sp. (phototrophic growth only). In *K. veneficum* fed on DMSP-poor prey, the cellular content of DMSP remained almost unchanged regardless of the rate of feeding, whereas the cellular content of DMSP in cells of *K. veneficum* fed on DMSP-rich prey increased by as much as 21 times the cellular concentration derived exclusively from phototrophic growth. In both cases, significant fractions (10–32% in the former and 55–65% in the latter) of the total DMSP ingested by *K. veneficum* were transformed into DMS and other biochemical compounds. The results indicate that the DMSP content of prey species affects temporal variations in the cellular DMSP content of mixotrophic dinoflagellates, and that mixotrophic dinoflagellates produce DMS through grazing on DMSP-rich preys. Additional studies should be performed to examine the universality of our finding in other mixotrophic dinoflagellates feeding on diverse prey species.

S3 Oral Presentations (Day 2)

May 18, 11:05 (S3-7945)

Reaching management goals under a changing climate: A management strategy evaluation of snow crab (*Chionoecetes opilio*) fishery in the eastern Bering Sea

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Average snow crab recruitment changed in the mid-1990s and appears to be related to the winter Pacific Decadal Oscillation (wPDO); however, management does not account for this fact. The stock has recently recovered after being designated "overfished" for 12 years. A measure of average recruitment is used in the overfishing definition, and the manner in which average recruitment is calculated can greatly influence management quantities. Several harvest control rules (including the status quo rule and rules that use dynamic methods for calculating average recruitment) were evaluated in a simulation framework to determine their performance in terms of long-term yield and probability of the stock becoming overfished. The operating models considered to represent reality included the status quo (*i.e.*, a single average recruitment over the history of the fishery), regime-based recruitment (*i.e.*, with shifts in average recruitment) but no underlying mechanism, and regime-based recruitment driven by changes in the wPDO. Projections of recruitment for the third model are based on trends in the wPDO informed by the Intergovernmental Panel on Climate Change projections. From preliminary results, the mean and variance of catch do not differ greatly among the tested harvest rules. However, the frequency of a stock being overfished decreases with a dynamic approach to calculating average recruitment.

May 18, 11:25 (S3-8033)

Predicting climate change-induced fishery shrink through bottom-up control around the southern waters of Korea by using a flow trophic model

Yun Ho **Kang**[1], Se-Jong Ju[2], Kyoung-Soon Shin[2], Young-Gyu Park[2], Sang-Duk Choi[3], Kyeong-Ho Han[3] and Ho-Seop Yoon[3]

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To predict and understand ecosystem dynamics in the southern waters of Korea, the Ecopath with Ecosim (EwE) model was used under climate and fishery management scenarios. Two climate change-induced water temperature scenarios were given based on *in situ* long-term temperature measurements during 1965–2007 and NOAA Geophysical Fluid Dynamic Laboratory (GFDL) model experiments, respectively. The GFDL model was applied to the spatially refined eastern Asia waters, with boundary condition obtained from the IPCC A1B scenario. Three fishery management scenarios were given, equal, double, and half the level of efforts averaged over the last 10 years. Laboratory experiments were also conducted to obtain growth curves of phytoplankton under the temperature range from 10°C to 30°C with increments of 5°C. The target species are *Alexandrium tamarense*, *Prorocentrum minimum*, *Skeletonema costatum*, *Thalassiosira nordenskioldii*, *Thalassiosira weissflogii*, *Chaetoceros debilis*, *Odontella longicruris*, and *Skeletonema* sp., comprising more than half of the total weight of phytoplankton in the study area. The EwE model was run for 100 years, with climate-based bottom-up forcing implemented. The model results show that biomass changes are dynamic depending on the climate and fishery management scenario.

May 18, 11:45 (S3-8158)

Quantifying the distribution and dynamics of forage fish by using a size-based ecosystem model

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Size-based representations of ecosystems are emerging as a powerful (and simple) method for understanding how marine communities assemble and change. Here, we present a global size-based ecosystem model that we have used to quantify changes in the composition and spatial dynamics of marine communities as they respond to climate change. At the foundation of our model are 2 general rules: (1) big things eat small things and (2) big things have more say in where they move than small things. These 2 rules are codified using the Lotka-Volterra predator-prey equations for species interactions, and with ideal-free distribution theory for movement. Our model sits on top of an Earth system model produced by the NOAA's Geophysical Fluid Dynamics Laboratory, specifically the Carbon, Ocean Biogeochemistry and Lower Trophics (COBALT) model. COBALT provides information on the mass distribution and productivity of multiple zooplankton groups, which we use as the base of the food chain for our size-based model. Our model is forced with a 60-year COBALT hindcast, and we resolve the prominent modes of variability, driven by climate change, in the size spectra and spatial dynamics of forage fish in various systems worldwide.

May 18, 12:05 (S3-8164) *Cancelled*

An ecosystem modelling framework for evaluating ecosystem attributes under fishing and climate regime shifts

Caihong **Fu**[1], Jennifer Boldt[1], R. Ian Perry[1], Jake Schweigert[1] and Yunne-Jai Shin[2]

Presented by R. Ian Perry on behalf of Caihong Fu

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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. It has been recognized that in order for EBFM to be effective, the effects of decadal scale climate variability on the inherent properties of ecosystems, *i.e.*, stability, resilience, and productivity, require explicit recognition and consideration. 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 impacts on four ecosystem attributes (stability, resilience, total biomass, and mean trophic level) under different climate regimes. 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.

May 18, 12:25 (S3-8132)

Impact of climate change on the development of marine aquaculture: A case study on the Japanese scallop in Dalian, China, using satellite remote sensing and Geographic Information Systems-based models

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In 1982, the Japanese scallop (*Mizuhopecten yessoensis*) was first introduced into Dalian from Japan as an alternative species for aquaculture. The species has been quickly cultured on a large scale in this region and accounts for approximately 90% of the Chinese total production. However, in recent years, Dalian scallop aquaculture has exhibited large-scale mortality. This problem may be due to the increased coastal pollution, high density in scallop aquaculture, pests and diseases, environmental and climate change, and other factors. Therefore, this research was conducted to analyze the distribution of suitable areas for Japanese scallop aquaculture by using Geographic Information Systems-based models and satellite remote sensing data (moderate resolution imaging spectro-radiometer [MODIS], sea-viewing wide field of view sensor [SeaWIFS], and Advanced Land Observing Satellite [ALOS]) to determine the annual change from 2004 to 2010. The results were combined with climatic factors (the Oceanic Niño Index [ONI]) to study the impact of climate change on these regions. The results show that the suitability scores of the scallop aquaculture areas were high in spring and winter. No significant change in scallop-suitable areas during the 7 years can be noted from the final annual average suitability area maps, in which the Changhai County and Lushunkou are the most suitable areas. These results are also consistent with the actual scallop aquaculture areas. Moreover, compared with ENSO (El Niño/La Niña-Southern Oscillation events, the average suitability score of scallop aquaculture areas in a serious El Niño year was lower than that in other years.

May 18, 12:45 (S3-7984)

Do phytoplankton, bacteria, and heterotrophic nanoflagellates gain competitive advantages by sacrificing parts of their clonal populations in favour of receiving resources for continuous growth?

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Measurements in a temperate marine ecosystem indicate maximal primary productivity in summer when phytoplankton biomass is low and nutrients are hardly detectable as measured at macroscales. This implies high grazing rates, rapid cycling of ample nutrients at microscales, and the dominance of edible phytoplankton over nongrazed species. A conceptual model is proposed to account for this phenomenon: motile phytoplankton, bacteria, and heterotrophic nanoflagellates (HNF), which are spatially structured at microscales owing to asexual reproduction, exploit microscale resource patches. They all gain competitive advantages by sacrificing part of their clonal populations in favour of receiving resources for continuous growth. Bacteria and HNF play important roles in the recycling of nutrients. Zooplankton graze where the concentration of their preferred algal prey is high. The remnant phytoplankton cells receive recycled nutrients from the grazers and from the bacteria-HNF loop and continue to grow. Patches dominated by nongrazed algae experience nutrient limitation, poor growth, and low abundances. Consequently, zooplankton exert a strong influence on the planktonic community. However, in contrast to the traditional concept of top-down control in ecosystems, both predator and prey enhance abundance by their coexistence. We suggest this interaction be termed as "predator-prey synergism." Synergism in the planktonic community may provide a mechanistic explanation for ecosystem resilience and abrupt regime shifts. Ecosystem shifts between contrasting states is a highly topical question at the prospect of global warming.

S4 Oral Presentations (Day 1)

May 16, 11:05 (S4-8265), Invited

Climate induced fluctuation of Japanese sardine, its influence on marine ecosystem and human being

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The catch of Japanese sardine has exhibited large fluctuation. It reached 2.5 million t during 1983-1989, however it had declined drastically in the early 1990s and less than 10 thousand t since 2002. Many studies suggested importance of climate regime influence on the sardine fluctuation. The large fluctuation of Japanese sardine biomass influences on other components of the marine ecosystems. Mackerel, Anchovy and other small pelagic fishes have shown species alternation with Japanese sardine. Density of large copepods in the subarctic region was decreased during the high abundance period of the Japanese sardine. A two-dimensional individual-based fish movement model coupled with fish bioenergetics was used to test the density-dependent effects on Japanese sardine and the model reasonably reproduced the decrease of prey plankton density and weight of Japanese sardine during the higher stock period. Moreover, the model reproduced expansion of the habitat area of Japanese sardine. The large fluctuation of Japanese sardine biomass also influences on human being. During the increase phase of Japanese sardine, the price of sardine is low and fisheries boats were rebuilt to the larger ones to increase the catch volume. However, after the stock collapse, fishermen had to continue to catch sardine to refund. As a result, excess catch of Japanese sardine accelerated the decrease of Japanese sardine and the economy of fishery ports was damaged. A fisheries management model analysis showed that there was no major decrease of self-sufficiency ratio of fish even if the building of the larger fisheries boats had been limited.

May 16, 11:35 (S4-8176)

Climate change impacts on the pelagic ecosystem off southern California: Comparisons of trends and variability within and between trophic levels

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The comparative approach is a powerful tool to disentangle climatological impacts on marine ecosystems, yet it is rarely used to its full potential. The California Cooperative Oceanic Fisheries Investigations (CalCOFI), supplemented more recently by the California Current Ecosystem Long-Term Ecological Research program is one of the longest-running multi-disciplinary, multi-trophic level studies in the world, with upwards of 60 years of data on biomass and distribution of species representing primary, secondary, and tertiary trophic levels. To test the hypotheses of similarity in responses of different trophic levels to climate change, and 'bottom-up' control of food web control structure and function, we investigated trends and variability in chlorophyll, zooplankton, icthyoplankton, and seabird biomass and distribution in the southern California upwelling system. We predicted that climate impacts to seabirds were indirect, mediated by intermediate trophic levels, and test this prediction using path analysis. Considering impacts by trophic level was not entirely satisfactory as different species showed varying timescale-dependent responses to climate and their biological environment (lower trophic levels). Species-level analysis revealed some declines in biomass and northward redistributions consistent with long-term ocean warming. Path analysis revealed the dominant pathways of response to seabirds were indirect, as predicted. Monotonic climate change impacts were apparent for some species, with trophic chains supporting a 'bottom-up' mechanism, but high and low frequency climate variability explained most of the biological variability. Perhaps these findings are to be expected as the effects of climate change should be subtle and the capacity of species to buffer change may be substantial.

May 16, 11:50 (S4-8306)

Climate change imprint on marine life from long-term observations

Elvira S. **Poloczanska**[1], Christopher J. Brown[1,2], William J. Sydeman[19], Wolfgang Kiessling[9], Pippa J. Moore[10,11], Keith Brander[3], John F. Bruno[4], Lauren Buckley[4], Michael T. Burrows[5], Carlos M. Duarte[6,7], Benjamin S. Halpern[8], Johnna Holding[6], Carrie V. Kappel[8], Mary I. O'Connor[12], John M. Pandolfi[13], Camille Parmesan[14,15], David S. Schoeman[16,17], Franklin B. Schwing[18], Sarah Ann Thompson[19] and Anthony J. Richardson[1,2,20]

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Evidence is rapidly accumulating of climate change impacts on the distribution, phenology and physiology of species globally. We present the first comprehensive synthesis and attribution of observed biological impacts of recent climate change in the world's oceans. We developed a global database of long-term observations of biological responses from the oceans that span ecosystems (coastal to open ocean), latitude (Antarctic to Arctic) and trophic level (phytoplankton to top predators). Our analysis focuses on the magnitude and consistency of shifts in biogeographic ranges, phenology and other physiological and biological traits. We show with rigorous meta-analysis that marine biological changes are overwhelmingly consistent with changes expected to occur as a consequence of climate change and attribute these changes to global temperature warming. Analysis of rates of changes in distribution and phenology show rapid changes that are comparable to or greater than rates of change observed for terrestrial organisms, despite slower ocean warming, but consistent with expectations from analyses of global temperature sets showing similar rates of thermal shifts over land and ocean during the past 50 years. Organisms showed considerable variability in responses, with differences in changes in phenology, distribution and abundance across taxa implying large-scale reorganization of marine systems. Despite remaining knowledge gaps, especially in equatorial regions and the Southern Hemisphere, it is clear that contemporary climate change has already had widespread impacts on marine life.

May 16, 12:05 (S4-7968)

Climate and cyclic hydrobiological changes in the Barents Sea in the 20th and 21st centuries

Gennady **Matishov**, Denis Moiseev, Olga Lyubina, Aleksandr Zhichkin, Sergey Dzhenyuk, Oleg Karamushko and Elena Frolova

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Changes in the biota of the Barents Sea in response to cyclic changes in the oceanographic regime are discussed. The data base of the Murmansk Marine Biological Institute of the Kola Scientific Centre of the Russian Academy of Science (MMBI KSC RAS) holds oceanographic and hydrobiological data sets collected over more than hundred years along the meridional Kola Transect across the Barents Sea. Analysis of those data demonstrates a high variability of the thermal state of the upper layer of the Barents Sea governed by the varying inflow of Atlantic water and by the regional climate. At irregular intervals, cold periods with extended seasonal ice cover are followed by warm periods. The most recent warm period started in the late 1980s and reached its maximum in 2001-2006. Those cyclic changes in the hydrological regime over the 20th century and the first decade of the 21st century are mirrored (with a specific delay of 1-5 years) by changes in species composition, abundance and distribution of boreal and arctic elements of macrozoobenthos and ichthyofauna. Cod and cod fisheries in the Barents Sea are closely linked to the marine climate. Recruitment to the stock of Kamchatka crab benefited from the warm climate in 1989 and 1990. It has been shown that in case of incomplete hydrometeorological information, climatic dynamics may be assessed by biological indices of abundance, biomass, and migrations of marine organisms, including commercial species.

May 16, 12:20 (S4-8147)

Impact of Atlantic Multi-decadal Oscillation on marine ecosystems

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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. It impacts on the dynamics of plankton, benthos and fish populations as demonstrated by a growing body of publications. Changes in abundance and shifts in distributions from plankton to fish have been shown to occur on both sides of the North Atlantic over multi-decadal periods. Particularly impressive are respective fluctuations of fish populations of cod, herring, sardines and anchovies which have been observed since the second half of the 19th century. This contribution will summarize the results of a recent ICES workshop on the basin-wide impact of the AMO, highlight new findings and draw comparisons to long-term fluctuations of North Pacific populations.

May 16, 14:00 (S4-8207)

Geographical distribution and abundance of North East Arctic (NEA) haddock (Melanogrammus aeglefinus) in a changing climate

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The NEA haddock is an important commercial fish species in the Barents Sea. Spawning areas are located off the coast of North Norway, upstream the inflow of Atlantic water. Substantial interannual to multidecadal temperature fluctuations characterise the marine climate in the area. During recent decades the long-term trend has shown an increase in temperature. Understanding how the NEA haddock stock reacts to these climatic changes is important when developing manabgement strategies for maintaining a sustainable haddock stock. Temperature changes are believed to have large impact on both year-class strength and geographical distribution of NEA haddock, however, few studies have addressed this question. The aim of my master thesis is to study how the distribution and abundance of NEA haddock are affected by climatic changes. The study is based on time series of trawl and temperature data from the Barents Sea collected annually in winter surveys since 1981. In this study I will compare the geographical distributions of all age groups between contrasting cold and warm years, compare local distribution to local temperature conditions, and analyse time series of abundance of haddock. The main objectives are: climate induced shifts in distribution, age specific temperature limits for distribution, and climate effects on abundance.

May 16, 14:15 (S4-7949)

To migrate or not? When may we expect groundfish species to move poleward?

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Fish are anticipated to shift their distributions poleward as the subarctic and Arctic oceans warm. In the past century, Atlantic cod moved northward into warming regions of the northern North Atlantic. In the eastern Bering Sea, walleye pollock, Pacific cod and arrowtooth flounder, among others, have shifted the centroids of their biomass northward and eastward when warm winters resulted in a reduced cold pool. A species' ability to adjust its distribution will depend on several factors including: 1) temperature tolerances during critical seasons; 2) migratory capacity; 3) availability of new spawning locations; 4) availability of adequate prey resources; and 5) timing of life history events relative to those of prey. In the Barents Sea, capelin are expected to continue to use the area south of the retreating sea ice for their summer foraging. Cod will likely follow the capelin northwards if temperatures allows. But what if capelin change spawning grounds and cease to visit the northern coast of Norway? Would a shift to alternate spawning grounds affect the growth and survival of cod? And what will happen to walleye pollock in the Bering Sea? There, pollock are at the northern edge of their range. They might be expected to move north, following the retreating ice edge and foraging on ice-dependent prey, which are at the southern edge of their distributions. However, cold bottom temperatures are expected to persist in the northern Bering Sea and may block their way. We explore some mechanisms likely to affect range changes in subarctic fish.

May 16, 14:30 (S4-8135)

Climate-mediated processes on the northern and southern shelves of the eastern Bering Sea and some implications for the ecosystem

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The potential impact of climate change on the eastern Bering Sea ecosystem can be estimated. Many of the predicted ecosystem changes will result from climate-mediated processes governing timing and extent of sea ice. Sea ice in the northern Bering Sea will be less common in May, but will continue to be extensive through April. In contrast, the southern shelf will have, on average, much less sea ice than currently observed, but with large interannual and multiyear variability until at least 2040. Thus bottom temperatures on the northern, but not southern shelf will remain cold. Biological responses to climate warming will vary according to life history. For example, we expect greater north-south differences in zooplankton community structure including disappearance from the southern shelf of two principal prey of higher trophic levels (*Calanus* spp. and *Thysanoessa* spp.). Some species of fish (*e.g.* juvenile sockeye salmon) may expand their summer range into the northern Bering Sea, but other species (*e.g.* walleye pollock and arrowtooth flounder) are unlikely to become common there. The projected warming will limit the distribution of arctic species (*e.g.* snow crab), and will likely permit expansion of temperate species into the southern Bering Sea. The distribution and abundance of baleen whales will respond to shifts in prey availability; an extension of range and an increase in seasonally migratory whale numbers is anticipated. Thus alteration of this ecosystem in response to climate change is expected to result in something other than a simple northward shift in the distribution of all species.

S4-Day1

May 16, 14:45 (S4-8233)

Climate change, ocean acidification and the fish and fisheries of the Arctic

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Persistent climate change has caused dramatic changes in the Arctic Ocean and the ecosystem and biodiversity it supports. Meanwhile, increasing atmospheric carbon dioxide may lead to reduction in ocean pH and saturation state of calcium carbonate. This change may have potentially negative consequences for benthic and pelagic calcifying organisms, and also affect the whole marine ecosystem. In the 2000s, the total landed value in the Arctic was US$ 2.2 billion in 2005 real dollars. Fisheries in this region also provide jobs to 0.6 to 1 million people and are important to the indigenous people. Biophysical and biogeochemical changes in the ocean and changes in the marine productivity under climate change may affect fisheries and eventually the economics in the Arctic. The objective of this paper is to briefly review existing knowledge and analyze how change in climate and ocean alkalinity under scenarios of anthropogenic CO_2 emission is expected to affect the economics of marine fisheries in the Arctic. We apply the Dynamic Bioclimate Envelope Model (DBEM) and outputs from Earth System Models to project future changes in distribution and maximum catch potential of exploited marine fishes and invertebrates. Using these potential catch changes, we compute the economic effect of climate change and ocean acidification on commercial fisheries in the Arctic in terms of changes in: (i) price and value of fish and fisheries products; (ii) fishers' incomes; (iii) fishing cost; and (iv) economic impacts throughout the economy. Results of this study would be useful for designing effective adaptation strategies, and measures to mitigate the potential negative impacts of ocean acidification in Arctic.

May 16, 15:00 (S4-7996)

Water exchange in the southern Barents Sea: Indirect integral characteristics and impact on the abundance of NEA cod

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Water exchange with the open North Atlantic is a key element in the Barents Sea ecosystem. Atlantic water is advected into the southern part of the Barents Sea where it is spread and modified, providing favorable conditions for primary production. Spawning, eggs and larvae distribution, migrations and feeding of major fish stocks, including the Northeast Arctic (NEA) cod, occur in that area. This cod stock is the largest one in the world and is intensively harvested by many commercial fleets. Growth of the NEA cod stock is generally associated with water warming. It has, however, been shown that temperature in the southern Barents Sea is rather weakly correlated with water exchange measured instrumentally or to NEA cod abundance estimated by fisheries monitoring. In the recent decade, instrument measurements in the main stream of the Atlantic current at the southwestern margin of the Barents Sea shelf were performed. Long-term data series on the aeration of the bottom layers was studied, and new indicators of water exchange intensity were suggested. These studies have permitted inclusion of characteristics of water exchange as input data for statistical models that reliably describe its correlation with NEA cod abundance and, for the first time, serve as a scientific basis for projecting recruitment to the commercial stock. The paper presents theoretical, empirical and statistical proof of the direct correlation between NEA cod abundance and water exchange in the southern Barents Sea. Implications of climate change on the NEA cod population are discussed.

May 16, 15:15 (S4-8060)

Projected spatial distributions for eastern Bering Sea arrowtooth flounder under simulated climate scenarios, with implications for predation

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Empirical relationships between the extent of the eastern Bering Sea shelf summer "cold pool" (bottom water $\leq 2°C$) and maximum sea ice extent and sea level pressure allow projections of cold pool area from global climate model simulations. The present study uses these projections to predict future spatial distributions of arrowtooth flounder (*Atheresthes sp.)* in the Bering Sea assuming these distributions are controlled primarily by the cold pool. An inverse relationship between the area occupied by arrowtooth flounder and the cold pool area has been observed from 1982-2010. Small cold pool areas and large arrowtooth flounder areas were observed in the warm years of 2003-2005, whereas the colder years of 2006-2010 have exhibited larger cold pool areas and smaller arrowtooth flounder areas. Projections of cold pool area from 2010 to 2050 based upon 15 International Panel on Climate Change (IPCC) model runs show a wide range of variability but an overall decreasing trend, resulting in the median arrowtooth flounder area across the 15 IPCC models increasing from 140,000 km^2 in 2010 to 160,000 km^2 in 2050. Changes in the spatial distribution of arrowtooth flounder relative to other species can affect their consumption of prey, of which age 1 and 2 walleye pollock (*Theragra chalcogramma*) comprise a large portion. The relationship between the area occupied within various EBS sub-areas and cold pool extent will be examined for arrowtooth flounder and walleye pollock in order to project future spatial distributions and assess the potential impact of arrowtooth predation on pollock.

May 16, 15:30 (S4-8153)

Effects of circulation and climate change on early life stages of Antarctic krill

Andrea **Piñones**[1], Eileen E. Hofmann[1], Kendra L. Daly[2], Michael S. Dinniman[1] and John M. Klinck[1]

Presented by Eileen E. Hofmann on behalf of Andrea Piñones

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The observed abundance and distribution of Antarctic krill (*Euphausia superba*) along the western Antarctic Peninsula (wAP) suggests that these populations are maintained by inputs from upstream sources via advection and by local reproduction and subsequent retention. The extent to which local inputs support the Antarctic krill stocks depends on the availability of spawning stock and the ability to complete the descent-ascent portion of the reproductive cycle on the continental shelf. The objectives of this study were to explore the influence of the circulation in supporting these two mechanisms and to consider the effects of potential changes due to climate induced modifications in wind strength and across-shelf circulation. A version of the Regional Ocean Modeling System (ROMS) configured for the wAP shelf was used to simulate present conditions of increased winds and increased onshelf transport of Circumpolar Deep Water (CDW). Simulation results showed that the present distribution of Antarctic krill results from local and remote inputs, with the latter primarily from the Bellingshausen Sea. The modified environmental conditions enhanced advection of krill larvae into areas of the shelf that would experience the largest reduction of sea ice, especially in winter. Although, changes in the wind strength and CDW transport enhanced larval advection onto the wAP shelf, survival and recruitment may be decreased because of habitat changes due to reduced sea ice.

May 16, 15:45 (S4-8305) - ***Cancelled***

The potential effects of climate change on southern ocean top predators

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Top predators integrate resources over time and space and depending on the particular species they represent different components of the marine environment. The habitat utilization of top predators has been studied using electronic tags to follow their movements and foraging behavior. These data along with studies of diet are informing us on how these important marine predators are likely to respond to climate change. Such changes in foraging behavior will also provide insights into how the Southern Ocean is changing. The Western Antarctic Peninsula has experienced the greatest and most rapidly changing temperature of anywhere in the Southern Ocean. As such changes in the populations of top predators in this region are indicative of changes that are likely to be observed throughout the Antarctic. For example, southern elephant seals forage over very large distances and breed on land while crabeater seals are limited to foraging along the continental shelf and breed on pack ice. Further, crabeater seals primarily feed on krill and krill is dependent on the seasonal pack ice for habitat. As the climate of the Southern Ocean warms species like elephant seals that forage over a greater range of habitat types and breed on land are likely to expand, while species like crabeater and Weddell seals that forage over a more restricted area and breed on sea ice are likely to decline as their habitat recedes. Similar changes have been observed within penguins. Chinstrap Penguins that are less dependent on ice are replacing Adelie Penguins. However, the overall availability of krill a preferred prey for both species is also in decline and thus all penguin populations across the Antarctic Peninsula appear to be in decline.

May 16, 16:20 (S4-8269)

Potential impact of global warming on skipjack tuna (*Katsuwonus pelamis*) habitat in the western North Pacific

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The potential impact of global warming (GW) on skipjack tuna (*Katsuwonus pelamis*) (SJT) habitat in the western North Pacific was studied using satellite remotely sensed and 4-dimensional variational (4D-VAR) data. Fishery presence-only monthly resolved data (March-November, 2004; February-June, 2005) for SJT were used. Sea surface temperatures (SST), chlorophyll *a* (CHL*a*), diffuse attenuation coefficient (K490) and sea surface heights (SSH) were used as SJT habitat indicators. Based on IPCC projections, we simulated GW by raising SSTs in 2025, 2050 and 2010 from Miroc 3.2 model. The 2004-2005 SJT and environment layers were used to make ecological niche factor analysis (ENFA) models and generate habitat suitability indices (HSI) from February-November. ENFA models were used to predict HSI from 2006-2009 and also based on simulated SSTs. Comparisons between HSIs generated by base models and by GW models were made using empirical cumulative distribution function and the KS test. Distributions of 4D-VAR data derived mixed layer depths (MLD) were also examined. Results indicate GW is likely to expand suitable habitats of SJT northwards, from February-June. We found significant changes in habitats, associated with rise in SST in this period. After July, SST rise had a negative or marginal impact on HSI. SJT habitats were consistent with declining MLDs from February to November.

May 16, 16:35 (S4-7958)

Use of a size-based ecosystem model driven by a climate model to project the consequences of climate change on fish abundance and catches in the North Pacific Ocean

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Output from an earth system model is paired with a size-based ecosystem model to investigate the effects of climate change in fish biomass and fishery catches in various locations across the North Pacific over the 21st century based on the IPCC Emission Scenario A2. The model results show a dipole pattern with fish carrying capacity and catches increasing over time in the California Current and decreasing in the subtropical and temperate biomes. For example, using fishing mortality of 0.2 and size of entry to the fishery of 2 kg for all regions, we project that by the end of the century relative to the beginning of the century; catches in the California Current will increase about 30%. While for 2 locations representing the interiors of both the subtropical and temperate biomes catches will decrease about 30% but for 2 locations near the temperate-subtropical biome boundary catches will drop about 60%. In the eastern tropical upwelling biome catches will remain unchanged in the interior of the biome and decrease about 80% at the western edge. These results are largely due to changes in the proportion of large phytoplankton, increasing in the California Current and decreasing elsewhere rather than changes in primary production or phytoplankton biomass.

May 16, 16:50 (S4-8017)

Potential impacts of climate change on the habitat of striped marlin (*Kajikia audax*) in the North Pacific Ocean

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Striped marlin is a highly migratory species distributed throughout the North Pacific Ocean, which shows considerable variation in spatial distribution as a consequence of habitat preference. It is important to understand the spatial pattern of striped marlin, and the influence of climate change, to develop effective fisheries management policies, given the economic importance of the species and as well as the impact of fishing. We examined the relationships between the spatial pattern and environmental conditions using generalized additive models fitted to longline fishery data using various oceanographic variables as covariates. Results indicated that sea surface temperature is the most important factor affecting spatial distribution. The increase in sea surface temperature driven by climate change is predicted to lead to a northward shift of the preferred habitat of striped marlin. The results enhance understanding of the variability in the habitat of striped marlin in the North Pacific Ocean. This has implications for the effectiveness of spatially-explicit management strategies such as time-area closures.

May 16, 17:05 (S4-8257)

Predicted ecological characteristics of common squid (*Todarodes pacificus*) larvae inferred by various climate models under IPCC SRES A1B Scenarios

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To predict the ecological characteristics of common squid (*Todarodes pacificus*), we simulated the present and future ocean circulations using an East Asia Regional Ocean model (Modular Ocean Model, MOM version 3) projected by the three different global climate models under IPCC SRES A1B scenario. Mean climate states for 1990-1999 and 2030-2039 from 20th and 21th Century Climate Change Model Simulation were used as surface conditions for simulations, and we examined changes in spawning ground, hatching condition, larval dispersion between 1990s and 2030s. To infer spawning ground, the temperatures range of 15-23°C at 50 m depth were used because the highest density of hatchling were found at 25-50 m depth. Also, spawning is considered to occur at the continental shelf and slope of 100-500 m depth. Since mixed layer depth (MLD) is regarded as one of important factor determining successful hatching of egg masses, we examined the variability of MLD, and discussed its impacts on hatching condition. Lastly, using the velocity field from each model simulation, variability of larval dispersion was examined under different climate conditions. We used individual-based model incorporated ontogenetic vertical movement in larval dispersion, and simulated individuals tracked from inferred spawning grounds for 60 days.

May 16, 17:20 (S4-7956)

Synchrony in the abundance trends of spear squid *Loligo bleekeri* in the Japan Sea and Pacific Ocean with special reference to the latitudinal differences in response to the climate regime shift

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Spear squid *Loligo bleekeri* is widely distributed in Japanese coastal waters and is a commercially important species for coastal fisheries in Japan. The fisheries depend largely on four stocks: the southwestern and northeastern stocks in the Tsushima Warm Current region of the Japan Sea and the southern and northern stocks in the Kuroshio/Oyashio Current regions of Pacific coast. Spear squid is one of the most important target species of pair trawlers in the southwestern Japan Sea and set-nets in the northeastern Japan Sea. It is fished mainly by pair- and single-trawlers in the southern and northern Pacific coast, respectively. CPUE for the northeastern stock in the Japan Sea decreased substantially during the 1980s but increased during 1990s; while the relative abundance index for southwestern stock was higher in the 1980s but lower in 1990s. On the other hand, CPUE for the southern stock in the Pacific coast was higher in the 1980s but lower in the 1990s, while CPUE for the northern stock exhibited an opposite pattern of variation. These patterns strongly suggest synchrony in the abundance trends in the Japan Sea and Pacific Ocean, and opposite variations between northern and southern stocks with abrupt changes around the late 1980s corresponding to a climate regime shift. Correlation analysis showed that the increase in water temperature had positive effect on the northern stocks and a negative effect on southern stocks. These results suggest that the abundance trends of spear squid were largely forced by the water temperature with latitudinal difference in response to the late 1980s climate regime shift.

May 16, 17:35 (S4-7986)

Vulnerability of small pelagic fish populations in non-upwelling areas under climate change

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Elucidating the impact of climatic changes on fish populations can be complicated due to the important number of associated factors that affect the environment and the biology of the species. Also, other anthropogenic alterations to the ecosystem, such as overfishing or eutrophication, often entail alterations in the trophic structure of marine communities. In the case of anchovy and sardine, studies show that in highly productive areas (*i.e.* Humboldt current system, Benguela current system, California current system and Galician coast) as well as in non-upwelling zones (*e.g.*, Kuroshio current system), these two species display regime shifts of abundance within the year. These fluctuations are thought to reflect long-term environmental variations. However, anchovy and sardine in the northwestern Mediterranean, an oligotrophic area compared to the formerly mentioned, do not seem to present temporal alternations in their populations. Another characteristic of these populations that is not found in most of the others is that spawning periods of the two species are temporally alternate, although diets, according to our findings, are basically similar. Moreover, fish from relatively less productive areas, like the Gulf of Lions, are more dependent on the adjacent lower trophic level than those from richer regions. At the same time, these lower trophic levels (*i.e.* plankton) are enormously affected by any change in the temperature of the environment. Giving these facts and the current scenario of climate change, we use trophic dynamics analysis of the species to anticipate major alterations in the Mediterranean populations of anchovy and sardine.

May 16, 17:50 (S4-8027)

Linking the impact environmental changes on clupeoid fish through the zooplankton: The example of North Sea herring

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The present study investigates a possible link between the change in plankton communities and the environmentally induced poor recruitment of North Sea herring. Clupeid fish are well known indicators of environmental change, with populations showing periodic fluctuations in productivity, which co-vary with environmental signals. North Sea autumn spawning herring provides such an example as changes in productivity co-vary with basin wide environmental drivers. However the direct causal mechanisms for these changes are unknown. Recent changes in productivity have been driven by variation in recruitment and are linked to the annual mean mortality of the overwintering larvae. Analysis of long-term plankton data collected by the Continuous Plankton Recorder (CPR) highlights a significant change in the composition of the North Sea zooplankton communities during the late 1990s-early 2000s that can be related to large-scale hydroclimatic variability and concords with poor recruitment since 2001. We investigate potential hypotheses about changes in the plankton affecting larval mortality.

Since 2001, a decrease in biomass of zooplankton < 2 mm and a significant increase of zooplankton > 2 mm has occurred during the autumn. This represents respectively a decrease in food and an increase in competitors/predators of herring larvae. We therefore suggest that the low survival rate of early-stage herring larvae could be due to a combined effect of zooplankton predation (top-down control) and/or competition for food (bottom-up). This hypothesis is reinforced by the analysis of variations of zooplankton and herring spatio-temporal distributions and supports other on-going studies. Thus re-enforcing the idea that productivity of clupeids is directly driven by environmental change.

S4-Day1

S4 Oral Presentations (Day 2)

May 17, 11:05 (S4-8242)

Shrinking of fishes exacerbates impacts of global ocean changes on marine ecosystems

William W.L. **Cheung**[1], Jorge L. Sarmiento[2], John P. Dunne[3], Thomas L. Frölicher[2], Vicky W.Y. Lam[1], M.L. Deng Palomares[1], Reg Watson[1] and Daniel P. Pauly[1]

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Changes in temperature, oxygen content and other ocean biogeochemistry directly affect the eco-physiology of marine water-breathing organisms. Previous studies suggest that the most prominent biological responses are changes in distribution, phenology and productivity. Both theory and empirical observations also support the hypothesis that warming and reduced oxygen will reduce body size of marine fishes and invertebrates. However, the extent to which such changes would exacerbate the impacts of climate and ocean changes on global marine ecosystems remains unexplored. Here, we employ a model to examine the integrated biological responses of over 600 species of marine fishes due to changes in distribution, abundance and body size. The model has explicit representation of eco-physiology, dispersal, distribution, and population dynamics. We show that assemblage-averaged maximum body weight is expected to shrink globally from 2000 to 2050 under a high emission scenario, due to changes in distribution and abundance and physiological limitation of oxygen supply and demand. The tropical and intermediate latitudinal areas are expected to be heavily impacted. Our results provide a new dimension to understanding the integrated impacts of climate change on marine ecosystems.

May 17, 11:20 (S4-7990)

Invasion of tropical herbivores into a temperate system results in devastating phase-shift mediated by the loss of canopy algae

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Fish herbivory is a critically important ecological process in tropical marine systems, as the maintenance of healthy coral-reefs depends on the removal of algae that can otherwise outcompete corals. In contrast, herbivorous fishes typically have minimal effects in temperate rocky reefs, where macroalgae are the main habitat-forming organisms. In 1869, the construction of the Suez Canal joined the tropical waters of the Red Sea and the temperate Mediterranean. Since then, two species of herbivorous rabbitfish, *Siganus luridus* and *S. rivulatus*, have established large populations in the Eastern Mediterranean and the distribution of both species is currently expanding westwards as temperatures continue to rise. We assessed the community-wide effects of these tropical herbivores along a gradient of distance to the Suez Canal and found extensive barren areas completely denuded of habitat-forming algae wherever rabbitfish are abundant. Moreover, the overall species richness of algae, fish and invertebrates significantly declined in regions populated by tropical herbivores. To detangle potential mechanisms that may mediate the observed shift in community composition, we quantified macrophyte consumption rates and feeding preferences of individual temperate and tropical fishes using video cameras. Surprisingly, temperate herbivorous fish showed the highest consumption rates of adult macroalgae, while tropical rabbitfishes appeared to maintain the observed barrens by persistent feeding on algal recruits. The process observed in the Eastern Mediterranean may serve as a 'warning canary' for what may happen in other parts of the world, since increasing ocean temperatures are already allowing tropical species to overwinter in other temperate areas.

May 17, 11:35 (S4-8055)

Assessing changes in distribution and range size of demersal fish species in the Benguela Current Large Marine Ecosystem in relation to long-term change in the environment

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The Benguela Current Large Marine Ecosystem (BCLME) adjoining the southwestern coast of Africa is an important centre of marine food production, but is considered to be critically vulnerable to any future climate change or variability in climate. Recent studies have shown long-term warming of sea surface temperatures over large areas of the BCLME. Distributional change, range expansion or contraction, has been shown to be manifested by many organisms in relation to changes in the environment. The extent of such distributional changes is also expected to increase in response to future climate change. In this study we analysed change in distribution and range size of several demersal fish species in the BCLME over the period 1985-2010. Recent studies have shown long-term warming of sea surface temperature over large areas of the BCLME which is expected to affect some aspect of the distribution of demersal fish species. In this study we analysed changes in the distributions of several fish species in the BCLME including those that are commercially targeted and by-catch species over the period 1985-2010. We then attempted to link the distribution, as measured by centre of gravity, and latitudinal or depth range, of demersal fish species to the long-term trend in environmental variables.

May 17, 11:50 (S4-8032)

Is the abundance of invasive cladoceran *Cercopagis pengoi* controlled by blooms of moon jelly *Aurelia aurita* in northern Baltic Sea?

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The density of both *Cercopagis pengoi* and *Aurelia aurita* in the northern Baltic Sea is very dependent on climatic conditions. Warm and calm water favors the waterflea *Cercopagis pengoi*, which has southern origin. The jellyfish *Aurelia aurita* occurs in the northern Baltic Sea on the edge of its salinity tolerance. Most of the medusas appearing in the north in late summer as migrants from the south. The abundance of jellyfish in the north depends on the success of reproduction in southern areas, but the properties of water movement are likely crucial. The spatial and temporal distribution of *Cercopagis pengoi* in the Baltic Sea has been well studied since the invasion, but there are only a few reports that quantify the distribution of jellyfish in the area. On the basis of semi-quantitative jellyfish data collected during the summers of 2008-2011, there is a strong evidence, that the number of *Cercopagis pengoi* was significantly lower during periods or in areas where jellyfish occurred in high numbers, although environmental conditions were favorable for *Cercopagis pengoi*. *Cercopagis pengoi* is clearly consumed by *Aurelia aurita* and both species are preying on smaller zooplankton, but predators did not control the abundances of other zooplankton species and the top-down effect of such predator interrelations remains unresolved.

May 17, 12:05 (S4-8071)

How predictable are species distribution shifts? Testing ecological hypotheses against four decades of observations

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Some of the most commonly predicted impacts of climate change are shifts in species distributions as they track preferred environmental conditions. These shifts are predicted to affect fisheries as target species are pushed poleward, while species shifting at different rates are likely to pull apart and reshuffle marine communities. Key questions remain, however, about the processes affecting these shifts, the factors driving differences among species, and the predictability of these shifts through time. While most approaches currently assume that climate alone sets species distributions and their dynamics at broad scales, ecological theory suggests that dispersal, population growth, ecological specialization, species interactions, and other sources of mortality such as fishing should have strong impacts. Our research uses three (Pacific) to four (Atlantic) decades of research bottom trawl surveys on the continental shelves of North America to test whether the direction and magnitude of range shifts among demersal fish and invertebrates are predictable from local climate, life history, and exploitation history. We find that range shifts vary substantially among species, but that local differences in climate trajectories can explain otherwise surprising differences in direction of shift. Life history traits and exploitation history explain additional variation among species, and we find indications that species interactions are important in certain cases. Results suggest which types of species will be winners and losers under climate change, how communities are likely to be altered by shifting ranges, and how the next generation of process-based species distribution models can be built.

May 17, 14:00 (S4-8224)

Latitudinal shifts in catch distribution of fisheries species in Korean waters during the past 30 years in relation to climate change

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Sea surface temperatures in Korean waters have increased by *ca* 1°C during the past 40 years, but the warming trend diminishes with water depths, becoming not significant at < 100 m depths. We analyzed spatially-explicit catch data of major fisheries species in Korean waters collected from 1983 to 2010 to evaluate and predict their range shifts in relation to climate-driven hydrographic changes. Preliminary results suggested that 1) small pelagic species such as anchovy, mackerel, sardine and common squid showed a stationary trend in their latitudinal ranges in catch, 2) large pelagic species such as bluefin tuna, king mackerel, and yellowtail showed northward shift, 3) demersal and bentho-pelagic species showed inconsistent pattern: hairtail and file fish showed stationary trend; small yellow croaker and red horsehead northward shift. Distribution of Pacific cod, known as cold-water demersal species, extended southward since the late 1990s, which seems to be related with intensified episodic penetration of deep waters from the Japan/East Sea to the Korea Strait. Water temperature and salinity, particularly in the mixed layer, showed significant correlations with the mean latitude in catch of some species, suggesting variation in the Tsushima warm current also could be important in range of fish species, together with temperature. Results implied that artisanal coastal fisheries, which have benefited from their ability in quick supply of live or unfrozen fishes, will become less competitive than industrialized fisheries in adapting to possible climate-driven range shifts of their target species.

May 17, 14:15 (S4-7957)

Transboundary climate induced distributional changes in an important recreational west African fish species – consequences and adaptation

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A Polymerase Chain Reaction-based Restriction Fragment Length Polymorphism molecular technique was used to distinguish between the morphologically similar Sciaenids, *Argyrosomus coronus* and *Argyrosomus inodorus* in the recreational shore fisheries of southern Angola and Namibia and compared with a similar study conducted in Namibia in 1995. The southern Angolan recreational fishery comprised *A. coronus* exclusively, while the ratio of *A. inodorus* to *A. coronus* in the west coast recreational area changed from 9:1 in 1995 to 4:6 in 2008/2009. This result and the rapid decline in the relative abundance (69% CPUE) and decrease in average size (29% mean length) of *A. coronus* in southern Angola between 2005 and 2009 indicate a recent southward distributional shift in this species. A 0.8°C decadal increase in sea surface temperature in this region is thought to be the main driver of this distributional change as *A. coronus* appear to be sensitive to temperatures above 20°C. While the consequences for the distributional shift include decreased catches in the southern Angolan inshore fisheries, the increase in the number of *A. coronus*, which have a large maximum size (77 kg) when compared with *A. inodorus* (36 kg), is likely to improve the Namibian recreational fishery. However, the greater size at sexual maturity of *A. coronus* (870 mm TL) when compared with *A. inodorus* (355 mm TL) is likely to result in an overexploitation of *A. coronus* under current management regulations, which includes a minimum size limit of 400mm TL. Additionally, the value of Namibia's current marine protected area network under the altered species distribution regime will have to be reviewed.

May 17, 14:30 (S4-8088)

Identifying and characterizing of demersal biodiversity hotspots in the Benguela Current large marine ecosystem: Its relevance in the light of global changes

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The marine environment is heterogeneous and resources tend to be patchily distributed in terms of diversity and abundance. Given their potential in terms of supporting human livelihoods and/or conservation of biodiversity and/or natural processes, and especially in the light of predicted climatic changes, identifying "hotspots" of biological activity in the marine realm and determining which factors govern and maintain them is a growing area of research. We used species distributional data to determine "biodiversity hotspots", in terms of species richness, entropy and evenness, of demersal fish species in the Benguela Current Large Marine Ecosystem (BCLME) at the eastern boundary of the South Atlantic Ocean. A Generalized Additive Model was used to relate spatial patterns in biodiversity to physical and prevailing environmental variables. We assessed the location of hotspots and their temporal persistence and whether any variability in these was attributable to environmental changes. Based on the above, in particular the relationships between environmental variability and biodiversity, we assessed the implications of potential future climate change effects on hotspots of demersal biodiversity in the BCLME, and its relevance to biodiversity conservation.

May 17, 14:45 (S4-7995)

Impact of a 'marine heat wave' on seaweed, coral and fish assemblages in a global biodiversity hotspot

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Extreme climatic events are predicted to increase in frequency and magnitude but their ecological effects are poorly understood, particularly in marine ecosystems. Heat waves are discrete, extreme warming events that are likely to increase in severity as a result of anthropogenic climate change. In marine ecosystems, physical drivers of heat waves are complex and vary between regions but ecological responses often include physiological stress, mass mortalities, species range shifts and changes in the structure of communities and entire ecosystems. In early 2011, the vast coastline of Western Australia experienced a significant warming event, where SSTs were the highest on record and warming anomalies of 2-4°C persisted for many weeks along >2000 km of coastline. The warming event was driven by unusually strong La Niña conditions, which were superimposed onto a decadal-scale warming trend. Here, we describe the effects of the heat wave on the benthic ecosystem of temperate Western Australia, which represents a global hotspot of diversity and endemism. Extensive biodiversity surveys were conducted by scuba divers and an Autonomous Underwater Vehicle (AUV) and compared with long-running baseline data to elucidate the effects of the warming event. Key ecological responses included: (i) localized extinction and regional range contraction of a prominent habitat-forming seaweed; (ii) anomalously high rates of bleaching at a high-latitude coral reef system; and (iii) considerable shifts in the structure of seaweed and reef fish assemblages. These observations, and their implications, are discussed within the general context of extreme warming events in marine systems.

May 17, 15:00 (S4-8058)

Ocean acidification and the possible loss of echinoderms: How will commercial fish and fisheries be affected?

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To date, views expressed on the potential impact of ocean acidification range from wholesale degradation of marine ecosystems through to no discernible impact with minimal consequences. Constraining this range of predictions is necessary to support fishery management and development of informed marine environmental policy. Laboratory experiments have tended to suggest that echinoderms are among the most vulnerable of organisms to ocean acidification, largely because species possess skeletal structures made of magnesium calcite; believed to be highly susceptible to dissolution at lowered pH. However it is not clear what a decline in echinoderm biomass or productivity might mean for commercial fish stocks that predate upon these species and consequently the 'knock on' consequences for fisheries.

In this study we have used a database of 200,000 fish stomach content records to explore the importance of echinoderms (in particular ophiuroids) to the sustenance of higher trophic level fish predators. We show that certain North Sea fish species (in particular haddock, plaice and dab) consume large quantities of echinoderms and this represents a major flux in the ecosystem. However, we also show from an analysis of historic diet data that fish can shift their dietary preferences when a particular prey item becomes less available. We have made use of a complex food-web model of the North Sea to try to predict the likely indirect consequences of a future decline in echinoderm biomass, allowing for predator-prey switching behaviour. We have used this model to explore implications for fisheries catches, revenues and profits.

May 17, 15:15 (S4-8310)

Synergistic impacts of climate change drivers on the developmental ecophysiology, growth and survival of the European lobster, *Homarus gammarus*

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Predicted increases in CO_2 emissions over the next century will lead to increases in global surface temperatures and ocean acidity. Global warming and ocean acidification (OA) may interact with one another altering species physiological status, development, and behaviour, ultimately playing major roles in changing the biogeography of species and thus altering marine ecosystems.

To predict how complex global changes may affect productivity and recruitment in marine taxa, we characterised aspects of the developmental eco-physiology of Stage I to IV larvae (calcification dynamics, energetics and metabolism, growth and development, morphometrics, and survival) of the ecologically, and ecomomically, important European lobster, *Homarus gammarus*, under OA and warming scenarios predicted for the year 2100.

Temperature increased developmental and survival rates, yet reduced final body mass and body length at Stage IV. Also under elevated temperatures lobster larvae invested more in the chelae and rostrum. In addition, thermal sensitivity of metabolism differed between larval stages, with Stages I and IV being more sensitive than Stages II and III. Finally, OA reduced survival at Stage II at lower temperatures, and no significant interaction between elevated temperatures and CO_2 on the traits characterised here was detected.

We conclude that elevated temperature is a greater driver of larval development, growth, and survival than OA, with larvae thermal sensitivity being stage-dependent. Thus we suggest that temperature and not CO_2 will represent the major factor driving lobsters recruitment and productivity in future ocean change scenarios, although there are detectable CO_2 effects which will influence their development.

May 17, 15:30 (S4-8178)

Effects of climate variability on 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, where they serve as prey for fish, seabirds, and marine mammals. The dominant euphausiid species in this region are *Euphausia pacifica* and *Thysanoessa spinifera*. How euphausiids respond to changes in climate will affect the higher trophic level predators that rely on them as a food source. Our ongoing time series study off Newport, Oregon, USA, has collected data twice per month since 2001. This time period encompasses warm and cold years (positive *vs* negative PDO) and different upwelling conditions (strong, weak, late onset, *etc.*). Our 11-year time series of environmental and biological data suggest that climate change will have different effects on these two similar species. The timing of the spring transition is closely tied to the spawning behavior of *E. pacifica*, while *T. spinifera* spawn mainly prior to the spring transition. *E. pacifica* were present year-round regardless of water temperature, while *T. spinifera* were more abundant during cold years and virtually absent during warmer years. For *E. pacifica,* a delayed the spring transition will delay spawning until later in the season which means larvae may not have enough time to mature in order to survive through the winter. Since *E. pacifica* probably live a maximum of two years, several years in a row of a delayed spring transition has the potential to reduce *E. pacifica* recruitment and spawning stock. Warmer water temperatures are likely to decrease *T. spinifera* abundance, making them effectively unavailable to predators.

May 17, 16:00 (S4-8231)

Climate change and fisher behavior in the Bering Sea pollock trawl and Pacific cod longline fisheries

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The two largest volume commercial fisheries in the US Bering Sea are pollock and Pacific cod. In this paper, we build upon work that independently examined the impact of climate change on the pollock and Pacific cod fisheries. We examine how both fisheries have adjusted to economic and environmental variation since 2000. For pollock, the mean location of winter fishing has varied little in warm and cold years, but there has been a northward shift in summer pollock biomass and fishing. This shift is related to the colder than average climate conditions in the latter part of the decade. For Pacific cod, the timing and location of winter fishing has shifted dramatically since 2000. This shift is related to the extent of seasonal sea ice and the timing of its descent and retreat. The summer Pacific cod fishery also shifted to the north, although the timing of the season remained constant. Climate affects relative spatial catch per unit effort (CPUE) in both fisheries by causing a cold pool (water less than 2°C that persists into the summer) that sub-arctic species such as pollock and Pacific cod avoid.

Understanding the relationship between fishing location, climate variables, and economic factors is essential in predicting the effects of future warming on the pollock and Pacific cod fisheries. We discuss key differences in our understanding of fisher behavior, climate conditions, and spatial changes in fish abundance in the two fisheries.

May 17, 16:15 (S4-8074)

Climate change impacts and adaptation in the real world of coastal communities

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Many studies indicate that, depending on the location and circumstances, climate change may have serious impacts on coastal communities and on the livelihoods of their residents. This may arise as a result of sea level rise, extreme events, shifts in resource distribution, and other causes. These potential impacts have inspired governments and development agencies to pursue an improved understanding of the exposure to and sensitivity of these communities to climate change, their adaptive capacity to cope with change, and their consequent overall vulnerability. At the same time, the lives of those in coastal communities continue from day to day, and in many cases the issue of climate change is not high on their personal agenda. While in some places, this could be due to a lack of knowledge on impacts of climate change, the reality in many poorer regions is that local people face more pressing concerns – such as a lack of food or drinking water, a shortage of livelihoods, or more immediate negative environmental changes. This paper describes two recent studies, one on the South Pacific island of Tuvalu and the other on the coast of Ecuador, where the acute development needs of communities meant that potential problems arising from climate change were low on the list of local priorities. This reality leads to a recommendation to focus on 'adaptation entry points' – those opportunities for a balanced and resilience-enhancing approach in which climate adaptation measures are embedded into broader initiatives to meet primary community priorities and development needs.

May 17, 16:30 (S4-8022)

Effects of climate variability on the distribution and fishing conditions of yellowfin tuna (*Thunnus albacares*) in the Indian Ocean

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In the tropical Pacific and Atlantic Oceans, relationships of apparent abundances of tuna species with climatic oscillations are recognized, but similar interactions have not yet been documented in the Indian Ocean. In this study, we investigated the catches and distributions of yellowfin tuna in relation to climatic and marine environmental variations in the Indian Ocean. Results indicated the longitudinal gravity centre of catch per unit effort (CPUE) showed similar variations with a climatic index. An advanced time series analysis also showed a significant negative correlation between the climatic index and the CPUE with a periodicity of 2-3 yr. It was suggested that decreases in areas of sea surface temperature (SST) and net primary production that are optimal for yellowfin tuna during positive Indian Ocean dipole events would decrease the CPUE in the western Indian Ocean, while an increase in optimal areas would result in an increased CPUE in negative Indian Ocean dipole events, especially in the Arabian Sea and seas surrounding Madagascar. Furthermore, an examination of the effects of climate change on possible displacements of potential habitats of yellowfin tuna based on the optimal SST range under conditions similar to those of recent years (2000-2008) showed that an SST increase of 1°C resulted in relatively little change in suitability scores, but increases of 2 and 4°C resulted in decreases of the most suitable areas.

May 17, 16:45 (S4-7977)

Stop, change or move: Practical adaptation of commercial fishers to spatial changes in fish abundance due to extreme weather events

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Climate change is resulting in alterations to the distribution of key fishery species. Regardless of whether species shifts are temporary or permanent, these changes have important implications for commercial fisheries. In tropical areas, climate change is predicted to result in an increased frequency of intense cyclones. Such events affect the abundance of the key fishery species in the area affected by the cyclone. In 2009, Cyclone Hamish (category 5) tracked along the southern Great Barrier Reef, Australia, dramatically reducing catches of commercially important coral trout. Commercial fishers in the affected area had a number of practical adaptation options: stop fishing temporarily until catches returned to normal, diversify their marketed catch, diversify into other fisheries, or move areas to where key species remained unaffected by the cyclone. We repeatedly surveyed affected fishers for 12 months following the cyclone, to explore if and how fishers adapted to this extreme weather event. Few fishers had the financial capacity to stop fishing, and most fishers were highly specialized and unwilling or able to diversify their catch or fishery, meaning the most viable option was to move. Regulations allowed fishers to move to any area within the 345,000 km^2 Great Barrier Reef Marine Park. However, fishers showed a high attachment to place, with numerous economic and social reasons limiting the distance they could move from the affected area. This study reveals that limitations for adaptation extend beyond policy and governance issues, highlighting the importance of understanding the economic and social drivers of fishers' behavior.

May 17, 17:00 (S4-7947)

Climate change impacts on coastal resources and dependent livelihood in Tamil Nadu, Southeastern India

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The 1076 km long Tamil Nadu coastline in Southeastern India consists of key ecosystems such as coral reefs, seagrass beds, mangroves, estuaries, tidal flats, islands, rocky shores and sandy beaches. The ecologically important identified areas are Gulf of Mannar (GoM) in the Ramanathapuram and Tuticorin districts with coral reefs, Vedaranniyam and Muthupettai in Nagapattinam district with mangroves, Pichavaram in Cuddalore district with mangroves and Pulicat Lake in Thiruvallur district with a lagoon. Several thousand coastal people depend on the associated fishery resources through traditional fishing. The change in the climatic pattern by an increase in the temperature and decrease in rainfall leads to steady reduction and fluctuation in catches of many economically important fish species throughout the coasts, in particular commercially important varieties like mackerel, snapper, barracuda, pomfret, grouper, jacks, lobster, mud crab and big-jawed jumper. The case study on big jawed jumper, *Lactarius lactarius* fishery in GoM reveals loss in catch, for example 1028 tons in 1969 and 175 in 1993 and change of fishing ground. The eco sensitive habitats like coral reefs in GoM have regularly experienced bleaching during summer since 2005 due elevated sea surface temperature. About 9% of living corals were dead in 2010. This resulted in the depletion of several associated fishes. Climate change along with other anthropogenic impacts cause loss of habitats (*e.g.* coral reefs, seagrass beds, mangroves), associated biodiversity and fishing ground, which ultimately affects the livelihood of dependent coastal communities leading to changes of profession, migration and destructive fishing practices.

May 17, 17:15 (S4-8189)

Dying fisheries in a changing environment: A study on livelihood strategies of fishery communities in Mumbai

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Over and unregulated fishing along with the increase in diesel price put tremendous pressure on fisheries, especially on urban fisheries. The traditional fishermen restrain insufficient knowledge to adapt the new fishery practices and to adapt the change in environment. Climate change problems like shift in rainfall pattern, increase in storm height and frequencies, increase in ocean surface temperature place additional pressure on fisheries. The livelihood of fisherman is vulnerable both economically and socially to such changes. Fishermen are also less able to diversify their earnings to other activities. The middle men act as moneylender and exploit fisherman most of the time financially. In the current paper a study of livelihood strategies of fishing communities residing in the coastal district of Mumbai India is presented. The study covers five major fishing villages (Versova, Madh, Khar, Mahim and Worli) situated in the waste coast of Mumbai. The data on various social, economic, demographic, physical, health characteristics and data on climate change perception, adaptation measures are collected through a structure questionnaire at household level. Mostly the climate change impact and vulnerability assessment studies are carried out at macro level. The vulnerability ranking of coastal districts in India shows Mumbai is one of the most vulnerable districts in terms of area and population affected to a 1m rise in sea level. In the most cases fishery communities are live close to the sea, and depend heavily on sea. Therefore in the current study we aimed at deriving vulnerability and vulnerability indicators at household and community level.

May 17, 17:30 (S4-8168)

Observations of climate change and subsistence harvests in Emmonak, Alaska

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Emmonak is a primarily Yup'ik (Eskimo) community located at the mouth of the Yukon River, Alaska. It is situated in an estuarine environment where hunters and fishermen access both marine and in-river, or terrestrial, resources. To successfully harvest in a variety of environments and throughout all seasons, Emmonak residents have accumulated a rich body of knowledge about the complex interactions of land and sea that shape their subsistence activities. However, subsistence users deal with the dual influences of a changing climate and socio-economic factors that affect these activities. For example, residents expressed concerns about shorter, warmer winters and wetter summers, affecting the formation of sea ice necessary for seal hunting, access to harvest locations, and conditions necessary for salmon processing, among others. Emmonak residents must also negotiate these challenges in the face of declining commercial fishing opportunities and changing technology that restructure how certain subsistence activities are organized. As such, this paper will analyze the "total environment of change" as experienced and described in Emmonak. Authors describe research conducted between March 2009 and April 2011 as part of the Bering Sea Integrated Ecosystem Research Project (BSIERP) on the local traditional knowledge of Emmonak hunters, fishers, and gatherers and analyze the strategies and adaptations they employ to deal with a changing world.

May 17, 17:45 (S4-8134)

The effect of climate change on shrimp aquaculture, Bangladesh

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The coastal aquaculture of tiger shrimp, *Penaeus monodon* has become an important economic activity in Bangladesh since 1970s. This is the second largest export commodity, and is an important source of income and livelihood for many coastal poor. However, the shrimp cultivation area, which is approximately 217,877 ha, is located in a low-lying deltaic environment of the Bay of Bengal and thus is particularly threatened by global warming. As shrimp are poikilothermic animals, rising habitat temperatures may therefore increase physiological stress on cultured stock, hence possibly will influence growth potential, yields, reproduction seasonality and immune response. A warming environment may also influence dissolved oxygen levels, increase the incidence of diseases, and range of pests and parasites, along with increased frequency of algal blooms. Moreover, climate change may pose a series of other threats, for example, frequency and severity of extreme weather events (*i.e.* aquaculture area may damage by tidal surges, storms, cyclones and floods), sea level rise and conflict of interest with coastal defenses, and enhanced anomalies in the rainfall pattern and coastal erosion and accretion process. There may be an uncertain future supply of fishmeal and oils from capture fisheries to meet the demand of artificial feed for farmed shrimp. These incidents, in turn, may lead higher risks and reduce returns to farmers. In contrast, higher temperatures may lead to increased growth rates and food conversion efficiencies, especially in winter months. All these issues are complex, poorly understood and difficult to predict but, nevertheless, the shrimp farming industry can expect to deal with in the future.

May 17, 18:00 (S4-7969)

Climate change effects and adaptation strategies in a Nigerian coastal agro-ecological zone

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This paper presents the results of a survey conducted to evaluate farmers' perception of climate change effects, identify and document effective indigenous and emerging technologies and innovations for climate change adaptation in the zone. Structured questionnaires were administered to farmers in a multi-stage survey followed by focused group discussions. Data obtained were analyzed on the Statistical Package for the Social Sciences (SPSS) in addition to other statistical tools. Results indicate that livelihoods in the survey area (Ogun Waterside Local Government Area) were fishing, aquaculture and crop farming; and that farmers were well acquainted with climate change and its effects which included: Biodiversity loss, reduced productivity and loss of income. Farmers opined that climate change resulted from fishing and fish farming activities (84%), industrial activities (9%), transportation (8%), urbanization (4%) and agro-processing (3%). Over 90 percent of respondents agreed that climate change reduced their productivity; and was responsible for increased flooding and reduced crop yields (47%), destruction of nets, capsizing of boats and general reduction in fishing effort (42%). Frequent windstorms also damaged residential buildings (5%) and processing sheds (3%). Reported biodiversity loss included *Chrysichthys nigrodigitatus*, *Lutjanus* species*, Polydactylus quadrifilis, and Phractolaemidae* spp. which farmers complained were now rarely captured. Adaptation strategies included the adoption of secondary livelihoods particularly water transportation, crop farming and aquaculture. The introduction and development of seaweed farming has a high potential for enhancing productivity in the zone.

S4-Day2

S4 Oral Presentations (Day 3)

May 18, 11:05 (S4-7980)

Climate forcing and the Kuroshio/Oyashio ecosystem

Akihiko **Yatsu**[1], Sanae Chiba[2], Yasuhiro Yamanaka[3], Shin-ichi Ito[4], Yugo Shimizu[4], Masahide Kaeriyama[5] and Yoshiro Watanabe[6]

Presented by Shin-ichi Ito on behalf of Akihiko Yatsu

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The Kuroshio and Oyashio, western boundary currents in the North Pacific, greatly influence climate, ecosystems and fisheries in the western North Pacific and its adjacent waters. The Kuroshio/Oyashio ecosystem (KOE) shows interannual and decadal variability including regime shifts. Under a collaboration of the Climate Forcing and Marine Ecosystem Response (CFAME) Task Team and Working Group 20 (Evaluations of Climate Change Projections) of PICES, we analyzed the observed time series of physics, nutrients, chlorophyll, zooplankton abundance and phenology, and productivity, biomass and catch of commercially important species, in order to assess impacts of IPCC's global change scenarios on KOE. Mechanistic linkages from climate forcing to fish population dynamics were explored for the Japanese common squid (*Todarodes pacificus*), Japanese sardine (*Sardinops melanostictus*), walleye pollock (*Theragra chalcogramma*) and chum salmon (*Oncorhynchus keta*). Future scenarios of zooplankton and commercial species were presented based on the empirical mechanistic linkages and results of projections for physical conditions and primary production in KOE derived from both empirical knowledge and 3D ecosystem-biogeochemical models. Associated data gaps, uncertainties and implications for managers were also discussed.

May 18, 11:20 (S4-8150)

Will climate-driven warming uncouple marine food webs? Projections from biophysical, size-based modeling

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Evidence suggests that climate-driven warming is changing the species and size composition of marine systems with potential consequences for the strength of coupling between lower and upper trophic levels. We examined how changes in the productivity of phytoplankton and size-spectrum of zooplankton could be linked in a physiological-based manner to changes in marine fish using a coupled model approach. A 3-D ecosystem model (ECOHAM4) provided estimates of seasonal changes in phytoplankton productivity and temperature that were utilized in a dynamic zooplankton size-spectrum model to create potential prey fields for early life stages of marine fishes. Model-derived characteristics of lower trophic levels (productivity, size spectrum) were corroborated using *in situ* (observed) data on phyto- and zooplankton collected in various regions of the North Sea. Modeled prey fields were compared to physiological-based requirements for the successful foraging, growth, and survival of the larvae of six, commercially-important marine fish species. Our coupled model results suggested that differences in early life history strategies of secondary consumers (*e.g.*, fish spawning times, larval stage durations, preferred prey sizes, metabolic requirements) will shape the potential outcome of climate-driven warming on trophic coupling. Results of this study highlight the complexity of interactions that can exist between climate-driven changes in both direct (temperature and water currents) and indirect (prey productivity and composition) factors. These interactions will be critical to take into account if one hopes to gain a cause-and-effect understanding of how climate-driven warming may affect the productivity of key fish species and trophodynamic coupling in marine systems.

May 18, 11:35 (S4-8100)

Ecosystem-based risk assessing the Korean major fisheries under climate change

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This paper considers the contributions of ecosystem-based fishery assessment approach (EBFA) to better understand climate change impacts on fisheries. Sea surface temperatures showed increasing patterns and accelerated in recent decades in Korean waters. The recent warming trend was associated with replacement patterns, that is, a decline in cold-water species and an increase in warm-water species, as well as with changes in spatial distribution of fish stocks in the Korean marine ecosystem. A pragmatic ecosystem-based approach, the Integrated Fisheries Risk Analysis Method for Ecosystems (IFRAME), is developed with an aim to assess and forecast impacts of climate changes and fishing activities on fish and fisheries of an ecosystem. Using IFRAME, the impacts of the climate change were evaluated by projected status of fish species and fishery for 50 years in Korean waters. This approach was applied to the Korean large purse seine and two-paired trawl fisheries, occupied over 22% of total catch production, for assessing risk indices of species, fishery and ecosystem and evaluating fishery management under the changing climate. Finally, implications for fisheries management were discussed under the changing climate in Korean waters.

May 18, 11:50 (S4-8232)

Impacts of climate change on waterbirds, mammals, fish and fishermen in coastal systems: The case of mangroves, coral reefs and coastal lagoons in the sub-region of the Congo Basin in Central Africa

Mbog Dieudonné **Marius**

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Global climate change is recognized as a threat to the survival of many wildlife species, the health of natural systems in oceans and local people who depend on them. Scientists around the world are looking today on ecological and hydrological impacts resulting from climate change. Natural systems such as mangroves and coral reefs, are vulnerable to changes in the quantity and quality of their water, nutrients and other physico-chemical elements. It is expected that climate change will have a pronounced effect on these systems by ecological dysfunction and alterations in hydrological regimes with high overall variability. Mangroves in coastal flood plains, coral reefs, salt marshes, coastal lagoons,... are very diverse habitats, with different stressors and therefore different management, restoration techniques are necessary. The Congo River, the delta of the Sanaga River (Cameroon), the Wouri river and the river Ntem in southern Cameroon, are examples of important wetland complexes, where the effects of climate change are evolving in different ways.

The consequences of climate change on ecosystems of coastal wetlands and animal communities that depend remains a major issue, despite a growing research effort at the international level.

Impacts on waterbirds

The general nature of the impacts of climate change on waterbirds can be identified, but their extent, intensity and timing are difficult to predict accurately, all models of global climate change being too large a scale and ecology of most waterbirds are poorly understood. Potentially, almost all aspects of their ecology may be affected directly or indirectly. However, the most serious impacts and those likely to occur soon (some have already been noted) include loss of intertidal habitats and increasing salinity in coastal freshwater habitats (due to the rising sea level), reduction of the surface of wetlands and flood longest resulting from changes in climate variability, and the loss of breeding habitat in wetlands, loss due to warming.

Much remains to be studied, especially as the scientific work of amateurs and professionals are not yet legion, particularly in France. There is a lack of sufficient follow course to draw conclusions more formal, and it remains, in many cases in the field of hypothesis or prediction. Nevertheless, the subject is important and this temperature increase has, to say the least, an anthropogenic origin.

May 18, 12:05 (S4-8294) - *Cancelled*

The many faces of the sea: Planning and implementing marine ecosystem science in a changing world

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Scientists, managers and policy-makers have long recognized the need for ecosystem science, yet defining and implementing it is not a straightforward endeavor. Large, interdisciplinary programs have become critical tools for tackling complex ecosystem questions, such as those linked to changing oceanic conditions, loss of sea-ice, changes in subsistence use of ocean resources and ecosystem-based management. Over the last five years, the North Pacific Research Board (http://www.nprb.org) has planned and successfully implemented two large integrated ecosystem research programs – one in the Bering Sea and one in the Gulf of Alaska. These integrated efforts involve more than one hundred principal investigators from more than 30 institutions, and include most major marine science disciplines (climate, physical and chemical oceanography; plankton; fishes; seabirds; marine mammals; humans; traditional knowledge and economics; and ecosystem modeling). From these programs, others may gain insights into the intricacies of integrated ecosystem studies, and their unique partnerships and program structures, the development and evaluation of fieldwork-informed ecosystem models, and their applications to management. The oceans are changing in complex, non-linear ways and it is imperative that scientists, managers, stakeholders, policy-makers and the public work together to understand these changes. We will review different strategies for implementing and managing applied ecosystem science research as one contribution towards the sustainable use of our oceans.

May 18, 12:05 (S4-8009)

From climate to fisheries: Performance of a 40-year hindcast for the Eastern Bering Sea

Ivonne **Ortiz**[1], Kerim Aydin[2] and Al Hermann[3]
Presented by Nicholas Bond on behalf of Ivonne Ortiz

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More and more, high resolution end to end models have started incorporating fish as one of their components. Such exercises are usually restricted to a few years, and do not include fisheries removals. Here, we present results of the fish portion of a vertically integrated model that links processes from climate to fisheries in the Eastern Bering Sea at a resolution of ~10km. The fish portion FEAST (Forage-Euphausiid Abundance in Space and Time) models 12 fish species linked to 5 zooplankton groups and 20 fisheries specified by sector, gear and target species. Species include walleye pollock, Pacific cod, arrowtooth flounder, salmon, capelin, herring, eulachon, sandlance and myctophids, squids, shrimp and epifauna; these have a two-way interaction with five groups from the NPZ module: small/large copepods, oceanic/shelf euphausiids and benthos. Temperature and advection estimates from the physical oceanography portion (ROMS) are used in the fish bioenergetics, movement and reproduction components. The hindcast is compared both to time series and spatial patterns obtained from historical field data, stock assessments and fishing effort data. This presentation summarizes what the model captures and what not, as well as implications for forecasts and resource management.

May 18, 12:20 (S4-8049)

Impacts of climate change on U.S. oceans and marine resources: Technical input to the 2013 U.S. National Climate Assessment

Jennifer **Howard** and Roger Griffis

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The United States is conducting a National Climate Assessment (NCA) to be completed by 2013 to determine U.S. vulnerability to climate change, help the federal government prioritize climate science investments, and help decision-makers and communities around the country plan more sustainably for our future. The 2013 report will feature, for the first time, a chapter specifically assessing the effects of climate change on ocean and marine resources. The Ocean and Marine Resources Technical Report for the NCA focuses on 1) the physical and chemical changes currently being observed in the marine environment; 2) how those changes affect marine organisms and ecosystems; 3) the effect of climate change on ocean services and the socioeconomic consequences; 4) potential international implications; and 5) management challenges, adaptation approaches, and opportunities. Evidence is mounting that the physical and chemical conditions present in different ocean regions are changing with time, and that climate can have substantial effects on organism physiology, species populations, and biodiversity. Less is known about the consequences of climate induced shifts for ecosystem structure and function and the resulting impacts on ocean and marine resources. There are many challenges ahead to fill gaps in the scientific knowledge, assess vulnerability risk, and implement adaptation strategies; however, many efforts at the local, regional, and national scale are already underway. The Ocean and Marine Resources Technical Report is the latest effort by the U.S. to highlight the issue of climate change and its effects on ocean and marine ecosystems.

S4 Oral Presentations (Day 4)

May 19, 11:05 (S4-8089)

Could fishery management be used to mitigate the climate change effects on marine ecosystem function?

Susa **Niiranen**[1,2], Johanna Yletyinen[1], Maciej T. Tomczak[1], Olle Hjerne[2] and Thorsten Blenckner[1]

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The Baltic Sea ecosystem in Northern Europe is expected to face some of the largest changes in regional climate to be seen this century. For the first time in the Baltic Sea, we studied the ecosystem-wide effects of future climate change (-2100) in a large-scale modeling study. Ecopath with Ecosim food web model for the open Baltic Sea (BaltProWeb) was driven by environmental forcing from an ensemble of biogeochemical models that were forced with two IPCC climate scenarios (A1B and A2, downscaled to the regional scale) each. In our projections the Eastern Baltic cod (*Gadus morhua*) stock, the dominant Baltic Sea top predator, was negatively affected by the combination of decreasing water salinity and deep-water oxygen concentration. When fishery was not adjusted to accommodate for the deteriorated reproduction conditions, a cod stock collapse was projected for the mid-century. This led to decreased predation pressure on pelagic fish and, via trophic cascades, increased predation on zooplankton. Model results show that the responses of several organism groups to environmental forcing are different before and after the cod stock collapse. For example, certain zooplankton groups are more affected by changes in climate variables when being exposed to lower predation pressure, *i.e.* before the cod collapse. Results demonstrate that an ecosystem approach is needed when climate change effects on marine ecosystems are evaluated. The role of ecosystem management measures, such as fishery regulation, in combating the undesired effects of climate change is discussed in the light of our findings.

May 19, 11:20 (S4-8223)

Projecting U.S. west coast sablefish recruitment under global climate change scenarios

Melissa A. **Haltuch**[1], Nicholas A. Bond[2], Ian J. Stewart[1] and Michael J. Schirippa[3]

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U.S. west coast sablefish (*Anoplopoma fimbria*) recruitment has been correlated with changes in July sea surface height (SSH) measured at Crescent City, CA. This SSH index has been correlated with zooplankton abundance and previous research suggests that feeding conditions as indexed by zooplankton abundance and SSH are the mechanism driving sablefish recruitment. Given that the SSH-recruitment relationship has held up over time it was evaluated as a component of the 2011 sablefish stock assessment model. Assessment results found that the use of the environmental index did not have a large effect on model results due to the reasonably consistent signals from fishery and survey data sources regarding year-class strengths. This analysis focuses on using multi-decadal SSH forecasts to allow management to better respond to shifts in productivity before they occur, rather than refining our 'hindsight' further. Future environmental conditions, as manifested by changes in the timing, dynamics and productivity of the California current ecosystem, via climate change, or cycles similar to the historical period, are considered a significant source of uncertainty in the stock status projections. Therefore, this project investigates methods for scaling between the currently used local environmental covariate and larger scale measurements of SSH such as those produced by SODA for past conditions and IPCC-class climate models for future conditions. This project then produces long term projections of the sablefish population under alternative global climate change scenarios using the 2011 stock assessment to assess possible directional changes in sablefish recruitment on multi-decadal time scales.

May 19, 11:35 (S4-8285)

Optimal harvest of Baltic Sea herring under environmental change

Jörn O. **Schmidt**[1], Massimiliano Cardinale[2], Piotr Margonski[3], Martin Quaas[1], Valerio Bartolino[2] and Rüdiger Voss[1]

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We applied an age-structured economic-ecological model, including cost- and price functions as well as environmentally sensitive stock-recruitment functions, to investigate optimal Central Baltic herring (MBH) management (in terms of profit) under different climate change scenarios. The model includes major species-interaction aspects by using a natural mortality function, depending on cod stock biomass (the major predator on juvenile herring). Interaction between the two clupeid stocks, *i.e.* herring and sprat, can also be included using a function for herring weight as depending on sprat stock size. We analyzed 2 IPCC climate scenarios: A2, and B2. Additionally, we performed a sensitivity analysis to test for the importance of environmental factors in relation to economic factors.

For most of the basic scenarios a relatively stable equilibrium in F, SSB, yield, and profit is reached about the year 2020. Under climate change scenarios, all values show a slightly increasing tendency even after 2020.

May 19, 11:50 (S4-8039)

Modelling of the effects of climate change on population dynamics of the Taitung spiny lobster, *Panulirus penicillatus*, fishery

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Understanding the effects of fishing pressure and environmental variability on the dynamics of exploited populations is critical for fishery management. Using the pronghorn spiny lobster (*Panulirus penicillatus*) fishery off the eastern coast of Taiwan as an example, we developed an individual-based model (IBM) to evaluate potential impacts of increased ocean temperature on population dynamics. The simulations suggest that warming temperatures will slightly reduce population abundance, but that catch will increase after 100 seasons. The average size of lobsters, spawning stock biomass and egg production also increased due to reduced intermoult period and increased spawning times associated with the warmer temperature. An evaluation of the effects of various management measures on the population dynamics of *P. penicillatus* suggests that the size regulation has the largest impact on estimates spawning stock biomass and egg production and the protection of berried females has the smallest impact. This study indicates that an explicit incorporation of the relationships between environmental variables and biological processes can greatly improve fisheries assessment and management.

May 19, 12:05 (S4-8062)

Management strategy evaluation for the Gulf of Alaska walleye pollock (*Theragra chalcogramma*) fishery: How persistent are the environmental-recruitment links?

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A management strategy evaluation for the Gulf of Alaska walleye pollock (*Theragra Chalcogramma*) fishery was performed based on data through 2005. One of the sources of error and uncertainty in the previous analysis included links between environmental indices and age-1 recruitment. The results suggested that winter precipitation and summer sea surface temperature (SST) had a positive impact and spring and autumn SST had a negative impact on recruitment when the normalized indices were included to account for some recruitment variability; these findings matched results from other studies. It is useful to reexamine these environmental-recruitment relationships after new data have been collected to assess how robust they are. This study includes 6 additional years of stock assessment and environmental data, and examines whether the environmental-recruitment links suggested previously have persisted. This study also extends the previous operating model configurations by considering additional local- and basin-scale environmental covariates which were available for the historical period and can be obtained or calculated from downscaled IPCC model output. Environmental-recruitment relationships were evaluated with cross-validation outside of the operating model, and a set of parsimonious models which explained a considerable amount of the recruitment variance were included in the operating model to generate future recruitment based on IPCC model output.

May 19, 12:20 (S4-7973)

Connectivity of Lobster Populations in the Gulf of Maine

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A coupled biophysical individual based model has been developed to investigate lobster (*Homarus americanus*) larval transport and connectivity patterns in the Gulf of Maine and Georges Bank stock assessment areas. The biophysical model is embedded in the Gulf of Maine Nowcast/Forecast System. In addition to circulation and dispersion, the model considers patterns of egg production, temperature-dependent larval growth, stage-explicit vertical distributions of larvae, and mortality. Distribution and abundance patterns of competent postlarvae in the model agree well with the observed, along-shore patterns of lobster settlement density. The predominant direction of larval movement follows the cyclonic Gulf of Maine Coastal Current with relatively low accumulation of planktonic stages along the eastern Maine coast and high accumulation along the western Maine coast. While the larval stages tend to remain relatively near shore, postlarvae can be driven offshore by the prevailing southwesterly wind in summer. Thus, the timing and strength of the southwesterly winds are important in determining the population of settlers. A connectivity matrix is defined to quantify the source-sink relationship among various subregions in the Gulf of Maine. Interannual variability is apparent in development times that vary as a function of year-to-year water temperature and current variations. The relationship also varies with the vertical distribution of larvae, which results in shorter connections in warmer waters of the western Gulf of Maine and elsewhere as seasonal warming progresses.

May 19, 12:35 (S4-8144)

Modeling fish and shellfish responses to climate change: Trade-offs in model complexity

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The marine science community has applied numerous techniques to project the effects of climate change on marine ecosystems and the responses of fishery dependent communities to these ecosystem changes. Considerable progress has already been made in coupling nutrient, phytoplankton and zooplankton into physical models using the existing Global Climate Model and Earth System Models. There is considerable interest in extending this capability to include commercially exploited fish and shellfish. Fish and shellfish exhibit complex responses to changes in the distribution and abundance of prey, competitors and predators. Incorporation of these complex processes will come at a high computational cost. This paper compares the costs and benefits of different methods for modeling fish and shellfish responses to climate change on a global scale. A variety of different modeling approaches are considered including: minimally realistic trophic energy transfers, size spectrum models, single species and multispecies stock assessment models, whole ecosystem food web models, spatially explicit coupled-biophysical models (*e.g.* NEMURO-FISH), and spatially explicit gradient tracking models.

S5 Oral Presentations

May 15, 14:05 (S5-8006), Invited

From ecosystems to genes: Climate change effects on Benguela sardine

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Direct and indirect responses of the world's oceans to climate change will occur across multiple levels, and ecosystem responses will arise from responses at individual, population, and community levels. We describe ecosystem-level changes observed in the Benguela Current upwelling region off southwestern Africa since the mid-20th century, using the pelagic realm as a case study and focussing on a key species, sardine *Sardinops sagax*. Sardine and other small pelagic fish species are typically abundant in upwelling systems where they play a critical role in energy transfer from lower to higher trophic levels. Their short life span and planktonic diet make them responsive to changes in ocean forcing and hence good candidates for investigating climate change impacts on marine ecosystems. They are also commercially exploited, and changes in their population dynamics and distribution patterns will be impacted by both climate change and fishing, likely synergistically. We examine how climate variability, climate change and fishing may have impacted and/or may still impact Benguela sardine, in particular off South Africa. These impacts and their ramifications are examined for sardine individuals, for sardine stocks and populations (including genetic changes), for the broader community (particularly sardine predators) and, ultimately, for the ecosystem. We suggest that such complexity needs to be recognised, and that examination of the impacts of fishing and climate at each of these levels is required in order to understand how their responses will translate into ecosystem responses. We conclude that fisheries management must adapt to take account of such complexity.

May 15, 14:35 (S5-8240)

Marine species' latitudinal distributions conform better to their thermal tolerance than terrestrial species: Implications for range shifts

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The redistribution of life on earth has emerged as one of the most significant biological responses to anthropogenic climate warming. Predicting the response of species' ranges to climate warming requires a fundamental understanding of how geographic distributions are influenced by temperature. Here we use thermal tolerance data of 169 species to show that marine and terrestrial ectotherms differ in the degree to which they fill their potential thermal ranges. Marine ectotherms fully occupy the extent of latitudes tolerable within their thermal niche and are consequently predicted to expand at their poleward range boundaries and contract at their equatorward boundaries with climate warming. By contrast, terrestrial ectotherms are excluded from the warmest regions of their latitudinal range, thus the equatorward, or 'trailing' range boundaries may not shift consistently towards the poles with climate warming. Using 603 observations of climate-induced range shifts, we test this prediction and show that in the ocean, shifts at both range boundaries have been equally responsive, while on land, equatorward range boundaries have lagged in response to climate warming. These results indicate that marine species' ranges conform to their limits of thermal tolerance, and thus range shifts will be easier to predict from niche modelling approaches. However, on land, warmer range boundaries are not at equilibrium with heat tolerance and understanding the relative contribution of other factors controlling their range limßits is critical for predicting local extinctions and invasions.

May 15, 14:55 (S5-8031)

Ocean acidification – The quest for unifying principles

Sam **Dupont** and Mike Thorndyke

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To understand the potential consequence of ocean acidification on any given ecosystem, it is critical to consider the relative impact on fitness for every interactive species, taking into account the synergy between stressors and natural fluctuations in the environment (*e.g.* pH, temperature, food concentration, abundance), and to discriminate between plasticity, with no direct impact on fitness, and teratology, with direct consequences for survival. In this presentation, we will introduce the concept of "physiological tipping points" in the context of ocean acidification. This will be illustrated by some work done on sea urchin development. Embryos and larvae of the sea urchin *Strongylocentrotus* were exposed to a range of pH from 8.1 to 6.5 and their energy budget was dissected (*e.g.* growth, development, respiration, feeding, calcification, pH regulation, gene expression). We will present a framework highlighting the key role of metabolism, energy and physiology on a species' sensitivity; direct (*e.g.* pH regulation) and indirect (*e.g.*, through food availability and/or acquisition) costs associated with environmental challenges are the major components to predict the impact of ocean acidification on a given species. For example, a given species may compensate or even benefit from ocean acidification through increased metabolism if not energy limited, or be totally unable to survive if insufficient energy is available to service additional costs. We further hypothesize that the ability or inability to cope with these additional costs (the physiological window) will be related to the natural variability currently experienced by a given species in its native ecosystem.

May 15, 15:15 (S5-8297)

Latitude and aptitude: The influence of climatic stress on the distribution, performance and function of seaweeds

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Combined studies of biogeography, ecology and physiology can provide unique information on how species and ecosystems might respond to climate change. An analysis of ~100,000 herbarium records document the profound influence of ocean climate on the distribution of seaweeds in Australia. The herbarium records also indicate that changes in distribution patterns have occurred over the past ~50 years, with several temperate species retreating poleward as the waters have warmed. Experimental studies along a latitudinal temperature gradient in southwestern Australia show how changes in temperature sensitivity of metabolic processes allow temperate seaweeds such as kelps, to maintain ecological function across ocean temperatures, but also that such physiological adjustments have implications for their ecological competency. Moreover, there are strong negative relationships between ocean temperature and the genetic diversity of these kelp populations, the physiological versatility of their individuals and the ecological resilience of the kelp habitat. This is compelling empirical evidence, that ecosystem function and vulnerability is linked to genetic variation and climatic stress.

May 15, 15:35 (S5-8214)

Climate-mediated diseases affecting habitat-forming seaweeds: Complex environmental effects on hosts and pathogens

Alexandra H. **Campbell**[1,2], Ezequiel M. Marzinelli[1,2], Tamsin A. Peters[1,2], Rebecca Neumann[1,2] and Peter D. Steinberg[1,3]

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Disease is emerging as a major factor in the decline of many species worldwide. The impacts of disease are arguably more severe when habitat-forming organisms are affected, as any negative effects of disease could cascade throughout other levels of the food web. On temperate rocky reefs, macroalgae are the dominant habitat-formers and evidence of their decline is being reported worldwide. Often, diseases are implicated in these declines, but this is rarely followed-up or confirmed experimentally. Here, we present descriptive evidence of disease-like symptoms affecting three habitat-forming seaweeds (*Delisea pulchra*, *Ecklonia radiata* and *Phyllospora comosa*; the latter two of which are in decline) from the south-eastern Australian coastline, a global-warming 'hot-spot'. We also present novel, experimental evidence of the involvement of bacterial pathogens in these seaweed symptoms and the complex influence of the environment (*e.g.* temperature, nutrients and light) on these macro-micro interactions. We also discuss the effects of proximity to urbanised areas on seaweeds and microbial pathogens. Generally, high temperatures lead to higher incidences of disease-like symptoms in these algae. Additionally, proximity to localised anthropogenic stressors (*e.g.* sewage outfalls) also affects the severity of stress and disease phenotypes in monitored macroalgae and can affect population structure. Understanding the mechanisms behind declines of important ecosystem engineers such as macroalgae is essential for their conservation and management in warming oceans.

May 15, 16:20 (S5-7999)

Climate changes (ocean acidification and warming) may impact the reproduction of the sea urchin *Hemicentrotus pulcherrimus*

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Climate changes (CC, including ocean acidification and warming) are pervasive problems which are attested to affect marine organisms' physiological performances. A variety of biological responses to CC during early development has been investigated across a range of taxa, but there is still a lack of data on the reproductive and physiological responses of adults to CC. Our current research focused on the effects of CC on the reproductive profiles and some relevant physiological parameters of the sea urchin *H. pulcherrimus* in a long-term (9-month, Nov. 2009 - Aug. 2010) exposure. During the experiment, sea urchins were exposed to separate or combined conditions of elevated CO_2 (1,000 ppm) and temperature (+2°C) over ambient. Spawning was completely inhibited in sea urchins reared in both treatments with high CO_2 (1,000 ppm) conditions. Food intake was reduced gradually in both high CO_2 conditions, but to a greater extent under the combined condition. Oxygen consumption was initially stimulated and then became *ca.* 40% of the control in both treatments with high CO_2 conditions towards the end of exposure. Mobility, as determined by light avoidance and food search, was significantly impaired under both treatments with high CO_2 conditions. There were no significant differences in the morphology of tests and the grazing apparatus, the ionic composition in the tips of teeth, and the histology of the digestive tract. Combined with our earlier study that showed significant reductions in the quantity of ovarian eggs in the same species, these results indicate that CC could have negative impacts on reproduction, energy intake, and mobility of the sea urchin.

May 15, 16:40 (S5-8287)

Food web effects of ocean acidification: Why is an increase in CO_2 availability important?

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Apart from the obvious effects of CO_2 on the pH of seawater, and the accompanying effects on organism physiology, there is another effect of increasing CO_2 concentrations on the ecosystem. Changes in CO_2 concentrations in the water will also change the availability of carbon for primary producers. Thus, increased CO_2 availability to primary producers changes the nutrient stoichiometry (ratios of the different nutrients) of these organisms. As a result, the quality of the primary producers as food for herbivores is affected. Here, we present experimental work showing that the copepod *Acartia tonsa* feeding on differently-grown *Rhodomonas salina* is indeed affected by the CO_2 availability to the algae. We discuss the potential pathways of excreting the carbon that is in excess in high CO_2 algae, and consider the possible consequences of different excretory pathways for the ecosystem.

Most likely, a continued increase in the CO_2 availability for primary production, together with changes in the nutrient loading of especially coastal ecosystems, will cause strong changes in the trophic links between primary producers and herbivores, which in turn will have consequences for higher trophic levels such as fish and gelatinous zooplankton. We discuss these potential effects on commercially important species.

May 15, 17:00 (S5-7998)

Antarctic krill in a high CO_2 Southern Ocean: Potential impacts on early development and adult growth

Atsushi **Ishimatsu**[1], Awantha Dissanayake[1,2], So Kawaguchi[3], Robert King[3], Haruko Kurihara[4], Akio Ishida[5] and Masahide Wakita[5]

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Antarctic krill (*Euphausia superba*) is a keystone species of the ecosystem in the Southern Ocean, where rising acidity (ocean acidification) is hypothesized to occur most rapidly. In the present study, we examined effects of predicted future ocean environments on early development and adult growth of the krill. Antarctic krill embryos and larvae were exposed to 380 (control), 1000 and 2000 µatm pCO_2. No significant effects were detected on embryonic development or larval behaviour at 1000 µatm pCO_2. However, at 2000 µatm pCO_2 development was disrupted before gastrulation in 90 per cent of embryos, and no larvae hatched successfully. We also compared growth of adult Antarctic krill reared for 21 days under separate and combined conditions of elevated temperature (4.5°C) and pCO_2 (1900 µatm) relative to controls (0.5°C, 380 µatm) in simulated summer (summer photoperiod/food) or winter ('dark adapted'/no food) conditions. Growth rates demonstrated a dichotomy of effects under the combined conditions: elevated growth rates in summer krill and negative growth ('shrinking') in winter krill. Krill under the combined conditions showed a higher oxygen uptake rate in summer but not in winter. Our model projections demonstrated that Southern Ocean sea water pCO_2 could rise up to 1400 µatm in krill's depth range under the IPCC IS92a scenario by 2100 (atmospheric pCO_2 788 µatm). These results point out the urgent need for understanding the impacts of future ocean environments on krill during developmental and later stages, in order to predict the possible fate of this key species in the Southern Ocean.

May 15, 17:20 (S5-8309)

Latitudinal variation in the vulnerability to elevated temperature and CO_2 in a marine gastropod

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Mounting experimental evidence shows a diverse array of responses of marine taxa to elevated temperature or low pH conditions, but only a few studies have tackled the interactive effects of these environmental variables. In addition, we are now entering a new phase where there is a pressing need for research to address wider-ranging questions concerning plastic responses to ocean changes in a changing climate. For example, it is essential that predictions of organismal responses are based on physiological limits and the potential for adaptation. This change in our current research vision is fundamental, as experimental results for some taxa suggest they may have limited plasticity to conditions predicted to occur in a few decades. However, differences in the responses among closely-related species and populations, as well as maternal effects, have been found, possibly indicating the existence of a genetic basis for vulnerability to global changes. Here we present results on the comparative physiology and ecology of six populations of the periwinkle *Littorina littorea* across a thermo-latitudinal gradient, and exposed to elevated levels of temperature and CO_2. Our results support the idea that differential levels of vulnerability to future environmental scenarios observed in marine taxa (here populations) may be characterised by a certain degree of genetic differentiation. Further, we show that existing levels of adaptation could influence future responses, including geographical range shifts, and could also underpin differences in the potential for further adaptation.

May 15, 17:40 (S5-8236)

Behaviour, thermal safety margins, environmental variability, and species-specific vulnerability to climate change

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Changes in the phenology, abundance and distribution of many marine species have been reported in response to warming oceans, but this has not been universally observed. Determining the vulnerability of species to increasing temperature is a priority in order to predict change, prioritize future research, and advise best practices for conservation, management and adaptation. Whilst the magnitude of experienced temperature is clearly important, environmental variability is also a key determinant of physiological plasticity and response, which will be crucial to species survival if variability also becomes more extreme. Mobile animals can use behaviour to modify their environment within a narrower window than they would otherwise experience. Here, we consider how environmental variability correlates with thermal behavioural responses in marine invertebrates and the role this may play in determining vulnerability of species to climate warming. We tested for animal escape responses to heat from habitats that represent a range of environmental temperatu re extremes.

Species from habitats with high temperature variability tended to select cooler fluids than their upper thermal limits and displayed highly responsive escape reflexes during rapid heating protocols. At the opposite extreme, those species from constant cold temperatures either lacked or exhibited long-delayed escape reflexes upon heating. The capacity to successfully orient to a cooler environment to maintain a wide thermal safety margin and escape extreme heat represents one important mechanism that allows survival in warmer and more variable conditions. Our results suggest that it is necessary to consider how the degree of natural temperature variability experienced by a species has shaped not only the physiological mechanisms but also the behavioural mechanisms that might influence species-specific thermal sensitivity.

S6 Oral Presentations

May 19, 11:05 (S6-8057), Invited

Marine Protected Areas (MPAs) and climate change – Will the organisms we are trying to protect, still be there in 100 years time?

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Marine protected areas and fishery no-take zones are being created around the world, in response to stronger environmental legislation, concerns about biodiversity loss and declining commercial fish catches. In most cases the designation process and legal instruments that create MPAs are not flexible, and there has been limited consideration of the possibility that species may shift their distribution away from the MPA in the future, possibly necessitating changes to the boundaries of existing reserves or creation of new ones to achieve the same objectives.

Several European fishery closure areas (*e.g.* the North Sea plaice box) seem to have become less effective as management areas, arguably because the commercial species they were designed to protect have moved away. The North Sea has been identified as a 'hot spot' of marine climate change, and has demonstrably warmed by more than 1°C over the past 100 years.

In this presentation we use outputs from a downscaled regional climate model to examine the projected change in surface and bottom temperatures at a number of existing and planned MPAs/fishery closure sites that have been created under the EU Habitats Directive and the EU Common Fisheries Policy.

We show that at many of the MPA sites studied, seawater temperatures are anticipated to increase by up to 3°C over the next 80-100 years. Given the narrow temperature preferences of many of the fish species these MPAs are designed to protect, we anticipate significant shifts in distribution, greatly affecting MPA effectiveness.

May 19, 11:35 (S6-8120)

Redmap: An online database and mapping resource for observational marine species data – Marine monitoring, community engagement and collaborative research effort

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Climate driven changes in the distribution of marine species are being reported from around the globe, however, the rate of range extension or contraction varies in both space and time. To minimise negative impacts and maximise opportunities, we need monitoring infrastructure in place to capture distributional changes within reasonable time frames and with a degree of certainty. Redmap (Range Extension Database and Mapping project, www.redmap.org.au) is an online database and mapping resource allowing members of the public to submit observational data (including photographs) of marine species occurring outside their known distribution (*i.e.* species that may be undergoing range shifts). A successful pilot in Tasmania is expanding to an Australian-wide long-term biodiversity monitoring system (launching October 2012), designed to be a low-cost and sustained approach to assess changing marine species distributions. Australia has over 3.5 million fishers and divers - many equipped with consumer electronics and the capacity to record verifiable observations. However, one challenge to the adoption of such datasets is the perception of bias or low quality. In addition to extracting geo-tag information from photographs (validating location), species identifications are verified by essentially 'crowd-sourcing' from a large panel of expert scientists using a semi-automated validation workflow. This initiative has the potential to generate large amounts of valuable information for researchers, engage communities, including Indigenous coastal communities, fishers and industry, in climate science (using their own data), and raise awareness of climate change impacts and consequences. Redmap is an early warning system for changes occurring in the marine environment, and has the potential to play a pivotal role in directing management decisions and actions.

May 19, 11:55 (S6-8301)

A preliminary climate change vulnerability assessment of Canada's Pacific Marine Ecosystems

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The marine ecosystems of Canada's Pacific, off the British Columbia coast, will undergo considerable change with global environmental change, but there was no regional framework for assessing ecological vulnerabilities to climate change. Canadian Pacific ecosystems are highly textured ecologically due to spatiotemporal complexity of geomorphology, hydrology/oceanography, natural cycles, and dynamic interfaces, thus requiring hierarchical assessment and management (adaptation) strategies. We present a screening-level approach to climate vulnerability assessment for prioritizing efforts to understand and respond to marine climate impacts. This preliminary assessment characterizes and summarizes vulnerability of marine life at the scale of habitats and the twelve marine 'Ecosections' of British Columbia. Potential climate change impacts are based on expert derived sensitivities of mapped habitats and regional exposure layers of three climate change variables (temperature, acidification and UV exposure) extracted from global datasets. Adaptive capacity estimates were the inverse of spatially-explicit estimates of the cumulative impacts of local human activities and stressors. Vulnerability to climate change for a given area was the product of the potential impacts of climate variables and the estimated cumulative impacts of other human activities and stressors. This initial assessment indicated that the Strait of Georgia, Queen Charlotte Strait, Johnstone Strait, and Juan de Fuca Strait have higher vulnerabilities to climate change, in part due to local stressors. On a coast wide basis the habitats that are considered most vulnerable are shallow rocky reefs, seagrasses, kelp beds, and undifferentiated shelf habitats. This analysis needs additional climate variables, more regionally-specific habitat and stressor information, and improved data.

May 19, 12:15 (S6-8250)

An overview of impacts and adaptation measures of climate change on seaports

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Climate change could affect ecosystems, biodiversity, human life and many economic activities in coastal areas. This paper reviews the possible effects of climate change on oceans and the potential consequences for seaports and their adaptation measures. Due to their location at the intersection between sea and land, seaport facilities are most vulnerable to changes of all sea-water parameters like mean sea level, storm surge, wind wave, *etc.* The infrastructure and superstructure are considered to be significantly impacted by future climate change. Detrimental effects include a general disruption of the infrastructure and activities designed for present-day climate conditions. We will present a guideline for port authorities, industries and organizations to identify locally relevant climate change impacts and vulnerabilities of seaport development and operation, and develop appropriate climate change adaptation measures.

May 19, 12:35 (S6-8080)

Exploring the effect of environment and fishing pressure on a key prey/predator interaction: Signals from an 'early warning' fishery within a global hotspot region

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The south eastern region of Australia is one of the fastest warming regions in the southern hemisphere (a global 'hotspot'). Whilst there is robust evidence of change in ocean circulation and physical parameters of the region, the linked responses in local ecosystems and associated socio-economics (*e.g.* commercial fishery) are unclear. The southern rock lobster (*Jasus edwardsii*) fishery in Tasmania has been identified as an 'early warning signal' of how Australian fisheries may be impacted by climate change. Ecosystem responses (function, structure and quality) are gaps in knowledge that would improve Ecosystem-Based Management (EBM). Currently there is limited knowledge on how physical factors (*e.g.* temperature) may modify trophic interactions at seasonal, temporal and spatial scales. In the Tasmanian lobster fishery, octopus predation within lobster traps is a major component of lobster mortality resulting in millions of dollars in lost biomass. Compulsory reporting of octopus induced lobster mortality and octopus catch has occurred since 2000. Given this predator is highly environment-dependant in its life-history and population dynamics, it provides an ideal case study to link variability in predatory patterns with climate induced changes. Using extensive commercial fishery data (2000-2011), this study evaluated whether octopus predation variability can be explained by increasing water temperature or/and degraded habitat condition, and lobster CPUE. This provides a framework for practical adjustments and improvements to the stock assessment process, for instance, to provide spatial estimates of lobster mortality by octopus and to understand how this interaction will change in the future.

May 19, 12:55 (S6-7964)

Building a regional alliance for sustainable science and governance in the Western Indian Ocean large marine ecosystems

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The western Indian Ocean (WIO) and its Large Marine Ecosystems represent a massive area that is still relatively unknown compared to many other oceanic systems. Conversely, this area is critically important to the food security and well-being of a number of African coastal countries and small island developing states. These same countries and islands will be among the first to feel the negative effects of the expected climate extremes. Over the last 3-4 years, significant efforts have improved the understanding of ocean-atmosphere interactions and their impact on the LMEs. Foremost among these has been the Agulhas and Somali Current Large Marine Ecosystems project funded by the Global Environment Facility. This project is achieving a high level of success primarily through a programme of partnership development and cooperation. One of the objectives of the ASCLME project is to develop an effective mechanism for translating scientific information into active management guidelines and policy for adaptive governance that can respond to variation in the ecosystems. The approach aims to use a peer-review process to identify significant trends in data that are sufficiently reliable that management and policy actions can be taken even in the absence of higher confidence limits. The ASCLME Project is aiming to consolidate the partnerships between countries, international agencies and institutions in an Alliance for long-term data collection and decision-making. It is hoped that this combination of an effective Science-to-Governance process coupled to an Alliance of partners will result in a more proactive and dynamic governance mechanism that can react more effectively and timeously to climate extremes, associated changes in the LMEs and the impacts of such changes on dependent communities.

S7 Oral Presentations

May 15, 14:05 (S7-8228), Invited

Large-scale modular mangrove planting – Adaptation to sea-level rise

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Sea-level rise is a major challenge for low-lying coastal cities and populated areas in many Asian mega-deltas and small islands. In the aftermath of the 2004 Indian Ocean tsunami, anecdotal and later scientific studies show that mangroves were effective in slowing down moderate tsunami waves and protected villages. Most mangrove planting techniques use individual plants for planting into the ground. A new method is proposed here to grow mangroves to various heights in large modules of different shapes (triangular, square, rectangle, hexagon) that could be fitted easily on a large-scale in the field. The modules can be made of compressed sediments with a binding cementing agent that would self-destruct after transferred into the seawater. The number of mangroves grown in each module can vary depending on the size and type of module. The main advantage is that mature mangroves can be deployed rapidly in large numbers so that they can survive on a coast that would otherwise destroy young mangroves. Additional sediments and nutrients can be added to the modules once they are deployed. Of various species found growing in South East Asia, field evidence suggests that *Avicennia marina* is the most suitable for replanting because of its wide geographical range, its tolerance to a wide range of environmental conditions, its occurrence across the mangrove belt, and its ability to grow on various substrates.

May 15, 14:35 (S7-8253)

Biogeochemical properties and ecological consequences of the 2011 floods in Moreton Bay, Queensland

Andy **Steven**, Russ Babcock, Geoff Carlin, Nagur Cherukeru, Phillip Ford, Felipe Gusmao, Gary Fry and Kadija Oubelkheir

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Coastal habitats along the Queensland coast are regularly exposed to pulsed river discharges associated with cyclones and tropical depressions. However the scale and continuity of flooding occurring in Queensland over later December 2010 and through January 2011 has not been seen for a very long time and is off a magnitude that is beyond our present capability to predict the likely consequences to coastal ecosystems such as the Great Barrier Reef, Great Sandy Strait and Moreton Bay. As soon as practicable, multi-institutional campaigns were quickly mounted to sample these flood plumes and continued for several months thereafter in order to assess the biogeochemical and ecological consequences. These campaigns comprised repeat surveys of stations for a range of biogeochemical, bio-optical and ecological parameters, deployments of gliders to profile the three dimensional structure of these plumes offshore, establishment of continuous *in situ* monitoring of key parameters and ongoing assessments of seagrass response. This presentation will overview some of the key biogeochemical and ecological results from these studies and comment on how these measurements provide insights into the resilience of these ecosystems.

May 15, 14:55 (S7-8015)

The impact of climate changes on coastal wetland ecosystem

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The impact of climate change on coastal wetland ecosystems is reflected in various ways: (1) wetland biodiversity is reduced, (2) wetland ecosystem service is weakened progressively, and (3) ecological capacity is reduced. As the wetland ecosystem declines its feedback effects may exacerbate climate change. In recent years a rising sea level has increased the disappearance of the Yangtze River delta, Liaohe delta, Liaodong Bay, Laizhou Bay and other low-lying coastal wetlands. By 2050 the sea level of the Yangtze River delta and adjacent areas is predicted to rise 18 to 21cm with direct impacts on the Yangtze River delta wetland area. In 2010 the National Marine Environment Monitoring Center carried out monitoring of the Panjin wetland. The results showed that in March and April, rain and snow increased causing a longer period of low temperature in the early spring. Consequently, the phenophases of plants in the Panjin wetland delayed for about 10-15 days with the sprouting of reed delayed from mid-April to early May and the growth period delayed from early-May to mid-May.

May 15, 15:15 (S7-8282)

Effects of climate change on Indian Oceans: Concepts, approaches and applications of Integrated Coastal Zone Management in planning and management of Indian coastal zone of India

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The Indian coastal region constitutes a privileged combination of valuable natural resources and unique landscape and has become the focal point of rapid development. Livelihood and social structure of coastal residents are directly linked to coastal resource utilisation. Therefore, many of the problems encountered in the coastal zone result in conflict between the broader concepts of conservation versus development. The goal of coastal planning and management in India is to achieve a balance between these two. In order to regulate coastal development and to ensure minimisation of long term problems, a specific coastal legislation namely Coastal Regulation Zone (CRZ) was enacted 1991 defining the various zones. This CRZ is an environment legislation attempting to regulate the relationship between people, their activities and the coastal environment. Unfortunately, it has not achieved a balance between the human activities and the environmental interests. Since, no government guidelines and regulation can be successfully implemented without strong public participation, the Government of India has initiated a more integrated and balanced approach towards planning and management of coastal zone. This paper highlights the need for implementation of such an Integrated Coastal Zone Management (ICZM) program as a prioritised national program in India.

May 15, 15:35 (S7-8221)

Coastal adaptation

So-Min **Cheong**

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Coastal adaptation has become an increasingly important area of study as the significance of climate change rises and coastal hazards continue to damage coastal space and communities. Coastal adaptation solely for climate change is not possible given the financial, infrastructural, and political constraints. A more realistic approach is to use existing methods and strategies of coastal adaptation that inform and meet new challenges of climate-change-induced vulnerabilities. They can be divided into engineering, vegetation, and policy solutions based on their respective disciplinary and science background. The presentation focuses on policy options such as relocation, retreat, zoning, insurance, and subsidy that have resurfaced as potent forces for combating coastal inundation and climate change. It reviews the issues surrounding the practice of these measures and discusses compatibilities of policies, engineering measures, and natural defense.

May 15, 16:20 (S7-7960)

Marsh derived DOC and CO_2 production in the coastal ocean of the northern Gulf of Mexico

Michael **Dagg** and Brian Roberts

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At a site in southern Louisiana, we have determined that DOC is transferred from a marsh to a nearby estuary during tidal flooding-relaxation cycles. Consistent with this, water at the marsh edge is net heterotrophic (respiration > photosynthesis) throughout the year, indicating an external source of organic matter. Furthermore, DOC concentration decreases from the marsh edge to the outer bay (20 km), suggestive of a marsh DOC source. The outer bay is also net heterotrophic on most days. DOC concentration further declines in the seaward direction from the outer bay to the coastal ocean. In the coastal ocean, DOC contributes significantly to C cycling via the microbial loop. DOC from coastal marshes, along with better-constrained sources from *in situ* production and the Mississippi/Atchafalaya Rivers, support heterotrophic components of the microbial loop. Appendicularians consume large quantities of 'loop' particles and produce up to 1 gC m^{-2} d^{-1} of rapidly sinking fecal pellets, stimulating the rapid vertical transfer of microbial web productivity in the surface layer to the sub-pycnocline layer that becomes hypoxic (strongly net heterotrophic) each summer. Owing to a combination of sea-level rise and coastal subsidence in this region, we anticipate that the marsh derived contribution of DOC to the bays, estuaries and coastal ocean of the northern Gulf of Mexico will increase with global warming. Continued rates of marsh degradation may result in strengthening coastal heterotrophy, further enhancing the coastal ocean as a CO_2 source.

May 15, 16:40 (S7-8063)

Impact of climate change on algae blooms and eutrophication in the lagoon ecosystems of the Baltic Sea

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Coastal lagoons are one of the most vulnerable coastal ecosystems to impacts of natural environmental and anthropogenic factors. The Curonian and Vistula Lagoons are the largest coastal lagoons of the Baltic Sea and are part of the highly productive water bodies of Europe. Hydrochemical and hydrobiological monitoring was carried out monthly from 1991 to 2011. Eutrophication is one of the main important problems. Multiple reductions of nutrients loading from the watershed area in 1990s did not result in considerable improvement of the ecological situation. Hydrological and chemical parameters are the main factors that influence the level of eutrophication in the lagoons. The water temperature appears to be the key environmental factor determining the seasonal and long-term variability of the level of production and algae blooms in the choked Curonian Lagoon. More intensive summer warming of the water in 1990s-2000s combined with other factors (freshwater conditions, slow-flow exchange, high nutrients concentration) created conditions for Cyanobacteria hyperblooms. Such hyperblooms lead to the deterioration of the water chemical parameters, death of fish in the coastal zone and pollution with toxins, with symptoms of exposure observed at different trophic levels (including zooplankton and fish) in the Curonian Lagoon. The climate warming in 1990s-2000s caused ongoing eutrophication of the Curonian Lagoon despite of significant reduction of nutrients loading. Therefore, the warming up of the water resulting from global climatic changes represents additional risk for coastal water bodies. Eutrophication of the restricted Vistula Lagoon did not attain its potentially possible level. Hydrodynamic activity and brackish water prevented Cyanobacteria hyperblooms.

May 15, 17:00 (S7-8024) - *Cancelled*

Study on the variability of chlorophyll *a* concentration in the Bay of Bengal and in particular along the east coast of India in changing climatic conditions

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Coastal and marine ecosystems are among the most biologically productive environments in the world and at the same time much vulnerable to climate change. Sea surface temperature is considered to be one of the key factors in studying the climate change. A rise in sea surface temperature in coastal and marine ecosystem has an abrupt influence on the abundance of chlorophyll *a*. Variability of chlorophyll *a* concentration in changing climatic environment has been given increasing attention with the availability of satellite derived chlorophyll *a* data. SeaWiFS derived chlorophyll *a* data and sea surface temperature data were used to observe the effect of rise in sea surface temperature on chlorophyll *a* concentration in the Bay of Bengal and in particular along the east coast of India. The analysis reveals that the chlorophyll *a* concentration is decreasing in the Bay Bengal as sea surface temperature is rising. During the post monsoon season chlorophyll *a* concentration shows an increasing trend along the east coast of India. A lag correlation analysis between chlorophyll *a* and river discharge data shows that the enhanced chlorophyll *a* concentration is due to the river discharge during the southwest monsoon season.

May 15, 17:00 (S7-8217)

Development of a large-scale, long-term coral cover database in the Philippines

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The Philippines is located in a tropical area and has one of the highly diverse coral reefs being within the Coral Triangle, the center of marine biodiversity. It is also regarded as the source of coral larvae in the northwestern Pacific as it is located at the upstream of the Kuroshio Current. However, it is a biodiversity 'hot spot' suffering from reef degradation driven by natural disturbances and intense anthropogenic pressure. Consequently coral researches focused to promote awareness of local reefs through conservation, management, and assessment of reefs to monitor the coral health. The status on coral reefs has been reported periodically in the Philippines since the surveys were initiated in 1970s. This study presents the preliminary steps to develop a large-scale, long-term coral cover database in the Philippines. This was done through personal communication and electronic searches of coral studies by different sectors (government, non-government organization, reef scientists) conducted all over the Philippines since the early surveys in 1970s. The collated data consist of hard coral cover percentages of 1270 sites from 2345 reef benthic surveys conducted between 1978 and 2010. These were analyzed to assess the spatial and temporal variability of the Philippine reefs and determine the recent trends in coral cover. The results showed an increase in poor coral cover (<25%) and greater reduction in excellent coral cover (>75%) from 1990-1999 to 2000-2010. Reported disturbances driving the reef decline are also discussed.

May 15, 17:20 (S7-7985)

Estuarine connectivity: Assessing species vulnerability to global change

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One of the main adaptation strategies to global change scenarios, aiming to preserve ecosystem functioning and biodiversity, is to maximise ecosystem resilience. The resilience of a species metapopulation can be improved by facilitating connectivity between local populations, which, in turn, will prevent from demographic stochasticity and genetic inbreeding. The main objective of this investigation is to estimate the degree of connectivity among the structural estuarine species along the Basque coast (south-eastern Bay of Biscay), in order to assess community vulnerability to downscale global change scenarios. The main climate change projections within the Basque estuaries throughout the 21st century is reviewed: sea level rise (29-49 cm), warming of surface air (especially heat wave episodes), sea warming (1.5-2.0°C), and the intensification of extreme daily rainfall of 10%. To address the objective, two proxies of connectivity have been used based on genetic and ecological drift processes: (1) molecular markers for the bivalve cockle (*Cerastoderma edule*) and seagrass *Zostera noltii*, and (2) neutral biodiversity theory prediction on the decrease of species similarity with geographic distance in estuarine plants and macroinvertebrates. Our findings suggest that saltmarsh plants and seagrass beds are especially vulnerable to expected changes because of their dispersal limitation in both overall community and *Z. noltii* populations. In contrast, estuarine soft-bottom macroinvertebrates did not present a spatial structure and *C. edule* is a unique panmictic population in the area. Therefore, estuarine soft-bottom macroinvertebrates with planktonic larval dispersal strategies may have a high resilience capacity to moderate changes within their habitats.

S8 Oral Presentations

May 17, 11:05 (S8-8094), Invited

Oxygen observation activities within the FP7 EU-project HYPOX: A step towards hypoxia monitoring in a rapidly changing world

Felix **Janssen**[1], Christoph Waldmann[2], Antje Boetius[3] and the HYPOX project team

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Hypoxic conditions in aquatic systems and the occurrence of 'dead zones' increase worldwide due to man-made eutrophication and global warming. Nevertheless, for most environments existing monitoring activities are either inadequate or missing completely. Up to date hypoxia observation for a rapidly changing world has to (1) account for the appropriate temporal and spatial scales, (2) separate anthropogenic from natural drivers and long term trends from natural variations, (3) assess ecosystem response, (4) use modeling tools for generalization and prediction, and (5) share data and obtained knowledge. In 2009 HYPOX (www.hypox.net) started out as a pioneering attempt to improve hypoxia observation capacities addressing these requirements. HYPOX target ecosystems cover a broad range of settings (*e.g.*, hydrography, biological activity, anthropogenic impact) and differ in their sensitivity towards change. Semi-enclosed basins with permanent anoxia (Black Sea, Baltic Sea), are included as well as seasonally or locally hypoxic land-locked systems (fjords, lagoons, lakes) and open ocean systems with high sensitivity to global warming (Arctic). HYPOX has built up oxygen observation capacities around Europe, including long- term deployments of observatories as well as supplementary ship based observations. Modeling is used to synthesize findings and obtain an in-depth understanding of hypoxia causes and consequences. In order to integrate the collected information into a global oxygen observing system, results are disseminated through the HYPOX portal following GEOSS data sharing principles. The presented work will introduce the characteristics of the selected sites, give an overview of the scientific approach of HYPOX, and highlight some results.

May 17, 11:35 (S8-8043)

Oxygen depletion events in the European Seas: Observations and modelling

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Formation of hypoxic and anoxic conditions are a threat to healthy ecosystems and thereby a direct danger to human health and economic welfare in coastal societies. These conditions depend on the combined effect of nutrient load and renewal of bottom layers with oxygenated surface water. An intensity of renewal is predetermined by climate forcing which is possibly regulated by large scale climate formations like the NAO. An interannual variability of the Black Sea sulfidic zone, flushing events in the Baltic Sea's Gotland Deep and the Oslo Fjord are clearly connected with winter weather conditions. Hot windless summers lead to the formation of bottom anoxia and fish kills (the Sea of Azov, Northwestern Black Sea, the Elefsis Bay in the Aegean Sea). An anthropogenic factor (eutrophication and waste water discharges) can be revealed in the interannual oxygen regime of the Sea of Azov and the Oslo Fjord. An application of O-N-S-P-Mn-Fe model ROLM (RedOx-Layer Model) simulates the main features of the biogeochemical structure of the redox interfaces and analyses a potential response caused by the oxygenated intrusions (Yakushev *et al.*, 2007, 2011). Modelling can be useful for analyzing and predicting oxygen regime responses to changes in climatic and anthropogenic forcing.

May 17, 11:55 (S8-8167)

Recent decadal changes of the northeastern Black Sea anoxic boundary position and interannual nutrient dynamics

Oleg I. **Podymov**

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The Black Sea is the best known example of permanent anoxia. A stable water column is characterized by a strong halocline, separating waters of riverine origin from the high salinity water from the Mediterranean Sea and resulting in complete oxygen disappearance at depth of 80-180 meters. The hydrogen sulphide boundary position indicates the volume of oxygenated water in the Black Sea and plays a major role in the functioning of the ecosystem. While this position is quite stable in the density field, it is still oscillates with an amplitude of 0.05-0.15 kg m^{-3} (5-10 m) depending on climate variability, changing the volume of the oxygenated waters by approximately 5-10%.

Using our database (>1700 stations with hydrochemical and hydrophysical data acquired mostly in the northeastern part of the Black Sea during last three decades), we estimated seasonal and interannual variability of the hydrogen sulphide boundary position, along with interannual dynamics of main nutrients, dissolved oxygen and carbon system elements in the redox layer, cold intermediate layer and surface. Recent years are characterized by a decrease in nutrient loads from land based sources in comparison with the 1980s and early 1990s, resulting in certain positive changes in the Black Sea ecosystem state. Furthermore, the observed alterations in Si, N and P concentrations may result in relatively stable quality change of the ecosystem, (*i.e.* changes of shares of diatoms and coccolithophores, possible recovery of N-fixation and further improvement of the plankton community as a whole).

May 17, 14:00 (S8-8193)

Two case studies for hypoxia in Korean coastal waters

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The occurrences of hypoxia in the Korean Coastal waters have been increasing ever since the 1970s. This study is focusing on two cases, Chunsu Bay (CSB) and Kang Jin Bay (KJB). These cases share common features, even though different processes cause hypoxia. In the CSB, organic rich dam water release would cause consumption of the dissolved oxygen in the water column, while in the KJB, fresh dam water release under the alarm warning of an approaching typhoon causes strong stratification in the surface layer, while in the bottom layer, sediment oxygen demand consumes dissolved oxygen.

These cases illustrate how two different processes produce the same hypoxia conditions in coastal waters. This understanding will lead to different approaches in solving and/or mitigating these catastrophic events to local clam fisheries. Research themes focus on estuarine dynamics with emphases on the vertical stratification switch against tidal mixing and density driven currents. Model experiments with local field measurements for the dynamical, water quality and ecological parameters were conducted.

May 17, 14:20 (S8-7927)

The effect of climate change on a Gulf estuary plume and its hypoxia variation

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The plume structure of the Perdido Bay Estuary (PBE), a typical bay on the Florida/Alabama coast along the Gulf, was simulated using an existing calibrated model (Xia *et al.*, 2011). To better understand plume dynamics in the PBE and similar bay systems, idealized sensitivity experiments were conducted to examine the influence of climate change on the 3-D plume signature. Results indicate that wind direction dominates plume orientation, while wind magnitude significantly influences plume size, width, length, and depth. The plume size was reduced under the effect of wind and increased wind forcing. A northerly wind could extend the plume length and duration at a lower wind speed (*e.g.* 3 m/s), but its surface size will be smaller than with no wind forcing. Plume length and width will usually be decreased with the wind effect compared to no wind forcing. Bay-shelf salt flux and water flux were also investigated since they are important for the formation of a 3-D plume structure. Model simulation shows that water flux to the coastal ocean is stronger under northerly, westerly, and easterly winds compared to that of a southerly wind at a given speed, possibly explaining why the plume signature varied under changing wind direction. With a high wind magnitude, the water flux typically increased compared to a no wind or low wind magnitude scenario, but salt flux to the coastal ocean results in a relatively large amount of salt outflow so that the surface plume size is reduced. Thus, the surface plume appears to be significantly correlated with the combination of bay-shelf water and salt flux. A detailed understanding of this water and salt flux is essential to the study of plume dynamics. Additional particle transport analysis using variable wind forcing was conducted to validate the existence of the transport mode, which also determined the influence of the plume on particle movement. The results showed a consistency between the surface plume, salt flux, and particle transport.

In addition, hind casts of Perdido Bay bottom hypoxia are provided in response to climate change (*e.g.* wind, temperature). Observed average wind speeds of 3 m sec^{-1} during July were capable of redistributing hypoxia, stressing the entire estuarine ecosystem. Easterly and westerly winds resulted in greater hypoxia near the shore, which put stress on near-shore habitats such as oysters and result in phenomena like jubilees. Westerly and southerly winds resulted in significantly larger areas of anoxic conditions due to longer water-residence times that allowed continued surface primary production and subsurface microbial decomposition. Northerly and easterly winds, in contrast, promoted water transport toward the Gulf of Mexico, enhancing the freshwater discharge direction from Perdido River. Wind speeds over 3 m sec^{-1} were sufficient to enhance the advection of dissolved oxygen into bottom waters through vertical mixing and resulted in significant reductions in areal coverage of hypoxia. Therefore, periodic summer storms may alleviate hypoxic conditions within the estuary. Temperature variation also strongly changed the distribution of bottom hypoxia.

May 17, 14:40 (S8-8246)

Vertical structure of dissolved oxygen and nitrate *in situ* profiles in the North-East Asian Marginal Seas

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Here we discuss results obtained during the cruises of R/V *Akademik M.A. Lavrentyev* and R/V *Professor Gagarinskiy* in the East/Japan and Okhotsk seas in 2009, 2010 and 2011. Measurements of dissolved oxygen have been made by the standard SBE 43 sensor attached to SBE 9 CTD profiler, while nitrate measurements were made using the *In Situ* Ultraviolet Spectrophotometer (ISUS) designed by Monterey Bay Aquarium Research Institute (MBARI). These results were validated using samples from Niskin bottles in laboratory conditions. The experiments with MBARI-ISUS calibration have shown that its *in situ* measurements may vary from those obtained in laboratory conditions. On the other hand a good correspondence with the data obtained by chemical analysis of sea water samples proves the reliability of the ISUS measurements. One of the main results of this study is a description of areas where a step-like structure of nitrate and dissolved oxygen occur, with typical vertical scale from a few to tens of meters. Such structure was observed in off-shelf areas and showed that the oxygen minima (maximum) and nitrates maximum (minima) is matched to each other within the mentioned 'steps'.

Maximum NO_3 concentration (during the warm season) was observed just under the layer of the maximum density gradient, within the upper 50 m layer. Some areas in the eastern Okhotsk Sea have a different distribution of these parameters, when at the deep layer the concentration of NO_3 decreases together with oxygen concentration. This odd distribution of dissolved oxygen and nitrate might be caused by a coupling of dynamic and biogeochemical processes which will be discussed in the presentation.

May 17, 15:00 (S8-8044)

The historical status and impacts of hypoxia in Changjiang estuary

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Ecosystems of the Changjiang estuary experience continuous change due to fast urbanization, occurring along Changjiang drainage area under the background of global change. Observed effects includea dissolved oxygen depletion, DO of the bottom layer in summer is decreasing, the hypoxic zone extends closer to the coast, biomass of benthic biomass is responding rapidly, harmful algal blooms are frequent over large spatial extents. The extension of the low oxygen zone extends to the 100m isobath in a southeastward direction along the bottom of the continental shelf of the East China Sea. During the last two decades, the minimum dissolved oxygen values in the low oxygen zone of the Changjiang Estuary have decreased. The variability of hypoxia together with eutrophication and the effects on biota, were analysed in the data time series 1985-2008. The linear regression of temporal trends based on ARMA and TDNN both indicate an increasing tendency of hypoxia without considering the influence of restoration projects and pollution control policy. Future characteristics of the Changjiang estuary are discussed, taking into account the development of driving forces.

May 17, 15:20 (S8-8175)

Predicting future habitat changes above oxygen minimum zones

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Oxygen availability is one of the most important factors for determining the distribution of organisms in the pelagic ocean environment. Oxygen minimum zones and areas of coastal hypoxia are increasing worldwide, and the effect that this resulting habitat compression will have on pelagic fisheries and ecosystems is an increasing concern. Predicting habitat compression is difficult because the physiological responses to hypoxic and suboxic levels of oxygen are highly variable among species. To quantify this effect, we developed a model that simulates gas exchange along a lamella in the gill of a teleost fish. This Gill Model incorporates physics, blood physiology, and gill morphology and can be adapted for different fish species. It is forced with temperature, oxygen, and carbon dioxide from global ocean data sets and NOAA's Geophysical Fluid Dynamics Laboratory Earth System Models. Results from the Gill Model indicate that temperature and carbon dioxide are important mediators of oxygen uptake. In addition, we quantify oxygen uptake and predict habitat thickness for a range of physiological and morphological traits in the global ocean for the present and also explore the potential impacts of climate change over the next century.

May 17, 16:00 (S8-8010), Invited

Implications of subsurface nutrient increases in the subarctic Pacific Ocean

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Nutrients accumulate in the deep ocean due to the remineralization of a constant rain of detritus from the surface layer. Areas of high productivity are fuelled by processes returning some portion of this nutrient reservoir to the upper ocean. At the end of the global thermohaline circulation, the subarctic Pacific (SAP) and its adjoining marginal seas are the richest nutrient repositories in the world oceans. Gentle, basin-wide upwelling transports these nutrients towards the surface where a fresh surface layer limits their supply to the photic zone. In recent decades, repeat surveys have observed a trend towards lower oxygen and higher nutrients in waters below the surface layer throughout the SAP. We assess this trend using time-series data from three independent programs and suggest increasing nutrient accumulation in the ocean pycnocline (depth range 100 to 500 m) is counteracting a climate-induced strengthening of upper ocean stratification by maintaining surface nutrient levels at fairly constant levels. Since SAP waters are exported into the Arctic, throughout the subtropical Pacific and into the Indian Ocean, changes in nutrient and oxygen distribution have far-reaching implications for habitat viability and ocean productivity.

May 17, 16:30 (S8-7974)

Oxygen sinks and sources along the coast of British Columbia, Canada

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Waters along the BC coast arise from two main sources, the Subarctic Pacific Current (SAC) carrying cool, fresh (minty) waters across the North Pacific and the California Undercurrent (CUC) transporting warm, salty (spicy) water from the tropics. These waters mix along the west coast of North America, with the SAC supplying virtually all the oxygen to waters below the mixed layer. Oxygen levels have declined in subsurface waters over the past 25 years, in large part due to reduced ventilation in waters along the Asian coast. Oxygen is consumed as various sources of organic matter are consumed. Detrital fluxes, a reservoir of sediment organics and a variety of methane sources (seeps, hydrates) all place demands on oxygen supply. We attempt to assess the importance of various oxygen sinks along the BC coast.

May 17, 16:50 (S8-8069)

Hypoxia over the continental shelf in the Northeast Pacific ocean

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Over the last decade, severe hypoxia (dissolved oxygen less than 0.5 ml/l, (<20 µM)) and even anoxia have been observed during the late summer upwelling season in near-bottom waters off the central Oregon coast. We use historical data and recent underwater glider and ship surveys to describe the temporal and spatial variability of hypoxia in Oregon coastal waters. Waters with the lowest oxygen values are found over the mid shelf (~80-100 m) as a result of upwelling of low-oxygen water onto the shelf, followed by decay of organic matter raining down from surface phytoplankton blooms. Dissolved oxygen measurements from 6 years of underwater glider transects are used to explore year-to-year variations in the extent of near-bottom hypoxia. Both the dissolved oxygen concentrations of the upwelled source waters and local winds explain variability in near-bottom shelf hypoxia. Oxygen in the upwelled source waters (26.5 kg/m^3) has declined by 0.6 ml/l (~25 µM) over the last 50 years. Recent near-bottom data collected by a variety of platforms reveals a ribbon of hypoxic near-bottom water at mid shelf all along the Pacific Northwest. The percentage of the continental shelf occupied by near-bottom hypoxic waters during the upwelling season varies from 25% to 80% and is related to the cumulative amount of upwelling-favorable wind stress. Inner-shelf (50-m isobaths) oxygen dynamics, including the intensity and risk of hypoxia events, are sensitive to changes in both upwelling source water oxygen levels and upwelling wind forcing.

May 17, 17:10 (S8-8173)

The influence of declining oxygen concentrations and mesopelagic fish biomass on ecosystem structure and carbon export in the California Current

J. Anthony **Koslow**[1], Peter Davison[1], Ana Lara-Lopez[1], Amanda Netburn[1] and Noelle Bowlin[1,2]

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Surveys carried out by the California Cooperative Oceanic Fisheries Investigations (CalCOFI) since 1951 indicate that midwater oxygen concentrations and populations of major mesopelagic fishes in the California Current have fluctuated coherently over this period. Both time series exhibit considerable decadal-scale and possibly longer-term variability, but the time series are significantly correlated even after long term trends were removed and following correction for autocorrelation. Over the past decade, midwater dissolved oxygen concentrations have declined approximately 20% and midwater fish populations by about 63%. CalCOFI acoustic/trawl surveys indicate that midwater fishes are key plankton consumers in the California Current. However, their ecological role in this ecosystem is poorly studied. We show that the time series of diel migratory and non-migratory midwater planktivorous fishes are highly correlated with each other and with midwater fish piscivores. These groups are also generally correlated with time series of the dominant epipelagic plankton feeding and piscivorous fishes in the region and with major indices of climate variability in the North Pacific: the multivariate ENSO index and the Pacific Decadal and North Pacific Gyre Oscillations. We examine the implications of declining trends in midwater oxygen concentration and the mesopelagic micronekton for trophic structure and carbon export in the California Current.

May 17, 17:30 (S8-8218)

Understanding the connection between ocean circulation and open-ocean oxygen levels

Anand **Gnanadesikan**[1], Daniele Bianchi[2], Irina Marinov[3], Jaime Palter[3] and Marie-Aude Pradal[1]

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This talk will examine the connection between ocean circulation and oxygen levels in the open ocean. We will demonstrate that the oft-used assumption that lower levels of overturning necessarily lead to lower oxygen levels is not necessarily true. For the bulk of the deep ocean, a better way of thinking about oxygen levels is to use the concept of preformed nutrients, nutrients which are not utilized at the ocean surface. The oxygen inventory of the deep ocean is negative related to the difference between the difference between the total nutrient inventory and the preformed inventory. Flow configurations that lead to high levels of preformed nutrient inventory thus tend towards high deep oxygen- leading to strong sensitivity to the balance of overturning between the North Atlantic and Southern Ocean. At intermediate depths, however, the preformed nutrient concept is much less predictive, as the total nutrient inventory need not be fixed over such depths. At these depths, an additional factor is added, the ratio of lateral exchange to deep upwelling. This highlights the potentially important role of lateral diffusion in setting open-ocean hypoxia. Results are presented from a number of general circulation models with embedded biogeochemical cycling.

S9

S9 Oral Presentations

May 18, 11:05 (S9-8188), Invited

Rapid transitions in the horizontal ocean circulation

Jacob **Schewe**[1,2] and Anders Levermann[1,2]

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The large-scale circulation of the world's oceans is essential for the redistribution of physical properties, such as heat and salt, as well as biological and chemical properties, such as nutrients and CO_2. It also is responsible for substantial regional differences in mean sea level height. Exploring the stability properties of individual parts of the ocean circulation is crucial in order to assess their response to expected changes in global climate. Extensive research has been directed toward the dynamics of the vertical overturning circulation, most prominently the Atlantic meridional overturning circulation (AMOC), for which the potential for two stable states under the same boundary conditions, and for abrupt transitions between these two states in the past, has been shown. In my talk I will focus on the large-scale horizontal circulation, including the subbasin-wide gyres, which, albeit closely tied to the vertical overturning, is governed by different dynamics. I will show that horizontal circulation features may be capable of abrupt transitions, too, either as a non-linear response to external forcing, or in a spontaneous manner, triggered by natural variability. I will discuss the potential mechanisms behind such transitions, and the implications *e.g.* for regional sea level.

May 18, 11:35 (S9-8113), Invited

Rising variance as a leading indicator of tipping points in marine ecosystems: A test using Alaskan crustacean data

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Ecosystem models show a suite of characteristic behaviors in key parameters (*e.g.*, rising variance, skew and autocorrelation) as resilience declines and a tipping point/regime shift approaches. It has been proposed that these model-derived regime shift indicators are "generic", that is, that they should be present in many complex systems and might therefore be useful in systems, such as marine ecosystems, where the dynamics underlying future tipping points are not understood. We tested the ability of two of the proposed indicators (increasing spatial variability and spatial skew) to predict fisheries collapses, using catch data from Alaskan crustacean fisheries, which experienced widespread collapse in the 1970s, 1980s and 1990s. We found that rising spatial variability did signal impending collapse in these fisheries. A random-effects model showed strong evidence of pre-collapse increases in variability across twelve collapsing fisheries. Rising variability could be detected 1-5 years prior to collapse, suggesting that this indicator might provide adequate warning for managers to prevent an impending collapse. However, our data did not show any evidence of rising skew in catch data prior to collapse. Further, while models predict that rising variability should be a transient phenomenon associated with the collapse point, our data showed that increased variability was a persistent characteristic of post-collapse fisheries. Thus, while our study supports the use of spatial variability to monitor the resilience of exploited populations, inconsistencies between our results and model predictions highlight the caution that is required when applying tools from simple models to large, complex ecosystems.

May 18, 12:00 (S9-8184)

Tipping points: Shifts in climatic variables or their relationships? Examples for the Far-Eastern Seas

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

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In the paper we have summarized our studies of the sharp transitions in the Far-Eastern Seas ('regime shifts') analyzing the time series of environmental parameters: the regional climatic characteristics (mainly sea ice coverage, air and water temperature) and large-scale climatic oscillations and patterns (Siberian High Index (SHI), West Pacific (WP) Index, Pacific Decadal Oscillation (PDO), Victoria patter and Arctic Oscillation (AO) indexes, SOI, *etc*). For the detection regime shifts we used mainly technique according to Rodionov (2004). Well-known large-scale climate regime shifts (*e.g.*, 1976/77 for northern and 1988/89 for southern areas of the seas) and regional and 'sub-regional' regime shifts (*e.g.*, the beginning of the 1980s in the Okhotsk Sea) have been found. Besides, there are tipping points in the relationships between regional climatic parameters and large-scale climatic patterns. So, pronounced reorganizations of the relationships with accompanied inverse (for example, between ice cover in the Okhotsk Sea and AO/PDO, winter SST in the Japan/East Sea and AO) correspond to the 1976/77 and 1988/89 regime shifts most often. After the climate shift in 1976/77 the correlation between SOI and ice cover in the Okhotsk Sea tended to decrease. Correlation between winter WP and ice cover in the Okhotsk Sea decreases sharply in the early 1980s ('sub-regional' regime shift) and started to decrease again in 2006. Thus, there are two appearances of 'turning-points': large-scale and regional regime shifts in the climatic variables and significant changes in the relationships between regional climatic parameters and large-scale climatic patterns for the Far-Eastern Seas.

May 18, 12:25 (S9-8149)

Multi-level oscillating trophodynamic control causes regime shifts in large marine ecosystem

Christian **Möllmann**, Justus van Beusekom, Rabea Diekmann, Jens Floeter and Axel Temming

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Changes in trophodynamic control from predominantly bottom-up (resource-driven) to top-down (consumer-driven) have been suggested as a mechanism causing sudden changes in the structure and functioning of foodwebs, so called ecosystem regime shifts. Trophic cascades represent top-down controls and conspicuous indirect effects over two or more links distant from the initial one. They are the most pronounced phenomenon related to changes in trophodynamic control and have been shown for multiple marine ecosystems. Fewer studies show oscillations between bottom-up and top-down control and do usually not consider interactions between all trophic levels. Here we provide evidence for oscillating trophodynamic controls over multiple trophic levels in the North Sea, one of the most productive ecosystems in the world ocean. We used a unique data set covering > 4 decades (1963-2007) and four trophic levels, *i.e.* phyto-, zooplankton, planktivorous and piscivorous fish. Moving correlation analyses revealed the alternating changes in control between trophic levels to strikingly coincide with major ecosystem regime shifts documented before. We further demonstrate by Generalized Additive Modelling (GAM) that oscillations in controls and hence ecosystem regime shifts are caused by complex interactions between climate, fisheries and eutrophication levels.

May 18, 12:30 (S9-7994)

Long-term responses of zooplankton in northern Yellow Sea of China: Implications of climate change

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In order to understand the effect mechanism of climate change to marine ecosystem in China, State Oceanic Administration has conducted climate-sensitive marine ecology pilot monitoring program since 2008. In the past 50 years, total biomass increase and seasonal variation changes of zooplankton have been detected in northern Yellow Sea. Compared with history date in 1958, zooplankton biomass increases significantly in every month in 2010. The biggest increase occurs in August, in which biomass is higher ten times than the same period. Biomass peak changed from June in 1959 to August in 2010. These changes were attributed to regional increase in sea surface temperature. Zooplankton species composition and community structure have changed, with an increase in the number of warm-water species association with northward extension in its latitude. The average abundance of *Doliolum denticulatum* in autumn has increased in its number from 62.38 ind/m^3 in 1982 to 81 ind/m^3 in 2009, with the highest abundance increasing from 571.42 ind/m^3 to 817.50 ind/m^3. The distribution scale of *D. denticulatum* reaches up to 39°N in autumn of 2009. Though the main dominant zooplankton species (*Calanus sinicus*) have not changed over past 50 years, its abundance is in increasing trend. These results indicate that global climate change has already affected zooplankton community structure and ecosystem stability of northern Yellow Sea in China.

May 18, 12:45 (S9-8271)

The future of Arctic zooplankton: Interplay between advection, life history traits and trophodynamics

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Ongoing and expected climate change will affect zooplankton in the Arctic Ocean through advection of Atlantic water, temperature increase and changing conditions of primary production. The three copepods *Calanus hyperboreus, C. glacialis* and *C. finmarchicus* dominate zooplankton biomass at least in the Eurasian basins. Changing environmental conditions, but also interspecific dynamics will influence their future in the Arctic in a different way.

Recent biological and oceanographic observations showed different gateways of North Atlantic Calanus congeners into the Arctic Ocean, with *C. finmarchicus* mostly advected through the Barents Sea, and *C. hyperboreus* through Fram Strait. Models and oceanographic data suggest that, as a consequence, these populations will have different drift tracks and hence regional distributions, which will finally determine their survival in the Arctic Ocean. Clearly climate effects on the source regions will also affect advected populations. Modelling indicates strong interannual variation in volume and pathways of inflowing waters, which will make early identification of ongoing faunistic changes difficult.

The reproductive traits of the three Calanus congeners differ mainly in the timing of spawning and the resources utilized for oogenesis. Therefore spatial changes, but also changes in timing and magnitude of primary production will decide on colonization or expatriation of advected species. Furthermore, by using observations made in the central Greenland Sea, we demonstrate the importance of interspecific predation for survival in the Arctic Ocean. Our results show, that climate change effects are species specific and imply a variety of mechanisms.

May 18, 13:00 (S9-8073)

Resonance effect of spawning match with spring bloom for some fish species in the Japan/ East Sea

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Dependence of fish reproduction on timing of spawning is considered for cold-water (saffron cod) and warm water (japanese sardine) species in the Japan/East Sea. Their reproduction is successful when the mass spawning occurs in a certain time before the peak of spring bloom, that is about 3 month for the saffron cod spawning in very cold water (< 0°C) and 15-36 days for the sardine spawning in subtropical waters. The relationships between the time from spawning to blooming *T* and a parameter of reproductive success *N* could be presented by a resonance function:

$$N = \frac{a}{\sqrt{1 + \left[Q \cdot \left(T - T_R\right)\right]^2}}$$

Where, T_R is the optimal value; *a*, *Q* – coefficients.

S10 Oral Presentations

May 19, 11:05 (S10-8179), Invited

An overview of the ocean CO_2 increase in the western North Pacific subtropical and tropical zones

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The trend in ocean CO_2 increase has been clearly shown for the past few decades by time-series measurements of carbonate parameters in the subtropical and tropical zones of the western North Pacific. In the northwestern subtropics, the partial pressure of CO_2 (pCO_2^{sw}) and dissolved inorganic carbon (DIC) in surface water have been increasing along with the atmospheric CO_2 increase. Increases in pCO_2^{sw} and DIC were also significant in the southwestern subtropics and in the warm pool of the western equatorial Pacific, although the rate of increase slowed down after the 1997/98 El Niño event due to the change in the subtropical cell. In the interior of the subtropical gyre, increase in DIC has been detected above the layer of maximum winter-outcropping density in the North Pacific (~26.8 s_q). The DIC increase in the interior has been affected by changes in circulation and/or biological activity that are seen in the change in dissolved oxygen concentration, but the rates of change in preformed DIC are consistent with those calculated from the rates of atmospheric CO_2 increase and buffer factors of waters when they were last in contact with the atmosphere. It is very likely that the formation of mode waters is an important mechanism for transport of anthropogenic carbon into the interior of the North Pacific. To quantify its transport from the surface into the interior, changes in its inventory, reemergence to the surface layer within the subtropics, and exports to the equatorial Pacific and to the Indian Ocean are the next challenges.

May 19, 11:35 (S10-8177)

Global Ocean Carbon Observations: Decadal challenges in addressing and understanding global climate and ocean ecosystem change (S2-8312, May 16, 10:10)

Pedro M.S. **Monteiro** and Christopher Sabine

May 19, 11:55 (S10-8177)

Ocean acidification over the industrial era constrained from tracer observations

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The ocean is an important sink of anthropogenic carbon (C_{ant}), sequestering roughly 30% of human CO_2 emissions. While this absorption of CO_2 serves to mitigate the human impact on the climate system, it is also a serious threat to the marine environment due to ocean acidification. The consequences of a change in ocean pH, particularly for marine organisms, are only now being fully understood. However, observations of this phenomenon remain sparse. Here, we present a time-evolving portrait of the spatial distribution of ocean pH over the industrial period. Our results are based on an inverse method that exploits a suite of well-sampled oceanic tracers such as CFCs, radiocarbon, temperature, and salinity to constrain the transport of tracers such as C_{ant} from the surface mixed layer into the interior. We find that globally-averaged pH decreased by 0.023 units between 1765 and 2011. Surface pH decreases range from 0.03 (South Atlantic) to 0.13 (North Pacific), with a surface mean of 0.1. At depth, changes are largely restricted to the North Atlantic. Corresponding to these changes is a shoaling of the aragonite lysocline depth, which can be as large as 800-1000 m in the tropical Atlantic, Southern Ocean and Labrador Sea. Comparisons with measurements based on repeat hydrography indicate important differences, possibly due to changes in ocean circulation and biogeochemistry not accounted for by inverse methods, highlighting the importance of ongoing observational programs. We also apply our inverse approach to produce a baseline prediction of future changes in pH for various emission scenarios.

May 19, 12:15 (S10-8098)

Decadal trend of carbon dioxide and ocean acidification in the surface water of the Ulleung Basin, the East/Japan Sea

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Since the Industrial Revolution, carbon dioxide emitted by humans has been perturbing the carbon cycle of the Earth, and both global warming and ocean acidification have accelerated. In this study, increasing CO_2 and ocean acidification in the surface of the Ulleung Basin (UB) of the East/Japan Sea are discussed. It was revealed by means of twelve direct observations of surface fCO_2 from 1995 to 2004 that the UB acts as a sink for atmospheric CO_2, depending on the season. The seasonal variability of fCO_2 is almost balanced between thermal and non-thermal effects. The long-term increasing trend of fCO_2 was estimated, considering the seasonal variability by harmonic analysis, which fit well to the *in situ* fCO_2 observation data. The estimated rates of increase of fCO_2 were 1.97 μatm yr^{-1} for the atmosphere and 3.36 μatm yr^{-1} for the surface ocean, exceeding the global mean of 1.5 μatm yr^{-1}. The ocean acidification trend, which was calculated from total alkalinity and fCO_2, is estimated to be 0.04 pH unit decade^{-1}. Surface seawater of the UB has been acidifying rapidly comparing with the global ocean (0.02 pH unit decade^{-1}). This study provides clues to the impacts of climate change and ocean acidification on a regional scale.

May 19, 12:35 (S10-8097)

Nutrient and phytoplankton responses to the intrusion of oceanic warm water in the western Seto Inland Sea, Japan

Naoki **Yoshie**[1], Naoki Fujii[2], Xinyu Guo[1], Tomohiro Komorita[3] and Atsuhiko Isobe[1]

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The Bungo Channel is a major channel connecting the Seto Inland Sea and the Pacific Ocean. In this region, periodic intrusions of warm oceanic water from the Kuroshio cause sudden increases of water temperature and strong currents, and have been studied from the viewpoint of physical oceanography. However there are only a few studies from the viewpoint of marine ecosystems. In this study, we investigated the spatiotemporal variations in the group composition of phytoplankton in Bungo Channel with high-frequency and wide-area field observations in the summer of 2010. From the variations in SST, we captured two small scale intrusions on 29 June and 4 July, and a relatively large scale intrusion on 10 July. SSS decreased in both small intrusions, and indicated that the warm waters might come not from the Kuroshio, but from the southeast coast of Kyusyu Island which has large rivers. Bottom water temperature decreased after 29 June due to a cold bottom water intrusion from the intermediate water of the Kuroshio. The timing and spatial distribution of the bottom water intrusions were different from those of the surface intrusions. Chlorophyll-*a* concentration increased in association with dominance of diatoms during both two small scale intrusions. On the other hand, in the relatively large scale intrusion, chlorophyll *a* concentration decreased while maintaining dominance of diatoms. This study showed that phytoplankton have different responses to the warm water intrusions.

May 19, 12:55 (S10-8206)

Effect of elevated carbon dioxide in seawater on the early life history of olive flounder, *Paralichthys olivaceus*

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Due to the increasing concentration of CO_2 in the atmosphere, the ocean is becoming acidified. However, little is known about how fishes respond to the reduced pH condition. We reared newly hatched larvae of the olive flounder, *Paralichthys olivaceus*, in three different concentrations of CO_2 (400, 850 and 1500 ppm atmospheric CO_2)

for up to 28 days to examine the acidification impacts on early life stages of fish. After 4 weeks, all fish larvae were sampled and body lengths were measured for growth comparison. The whole bodies of fish larvae were vacuum freeze dried and the concentration of calcium and some trace elements were measured using ICP-AES. Results indicated that body length and weight of flounder larvae were significantly increased with increasing carbon dioxide concentration ($P<0.05$). Calcium and trace elements also showed increasing tendencies with increasing CO_2 in seawater, although there were no statistically significant differences.

May 19, 13:15 (S10-7965)

Influence of equatorial upwelling on biological productivity in the eastern equatorial Atlantic

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The Eastern Equatorial Atlantic has been described as a region of intense upwelling; and upwelling in this region has significant impacts on the climate and fisheries of the area. It has been shown that while upwelling areas only cover approximately 1% of the ocean surface, they are directly responsible for 50% of the world's fisheries. This study therefore serves as a reflection of the importance of equatorial upwelling to biological productivity in the eastern equatorial Atlantic using oceanographic data collected along 10^{o}W during EGEE/AMMA cruises between 2005 and 2007. Year 2005 witnessed the strongest nutrient enrichment episodes in boreal summer, and consequently the highest biological productivity was observed in June 2005. The trend in the intensity of nutrient enrichment was 2005 > 2007 > 2006. Climatology and past data within this region were used to study possible trends that could be linked to climate change.

May 19, 13:35 (S10-8104)

Enhanced phytoplankton production in the US east coast due to precipitation containing nitrate

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Precipitation over the ocean surface near the industrialized and populated continents can increase ocean nitrate concentration and can subsequently enhance ocean primary productivity. Using satellite data products (precipitation, wind speed, and chlorophyll *a*) we evaluated the impact of precipitation on ocean productivity in US east coast and offshore waters located downwind of the continental US. We found that precipitation discernably increased levels of chlorophyll *a* up to ~20% in the low nutrient areas (nitrate < 1 μM), but decreased them in the high nutrient areas (nitrate > 1 μM). Such contrasting responses of ocean productivity to precipitation are probably attributable to different demands of phytoplankton for nutrients and light during photosynthesis. An increase in wind speed typically accompanied by precipitation events deepened the mixed layer, which added extra nutrient to the mixed layer but reduced light availability. The added nutrient increased phytoplankton productivity in the nutrient-depleted area, while the reduced light availability lowered production in the nutrient-replete area where light limits the growth of phytoplankton. The coherent patterns between changes in chlorophyll *a* due to precipitation increase and those due to wind speed increase indicate that wind speed increase during precipitation is a major cause for the observed changes in chlorophyll *a* due to precipitation. By contrast, the wet deposition of pollutant nitrogen was estimated to contribute to < 7% of new production and < 5% of chlorophyll *a* concentration.

S10

W1 Oral Presentation

May 18, 14:20 (W1-8091)

Initiation of a Global Alliance of Continuous Plankton Recorder Surveys (GACS)

Graham Hosie[1], Sonia Batten[2], Sanae **Chiba**[3] and The GACS Board of Governance[4]

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Continuous Plankton Recorders have been deployed as a sampling tool for decades in the North Atlantic providing data used to describe plankton diversity, biogeography, response to climate forcing and influence on upper trophic levels. Other regions have since been monitored with CPRs; the Southern Ocean for >20 years, north Pacific for >10 and new surveys have recently begun around Australia, New Zealand, Brazil and the Benguela Current. The CPR remains the instrument-of-choice because it offers a cost-effective way to routinely sample deep ocean basins and coastal ecosystems seamlessly, and is the only current instrument that does so while measuring biodiversity of zooplankton and larger phytoplankton. The CPR is standardised between all regional surveys and standardised over time. Recognising the need to address global issues affecting lower trophic levels (ocean warming, acidification) a Global Alliance of CPR Surveys (GACS) was formed in September 2011 at a specially convened meeting attended by heads of regional surveys. Available key stakeholders from PICES POGO and IOC also attended and provided much needed support and advice. A Memorandum of Understanding was signed by the regional representatives and witnessed by the stakeholders. The general goal of GACS is to understand changes in plankton biodiversity at ocean basin scales through a global alliance of CPR surveys. By "understand" we mean characterise, analyse and interpret. Other specific aims are to produce a regular ecological status report for global plankton biodiversity, and to provide an interface for plankton biodiversity with other global ocean observation programmes.

W2 Oral Presentations

May 13, 09:10 (W2-7989), Invited

Nereus: Predicting the Future Ocean

Villy **Christensen**

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The Nereus – Predicting the Future Ocean Program is a long-term, collaborative, and capacity-building effort initiated jointly by the Nippon Foundation and UBC. Partners include Princeton, Duke, Cambridge, and Stockholm universities, and UNEP's World Conservation Monitoring Centre. Our work is interdisciplinary and centered on how climate change may impact higher-trophic level life in the global ocean and the people that rely on these resources. Adaption is a key, and we seek to develop governance systems that are resilient to the impact of climate change. We base the predictions on a global data and modeling framework that among others includes ocean climate models, food web and fisheries models, biogeographic models, and rules for management and governance. On the science side, the predictions build on years of experience with modeling and synthesis, but producing the science is just the start – we also need to make the science accessible and relevant for policy makers. Our traditional means of sharing this information – using spreadsheets, tables, and scientific reports – are OK for communicating between scientists, but not with policy makers. Realizing this, we have teamed up with "gamers" to make the science more accessible through 3-dimensional visualizations, presenting a more stimulating virtual underwater world. We use a 3D gaming engine as an interface for the scientific models in order to present a science-based view of how the oceans once looked, how they look now, and how they may look in the future depending on our actions.

May 13, 09:50 (W2-8126), Invited

Exploring the drivers of climate change impacts on shelf and coastal marine ecosystems: Consequences for downscaling experiment design

Jason **Holt**[1], James Harle[1], Sarah Wakelin[1], Momme Butenschön[2], Yuri Artioli[2], Icarus Allen[2], Jason Lowe[3] and Jonathan Tinker[3]

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Coastal and shelf seas are susceptible to climate change impacts through a variety of contrasting drivers of larger scale atmospheric, oceanic and terrestrial change. These drivers can be characterized by the fluxes of heat, momentum and nutrients across the key interfaces: ocean-shelf, air-sea, diapycnal, benthic-pelagic and land-sea. We review the physical processes that mediate these fluxes in different shelf sea regions and explore their potential susceptibility to climate change. We explore the sources of uncertainty in each case and how these relate to the design of downscaled regional model experiments using coupled hydrodynamic ecosystem models. For this we draw on a series of experiments using POLCOMS-ERSEM forced by both IPCC AR4 simulations and a fine resolution regional climate model (HADRM3), and investigate the relative importance of forcing (model, temporal/spatial resolution, downscaling method) and internal model dynamics (*e.g.* resolution and sub-grid scale parameterization) for each of these drivers. We focus on the Northwest European continental shelf guided by observations from the World Ocean Data Centre. We exploit the contrasting shelf sea regions in this area (including upwelling, downwelling, open-shelf, coastal and isolated seas) to explore how differing levels of uncertainty in the dominant driving processes lead to different levels of confidence in the resulting simulations, and hence inform downscaling experiment design in comparable shelf sea regions around the globe.

May 13, 11:00 (W2-8141), Invited

On the use of IPCC-class models to assess the impact of climate on living marine resources

Charles A. **Stock**[1], Michael A. Alexander[2], Nicholas A. Bond[3], Keith Brander[4], William W.L. Cheung[5], Enrique N. Curchitser[6], Thomas L. Delworth[1], John P. Dunne[1], Stephen M. Griffies[1], Melissa A. Haltuch[7], Jonathan A. Hare[8], Anne B. Hollowed[9], Patrick Lehodey[10], Simon A. Levin[11], Jason S. Link[12], Kenneth A. Rose[13], Ryan R. Rykaczewski[14], Jorge L. Sarmiento[14], Ronald J. Stouffer[1], Franklin B. Schwing[15], Gabriel A. Vecchi[1] and Francisco E. Werner[16]

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Understanding of the climate system and its representation within climate models has progressed such that many climate model outputs can now be used effectively to project the impact of climate on Living Marine Resources (LMRs). Uncertainty in these climate-LMR projections, however, is often large due to a range of physical and biological factors. Limitations of present physical climate projections include coarse resolution, model biases, and inter-model spread. Manifestations of these issues can be particularly significant at regional scales and in coastal areas. Bias-corrections, ensemble approaches, and downscaling techniques provide ways forward, but the assumptions underlying these approaches must be carefully assessed for each application. Priority climate model developments include improved model resolution and accuracy (particularly at regional scales and in coastal regions), inter-annual to decadal scale predictions, and continued development of Earth System Models capable of simulating both the physical climate system and the biosphere. For LMRs, improved understanding of the multi-scale mechanisms that link LMRs and climate is needed to develop holistic models grounded in robust physiological and ecological principles that will hold in a changing climate. Achieving these objectives requires an extensive observational baseline with both detailed process studies to elucidate climate-LMR links, and long time series for detecting climate impacts and validating models. Efforts toward priority developments should occur in parallel and be informed by the continued application of existing tools and knowledge.

May 13, 11:40 (W2-8243), Invited

Modelling large scale effects of global change on marine ecosystems and fisheries

William W.L. **Cheung**[1], Jose Fernandes[2], Thomas L. Frölicher[3], Jorge L. Sarmiento[3], U. Rashid Sumaila[1] and Daniel P. Pauly[1]

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This presentation aims to discuss the use of the Dynamic Bioclimate Envelope Model (DBEM) in assessing global change impacts on marine ecosystems and fisheries at large spatial scale. Previous projections using the DBEM suggest that ocean warming are expected to result in species' range shift and redistribution of maximum fisheries catch potential by 2050 relative to the 2000s. To investigate the additional effects from ocean acidification, changes in oxygen level, and characteristics of phytoplankton production, an updated version of the DBEM model that explicitly account for the effects of these factors are developed. Projections from the updated model suggest that some perceived regions of 'winners' from ocean warming along are expected to become 'losers' when these multiple climate stressors are considered. Comparison of projections using outputs from multiple Earth System Models highlights areas of robustness and uncertainty. Moreover, the incorporation of inter-specific interactions and fishing effects in the latest version of DBEM helps us assess the implications of trophic effects and multiple human stressors for future changes in marine ecosystems. On-going and future efforts in historical projections, comparison with empirical data and between different ecosystem models would help assess the confidence of the future projections.

May 13, 14:00 (W2-8172) - Cancelled

Interpreting the impact of climate variability on the Black Sea ecosystem with a higher-trophic-level marine ecosystem model

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The Black Sea and the changes in its biogeochemical and ecological structure have been widely studied with modeling and empirical efforts for more than four decades. Only in the recent two decades, modeling studies that incorporate higher-trophic-level models have started to contribute to those efforts aiming to analyze the impacts of the changes in the Black Sea in the whole trophic structure of its ecosystem – from primary producers up to marine mammals. These models were successful to observe anthropogenic interventions such as overfishing or succession of single species, however, the interpretation of the effects of climate variability on the ecosystem remained limited in these models under complicated multi-species trophic structures mostly because of their limitation to implement these traits in their formulation of these complex organisms. With the recent comprehension of the importance of end-to-end modeling approaches in marine ecosystems, such interpretation has become a mandate to have a holistic understanding of the functioning of these ecosystems and to forecast their responses under a changing climate. In this study, we aim to incorporate such implementation in one of the most widely adopted higher-trophic-level models, Ecopath with Ecosim (EwE), coupled with a lower-trophic-level biogeochemical model under a complex setup of the Black Sea ecosystem and validate it against the observations of ecological changes that had occurred in the second half of the 20th century under strong anthropogenic and climatic forcing.

May 13, 14:00 (W2-8293)

Dynamic downscaling to marine ecosystems

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Dynamic downscaling has so far mainly been focused to the regional atmosphere and regional climate models are still mainly atmosphere-only models. Downscaling has largely been interpreted as the challenge to add regional disturbances to the mean climate signal. The study of climate change impacts to marine ecosystems has significantly intensified during the last years and dynamic downscaling of the marine environment got more attention. Insights gained from a variety of downscaling exercises also increased the awareness about the challenges and lead to improved downscaling experimental design. Here we aim at sharing experiences from downscaling exercises for the Baltic, North and Barents Sea ecosystems with the focus to lower trophic level production and larvae fish. Based on the lesson learnt we will propose good practices to design marine downscaling experiments.

May 13, 14:30 (W2-8046)

Modeling Peru upwelling ecosystem dynamics: From physics to anchovy

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Recent advances in observing systems, computational power and understanding of ecosystem function offer evidence that the variability of the ocean ecosystem and its impact on fishery yield can be forecasted with enough lead time to be useful to society. In this contribution I present efforts to enhance the current decision support system for the small pelagic fishery and upwelling ecosystem in the coastal ocean off Peru. In order to link climate variability with nutrients and plankton dynamics to Peruvian anchovy growth, distribution, and abundance, a Peru upwelling ecosystem model has been developed, which consists three components. First, a Pacific basin-wide circulation model based on the Regional Ocean Model Systems (ROMS) is forced with daily air-sea fluxes derived from the satellite derived wind stress and NCEP reanalysis. Second, biogeochemical processes are simulated with **C**arb**o**n, **Si**$(OH)_4$, **N**itrogen **E**cosystem (CoSiNE) model containing multiple plankton groups. The Pacific ROMS-CoSiNE model is integrated synchronously, and produces 3-day averaged outputs of three-dimensional temperature, current, nutrient and plankton distributions. The third component is an anchovy dynamical model using an individual based model (IBM) approach. The IBM anchovy model takes the ROMS-CoSiNE model outputs for the Peruvian coast, and links each life-stage of the anchovy growth and reproduction with environmental conditions. Our analyses focus on each sub-model system performance, their connections, and how these processes along the coast of Peru respond to ENSO and PDO. Also, I discuss how to integrate ENSO predictions into the physical-ecosystem modeling system to produce forecasts with 9 month lead time, which is useful for improving fishery management.

May 13, 15:00 (W2-8315)

Development of a climate-to-fish-to-fishers model: Implementation in the Eastern Pacific sardine and anchovy system

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An ecosystem approach to understanding large-scale patterns in exploited systems caused by both climate change and human activity increasingly relies on the use of numerical models. In the past, physical, lower and higher trophic level models were developed, tested, and implemented independently of each other. Recently, the advances in physics and biology have created the needed pieces for a comprehensive (end-to-end) ecosystem model, including humans as a dynamical component. The challenge is to integrate all the components, and examples of fully-coupled end-to-end models are relatively rare. This is partly due to the perception that blending separate yet complex sub-models is impractical because of demanding computational requirements and partly due to the respective communities working independently. In this presentation, we present our progress to date on the development of an end-to-end model modeling framework within the widely-used ROMS (Regional Ocean Modeling System) circulation model. The NEMURO Nutrient-Phytoplankton-Zooplankton (NPZ) submodel provides the lower trophic level dynamics, and a multi-species individual-based submodel simulates fish population and community dynamics, including fishing fleets as one of the predator species. All of these models exist in various forms, but the individual sub-models have never been harmonized together into one integrated analysis tool useful for synthesis, integration, and prediction. This model framework was designed to investigate the effects of climate and fishing on marine ecosystems within one model that includes dynamical feedbacks among the different systems. We will present results of a test-bed application developed to study the low-frequency fluctuations of sardine and anchovy.

W3 Oral Presentations

May 14, 09:10 (W3-8052), Invited

Vegetated coastal habitats as intense carbon sinks: Understanding and using Blue Carbon strategies

Carlos M. Duarte and Núria **Marbà**

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Vegetated marine ecosystems support high primary production rates and their canopies are efficient at filtering particles out of their water column as well as in preventing resuspension of the sediments. In addition, decomposition rates in vegetated sediments are slow, because of low nutrient concentration in the detritus produced and low oxygen concentration in the sediments. These characteristics result in high carbon burial rates in vegetated ecosystem, which have the capacity to accumulate large stores of carbon in their sediments. Carbon fingerprinting techniques allow to calculate both the age of these deposits and, therefore, the rate of carbon burial and identify the contribution of carbon produced by the plants themselves. The conservation and afforestation/culture of vegetated coastal habitats has the potential to help mitigate climate change while delivering important ecosystem benefits. Yet, data on the regional cover and carbon stocks in vegetated habitats is sparse for some regions, particularly the Indo-Pacific, Africa and South America. In addition, our understanding of the factors regulating the variability in carbon sink capacity among seagrass meadows is limited. These gaps limit the capacity to formulate strategies to mitigate climate change based on the carbon-sink capacity of seagrass meadows. A research strategy needs be formulated to address these gaps and provide the necessary protocols to ensure the accountability of mitigation actions involving the conservation and restoration of seagrass meadows.

May 14, 09:50 (W3-8311)

The UNEP Blue Carbon Initiative

Gabriel **Grimsditch**

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Recent reports by UNEP, IUCN, Duke University and the World Bank have highlighted the importance of coastal ecosystems such as mangroves, seagrasses or salt marshes for mitigating climate change by sequestering and storing carbon ('blue carbon'). These reports have catalyzed international interest in blue carbon and identified it as a missed opportunity for international climate change mitigation strategies. In order to address this gap, the United Nations Environment Programme has launched a Blue Carbon Initiative that aims to develop global partnerships to advance the sound management of coastal ecosystems in order to ensure that their carbon sequestration/storage functions and wider ecosystem services are maintained. Furthermore, ecosystem-based management of blue carbon sinks should be appropriately incorporated into global climate change mitigation discussions and financing schemes. The initiative supports the development of global, regional and national policies for ecosystem management and of possible financial instruments to maintain and enhance blue carbon ecosystems.

Its proposed key elements are:

1. Developing methodologies, standardized around the world, for carbon accounting and economic valuation of ecosystem services in coastal ecosystems;

2. Using these methodologies in a range of pilot projects;

3. Filling gaps in our knowledge of ecosystem services and of carbon sequestration and storage in coastal ecosystems;

4. Exploring how the international community can adopt the methodologies to influence international climate frameworks and create incentives for protecting ecosystem services and carbon.

May 14, 10:10 (W3-8316)

Predicting the response of coastal marshes and mangroves to sea level rise and human impacts: State of science and information needs

Stephen **Crooks**

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The response of coastal marshes and mangroves to changes in sea level rise (SLR) and human impacts, most notably changes in sediment supply and hydrology, id landscape context dependant. Some coastal wetlands are sensitive and vulnerable to minor changes in environmental conditions, while others are resilient to considerable rates and magnitude of change. Space is important. Effective management of coastal systems requires that we understand the landscape context and accordingly focus our efforts and resources to balance the needs for climate change mitigation, adaptation, conservation and development of sustainable livelihoods.

Predicting the response of coastal wetlands to SLR and human impacts can be aided through by semiempirical geomorphic tools and physical modeling (of ranging complexity). Models in development connect tidal marsh response to SLR, sediment supply and speciation with both quantification of carbon sequestration rates and risk of wetland drowning. Simple landscape metrics may inform assessment of the likely vulnerability of a coastal wetland to environmental change and aid identification of areas for protection and / or restoration.

Information on coastal wetlands is lacking for much of the globe. We have poor knowledge of distribution and rate of change, and importantly varying soil carbon stocks; though conceptual and numerical models may be applied to point to location of carbon hotspots. Much of the science quantifying flux of carbon has been undertaken in relatively pristine systems, yet the major emissions appear to be driven by conversion of wetlands to other uses. The fate of eroded marsh carbon is poorly quantified.

May 14, 11:00 (W3-8318)

Assessing the permanence of Blue Carbon sinks with rising sea levels

Gail L. **Chmura** and Dante Torio

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The high rate of carbon storage in soils of saltmarshes and mangroves has spurred interest in using tidal wetland preservation or restoration in carbon offset programs. However, a number of issues first must be addressed to determine if a site meets the requirements of these programs. To meet the requirement of permanence, it is essential to determine the sustainability of these Blue Carbon sinks under rising sea levels. In many areas the vegetation responsible for wetland soil accretion may not survive increased flooding periods, resulting in submergence of the wetland in its present location or inability to restore a wetland at its previous elevation. If allowed to migrate inland, the wetland and its carbon sink may survive. Thus, assessment of permanence requires a determination if inland migration will be hindered by barriers such as high slopes or development, *i.e.*, if there is a coastal squeeze. Presently, the only technology that provides elevation models at the required vertical accuracy is Lidar. We have used Lidar to develop an index to assess the threat of coastal squeeze and to rank sites considered for offset programs with respect to their sustainability. Our presentation demonstrates the application of the coastal squeeze index to saltmarshes of the northeastern North America and the need for Lidar data, which is not available for all coastlines, even in the developed world. We stress that effective planning for the future of our coastlines requires Lidar coverage and its free availability for impact assessments such as the coastal squeeze index.

May 14, 11:20 (W3-8320)

Mangroves and carbon in West and Central Africa

Gabriel Grimsditch[1], Gordon **Ajonina**[2] and James Kairo[3]

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Mangroves are among the most carbon-rich forests in the tropics, containing an average of 1,023 tons of carbon per hectare and can therefore play a role in climate change mitigation. Due to anthropogenic activities, mangrove cover has been observed to decrease by 30-50% in the last century and this has resulted in the loss of carbon sequestration potential, as well as the release of carbon into the atmosphere from oxidation of organic sediment and biomass. However, figures quoted are derived from a limited number of studies from a limited number of regions as well as from unvalidated satellite data. Approximately 14% of global mangrove cover is found in West and Central Africa but areal cover of mangrove ecosystems in the region has not been validated and hardly any studies exist quantifying their carbon reservoirs, sequestration rates and possible emissions in response to disturbance. In order to further improve our global understanding of the climate change mitigation potential of mangroves, the UNEP Blue Carbon initiative is working with partners in West and Central Africa to a) validate satellite data of mangrove cover and deforestation rates with local experts, b) measure carbon sequestration rates, c) measure carbon stocks in biomass and soil, and d) value wider ecosystem services provided by mangroves. These data will be used to analyze the feasibility of mangroves in the region for carbon market and REDD projects. This presentation will describe the methodologies used and data collected in the research so far.

May 14, 11:40 (W3-8322)

Effects of tidal regimes, mariculture and restoration on carbon pools and fluxes in subtropical mangrove ecosystems of China: Implications for blue carbon managements

Guanghui (George) **Lin**[1,2], Hui Chen[2], Weizhi Lu[2], Shengchang Yang[2], Hao Wu, Q. Li[1] and Dai Jia[1]

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Mangrove wetlands occur along the coastlines throughout the tropical and subtropical regions of the world, and provide important ecosystem services including carbon sequestration (part of so called "blue carbon"). However, mangrove wetlands are increasing threatened by climate change and human disturbances. In China, for example, mangroves have been severely disturbed and removed widely, mainly by mariculture and land reclamation activities. The total area of mangrove forests in China has reduced by more than 50% over last six decades. Chinese government has made great efforts in restoring mangroves during last 15 years which successfully reversed the degradation trend. These activities should have significant impact on carbon sinks in China's coastal wetlands but data are surprisingly spare on mangrove whole-ecosystem carbon pools and fluxes. In 2008, we established long-term field study sites in two mangrove ecosystems with distinct climate and tidal regimes, one in Yunxiao (23° 55′N, 117° 23′E) of Fujian province with regular semi-diurnal tides and the one in Gaoqiao (21° 34′N, 109° 45′E) of Guangdong province with irregular daily tides. For both stations, we set up permanent plots for repeat measurements of biomass, soil carbon and litter fall. In addition, we established Eddy covariance towers for continuous monitoring of energy, CO_2 and water exchange. We also quantified the magnitude of mericulture operations near the major mangrove wetlands of southern China, and evaluated its possible impact on mangrove carbon cycle processes. In this talk, we will report our preliminary results from these studies and discuss their implications for blue carbon managements.

W3

May 14, 12:00 (W3-8160)

Kelp forest/seaweed bed as mitigation and adaptation measure: Korean project overview

Ik Kyo **Chung**[1], Jung Hyun Oak[2], Kwang Seok Park[3], Jong Ahm Shin[4], Jong Gyu Kim[5] and Jin Ae Lee[6]

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The utilization of seaweed production holds great promise not only in its provision of a significant CO_2 sink, but also in meeting to some extent global food, fodder, fuel and pharmaceutical requirements. This topic was discussed at the 4th Asian Pacific Phycological Forum 2005 in Bangkok and initiated within the "Asian Network for Using Algae as a CO_2 Sink". Recently the idea was revived in Korea through the project - Greenhouse gas emissions reduction using seaweeds. The project has utilized innovative research on seaweeds in developing new baseline and monitoring methodologies for the Clean Development Mechanism (CDM) and Project Design Document (PDD). The new concept of the Coastal CO_2 Removal Belt (CCRB) has been established for natural and/or man-made plant communities in the coastal region, to accomplish CO_2 removal in the manner of a forest, and that is implementable on various spatial-temporal scales. About 10 tons of CO_2 per ha per year could be draw down in the pilot scale CCRB farm with a perennial brown alga *Ecklonia* estimated by the biomass increment and dissolved inorganic carbon change.

W4 Oral Presentations

May 14, 9:10 (W4-8119)

Climate change and its impacts: Comparisons between the polar and subpolar regions of the Arctic and Antarctic

Kenneth F. **Drinkwater**, George Hunt Jr., Eugene Murphy and Jinping Zhao

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A series of disciplinary presentations prepared by small teams of experts will be given comparing and contrasting climate change scenarios and their impacts on the marine ecosystems in the polar and subpolar regions of both the Arctic and the Antarctic. The presentations will focus particularly on the role and possible effects of changes in advection, but not exclusively. Following a presentation on future climate, separate presentations will discuss recent observed changes and the expected future responses on different components of the ecosystem including physical oceanography and ice, biogeochemistry, microbes, ice biota, phytoplankton, zooplankton, benthic-pelagic coupling/benthos, fish, marine mammals, and seabirds. For each of these ecosystem components, the impacts of climate change in each of the polar and sub-polar regions will be discussed and the processes responsible for the observed and expected changes will be presented. These regional responses will be compared to determine which responses might be fundamental and which might be unique. Finally, a summary/synthesis will be provided based upon the results from the various presentations that will include identification of the major gaps in our knowledge and likely avenues for future research.

May 14, 11:20 (W4-8248)

Interannual changes in primary productivity and sea surface temperature in the polar oceans

Toru **Hirawake**[1], Katsuhito Shinmyo[1], Shintaro Takao[2], Amane Fujiwara[1] and Sei-Ichi Saitoh[1]

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Interannual trends from 2003 to 2008 in primary productivity (PP) of phytoplankton and sea surface temperature (SST) in the polar and sub-polar oceans of Pacific sector were investigated using satellite data. The relationship between the trends was also analyzed. For estimation of PP, the light absorption-based primary productivity model (ABPM), which does not use SST as a variable to derive photosynthetic rate, was developed and applied to the satellite data. A positive trend in annual mean daily primary productivity was shown in the Arctic, sub-Arctic and Antarctic oceans; in contrast, a negative trend was found in the sub-Antarctic region. While annual mean SST increased in the Arctic Ocean, a decreasing trend was exhibited in the sub-Arctic, Antarctic and sub-Antarctic Oceans. Although large seasonal variations in these trends were recognized, overall responses of primary productivity to SST change for this period are different between the polar oceans.

W4

May 14, 11:55 (W4-8146)

Copepods in Austral summer in Sub-Antarctic region of western Indian Ocean: A synthesis of 1964 and 2004 observations

Rosamma **Stephen**, P. Jasmine and N.V. Madhu

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The International Indian Ocean Expedition (IIOE, 1960-65) collections include zooplankton samples taken from the Antarctic section of the western Indian Ocean during austral summer. After four decades, in 2004, zooplankton samples were taken from the same area as part of southern ocean studies. Copepods from these two sets of collections form the material for this study. In the IIOE samples *Nannocalanus minor Mesocalanus tenuicornis, Calanoides carinatus, Neocalanus tonsus, Subeucalanus longiceps, Mecynocera clausi*, *Metridia lucens, Clausocalanus* spp., *Lubbockia* spp., *Conaea rapax, Aegisthus* sp were frequent. In the collections of 2004 *Rhincalanus gigas, Aetididae, Scolecithricidae, Luciutiidae, Heterorhabdidae, Metridiidae, Acartiididae, Oncaeidae* and *Corycaeidae* were well represented. Numerical abundance of species of *Oncaeidae* and *Corycaeidae* showed a marked increase from the previous observations. Among calanoids species, *Clausocalanus*, *Calocalanus*, *Candacia* and *Acartia* were well represented. The distribution of copepd species is discussed in relation to the hydrographical properties. A marked increase in the percentage of carnivorous components was evident in the later collections, which points to an altered trophic structure of the epipelagic realm in recent years.

W5 Oral Presentations

May 14, 09:10 (W5-8138), Invited

Outcomes of the first pan-European poll on public perception of marine climate change impacts

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The recently completed EU project 'CLAMER' (Climate change and marine ecosystems research) examined the belief that there is a gap between what the research community understands about marine climate change impacts, and what the public knows and cares about.

Here we report on the findings of a major public opinion poll commissioned by CLAMER, the first of its kind to focus on marine climate change. In total, some 10,000 European citizens from 10 different countries, spanning seas from the Arctic to the Mediterranean, took part in the poll.

Awareness and concern about marine climate change issues was set in the context of wider marine environmental issues (*e.g.* pollution, overfishing and habitat destruction) and country and demographic differences examined. With regards to marine environmental issues the public know and care about, it is pollution, a non-climate change issue that comes out top, although a range of more 'visible' climate change related issues (melting sea ice, sea level rise and flooding, erosion and extreme events) also score highly.

On some marine climate change issues, the poll results challenge preconceptions that the public has limited knowledge of marine climate change impacts. For example, rates of sea level rise and sea temperature change provided by the public matched well with current scientific understanding. However, for other key issues, such as acidification, public awareness is very low.

Overall, what emerges is a fascinating insight into public awareness, concern and priority setting on marine environmental issues, which present major communication challenges for the research community.

May 14, 09:40 (W5-8064)

Public perceptions of wetland restoration benefits in Louisiana

Tae-Goun **Kim**[1] and Daniel R. Petrolia[2]

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We conducted a referendum-style contingent-valuation survey to investigate public perceptions of wetland restoration benefits including storm protection, ecosystem services, and recreational benefits, and to analyze willingness to pay for large-scale coastal restoration in Louisiana. Results of ordered probit and binary probit models indicate that the public perceives both a strong relationship between increased wetland loss and increased storm risk and a substantial likelihood of increased storm-protection benefits from wetland restoration. However, respondents expressed that they were less likely to believe the improved storm reduction benefits from restoration when they perceived a high frequency of Category 3 or greater storms. Additionally, we found that hurricane protection benefits were the most important factor explaining willingness to pay (WTP) for wetland restoration for preventing expected future land losses in coastal Louisiana.

May 14, 10:40 (W5-8181), Invited

Outreach and adaptation strategy for climate change; Japanese examples

Mitsutaku **Makino**

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This study introduces three Japanese examples of outreaching activity and strategy against climate change. The first example is the national government campaign called "Challenge 25" which was started in February 2010. Variety of easy practices for reducing green house gas emissions are introduced and promoted for public citizens by means of webpage, mail-magazine, festival, *etc*. In March 2011, the Great East Japan Earthquake severely destroyed many of coastal fishing communities. The second example, National Reconstruction Plan against the Earthquake, prescribes the development of alternative energy industry (solar, wind, water, geotherm, *etc*.), and the concept of "smart communities". Also, the Fisheries Agency introduced various financial and technical assistances for establishing low-emission fisheries. As the final example, discussions on the Climate Change Strategy for the Shiretoko World Natural Heritage are briefly summarized.

W6 Oral Presentations

May 20, 09:20 (W6-8108), Invited

Climate change and range shifts in the ocean, theme 1: Detection
Detecting species distribution shifts with climate warming to inform adaptation

Thomas **Wernberg**, Amanda E. Bates, Gretta T. Pecl, Alistair Hobday and Dan Smale

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Climate driven changes in the phenology, abundance, and distribution of marine species are being reported around the globe, particularly in areas where the ocean is warming most rapidly. Species distribution changes have been commonly detected, sometimes involving range extensions or contractions of 100's of km over timescales as short as a decade. However, within assemblages, only 25 to 75% of species present have been observed to shift in a polewards direction with increasing environmental temperature. Moreover, of the species that have shifted, the rate of range extension towards the poles (leading range boundary) or contraction away from the equator (trailing range boundary), varies in both space and time. However, it is currently unknown how much of the variability in range response between species and at different scales is a product of our capacity to detect range shifts in the first place. Are the generic biological monitoring programmes that are presently underway sensitive enough to detect climate-forced distributional changes? We will evaluate methods commonly used to quantify climate driven range shifts to make suggestions on how best to detect range shifts at the trailing and leading boundaries and at different time scales for a variety of species. In addition, we will consider the how monitoring can be tailored to tease out attribution effects, such as fishing pressure. By identifying knowledge gaps in the methods used to detect range shifts over space and time, we will rethink monitoring strategies in a range shift context in order to contribute to optimizing prediction capabilities and management of shifting marine resources.

May 20, 09:55 (W6-8109), Invited

Climate change and range shifts in the ocean, theme 2: Prediction
Predicting species' distribution shifts with climate warming: The role of monitoring and modelling in adaptation

Alistair **Hobday**, Gretta T. Pecl, Amanda E. Bates and Jennifer Sunday

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Detailed investigation of ocean warming hotspots, or regions of rapid warming, can advance our understanding of climate driven distributional change in marine species, and indicate to what capacity we may be able to predict biological responses. We will explore the utility of individual species traits and various modelling approaches to predict species' vulnerability to ocean warming at both trailing and leading range boundaries. We will assess whether it is possible to gather the data required to identify species traits or parameterize species-specific models for entire assemblages in order to compare the shifting potential of different species within the timeframes required to implement adaptation strategies. In addition, we will question how "typical" prediction approaches can be supported by real-time monitoring to provide critical baselines and early identification of shifting species to enable timely human responses to range shifts. Lastly, because both detection and prediction of distributional changes will be associated with uncertainty, and "ecological surprises" are expected as novel sets of species interact, we will explore options for science to provide information at appropriate temporal and spatial scales to test prediction models, and best inform adaptive management and policy.

May 20, 11:00 (W6-8110), Invited

Climate change and range shifts in the ocean, theme 3: Adaptation
Adaptation to species distribution shifts with climate warming: Marine resource management, policy and governance responses for present and into the future

Warwick H.H. **Sauer**, Stewart D. Frusher, David Vousden and Renae C. Tobin

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Distributional changes in exploited species may affect the utilization of marine resources with ramifications that range from fishers' profitability and livelihoods to food security, poverty and social cohesion. Thus, contextually relevant response strategies to ensure sustainable resource use, management and food security should be robust to uncertainty in both detection and prediction of species shifts. We aim to identify and further develop effective mechanisms for translating scientific information into active management guidelines and policy for adaptive governance, allowing effective responses to changes in the distribution of marine resources. In addition, we will be explore the question of whether emerging trends in biological data sets are sufficiently reliable to enable management and policy actions to be taken even in the absence of higher confidence limits. Science-to-Governance processes which are, or may result, in a more proactive and dynamic governance mechanism that can react more effectively to climate extremes, associated biological changes, and the impacts of such changes on dependent communities will be considered. In doing so, we will develop a conceptual framework that links the responses of science, management, policy and governance to shifting marine resources at relevant spatial and temporal time scales.

W7 Oral Presentations

May 20, 09:10 (W7-8148), Invited

Integrating marine fish physiology, behaviour and physical constraints into early life stage biophysical IBMs: Recent advances and future challenges

Myron A. **Peck**[1], Klaus Huebert[1], Marc Hufnagl[2] and Joel K. Llopiz[3]

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This presentation summarizes our efforts to review key aspects of the ecophysiology and development of marine fish early life stages (eggs, yolk-sac and feeding larvae) and how they have been included in model parameterizations utilized in biophysical IBMs. This literature synthesis compares the morphology, growth physiology, behaviour and resulting trends in feeding and diet among larvae in different taxonomic groups and marine habitats (latitudes) to reveal key differences in early life history strategies. Key differences in diet are highlighted and discussed with respect to ongoing efforts to utilized model-derived prey fields. Early life history strategies are discussed in terms of key processes affecting survival including match-mismatch dynamics with prey (bottom-up) and the inherent need for rapid growth during the larval period to avoid predation (top-down). Gradual and/or abrupt changes occurring during the larval and juvenile ontogeny are highlighted in the hope of building models that more seamlessly link subsequent life stages in full life cycle representations. Given ongoing, climate-driven changes in marine systems, the effects of key abiotic factors (temperature, light, turbulence, turbidity) on early life stage feeding, growth and survival are also reviewed. We review the current "state-of-the-art" in representing early life stages in IBMs and provide future recommendations to advance the field.

May 20, 09:40 (W7-8266), Invited

Beyond dispersion: How to model migration of Japanese sardine (*Sardinops melanostictus*) in the western North Pacific

Shin-ichi **Ito**[1] and Takeshi Okunishi[2]

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A two-dimensional individual-based fish movement model coupled with fish bioenergetics was developed in order to simulate the observed migration and growth of Japanese sardine (*Sardinops melanostictus*) in the western North Pacific by Okunishi *et al.* (2009). While the model successfully reproduced a reasonable migration pattern for the Japanese sardine, recent observations showed a northward migration across the Subarctic Boundary of Japanese sardine in autumn which had not been reproduced in the model. In a model using satellite observed ocean-environmental data as the driving force, fish movement was investigated. Three types of migration algorithms (fitness, kinesis and extended kinesis) were tested to explore whether the northern migration across the Subarctic Boundary can be reproduced. The fitness and kinesis algorithms were not able to reproduce the northern migration across the Subarctic Boundary. The extended kinesis algorithm was the only model that reproduced the northern migration across the Subarctic Boundary. In the extended kinesis algorithm, the model fish are assumed to slow down their migration speed when the environment is comfortable for them. However, even the fitness algorithm was able to reproduce the northern migration if an escape behavior from predators such as skipjack tuna was included in the model. Modeling the migration of small pelagic fish is difficult because it is difficult to observe real migration routes of individual small pelagic fish. Modeling species interactions is even more difficult. Surveys that describe whole population movements will be needed for small pelagic fish species in order to develop migration models for them.

May 20, 10:10 (W7-8290)

Understanding climate change through the coupling of bioenergetic and biophysical models: A review of the state-of the art, constraints and challenges

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Recent studies have shown that climate change, through changes in physical features, can affect processes such as growth (temperature), spawning and reproduction (temperature, small scale turbulence), abundance and recruitment (wind, advection, entrainment, upwelling), distribution and migration (temperature), natural mortality and fishing availability (temperature), by affecting specific biological features such as age of sexual maturity, timing of spawning, egg incubation time, larval size at hatch, larval feeding success and rates, larval transport/advection/retention, food availability, migrational cues, swimming speed, and vertical location in the water column. Climate change may affect, as well, abundance and distribution of prey and or/predators, which in turn may exert changes on the focal populations' growth rates, thus affecting control mechanisms in the ecosystem. The combination of these abiotic and biotic influences are integrated by individual energy budgets and translated from individual to the population and ultimately to the community, which makes coupled biophysical and bioenergetic models a sound candidate to predict the impact of climate change on the early life stages of marine resources. Bioenergetic models provide a theoretical framework to allocate consumed energy into metabolism, growth and wastes, while biophysical models deal with influences of oceanographic transport of early stages and recruitment variability in marine fish species. This study reviews the state of the art of current coupled biophysical-bioenergetic studies, constraints, limitation of individual model approaches (such as the lack of agreement with data), difficulties in model parameterization, and the challenges for coupling these models toward climate change prediction of regional biodiversity, species range limits, and community and trophic organization.

May 20, 11:10 (W7-8258)

Influence of ontogenetic vertical migration on transport processes of common squid (*Todarodes pacificus*) larvae in the East China Sea using a coupled behavioral-physical model

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Ontogenetic vertical migration (OVM) of squid larvae indicates an increase in an individual's mean depth as it develops. In this study, we estimate the influence of OVM on transport processes in the early life stages of the Japanese common squid (*Todarodes pacificus*) by simulating the trajectories of fixed-depth and vertically migrating individuals. Daily velocity fields from Regional Ocean Modeling System (ROMS) oceanographic model were applied to a Lagrangian particle-tracking model to simulate the transport of eggs and larvae of *T. pacificus*. We developed a very simple individual-based model (IBM) that incorporated the ability of squid larvae to migrate vertically to a preferred depth range. It was applied to particle tracking module of ROMs to incorporate vertical movement based on their ontogenetic changes at preferred depth range. We set the durations of egg, hatchling, and larval stages, and simulated individuals are tracked in 3-dimensional space through time from the spawning grounds, undergoing dispersal due to advection and diffusion. We also examined the influence of vertical swimming speed on their transport by simulating the vertical movement with various swimming speeds.

May 20, 11:40 (W7-8035)

Spatially-explicit, individual-based model for Pacific anchovy in Korean waters

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To project changes in fisheries driven by global warming and climate change in the northeast Asian marginal seas, we have been developing an individual based model (IBM) for Pacific anchovy (*Engraulis japonica*) as a first step in establishing predictive models for important commercial species. We tracked the attributes of individual anchovy eggs and larvae responding to spatiotemporal variations in oceanographic environment based on a general circulation model and a biophysical coupling model incorporating the derived temperature- or size-dependent response functions of incubation, growth, fecundity and mortality of anchovy. Because of lack of anchovy egg data, uniform egg distribution was initially assumed to exercise the model to identify hot spots for anchovy recruitment and fishing in Korean waters (123°30′-132°30′N, 31°30′-36°40′E). Model outputs were compared with egg and catch distribution observed and reported for spring and summer in 2002 to validate and improve our anchovy IBM. Comparisons tentatively implied that anchovy larvae tend to be aggregated in shallow areas along the Korean Japanese coast line, especially in summer, and that anchovy catch could have been underreported in the Yellow Sea. The developed IBM will be used to project long-term changes in anchovy fishery driven by climatic and oceanic changes predicted by IPCC-class climate models.

May 20, 12:00 (W7-8256)

Diet of anchovy *Engraulis japonicus* in the southern coastal waters of Korea

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The Japanese anchovy *Engraulis japonicus* is widespread in the western North Pacific and it is an important species to link between plankton to higher trophic levels in pelagic ecosystem. To understand the spatial and ontogenetic variation in anchovy prey items in the southern coastal waters of Korea, we analysed the gut contents of anchovy and the structure of the zooplankton community at three study sites (Jindo, Yeosu and Tongyeong) for July, 2011. The prey items of three size groups (3-4cm, 6-7cm and 9-11cm) were also analyzed at the Jindo site for July and September 2011. The main prey items in Yeosu and Jindo were cyprii stage of barnacle (>35%) and copepod *Calanus sinicus* (>22%) in July. However, predominant prey items in Tongyeong were small copepod *Paracalanus parvus* s.l. (41%) and *Corycaeus affinis* (22%). During the same period, the dominant zooplankton were cladocera *Evadne tergestina* (39%) in Yeosu, small copepod *Paracalanus parvus* s. l. (28%) in Jindo and cladocera *Evadne tergestina* (14%) in Tongyeong, respectively. By anchovy size group, the dominant prey groups were small copepods in the 3-4cm group, cyprii and decapods larvae in the 6-7cm group, and large zooplankton such as amphipods, euphausiids, large copepods and fish larvae in the 9-11cm group. These results suggest that the food selectivity of anchovy might depend on the biomass and species composition of zooplankton communities, as well as ontogenetic changes in diet related to mouth size and energy requirements of anchovy and behaviors of prey items in the southern coastal waters of Korea.

May 20, 12:20 (W7-8199)

Eddy-induced chlorophyll bloom in the southeastern tropical Indian Ocean during Indian Ocean Dipole event

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An eddy-resolving coupled physical-biological model was used to study the effect of cyclonic eddy in enhancing offshore chlorophyll *a* (Chl-*a*) bloom in the southeastern tropical Indian Ocean during the 2006 boreal summer-fall. The results indicate that the offshore Chl-*a* blooms are markedly coincident with areas of high eddy kinetic energy. Moreover, the vertical variations in Chl-*a*, nitrate, temperature, and mixed-layer depth (MLD) strongly imply that cyclonic eddies induce surface Chl-*a* bloom through the injection of nutrient-rich water into the upper layer. The response of subsurface Chl-*a* to the eddy pumping is remarkable, although it is hardly observable at the surface. Interestingly, we found that the surface bloom only occurs when the deep Chl-*a* maximum is located within the MLD.

May 20, 14:00 (W7-8289) - *Cancelled*

Conceptual approach to couple biophysical transport and bioenergetic models to predict influences of a varying environment on small pelagic populations off central Chile

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Common sardine (*Strangomera bentincki*) and anchoveta (*Engraulis ringens*) are small pelagic fishes (SPF) endemic to Humboldt Current System. SPF support an important mixed fishery and play a key trophodynamic role by transferring energy from primary production up the food web. SPF are especially sensitive to environmental variability that seems to modulate the recruitment through controlling the survival of early life stages. Food availability for larvae, on the one hand, has been identified as a dominant factor related to bottom-up control of the SPF populations. On the other hand, top-down control on fish larvae can also be exerted by predators. Favorable growth conditions might increase recruitment success as larger larvae can avoid predation. Bioenergetics describes process by which food is acquired, assimilated, and allocated among maintenance, growth, and reproduction. Accordingly, bioenergetics serves as a primary linkage between physiological processes of individuals and the ecological patterns of the populations. Recent studies have demonstrated the capability of biophysical models to assess connectivity and study the effect of SPF spawning variability on the pre-recruitment process off central Chile. However, there is lack of studies that couple biophysical with bioenergetic models to predict population changes in a varying environment. There is an increasing necessity of develop guidelines to understand how climate change could affect common SPF and the relationship with bioenergetics. The objective of this contribution is to propose a modeling framework encompassing biophysical and bioenergetic models to deal with effects of climate change on SPF population in the South Pacific.

May 20, 14:00 (W7-8291) - *Cancelled*

Conceptual framework for coupling biophysical and bioenergetics models to assess the impact of climate variability and change on Juan Fernandez rock lobster (*Jasus frontalis*) in the oceanic islands off Chile

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Approximately 360 nm off the Chilean coast there are two small groups of oceanic islands, the archipelago of Juan Fernández and Desventuradas Islands. These islands have unique oceanographic and biological characteristics with respect to the coast of Chile. Currently, the local economy of the islands is based almost exclusively on the extraction and marketing of marine resources, focusing mainly on the exploitation of lobster (*Jasus frontalis*), which is one of the oldest crustacean fisheries in the country (1912). A systematic catch decline observed from the early 1960s has been repeatedly associated to overfishing. However landings and relative abundance have recently reached historic high levels, while fishing effort has remained constant. We hypothesize that this is a recruitment driven fishery, where the observed variation in catch is not caused by the fishery, but rather by environmental factors. To address this question, efforts are focused on understanding the dynamics of larval connectivity and its relationship to lobster productivity in the system through the implementation of an individual-based model. Understanding this problem in a global context requires studying the productivity of the system and its link to population-specific factors, such as growth, mortality, and connectivity/retention as they all affect the overall population abundance. In this work we develop a preliminary framework for coupling a biophysical and a bioenergetic model to assess the impact of climate variability on Juan Fernandez lobster population abundance.

May 20, 14:00 (W7-8185)

Coupling a particle-tracking model (Ichthyop) and a bio-energetic model (Dynamic Energy Budget theory) to estimate Atlantic bluefin tuna larval survival in the Mediterranean Sea

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Early life stages are critical for the renewal of marine populations. Larvae are particularly sensitive to environmental conditions which can lead to very high mortality rate (more than 99%). Recruitment variability stems from processes that influence the timing of spawning and the quantity and quality of eggs. The understanding of processes affecting recruitment is crucial to inform sound management and conserve marine species. Here we focus on the impact of environmental conditions on the survival of the earliest life stages of the Atlantic bluefin tuna (*Thunnus thynnus*) in the Mediterranean Sea. To do so, we develop a generic approach to couple a Lagrangian tool that simulates tuna larval dispersal (Ichthyop, Lett 2008) with a bio-energetic model based on the Dynamic Energy Budget (Kooijman 2010) that simulates growth and survival of numeric larvae. Particle behavior (*e.g.* vertical migration) is known to change according to the size/stage of the larvae. In our approach, the online coupling of these 2 models enables us to change larval behavior according to the environmental conditions they encounter. The impact of including the size specific behavior directly in an online modeling approach is compared to an offline time-dependent behavior approach.

Abstracts
Poster Presentations

S1 Poster Presentations

S1-P1

Sea surface height variability in the Gulf of Thailand and South China Sea using altimetry data

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Monthly mean TOPEX/POSEIDON, ERS-2, ENVISAT, Jason-1 and Jason-2 crossover data in the Gulf of Thailand (GOT) and South China Sea (SCS) are used to investigate the spatial and temporal variability of sea surface height anomaly (SSHA). Distribution of SSHA shows two modes: (1) Low water level remains along the axis with heights on both sides (coasts of Asian continent, Borneo and GOT) when northeast monsoon prevails (November to January) (2) High water level remains along the axis with lows on both sides when southwest monsoon prevails (May to August). This regular or normal mode is affected by ENSO events. Analysis of satellite altimetry data also yields an average sea level height rise of 4-5 mm/yr in the GOT and a higher rate of rise in the SCS.

S1-P2

Recent collapse of the copepods in the northern East China Sea: Effects of Three Gorges Dam?

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Damming major rivers can have broad impacts on the ecological processes in adjacent marine ecosystems. Thirty years of zooplankton data in the northern East China Sea show that the Three Gorges Dam on the Changjiang (Yangtze) River had dramatic impacts on the zooplankton community, with a substantial increase in zooplankton wet weight but sharp declines in all crustacean zooplankton abundance. With the sea surface temperature rising in a region that favors the growth of gelatinous zooplankton, these results may demonstrate the "fishing down the food web" process in which overfishing leads to a proliferation of gelatinous zooplankton in this historically overfished region.

S1-P3

Multiple scale climate variability in the Asian Pacific: Teleconnections and anthropogenic effect

Vladimir I. **Ponomarev**[1], Elena V. Dmitrieva[1], Vera A. Petrova[1], Svetlana P. Shkorba[1], Lubov N. Kuimova[2] and Pavel P. Sherstyankin[2]

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Multiple scale climate variability and linkages between anomalies in the Asian Pacific and Arctic are studied by using statistical methods, Hadley SST (1900-2008), NCEP NCAR reanalysis (1948-2009), ice extent in the Okhotsk and Japan Seas, and other time series from the observational record including Lake Baikal ice thickness, precipitation, and Selenga and Amur Rivers discharge. Changes in Arctic - Pacific tropical and extra-tropical teleconnections from the first to the second periods of the observational records, as well as from negative to positive phase of the 60-years oscillation in Arctic and moderate latitudes of the Asian Pacific are shown using SST and other time series of centennial time scale. Typical change in the Pacific SSTA relationship is associated with an amplification of the AO signal with seasonal lag in the tropical-equatorial Pacific. The changing lagged/unlagged statistical relationships between SSTA in the tropical Pacific, ice extent in the North Pacific/Arctic

marginal seas, and climatic indices are revealed after the climate regime shift in late 1970s. It is shown that during recent warming high negative anomalies of the net heat flux in the western area of the North Pacific subtropical gyre is closely related to cold outbreaks in winter, negative anomalies of winter air temperature and SST, and positive anomalies in ice extent in the Japan/East and Okhotsk Seas. Similar cold outbreaks in South Siberia and Alaska region result in corresponding anomalies in the regions of Lake Baikal and Northeastern Pacific, respectively. Anthropogenic effects on the Selenga and Amur Rivers discharge during last 10-15 years is also discussed.

S1-P4

Changes of extreme events in regional climate simulations for Russian Far East

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This study examines changes of extreme events due to greenhouse effects (increase of CO_2) over Northeast Asia, with focus on Russian region, using simulations by a regional climate model (RegCM4.1). Analysis of a control run of the RegCM was carried out in terms of its simulations of temperature and precipitation in Russian Far East. The spatial correlation coefficients between simulated and observed annual temperature and for annual precipitation were estimated. A simulation with increasing concentrations of CO_2 features remarkable increases in annual air surface temperature and precipitation. The RegCM is also able to reproduce the observed nature of extreme events in its control simulation. The simulation indicates statistically significant changes in the number of rainy days and precipitation intensity in various regions.

S1-P5

Satellite observations of decadal changes in the Japan/East Sea phytoplankton chlorophyll *a* concentration

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Decadal changes in phytoplankton chlorophyll *a* concentration during the last decades (the 1980s and the 2000s) were studied using the satellite ocean color data in the Japan/East Sea (JES), which is a miniature ocean showing many characteristics of large ocean. The seasonal cycles of phytoplankton chlorophyll *a* in the two time periods, 1979-1986 and 2003-2010, were examined from the Coastal Zone Color Scanner (CZCS) for the first period and the Moderate Resolution Imaging Spectroradiometer (MODIS) for the second period. The spatial distribution of the phytoplankton chlorophyll *a* concentration from CZCS and MODIS images were examined and the differences between 1980s and 2000s were investigated using statistical analysis. The long-term measured *in situ* data such as the water stratification, zooplankton biomass, and Secchi depth were used to compare with the satellite-derived changes in the JES. In addition, the decadal patterns of the phytoplankton chlorophyll *a* concentration in the JES were compared with the large scale climate patterns such as the El-Niño Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO) data to investigate how the large scale climate changes link to the decadal phytoplankton variability in the regional oceans. Possible reasons of the decadal changes in the temporal and spatial distributions will be further discussed.

S1-P6

Interdecadal variations in phytoplankton communities associated with rapid regional climate change in the Gyeonggi Bay

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Marine phytoplankton are responsible for roughly one-half of the global primary production. Marine phytoplankton represent sensitive indicators of climate change, because phytoplankton can respond easily to changes in temperature and oceanic current systems by expanding and contracting their ranges. Using five decades of meteorological and three decades of oceanographic data, we present evidence that climate warming (0.27 °C decade^{-1}) is diminishing summer biological productivity (>11% Chl.-*a*) with the dominance of dinoflagellates over diatoms and, consequently, increasing winter diatom blooming in Gyeonggi Bay (GB) over the last 30 years. In parallel with regional warming patterns since the 1990s, a rise in sea surface temperature (+0.11 °C decade^{-1}) has increased the stability of the water column. A regional decrease in wind speed (-0.21 ms^{-1}decade^{-1}) has contributed to reduced mixing, a decrease in the nutrient supply from depth, especially with respect to silica, and lowered diatom productivity. In addition, the recent late winter blooming in GB represents an anomaly from the past spring bloom patterns in terms of abundance and recurring dominance of pelagic diatom (*Thalassiosira nordenskioeldii*, 80% of total biomass) over tychopelagic (*Paralia sulcata*). We hypothesize that GB's recent winter blooming could be followed by winter warming, contraction of the winter period of heat input to the atmosphere and strong winds, with significant effects on benthic resuspension processes. Shifts in the dominant winter-summer bloom algal groups will need to be considered in future studies of marine ecosystems, geochemical cycling, ocean circulation and fisheries.

S2 Poster Presentations

S2-P1

Tidal information of Chinese Seas from altimetric data

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The tidal characteristics of the Bohai, Yellow, East and South China Seas are analyzed using altimetric data from the TOPEX/POSEIDON Satellite, before the orbital transfer, and then the Jason1 and Jason2 Satellite altimeters, respectively. The two groups of harmonic constants of 68 tidal constituents are calculated at net points in the study area obtained by interpolating the data to the reference track. The two groups of cotidal charts for four tidal constituents M2, O1, K1 and Sa are used to compared with each other and the results of other researchers in detail, which proves that the charts conform better in the deep water and open oceans than those along costal areas; also, they conform better in amplitudes than in phase-lags. This may be attributable to the selection of the net points. The results also reveal the sea surface height variability in past twenty years, to a certain extent. Compared with the results from the data of tide gauge stations, the average absolute error of the observed harmonic constants for amplitudes and phase-lags are more accurate than Peiliang (2000) but less accurate than Guohong (2004).

S2-P2

Present-day state of the gyre/overturning circulation at the northern periphery of the Atlantic Ocean: An estimate based on repeat hydrographic measurements and satellite altimetry data

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A mean state of the full-depth summer circulation in the Atlantic Ocean in the region in between Cape Farewell (Greenland), Scotland and the Greenland-Scotland Ridge (GSR) is assessed by combining 2002-2008 yearly hydrographic measurements at 59.5°N, mean dynamic topography, satellite altimetry data and available estimates of the Atlantic-Nordic Seas exchange. The mean absolute transports by the upper-ocean, mid-depth and deep currents and the Meridional Overturning Circulation (MOCs=16.5±2.2 Sv, at s_0=27.55) at 59.5°N are quantified in the density space. Inter-basin and diapycnal volume fluxes in between the 59.5°N section and the GSR are then estimated from a box model. The dominant components of the meridional exchange across 59.5°N are the North Atlantic Current (NAC, 15.5±0.8 Sv, s_0<27.55) east of the Reykjanes Ridge, the northward Irminger Current (IC, 12.0±3.0 Sv) and southward Western Boundary Current (WBC, 32.1±5.9 Sv) in the Irminger Sea and the deep water export from the northern Iceland Basin (3.7±0.8 Sv, s_0>27.80). About 60% (12.7±1.4 Sv) of waters carried in the MOCs upper limb (s_0<27.55) by the NAC/IC across 59.5°N (21.1±1.0 Sv) recirculates westwards south of the GSR and feeds the WBC. 80% (10.2±1.7 Sv) of the recirculating NAC/IC-derived upper-ocean waters gains density of s_0>27.55 and contributes to the MOCs lower limb. Accordingly, the contribution of light-to-dense water conversion south of the GSR (~10 Sv) to the MOCs lower limb at 59.5°N is one and a half times larger than the contribution of dense water production in the Nordic Seas (~6 Sv).

S2-P3

Importance of stratification, upper ocean heat content and eddies in the genesis and intensification of storms over Bay of Bengal

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Bay of Bengal receives huge amount of fresh water through major rivers on the east coast of India which is expected to influence the circulation and stratification. Though the importance of stratification is qualitatively discussed in some of the earlier studies, the importance of stratification and UOHC has not been studied so far. The UOHC with and without stratification has been estimated for Bay of Bengal during pre-monsoon and post-monsoon seasons from WOA-09, and it's role in the genesis and intensification of storms in Bay of Bengal has been examined. Most of the severe cyclones in the pre and post monsoon seasons are forming over high UOHCs (with stratification; > 160 kj/cm^2) and the tracks are also following the high UOHCs. It is interesting to note that the UOHC is the dominant factor in pre-monsoon while UOHCs is the dominant factor in post monsoon, which clearly shows the importance of stratification after the southwest monsoon season. In pre-monsoon most of the cyclone tracks are towards north following the high UOHCs, where as in post monsoon season the cyclone tracks are following high stratification factor in the central east and western parts. In addition to these eddies induced by the East India Coastal Current are playing a major role in the intensification of cyclones in pre and post monsoon seasons.

S2-P4

Analysis of spatio-temporal distributions of ice characteristics in the Bering Sea

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The ice cover variability of the Bering Sea is considered within the Chetyrbotskii A.N. large-scale model of sea ice evolution. For detailed representation of dynamics of an ice cover the joint changes of ice areas, volumes, areas (as a result of ice hummocking) and their thickness are considered. The ice cover is divided into fast ices and sea-way ices. The total evolution cycle of the areas, volumes and areas (as a result of ice hummocking) of fast ices and sea-way ices, according to types is studied. Tipizations allow to reveal repeating situations, to establish regularities in sequence of changes of processes. Tipization has revealed that the general spatial pictures of distributions of ice areas, ice volume and ice areas (as a result of ice hummocking), according to thicknesses coincide. The probability of coincidence of all types of distributions of the areas and ice volumes on all water area of the sea makes 82.9 %. The probability of coincidence of all types of distributions of ice areas and ice areas (as a result of ice hummocking) on all water area of the sea makes 79.3 %. The probability of coincidence of all types of distributions of ice volumes and ice areas (as a result of ice hummocking) on all water area of the sea makes 64.6 %.

S2-P5 - *Moved to Oral, May 16, 12:15*

Interannual variability of the Antarctic Circumpolar Current strength based on merged altimeter data

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Interannual variability of the Antarctic Circumpolar Current (ACC) strength is studied with the latest Absolute Dynamic Topography (ADT) product from AVISO. A stream-coordinate projection method is developed to calculate the ACC strength and remove the influences from neighboring subtropical and subpolar gyres. The approach enables us to consider the zonal asymmetry of the ACC rather than assume that the ACC is a purely zonal current. The result shows that the ACC strength exhibited large interannual variations with peaks around 2000 and 2009. The large interannual variation appeared mainly in the Indian and Pacific sectors of the Southern Ocean, and the strongest signal was located south of Australia. The intensification of the westerly wind in 1998 and 2008 may cause the strengthening of the ACC with a time lag of 1-2 years.

S2-P6 - *Cancelled*

Features of spatial and temporal sea level variability in the Japan and Okhotsk Seas based on satellite altimeter data

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In this paper we studied sea level interannual variability of the Japan and Okhotsk seas for the last twenty years. For more complete understanding of sea level variability a spectral analysis was performed, which revealed a 3, 2-year, annual and semiannual variations. Values of amplitudes of oscillations were got and their contribution of the total variance of sea level variability was estimated. To assess the internal nonlinear redistribution of energy between oscillations of different time scales, the wavelet analysis was performed. We found that in 2001-2003 years in the north part of the Japan sea energy flow directed from high to low frequencies. In physics this phenomenon is called "motion with negative viscosity". Also, we obtained statistical and probabilistic estimates of linear and square trends of the sea level in the Japan and Okhotsk seas. Linear approximation of the sea level trend in the Japan Sea pointed to a rise at a rate of 0.6 mm/year, and a similar trend approximation in the Okhotsk Sea to its decline - 1.2 mm/year. The variability of sea level in marginal seas is determined by a number of factors which is hard to evaluate quantitatively. Meanwhile, some of these factors can be represented by climatic indices that characterize a state of the atmosphere and ocean and thus can evaluate the connections between sea level variations and global and regional changes. Connection between the sea level of the Japan and Okhotsk seas and the Pacific sector indices of atmospheric and oceanic circulation was investigated by a correlation, a cross-correlation and a regression analysis. The most stable relationships were observed with the Solar activity index, Trans-Niño Index, The Pacific/North American teleconnection index, Earth angular rotation index and Quasi-Biennial Oscillation of zonal wind index.

S2-P7

Operational oceanographic system for the coastal waters of Korea using ROMS

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Operational oceanographic system has been developed for the coastal waters of Korea. The operational modeling system comprises of coastal circulation model ROMS coupled with wave model SWAN, internally coupled sediment transport model CSTMS and externally nested water quality model CE-QUAL-ICM. The hydrodynamic variables such as sea surface elevation, currents, temperature, salinity, storm surge height, and wave information are predicted twice a day in the 72 hours base. The coastal information system which is based on web-GIS system provides the predicted results with real-time monitoring data for dissemination to the public and validation of the operational model using various visualization techniques.

The surface forcing for the operation model ROMS and SWAN is derived from the predicted results of the operational meteorological model WRF or UM which forecasts atmospheric data for the East China Sea and the East Sea. The open boundary condition for the down-scaled ROMS is nested with the predicted results derived from another operational model ROMS for the Yellow Sea or global operational hybrid ocean model HYCOM which forecasts ocean circulation with data assimilation. The previous results simulated 12 hours before are used as an initial condition for the operational oceanographic system.

The hydrodynamic results have been calibrated with tidal surface elevation and verified with currents observed by bottom mounted acoustic current meter ADCP or AWAC for the coastal waters of Korea. For the validation of predicted results we use real-time monitoring data such as hydrodynamic observation monitored by remote Buoy system and ocean observatory tower and 1 hour averaged surface currents derived from HF-Radar system. The suspended solid particles (SS) image generated from Geostationary Ocean Color Imager (GOCI) of the satellite COMS will be used for validation of the model prediction on the suspended sediment transport. This operational coastal modeling system will also be used for validation of surface vector algorithm which will be developed through the pattern analysis of SS or Chlorophyll images derived from hourly produced GOCI data.

S2-P8

Estimation of phytoplankton communities' state from satellite ocean color scanners

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Phytoplankton communities' state can be estimated on the basis of relationships between chlorophyll *a* and dissolved organic matter (DOM). Of course there are many uncertainties and complexities in interpretation of such estimation. But the main advantage is a possibility to realize method in the remote sensing devices, *e.g.* lidar and radiometers. Thus it will be possible to make investigation on the large time-spatial scales include global and climate, especially if we use the approach at the satellite platforms.

The idea of present research is algorithms developing for "chlorophyll *a* – DOM" scatter plots estimation from satellite ocean color data and further analysis of the scatter plots in the various regions of Oceans. Algorithms developing utilizes shipboard data of chlorophyll *a* and DOM concentrations, shipboard data of remote sensing reflectance spectra, satellite ocean color data from MODIS-Aqua, SeaWiFS and GOCI. In order to divide chlorophyll *a* and DOM signals from ocean color data, sun-induced fluorescence of chlorophyll *a* were used and optimal wavelength diapasons for DOM estimation were selected.

Retrieved scatter plots of "chlorophyll *a* – DOM" can be depended on phytoplankton development stage, state, species composition. So the scatter plots were analyzed in the different water areas of Pacific, Indian and Atlantic oceans where satellite and shipboard data were available. And main factors which affect the scatter plots parameters were determined for the various regions and seasons.

S2-P9

Sea ice records and some limited ocean measurements from a small Antarctic coastal embayment; Trends and implications

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We attempted to describe sea ice cycles in the northern part of Maxwell Bay and Marian Cove, King George Island, Antarctica, examining the weather logbook and limited ocean measurements from a coastal year-round research station, King Sejong. Sea ice duration and coverage differed widely year to year, reflecting its low latitude maritime Antarctic locality. The onset and development of sea ice formation and its break-up was strongly affected by local weather, the air temperature as well as the wind field. However, the sea ice formation and duration in this small bay appear to be governed by a geographically much wider scale trend. The sea ice forms in open waters further south to the bay, and enters and advances into the bay. The decline of sea water temperature might be a coarse predictor of sea ice dynamics in the upcoming winter. Melt sea ice tends to induce either a short-lived or longer lasting algal bloom. Examination of near 20 year record shows that the sea ice tends to form later and for a shorter length recently, although the trend is weak and not necessarily unidirectional. This should have an implication for this site of enhanced biological activity and glacial retreat.

S2-P10

Implementation of Self-Organizing Maps (SOM) to analyses of environmental parameters and phytoplankton biomass in a macrotidal estuary and artificial lake

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Self-Organizing Maps (SOM) have been used for patterning and visualizing ten environmental parameters and phytoplankton biomass in a mactrotidal (>10m) Gyeonggi Bay and artificial Shihwa Lake during 1986-2004. SOM segregated study areas into four groups and ten subgroups. Two strikingly alternative states are frequently observed: the first is a diverse non-eutrophic state designated by three groups (SOM 1-3), and the second is a eutrophic state (SOM 4: Shihwa Lake and Upper Gyeonggi Bay; summer season) characterized by enhanced nutrients (3 mg l^{-1} DIN, 0.1 mg l^{-1} PO_4) that act as a signal and response to that signal as algal blooms (24 µg Chl.-*a* l^{-1}). Bloom potential in response to nitrification is affiliated with high temperature ($r = 0.26$), low salinity ($r = -0.40$) and suspended solids ($r = -0.27$). Moreover, strong stratification in the Shihwa Lake has accelerated harmful algal blooms and hypoxia. The non-eutrophic states (SOM 1-3) are characterized by macro-tidal estuaries exhibit a tolerance to pollution with nitrogen-containing nutrients and retard any tendency toward stratification. SOM 1 (winter) is more distinct from SOM 4 due to higher suspended solids (>50 mg l^{-1}) caused by resuspension that induces light limitation and low chlorophyll *a* (<5µg l^{-1}). In addition, eutrophication-induced shifts in phytoplankton communities are noticed during all the seasons in Gyeonggi Bay. Overall, SOM showed high performance for visualization and abstraction of ecological data and could serve as an efficient ecological map that can specify blooming regions and provide comprehensive view on eutrophication process in a macrotidal estuary.

POSTERS-S2

S2-P11

Reproduction efficiency of dissolved organic matter by phytoplankton cells as the indicator of climate changes influence on the phytoplankton communities' state

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Nowadays climate changes' influence on phytoplankton communities usually measured by one parameter – chlorophyll *a* concentration. It is closely related to the fact that contemporary measurement methods allow to measure this parameter with sufficient accuracy on the synoptic and global scales.

However, not only chlorophyll *a* concentration dynamics ought to be investigated in order to study climate changes influence on the phytoplankton communities correctly. In some cases it is possible to appraise the state of the phytoplankton communities according to *in situ* measurements of dissolved organic matter (DOM) concentration in the sea water. So it allows estimating the reproduction efficiency of DOM by phytoplankton cells.

Here it is reported about proper parameter which was estimated from concentration of the chlorophyll *a* and DOM. The results of full-scale measurements of the above mentioned parameter made in different places of the World Ocean by laser fluorometry are presented here. Also the possibility of such monitoring by usage of data from the sea surface color scanner is appraised herein.

S2-P12

Analysis of the relationships between chlorophyll *a* and dissolved organic matter (DOM) concentrations depending on type of the DOM

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The relationships between chlorophyll *a* and dissolved organic matter (DOM) concentrations depends on many factors. One of the most important is phytoplankton community state. Taking into account that the relationships can be measured by automotive active and/or passive remote sensing methods it can be used for global estimations of phytoplankton community state and thus for climate change research. It is hard to interpret the parameters of the relationships because there are many factors which can have influence. Interpretation and observed relationships depends on the spatial scale of analyzed data and the method which used for DOM and chlorophyll *a* measurements.

Time-spatial analysis of relationships between DOM and chlorophyll *a* fluorescence intensities were conducted. Temperature-salinity scatter plots were taken into account during the analysis. Data were obtained by the flow-through thermosalinographs and fluorometers with different excitation wavelengths. Area of study was the around-the-world route and north-western Pacific where a number of marine expeditions were carried out from 1998 to 2010. More than 200000 seawater fluorescence spectra were measured and the length of investigated route was about 100000 km. Correlation coefficients, slope and intercept coefficients of regression between chlorophyll *a* and DOM fluorescence intensities were calculated for the spatial series of various length. Spatial scales where significant linear dependence appeared were analyzed. Statistical distributions of measured biooptical and hydrological parameters were investigated during different phytoplankton vital stages. Presented statistical analysis allows investigate phytoplankton communities functioning and it is perspective to get additional parameters when using several methods of DOM determination.

S3 Poster Presentations

S3-P1

The role of atmospheric aerosol in temperature field formation in the Primorsky region

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Besides having a direct impact on radiation balance, atmosphere aerosols have an indirect effect through changing the microphysical and optical parameters of clouds, acting as a condensation nuclei. Radiation forcing leads to a change in temperature stratification of the atmosphere, and moreover, to change of temperature on the earth's surface. Thus, temperature can increase or decrease, depending on the parameters of the aerosol particles, their height distribution, and certain external factors.

This study primarily aimed to evaluate the role of atmospheric aerosols in temperature field formation in the Primorsky region. The investigated area is under the influence of different aerosol sources, the strongest one being the Gobi desert. In studies, the results of 2-year photometric measurements of direct sun radiation were analyzed. On the basis of experimental data, the aerosol optical depth (AOT) and aerosol microphysical parameters were retrieved. The AOT characterizes the extinction of solar radiation owing to aerosol particles. This study also uses surface temperature values obtained from meteorological stations during the investigation periods. The correlation relations between AOT and the earth's surface temperature were analyzed.

S3-P2

Complex investigation of basic climate-forcing factors in the northwest part of the Pacific Ocean

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Analysis of climate changes in the Pacific region should be performed using dynamic processes of basic climate forcing. The atmosphere has radioactive components and processes that influence these components. Besides the usual and well-known meteorological processes, it is necessary to consider the influence of processes such as dust storms, volcanic eruption, tropical hurricane, and ozone layer changes. Moreover, anthropogenic factors play a very important role in the changes in the earth's radiation balance in this region.

The role of phytoplankton in global climate changes is currently being greatly focused on. Phytoplankton is now specifically appraised as a key factor in controlling the concentration of carbon dioxide and maintaining the necessary concentration of oxygen. Moreover, the influence of climate changes on marine ecosystems should be investigated including the changes they induce in the condition of phytoplanktons. In this case, phytoplankton should be considered a climate-forcing factor in the Pacific region.

Regular measurements were performed to investigate all the changes in the radioactive components of the atmosphere, and the interaction between basic climate forcing and phytoplankton was investigated. The special feature of these measurements is the combination of different spatial scale investigations, which includes combined appraisal of satellite data, and shipboard and stationary measurements.

The complex system created by the atmosphere, ocean, and phytoplankton provides the starting point for investigating the role of phytoplankton in regional climate and the influence of climate forcing on phytoplankton.

S3-P3

The impact of climate-forcing factors of the north-western Pacific on radiative budget

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The earth's climate is influenced by various climate-forcing factors, which include atmospheric aerosols, stratospheric ozone, surface albedo, incident solar radiation flux, greenhouse gases, and radiation budget. Spatial and temporal variations in these factors are crucial in the study of climate change. Variations in these climate-forcing factors can be caused by the following natural and anthropogenic phenomena: dust storms, volcanic eruptions, tropopause breaks and foldings, cirrus cloud formation, indirect radiative effect due to aerosol-cloud interactions, and anthropogenic activities. These processes occur both episodically and on a regular basis and have strong spatial variability. In Primorye, in the northwest Pacific coast, regular variations in climate-forcing factors are determined, first, by dust storms, which are active in the winter and spring, and which supply a large amount of dust to the atmosphere of the investigated area; second, by jet streams (including the subtropical and polar), whose effects are primarily in the winter when the axis of the subtropical jet stream is closest to the investigated area and a layer of high ozone concentration due to its inflow from the polar regions through the polar jet stream is formed in the atmosphere; and third, by the process of stratosphere-troposphere exchange. Episodic processes include volcanic eruptions, supplying a large amount of sulfite stratospheric aerosols, effectively absorbing incident shortwave solar radiation.

The report presents some results of a comprehensive experiment studying variations of the basic climate-forcing factors in Primorsky Krai and their contribution to the radiation budget. Variations in radiative forcing due to changes in the spatial distribution of atmospheric ozone are shown. The results of radiative forcing calculations of cirrus clouds and atmospheric aerosols are presented.

S3-P4

Effects of global warming on the oceanic systems of the northwest Pacific Ocean

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In the ocean, climatic changes will induce temperature changes and associated adjustments in the ocean circulation, ice coverage, and sea level. This, in turn, will affect marine ecosystem structures and functioning with feedbacks to global biogeochemical cycles and the climate system. The importance of estimating potential climatic changes resulting from variations in atmospheric composition has been well recognized. Many studies have used climate-modeling results as a tool for predicting the potential effects of climate change. Regional-scale climate changes will be different from global average changes. However, at present, there is only very limited capability to estimate how various regions will respond to global climate changes at subsequent regional oceanic systems. We have investigated the response of climate models to a gradual increase of atmospheric carbon dioxide at 1% per year compounded for doubling and quadrupling as per IPCC scenarios, using NCAR fully coupled climate system model with special emphasis on the northwest Pacific Ocean by means of enhanced grid resolution of an ocean model. In this presentation, we provide the effect of global warming from $2xCO_2$, $4xCO_2$ experiments in terms of changes in the atmospheric system, which will in turn be reflected in ocean properties, circulation, major parameters concerning physical conditions of the oceans, and linkage between atmosphere/ocean physics, which will affect the ecosystems of the northwest Pacific Ocean. The impacts of climate warming on fisheries production may then be evaluated through changes in the major variables provided.

S3-P5

Climate change in the northwest Pacific as seen in the SRES A1B simulations of AR4 models

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Climate change in the northwest Pacific during the 21st century is investigated as manifested in the SRES A1B scenario of several AR-4 models by using cyclostationary empirical orthogonal function (CSEOF) analysis. In case of the high-resolution MIROC model, 12 atmospheric variables, including 2-m air temperature (t2) and 5 oceanic variables (sea surface height and temperature, salinity, and ocean current defined at 47 vertical levels), were analyzed. The CSEOF decomposition of each variable identifies 2 major modes—the annual cycle and the climate change signal. Then, atmospheric and oceanic variables (predictor variable) were regressed onto the principal component time series of t2 (target variable) to find the exact physical relationship between the evolution of air temperature and those of other variables. The climate change mode exhibits a linear trend. Air temperature increases by ~4°C during the 21st century. Oceanic variables are highly correlated with t2. The largest change occurs along the path of the Kuroshio and its extension. Cyclonic and anti-cyclonic circulations that appear to the south and the east of Japan are clearly seen in the sea surface height, current, and ocean temperature; cyclonic circulation is associated with positive sea level height anomaly and positive temperature anomaly. The Kuroshio becomes stronger and extends farther eastward, while its position remains almost unchanged. Such factors such as wind stress curl change, increased baroclinic instability of the Kuroshio, and more heat transport from the tropical ocean could potentially contribute to the strengthening of the Kuroshio; however, further study is required for a clear understanding of their roles.

S3-P6 - *Moved to Oral, May 18, 12:05*

Hindcast and historical assessment of Cyclone Tomas and climate change impact analysis on tropical cyclones in the South Pacific

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The South Pacific is an extremely sensitive and vulnerable area against coastal climate change. Sea level increase will cause significant impacts on these small southern islands. Moreover, climate change may also affect tropical cyclone (TC) intensity in the future climate. In this study, wind and wave hindcast simulation was carried out to examine how TC Tomas caused damage locally in Fiji and how large this TC was historically. Additionally, whether TC intensity in the South Pacific will vary because of climate change was investigated with statistical analysis. Mesoscale weather hindcast simulation was carried out by the weather research and forecasting model, and its output was used as a driving force of wave hindcast simulation by SWAN. The simulation period was 12/March/2010, 0:00 to 17/March 0:00 UTC. The calculation results were a significant strong southerly wind faster than 50 m/s and a maximum significant wave height estimated as 26 m. To investigate climate change impact, global climate simulations employing general circulation models (GCMs) were conducted for the present (1979–2003) and the future (2075–2099) by the Meteorological Research Institute, Japan (MRI) (Kitoh *et al.*, 2011). The ensemble mean of the TC central pressure in the South Pacific was estimated from 6 runs of MRI-GCMs. The return period calculated by Weibull cumulative distribution function of MRI-GCMs around Fiji was estimated as less than 10 years for present climate, but approximately 10 years for future climate. The intensity of TC Tomas was found not to be the worst historically and that the intensity of TC near Fiji would be weaker.

S3-P7

Impacts of variations in river runoff on coastal cod subpopulations

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Presented by Svein Sundby on behalf of Mari S. Myksvoll

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The Norwegian coastal cod consists of many subpopulations that spawn several places along the coast and inside the fjords of Norway. The total biomass of coastal cod has been declining since 1994, and large local variations in abundance are observed between neighboring locations. We study the transport of offspring from spawning grounds in a fjord system in northern Norway where the dispersion is strongly linked to the estuarine circulation and varies correspondingly with the river runoff. Retention of early life stages inside the fjord is assumed to be very important for the local recruitment and maintenance of the subpopulation. A numerical model is used to simulate the transport of cod eggs with varying river runoff, evaluating the impact of river regulation caused by hydroelectric power production and increased river runoff caused by climate change. River regulation alters the seasonal cycle of river runoff, with increased discharge during winter/spring and reduced discharge during summer. Downscaling of climate models predicts approximately 50% increase in river runoff during all seasons except summer. The results here show that increased river runoff also increased the transport of cod eggs away from the spawning area and reduced the local retention. Moreover, the impact of altered river runoff caused by hydroelectric power production is larger than the impact of 50% increase due to climate change.

S3-P8

Development of a global 4D-VAR data assimilation and forecast system focusing on climate variability in the North Pacific and use of Argo profiling data: Experiment of 2010–2011

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A global 4D-VAR data assimilation and forecast system based on a fully coupled general circulation model is developed to reproduce and predict basic climate states in 2010–2011, focusing on the North Pacific. In this system, ocean initial condition and bulk parameters are optimized by assimilating 10-day mean observations into the model. The assimilation window is 3 months. In the standard experiment, several atmospheric observational data and observational sea surface temperature data are used for the assimilation element. By using optimized oceanic initial conditions and bulk parameters, 11-member ensemble forecast experiments are conducted for 3 years. The results well reproduce the ocean state and predict major tropical climate variations. However, more improvements would be needed to properly reproduce the oceanic subsurface state and forecast climate variations in the North Pacific. To do so, we incorporate Argo profiling float data as the assimilation data and examine its impacts on the climate forecast.

S3-P9

Potential impact of climate variability on Japanese scallop aquaculture in southern Hokkaido, Japan

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The sustainability of scallop aquaculture can be influenced by environmental changes associated with climate variability, threatening optimum growth temperature, and the weather. El Niño, the most well-known zonal index, is very useful for ecosystem research investigating climate effects. In this study, to model the potential impact of climate variation on scallop aquaculture, we analyzed different climatology years (El Niño years and normal years) for Japanese scallop aquaculture site selection. The suitability of sites for scallop aquaculture was determined using integrated remote sensing and a model based on a geographic information system (GIS). Multicriteria evaluation was adapted to the GIS models to rank the sites on a scale of 1 (least suitable) to 8 (most suitable). By evaluating the suitability of sites in an El Niño year, we found that the suitable sites for scallop aquaculture changed considerably relative to the normal year. As El Niño occurred, the most suitable sites (scores 7 and 8) decreased significantly (33%) compared with the normal year (46%). The results suggest that climate variability could influence the development of scallop aquaculture through change in site suitability. The adaptation of this change should be considered in developing the plan and management of scallop aquaculture.

S4 Poster Presentations

S4-P1

Impacts of climate change on the coastal fisheries resources of Bangladesh

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The impacts of climate change are expected to be both diverse and extensive, and will include alternations of physical, chemical, biological and socio-economic elements. Increased ocean temperature may alter coastal ocean currents that have influence on the residence time of water in near-shore environments which may have negative consequences on the growth and survival of many aquatic animals. Carrying capacity of the Bay of Bengal (BOB) is likely to be changed due to increases in total chlorophyll leading to considerable change in the distribution of various pelagic fish and consequent changes in the location of fishing grounds. Contribution of estuarine zones is likely to increase due to areal expansion. Hilsa production in inland fisheries is declining and is likely to decline further. Migratory routes of some species may change, *e.g.*, tuna fishing areas may expand in the Bangladeshi waters of the BOB. The migration route of Hilsa may extend southwards and anadromy in the Ganges-Meghna-Brahmaputra (GBM) rivers may shift to Myanmar rivers. Catadromy of larvae of tiger shrimp may also follow changed migratory routes. Offshore fisheries may be the least affected by future climate change and SLR. However, there will be a profound change in the near-shore and coastal marine fisheries. The greatest impact may be on fish species, which are dependent on the estuaries and coastal zone for breeding and spawning.

S4-P2

30 years of oceanographic monitoring at the south Atlantic: Highlights of climate change

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Both climate change and anthropogenic impact are creating a dynamic of continuous changes in ecosystems. While the expected consequences of these changes are global, the occurrence of extreme events and specific environmental problems are usually local or regional phenomena. In particular, the coastal ecosystems are among the first vulnerable areas to show those changes; in spite of this, coastal ecosystems are among the least studied. The Bahia Blanca estuary, Argentina, is located on the South Atlantic at 38° 40′ S and 62° 09′W and includes an area of 2300 km^2, with long extensions of intertidal marshes and islands. Along the northern shore of the estuary is the most important deep-water harbor of the country, from which most of the nation's agricultural and industrial products are exported. On the same shoreline is the principal Navy harbor of the country. At least two monitoring points in this area have had continuous fortnightly full oceanographic monitoring since 1974. Based on this multi decadal oceanographic monitoring and meteorological data , a co-relational analysis approach was used to consider trophiv level changes in phytoplankton and zooplankton assemblages, commercial crustaceans and fisheries. The results suggest several novel hypotheses regarding cause-and-effect relationships. As an overall conclusion, these findings strengthen the theory of climate driven changes at marine coastal ecosystems and establish the need of further studies.

S4-P3

Role of sea surface temperature and rainfall in the fluctuation of production and abundance of the stock of the common octopus in the East of Tunisia

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Common octopus (*Octopus vulgaris*, Mollusca) is an important fishery resource on the eastern and southern coasts of Tunisia. Its annual landings are highly variable. The effect of fishing on the stock and the effects of environmental variation on octopus catch per unit effort (CPUE) were studied over a 12-year period. Correlation analyses and an incorporation into surplus production models of sea surface temperature (SST) and rainfall data collected during cold (January-May) and hot (August-October) seasons were used. CLIMPROD software was used to select the appropriate model and fit it to the fishery and environment data. In both seasons, SST significantly contributed to CPUE variability; fishery production was influenced positively by cold season SST but negatively by hot season SST. Due to a poor fit with cold season data, the impact of rainfall was analyzed only for the hot season, during which it has a positive effect on production.

S4-P4

In the path of the polar front: Extracting environmental time series from a large scale oceanographic feature with application to the Alaska sablefish stock assessment

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In fisheries stock assessment reliable estimation of recruitment is often hindered by lack of data on early life history stages and limited knowledge of the underlying processes influencing recruitment. One solution to this problem is to incorporate environmental time series into the population models. Here we characterize a large scale oceanographic feature, the North Pacific Polar Front (NPPF), and investigate the influence of this feature on recruitment of Alaska sablefish (*Anoplopoma fimbria*). Our hypothesis is that advection of oceanic properties along the NPPF plays a key role in shaping the oceanographic environment that sablefish encounter during their early life history. We collected and analyzed time series of oceanic properties along the NPPF mean path, integrated relevant time series into the sablefish stock assessment model, and evaluated the impact of these series for increasing precision of recruitment estimates. Covariates representing the thermal conditions and the productivity regime along the NPPF path were integrated into the recruitment equations of the sablefish assessment and models were evaluated using a multistage hypothesis testing approach. The best model suggested that wintertime thermal conditions in the central North Pacific represent oceanic conditions that create positive recruitment events for sablefish. We plan to incorporate results on sablefish recruitment from current integrated ecosystem research programs to improve the selection of environmental covariates for this model. Successfully incorporating these environmental time series into the sablefish assessment will establish a foundation for future ecosystem based management and may allow for more informed and efficient resource allocation to stakeholders.

S4-P5

Comparison of siphonophore assemblages under the influence of two different monsoon seasons in the Taiwan Strait, western North Pacific

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We analyze spatial patterns of siphonophore assemblages in relation to local hydrographic features during two different monsoon seasons (the northeasterly monsoon in winter vs. the southwesterly monsoon in summer) in the Taiwan Strait. Forty-eight species of siphonophores were identified, with *Lensia subtiloides*, *Chelophyes appediculata*, *C. contorta*, *Bassia bassensis*, and *Diphyes chamissonis* as the most abundant species. Significantly higher abundance was recorded in summer than in winter. Differences in species compositions were observed between the northern and southern Taiwan Strait, with significantly higher diversity in the southern waters. The distribution patterns of siphonophore assemblages were closely linked to the hydrographic features influenced by the dynamic nature of the currents in the study area, with temperature, salinity, and zooplankton biomass being the three most important factors. The present study not only expanded our knowledge of siphonophore distribution in the Taiwan Strait, but also provided good evidence of biotic response to time-varying hydrographic conditions and interactions among the surveyed waters.

S4-P6

What was the major factor causing the change in the migration pattern of Japanese common squid *Todarodes pacificus* associated with the 1989 regime shift?

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The spawning migration pattern of Japanese common squid *Todarodes pacificus* changed with the 1989 regime shift in the Sea of Japan with an increase in the stock size. This study identifies major factors that affected changes in Japanese common squid migration patterns associated with the 1989 regime shift. Daily relationships between the distribution densities of Japanese common squid and water temperatures (SST and 50m depth) were calculated, based on the results of experimental jigging surveys conducted in 1973-2000 (all periods), 1977-1988 (before the 1989 regime shift) and 1989-2000 (after the 1989 regime shift). Migration patterns were estimated using the daily relationships and the horizontal distribution of water temperatures in the Sea of Japan in the 1980s and 1990s. Migration was found to show the same patterns before (after) the 1989 regime shift using the relationships of before (after) the 1989 regime shift and the water temperatures of either the 1980s or 1990s. However there were no clear differences between the estimated migration patterns using the relationships of all periods and the water temperatures in the 1980s or 1990s. These results suggest that changes in the migration pattern of Japanese common squid with the 1989 regime shift were not directly caused by changes in the water temperatures, but were caused by changes in ecological traits (*e.g.* variation in the spawning seasons) associated with the 1989 regime shift.

S4-P7

An IFRAME approach for estimating exploitable biomass of fish stocks changing climate

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Climate changes such as global warming can affect ocean conditions, and thus affect the functioning mechanism of marine ecosystems and the distribution and abundance of fisheries resources. There has been an increasing trend in sea surface temperatures which has accelerated in last decades in Korean waters. The recent warming trend in Korean marine ecosystems is associated with the absence of cold-water species (*e.g.* walleye pollock) from Korean waters and an increase in abundance of warm-water species (*e.g.* bluefin tuna). This warming trend is also associated with changes in spatial distribution of some pelagic fish stocks such as chub mackerel and tunas in Korean waters. The impacts of the climate change were investigated by projecting distributional ranges of fish species in this study. Based on the Integrated Fisheries Risk Analysis Method for Ecosystems (IFRAME) approach, we projected expected changes in fishing ground of the Korean large purse seine fishery based on distributional ranges of pelagic fish due to warming, forecasted expected exploitable biomass of target and bycatch species of the Korean large purse seine fishery by taking account of the effects of changes in ocean biogeochemistry such as ocean acidification and reduction in oxygen content and also changes in maximum layer depth (MLD) due to warming, and finally evaluated the variability and sensitivity of biomass estimation due to forcing factors involved in the forecasting process. A sensitivity analysis was conducted to examine which factor was most sensitive to biomass estimation.

S4-P8

Climate change and fluctuations of pelagic fish populations in the Far-East region

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Time series of ocean climate indices and catch records were used to identify alternation patterns of pelagic fish populations in relation to climate regime shifts. During 1910-2008, an orderly alternation of dominant pelagic fish groups was observed in the Tsushima Warm Current (TWC; Yellow Sea-East China Sea-East Sea/Japan Sea) and Kuroshio-Oyashio Current (KOC; Northwestern Pacific) regions. After the collapse of herring fishery in the late 1920s, the sardine (A group) dominated in the 1930s, 3 other species (C group; Pacific saury, jack mackerel, and anchovy) dominated in the 1950s-1960s, chub mackerel (B group) dominated in the 1970s and, then sardine (A group) dominated again in the 1980s. As sardine biomass decreased in association with the climate regime shift (1988-1989), catches of C group immediately increased in the early 1990s. Alternations of dominant fish groups have occurred 6 times between 1910 and 2008. The dominant period of the 7 species lasted for 10-20 years.

The catch of Pacific sardine in the TWC and KOC regions showed a negative correlation with the catch of the other 5 species (Pacific herring, anchovy, jack mackerel, Pacific saury, and common squid), suggesting that the abundance of the 5 species are strongly affected by the abundance of Pacific sardine in relation to the climate regime shifts. The total catch level of the 7 species in the KOC region was generally higher than that in the TWC region before 1991 but was lower after 1992, suggesting that the fish populations in the Pacific side are shifted to the TWC region by zonal oscillation of the oceanic conditions in relation to the climate regime shift in the late 1980s.

S4-P9

Variations in abundance, body size, age, and growth of chum salmon in relation to climate changes and density-dependent interactions

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Presented by Elena I. Ustinova on behalf of Alexander V. Zavolokin

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Based on our data and published results, we studied changes in abundance, size, age, and growth of chum salmon from 1960-2010 and analyzed possible causes of these changes. Over the last 40 years, abundance of Pacific salmon has been increasing. This has coincided with decreases in age-specific body size and increases of spawning age for most populations of chum salmon. Annual growth dynamics showed different patterns. First-year growth of chum salmon was enhanced from the 1960s to the 2000s. After the first year, growth was reduced. Intra-annual scale increments showed that growth reduction of chum salmon after the first year occurred both in over-wintering (North Pacific) and foraging (Bering Sea) areas. Hence there are some large-scale factors that influenced these species and had an effect in the vast areas of the North Pacific. Our results do not corroborate the decisive importance of density-dependent factors for Pacific salmon productivity. Based on high correlations of chum salmon growth and abundance, both coupled with indices of ocean surface temperature and heat content of the North Pacific, we suggest that an important determinant affecting long-term growth changes was water temperature. Warming in the North Pacific probably encouraged survival of juvenile salmon which resulted in increased abundance. However, warming ocean waters might decrease the efficiency of food assimilation for adult fish that caused the reduction of salmon growth. Thus, chum salmon growth reduction after the early marine period may be a mixture of increasing abundance of Pacific salmon combined with changing ocean conditions.

S4-P10

Long-term variation in the relative abundance and body size of Pacific Salmon, *Oncorhynchus* species

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To clarify relationships between the abundance and biological characteristics of Pacific salmon, we analyzed spatiotemporal changes in fork length, body weight, and an index of relative abundance (catch per unit effort, CPUE) for pink, chum, and sockeye salmon collected by research gill-nets from the T/V *Oshoro-maru* and *Hokusei-maru* of Hokkaido University in the North Pacific during 1953-2007. Since 1970, the average body size of chum salmon at ages 0.3-0.4 has generally declined in the western North Pacific (NP) and central NP. However, the body sizes of sockeye and pink salmon have not shown temporal changes. Chum salmon showed significant negative correlations between CPUE and body size for populations in central NP at ages 0.2-0.3 for both sexes and significant positive correlations between CPUE and body size for populations in eastern NP at age 0.1 for both sexes. In general, sockeye salmon also showed significant negative correlations between CPUE and body size for populations in the eastern Bering Sea at ages X.2-X.3 and significant positive correlations between CPUE and body size at age X.1 for both sexes, except in central NP at age X.2. Our results suggest that better growth by chum and sockeye salmon in the early periods of their ocean life histories might produce higher abundance. This higher abundance, which might also be affected by overlapping distributions among Pacific salmon species and populations in certain seas, in turn appears to cause density-dependent declines in growth in the following ocean life history period due to the limited carrying capacity of the seas. To understand complex dynamics in Pacific salmon species in the North Pacific Ocean, research on interactions among species and populations is needed.

S4-P11

Modelling the distribution of small pelagic fish species in the Southern Benguela using remotely-sensed data

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The effect of environmental variability on the distribution and abundance of different life history stages of small pelagic fish species in the Southern Benguela has been the subject of various studies, ranging from simple statistical models to complex virtual ecosystems. This study considers how the distributions of juveniles and adults of three small pelagic fish species (anchovy *Engraulis encrasicolus*, sardine *Sardinops sagax* and round herring *Etrumeus whiteheadi*) in this system are influenced by the environment, particularly by variables that are expected to be impacted by climate change and that can be remotely sensed Sea Surface Temperature, Sea Surface Chlorophyll, Sea Surface height anomaly, and wind stress. We further assess the relative importance of these variables in determining fish distribution patterns. Preliminary results show that remotely-sensed data can be used effectively to model the distribution of these small pelagic fish species, and that response curves for selected environmental variables differ between species. Considering that climate change is expected to affect the distribution of marine taxa, understanding how present distribution patterns of small pelagic fish are related to environmental variables is a necessary first step before investigating how changing oceanographic conditions might affect their future distributions. This is important for the development of appropriate management strategies and the long-term sustainable exploitation of these valuable marine resources.

S4-P12

The performance of multiple species distribution models in replicating the distribution of small pelagic fish in the Southern Benguela

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Future climate change (manifested by overall warming and increased variability) is predicted to result in distributional shifts of marine organisms. These expected distributional changes have typically been predicted from models developed with the purpose of understanding current distribution patterns, but predictions appear to vary from model to model. Solutions to this problem include applying multiple models and selecting the best performing model or applying ensemble forecasting where prediction from the different models are used to construct an overall response. In this case study we followed the first approach where six (GAM, GLM, MARS, CART, GBM, and ANN) of the most commonly used ecological niche models were used to predict the distribution of small pelagic fish (sardine, anchovy, and redeye round herring) in the Southern Benguela. The performance of these models was assessed by means of Kappa, TSS, AUC or ROC, all of which are commonly used to assess the performance of classification type models. The results indicate that the performance of these models varies, but that the performance of GBM followed by GAM models is consistently superior for all three species considered.

S4-P13

Fish story repeats itself

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The oceanographic conditions in the north Pacific have shifted to a colder period, Pacific sardine (*Sardinops sagax*) biomass has declined precipitously in the California Current, the international sardine fishery is collapsing, and mackerels (*Trachurus symmetricus* and *Scomber japonicus*) are thriving. A similar situation occurred in the mid-1900s; indices of current oceanographic conditions and the results or our acoustic—trawl surveys indicate it is likely recurring now, perhaps with similarly dire socio-economic and ecological consequences. Also alarming is the repetition of the fishery's response to a declining sardine stock -- progressively higher exploitation rates targeting the oldest, largest, and most fecund fish. Furthermore, our data indicate the recent reproductive condition of sardine is poor and their productivity is below modeled estimates used to derive the current fishery-exploitation rates. Consequently, the sardine population has been reduced to two cohorts that are unlikely to produce an appreciable new cohort. Thus, a near-term recovery of this important stock is unlikely and will depend on the return of warmer oceanographic conditions, reduced pressure from mackerel species, and perhaps the adoption of a more precautionary strategy for managing the residual sardine population.

S4-P14

Expert survey of climate change and marine life: Gulf of California to the Beaufort Sea

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Knowledge of the effects of climate change on marine fish and fisheries, and other marine life, is increasing, but a large proportion of this knowledge is observational and much of it qualitative. It is held by several demographic categories of knowledge holders, scientists being but one. This knowledge is not well documented or catalogued, though some limited international efforts have focused on improving this situation. Even quantitative measurements of changes that might be associated with long-term and global-scale physical climate and oceanographic changes are incompletely documented, and not well catalogued. Important knowledge about marine climate change impacts from all sources can thus remain practically inaccessible, and even become lost. We set out to test an online survey approach for gathering expert knowledge about climate change impacts in a case study region—the coastlines and nearshore waters of the northeastern Pacific Ocean from the Gulf of California to the Beaufort Sea, along the west coast of North America. This survey was developed to inform efforts of the Global Marine Hotspots Network, which convened initially at the first international symposium on the effects of climate change in fish and fisheries (April 25-29, 2010, Sendai, Japan). The results will be useful for a variety of applications such as vulnerability assessment, informing and groundtruthing the modeling of climate change effects such as with bioclimatic envelope modeling and trophodynamic modeling, and other approaches, and more directly in policy and management. Information emerging from this type of approach will complement information and data collected in other ways.

S4-P15

Effects of long-term environment variability on the gray mullet (*Mugil cephalus* L.) abundance in the Taiwan Strait

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Gray mullet is one of the important commercial species in Taiwan and the schools of the mature gray mullet migrate from the coastal mainland China to the Taiwan Strait in winter. This study collected satellite-derived sea surface temperature (SST) data to investigate its relationship with catch of gray mullet around the Taiwan Strait during the period of 1988-2008 by using advanced time series analysis. The fishery data were provided by fishermen's associations around Taiwan in the fishing season from November to January of next year. The results indicate that the center of gravity of catches were concentrated in the southern Taiwan Strait from 1988 to 1997 but have shifted northward since 1998. Annual catch appears to be characterized by a declining trend since 1998. Time series analyses showed a long-term increasing trend in SST, over this same period. Thus SST appears to drive interannual variations in the catches of gray mullet. Catches showed significant correlation with SST from the 1988 to the middle of the 1990s with a periodicity of 1-2 yr but it changed to 4-6 yr after 1998. It is suggested that increased SST would cause the gravity center of catches to move northerwards and result in decreased the catch of gray mullet in the Taiwan Strait.

S4-P16

Arctic auks, advection and oscillations: The impact of climate change on planktivores of the Greenland Sea

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The Atlantic sector of the Arctic is undergoing widespread climate change. We studied planktivorous seabirds, little auks (*Alle alle*), breeding on West Spitsbergen and East Greenland to determine how they respond to warming in the Greenland Sea. We hypothesized that when little auks are faced with suboptimal foraging conditions (smaller prey associated with warmer Atlantic influenced water) they work harder to find food, incur higher stress levels and have lower reproductive success. We tested this hypothesis by attaching time-depth recorders to provisioning little auks at three colonies adjacent to different water masses (the West Spitsbergen Current, the East Greenland Current, and the Sorkapp Current). We also examined how variability in the strength and distribution of these currents influenced foraging and breeding on an inter-annual basis. We determined the length of time little auks spent collecting prey for themselves and their chicks. We measured circulating corticosteroid hormone levels in their blood to assess stress levels. We collected chick meals to determine the energetic content of prey fed chicks. We found that when little auks are exposed to less profitable prey they made longer foraging trips and worked harder while at-sea to collect prey for themselves and their chicks. We use this inter-colony and inter-annual comparison of little auk foraging and reproductive behavior as a model to understand how continued warming in the Greenland Sea may influence the Arctic marine foodweb including fisheries. Declines in auks may also impact terrestrial food webs because they contribute large quantities of guano to the tundra.

S4-P17

Going the wrong way? Changes in distribution of the cape fur seal *arctocephalus pusillus pusillus* (southern Africa, 1972-2009)

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A time series of aerial censuses of Cape fur seals colonies, spanning four decades (1972-2009) and three range states (South Africa, Namibia and Angola), was analyzed to assess spatio-temporal changes in population numbers. A quantile regression approach was used to estimate trends in pup counts that were used as proxies for numbers of breeding animals at colonies. There was a 74% increase in the number of breeding colonies over the study period, from 23 in 1972 to 40 in 2009. There was also a significant geographical shift in the distribution of the breeding population: contrary to mainstream predictions of climate change responses for temperate species, their range expanded towards the equator. Despite range expansion and the development of new colonies, the overall size of the population in 2009 was similar to that of the early 1990s, according to the pup count models. Potential mechanisms for the observed changes were considered, including anthropogenic influences and environmental effects on prey distribution.

S4-P18

Climate forcing and the Yellow Sea/East China Sea ecosystem

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As the temperature over the continental East Coast of Asia increased, as suggested by the concept of global warming, the winds that help drive the Kuroshio Current and subsequent currents in the Yellow and East China Seas, increased and the Yellow and East China Seas underwent significant warming. Ocean warming coupled with increased strength and width of the Kuroshio Current, is expected to affect the hydrography of the Yellow and East China Seas and regional ecosystems. The Kuroshio Current has been investigated for several regime shifts over the last 30 years. A stronger and warmer Kuroshio Current subsequently increased the seasonal flow of the Yellow Sea Warm Current from the Cheju Warm current into the Yellow Sea. With continental warming, freshwater runoff increased due to increased precipitation, although it is difficult to ascertain the magnitude of runoff. The position of river plumes was affected by the magnitude of the current that forces the continental shelf water to the south. Warming of the Kuroshio Current has been shown to result in earlier timing of the spring bloom. Seasonal stratification of the water column in the spring and summer changed as a consequence of an altered Kuroshio Current. An increase in mixing could cause (1) an increase in primary production due to increased availability of nutrients, or (2) a decrease in primary production due to mixing that is too strong for nutrient uptake by primary producers. The major fish assemblages overwinter in an area that seems to correspond with the largest east-west distance between mainland China and the Kuroshio Current, south of the Kuroshio Current bifurcation into the Tsushima Warm Current. An increase in both the flow strength and width of the Kuroshio Current, may cause the overwintering grounds may constrict somewhat, whereas, the summer feeding grounds may be more constricted. If predators and prey occupy an area that becomes smaller due to climate change, predation pressure may increase. Further, increased predation on forage species such as Japanese anchovy could counteract any potential benefit of an increase in primary production in the Yellow and East China Seas. With increased temperature and current, significant portions of fish stocks could migrate to a region that has a more compatible environment to present conditions. If the intensity of the Kuroshio Current were to increase, the distribution of predatory subtropical fish species (spotted mackerel *Scomber australasicus*, Japanese scad *Decapterus maruadsi*) and highly migratory predators (*i.e.*, tunas) may shift into this region causing an increase in predation.

S4-P19

Influence of oceanographic variability on the spatio-temporal distributions of Pacific saury (*Cololabis saira*)

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Logbook data of the 2006-2010 Taiwanese Pacific saury fishery in the northwestern Pacific, coupled with satellite-derived sea surface temperature (SST), chlorophyll *a* concentration (Chl-*a*), and net primary production (NPP) data were used to determine Pacific saury's habitat preferences using the empirical cumulative distribution function. Results indicated that the SST, Chl-*a*, NPP preferences ranged from 14 to16°C, 0.5 to1.0 mg m^{-3} and 500 to 750 mg C m^{-2} day^{-1}, respectively. Possible changes in potential saury habitats were estimated under four scenarios of SST increase due to climate change. Results revealed an obvious poleward shift of potential saury habitats under the influence of SST increase. Additionally, the geographical weighted regression (GWR), a local modeling technique, was applied to examine the influence of oceanographic variability on the distribution of saury, which was then compared with those examined by generalized linear model (GLM) and generalized additive model (GAM). Consequently, GWR results revealed spatial regions in the relationship between saury and oceanographic variables and explained significantly more variability than the GLM and GAM regressions.

S4-P20

Effect of climate change on feeding preference of Antarctic fish

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Emerald notothen, *Trematomus bernacchii* Boulenger, 1902, and Bold notothen *Pagothenia borchgrevinki* (Boulenger, 1902) were collected during the 46^{th} and 51th Japanese Antarctic Research Expeditions in 2004 and 2009. All samples were from the sea around Syowa Station. After the fish samples were collected, the samples were brought back to the laboratory for stomach content analyses to determine the food preference of *T. bernacchii* and *P. borchgrevinki* between years. The results showed that there was a difference of food preference of *T. bernacchii* and *P. borchgrevinki* between years. In 2004, both fish preferred krill and amphipods. However, the results from the 2009 samples showed that high proportions of larger invertebrates such as crabs and octopus were observed. Differences in sea ice melting and other environmental parameter values such as salinity and water temperatures between the years plays an important role on the foraging behavior of *T. bernacchii* and *P. borchgrevinki* in Syowa Station.

S4-P21

Modelling the impacts of environmental variation on the habitat of swordfish, *Xiphias gladius*, in the North Atlantic Ocean

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Swordfish, *Xiphias gladius*, is a highly migratory species of important commercial value and widely distributed in the three Oceans. The preference of this species for particular habitats may affect its distribution and vulnerability for being caught. The relationships between spatio-temporal distribution of swordfish and oceanographic conditions, which may be influenced by climate change, were examined using a habitat suitability index (HSI) model. Distributions of swordfish abundance in the North Atlantic Ocean, based on the combined suitability indices, indicate annual variation in the distribution of swordfish. The interannual variability in swordfish distribution appears to be associated with the events of North Atlantic Oscillation and is related to shifts in sea surface temperature and other oceanographic variables. The GIS maps of the predicted habitat suitability, cross validated by the observed relative abundance, suggest that the HSI model can be used as a tool to explore future changes of potential fishing grounds and provide a scientific basis for the time-area-closure-based management.

S4-P22

A link between the phase-shift Niño-Niña phenomenon and faunistic composition of small scale fisheries in the Colombian Caribbean

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Colombia is influenced by Niño and Niña phenomenon in Pacific coast. Review of the historical register for the county showed the highest recorded rainfall occurred during the recent Nina years 2010 and 2011. However, these effects are fairly unknown on Colombian Caribbean and the relationship of Nina events on small scale fisheries has not been examined. On the north-east coast, a region representing 5% of the coast line of the whole Colombian Caribbean produced 33% of the artisanal captures for demersal fishes. Records show 7800 landings for a fleet of 230 gill net fishing vessels on the continental shelf, during the period among June 2009 and June 2011. We defined four fishing areas according to the proximity of estuaries, the continental tributaries and the nucleus of coastal upwelling. The monthly faunistic composition was clustered and related with the Niño and Nina phenomenon and neutral period. A two way ANOVA analysis was used to evaluate the relationship between climate phase and the species composition of the catch by fishing area. The results showed a strong variation of faunistic composition according to the phase-shift Niño and Niña for the west area (r^2: 0.91), which has the highest influence of rivers and estuaries. The other three areas, which are in the center and east of the continental shelf and have less influence of continental inputs and a greater proximity to upwelling nucleus, showed less related variations with climatic phases (r^2: 0.6). Although, *Haemulon plumieri* and *Lutjanus synagris* are the most abundant species, other species related with estuarine ambients show abundance increases during Nina phase.

S4-P23

Natural indicators and climate change in Emmonak, Alaska

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Fishers' specialized and adaptive local knowledge can provide long-term observational data to fisheries managers and scientists and aid in understanding environmental variability that influences fluctuations in populations of Pacific salmon. Alaska Native fishermen and women from the Yukon River have long relied on their elders and traditional or local knowledge to guide them in preparation for the salmon arrival. This poster explores the use of natural indicators—empirical observations that correlate with specific ecological phenomena—by Emmonak residents in subsistence salmon fishing and their relationship to local observations of climate change. Research between 2005 and 2009 associated with two research projects including the Bering Sea Integrated Research Program (BSIERP) suggests that fishermen implicitly separate their observations of natural phenomena into either causal (events that make something happen with the fish run) and correlative (observations that occur with the salmon run) indicators. Throughout this study, participants expressed concern about environmental changes that make natural indicators less predictable or reliable. The changes include weather shifts, warmer winter air temperatures, an increase in sandbars, and reduced salmon abundance. Most residents believe that these changes affect both how people fish and the fish themselves.

S4-P24

Climate effects on marine benthic organisms: A case study of an abalone *Haliotis discus hannai* on the Pacific coast of northern Japan

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Climate effects on marine ecosystems have been studied at various ecological levels. There are recently increasing results of climate effects on benthic ecosystem. The abalone *Haliotis discus hannai* is a keystone species of benthic rocky shore ecosystem of northern Japan. The catch fluctuation of the abalone during the last century has been reported to be inversely correlated with the Aleutian Low Pressure Index. However, the underlying ecological process has not been remarked. The ecological studies since the middle 1990s have indicated several aspects of climate effects on abalone and surrounding benthic community. In this presentation, we provide the synthesis of the recent findings of climate effects on the abalone population in various aspects: catch fluctuation, post-settlement process, community structure. The cohort tracking studies during the last decade have revealed that the high overwintering mortality of young-of-the-year (YOY) abalone was led by coastal intrusion of the Oyashio current intensified by the Aleutian Low during the cold regime. The survival of YOY abalone appeared to greatly affect the 4-years-after catch of the abalone. The comparison of community structures between 1989 and 2008 indicated that the species composition was changed. Trophic studies using stable isotope ratios suggested that the competitive species was replaced by non-competitive one against post-larval abalone, implying favorable species interactions during early life stages. This study highlights that climate effects on a benthic organism could shape the dynamics of species interactions and the structure of benthic community as well as the life history of the target organism.

S4-P25

Time-lag and EOF analysis for study of environment impact to Purse Seine fisheries in Java Sea

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The variation of sea surface temperature (SST), chlorophyll *a*, indices of climate variability (Southern Oscillation Index and Indian Ocean Dipole Mode Index), precipitation, wind and ocean current during 1996–2010 was studied in Java Sea, Indonesia, using Ocean Motion and Aqua MODIS data were analyzed for their relationships with catch per unit of effort (CPUE) of pelagic fish that caught by purse seine. An inverse relationship was found between SST and chlorophyll *a* anomalies. This relationship corresponded with upwelling processes represented by a drop of SST during the El Niño event that coincided with changes in the Indian Ocean Dipole. There was an un-lagged response between chlorophyll *a* and SST. However, there was an integrated response between chlorophyll *a* and the CPUE. Beside that effort that important part of CPUE are also influenced by intensity of precipitation, wind and ocean current.

S4-P26

Impact of environmental variability in the Kuroshio Extension on neon flying squid stock

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Neon flying squid (*Ommastrephes bartramii*) is an oceanic squid that is distributed over entire subtropical waters. The North Pacific population comprises an autumn spawning cohort and a winter–spring spawning cohort. The winter–spring cohort is a major target of an international jigging fishery, while the autumn spawning cohort is known to utilize the productive water of the transition zone chlorophyll front (TZCF). Unfortunately, a recruitment process of winter–spring spawning cohort is still unclear. For the stock assessment of a winter–spring spawning cohort, jigging surveys have been conducted by Fisheries Research Institute, Aomori prefectural Industrial Technology Research Center in the seas near Japan (between 140–150°E and between 35–44°N) from 2001 to 2007. We have estimated the catch per unit effort (CPUE; kg Jig^{-1} hour^{-1}) from survey data and compared it with the level-3 data of SeaWiFS chlorophyll *a* concentration. As a result, we have detected a significant positive correlation between the CPUE and the chlorophyll *a* concentration in the downstream region of the Kuroshio Extension where is a part of TZCF. We have also found that the shallow mixed layer state induces high productivity in the downstream region by analyzing the ecosystem model output. These results suggest that stock of winter–spring spawning cohort is affected by the feeding condition on the downstream region of the Kuroshio Extension and the environmental variability behind it.

S4-P27

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

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The fluctuation of Pacific cod catch in the Yellow Sea is influenced by changes in hydrographic conditions due to the Siberian High (SH). The cooled surface waters by the SH in winter season form the Yellow Sea Bottom Cold Water (YSBCW) that exists at the bottom of the Yellow Sea, even in summer. Therefore, the formation and distribution of the YSBCW is affected by the strength of the Siberian High. The cooling period of sea surface waters corresponds to the main spawning season of Pacific cod in Korean waters. The effect of the SH on water temperature is an important factor for dominating an early life of the Pacific cod in the Korean waters. Furthermore, the main of the YSBCW temperature when of Pacific cod catches are made in the Yellow Sea ranged 6 to 10°C. The YSBCW was limited to the middle area of the Yellow Sea in early 1990s when the Pacific cod catches were the lowest level but the catches reached the highest levels when the YSBCW distributed over the entire Yellow Sea in 2007. However, the scenario due to the effect of the SH variation could not explain the influence by a global warming. The increase of the water temperature by global warming will affect the spawning area and spawning period of Pacific cod in the Yellow Sea. Therefore, the effect of the SH will be coupled with the global warming through the IPCC model for the catch fluctuation and its prediction of Pacific cod.

S4-P28

Impacts of climate change on the Black Sea marine and coastal environment

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During the 1980s, the Black Sea experienced the most dramatic changes ever encountered throughout the last century. The upper layer water column cooled significantly in response to large increases in the North Atlantic Oscillation index. A three-fold increase in the subsurface peak nitrate concentration due to excessive nutrient input from the River Danube, when combined with strong winter cooling and preconditioning, led to very high phytoplankton biomass. The impact of nitrate concentration then propagated to higher trophic levels and contributed to considerable increase in herbivorous and carnivorous zooplankton abundance (bottom-up control). At the same time, the intense eutrophication together with over-exploitation of pelagic fish stocks caused diversion of the classical phytoplankton-zooplankton fish food chain to an alternative pathway dominated by gelatinous and opportunistic species. At present, no projection on how climate change may affect this region is available. The data show well defined oscillations during the past 100 years and there is no reason to expect that these oscillations will not continue into the future. However, these oscillations may be superimposed on a more well-defined general trend of warming. The Black Sea region is influenced by several teleconnection patterns, making future predictions more challenging than areas that are mainly modulated by, for example, the North Atlantic Oscillation alone. In addition, this region was strongly influenced by external factors other than climate change alone, such as eutrophication and overfishing. Both eutrophication and overfishing have had tremendous impacts on the ecosystem and still have a strong influence.

S4-P29 - ***Cancelled***

Foraging behavior of a widely ranging meso-pelagic top predator, the northern elephant seal

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The mesopelagic zone of the northeast Pacific Ocean is an important foraging habitat for many predators, yet few studies have addressed the factors driving basin-scale predator distributions or inter-annual variability in foraging and breeding success. Understanding the oceanographic features that top predators current rely on can inform predictions of how climate change will affect these organisms. We collected diving, tracking, foraging success, and natality data for a large number of adult female northern elephant seals over seven years. Mean foraging success varied by factor of two across years and was a significant predictor of natality. At sea, behavioral foraging metrics based on diving and tracking data suggest the boundary between the sub-arctic gyre and subtropical gyre contains a rich and persistent prey resource at mesopelagic depths, but a small proportion of seals were also successful north of the boundary in the sub-arctic gyre and neighboring continental shelf breaks. Seal density distributions and temperature profiles show a strong association with the gyre-gyre boundary during both annual migrations, consistent with previous reports that the latitude of the gyre-gyre boundary is stable relative to dynamic surface features, such as the transition zone chlorophyll front. These oceanographic features are likely to change in response to a changing climate in the North Pacific Ocean.

S4-P30 - ***Cancelled***

The changing face of El Niño: The influence of a strong central pacific El Niño on the foraging behavior of northern elephant seals

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The El Niño Southern Oscillation (ENSO) impacts many marine species, including northern elephant seals (NES), by altering prey distributions, availability, or oceanographic foraging cues. The 1997-98 El Niño strongly impacted the diving behavior and foraging success of female NES. In the past few decades, the warm phase of the ENSO has shifted its classic pattern, moving the maximum warm anomaly from the eastern to the central-equatorial Pacific. Here we examine the impact of the 2009-10 Central Pacific (CP) El Niño, the strongest recorded to date, on foraging behavior of adult female NES during their post-breeding migration. Female NES exhibit two distinct foraging strategies: a westerly, pelagic foraging route and a northerly, coastal route. We tested whether the 2009-10 CP El Niño affected seals foraging in these regions differently. We compared the foraging behavior of 16 previously-tracked female NES (8 coastal, 7 pelagic, 1 mixed) to their behavior observed during the 2009-10 El Niño. We compared the diving behavior, energy and mass gain, and movement patterns of these females. We found no significant impact of the CP El Niño on trip duration or energy gain in either coastal or pelagic foragers or when pooled together (paired t-tests, $p>0.05$). During the 2009-10 El Niño, females dived deeper during foraging (paired t-test, $p<0.05$) and experienced deeper thermocline depths. This suggests that during the CP El Niño, NES females were able to increase their foraging effort to compensate for altered foraging conditions compared to the greater magnitude 1997-98 'classic' El Niño. This implies a threshold effect, which has critical implications considering the increase in occurrence and intensity of CP ENSO events that may be linked to climate change.

S5 Poster Presentations

S5-P1

Trophic strategy of biota in a tropical estuarine ecosystem indicated by fatty acid composition

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Fatty acid compositions of primary producers and consumers inhabiting a tropical estuary were analyzed. Mangrove forests, seagrass meadows and coral reefs are distributed in the estuarine waters. The fatty acid compositions of the seston samples in the mangrove creek were characterized by high 16:1n-7, 18:1n-7, 20:5n-3 and 22PUFA concentrations. The dominant fatty acids of mangrove leaves were 18:3n-3, 18:2n-6 and 22:6n-3. Seagrass and mangrove leaves contained high 18:3n-3 and 18:2n-6 concentrations. The fatty acid composition of macroalgae was characterized by high 20:4n-6, 18:1n-9, 18:4n-3 and 20:5n-3. 17:0, 18:1n-7 and 16:1n-7 were the dominant fatty acids in the surface sediment. All the consumers, including jellyfish, fish and crustaceans, were separated into five groups based on their fatty acid compositions. Significant differences existed in the fatty acid compositions of organisms in the five groups (ANOSIM, R=0.859, p=0.001). The organisms in Group 1 were characterized by high 20:5n-3, 20:4n-6, 22:4n-6 and 18:4n-3 concentrations, suggesting planktivorous and detritivorous feeding. The dominant fatty acids in organisms in Group 2 were 18:2n-6+18:3n-3, 20PUFA and 22:5n-3, which indicated that macroalgae was their dominant diet. The fish in Group3 contained high 22:6n-3 and n-3/n-6 ratios, suggesting that their diet was zooplankton-based. For those in Group 4, 16:1n-7 was the important fatty acid, which indicated that diatoms were important dietary items for them. As for those in Group 5, high 22:6n-3 and 22:5n-6 concentrations indicated that they were high-level predators, and invertebrates and fish may dominate their diets.

S5-P2

Responses of intertidal microphytobenthos community to environmental factors

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Microphytobenthos (MPB) community was investigated from August 2006 to March 2008 in the intertidal flats of Nakdong River estuary, Korea. The community biomass varied between 0.47 and 16.58 µg cm^{-3}, abundance changed from 5.25 to 414.75 × 10^3 cells cm^{-3}, and the Shannon diversity indexes ranged between 0.69 and 2.35 H'. Among identified thirty-nine MPB taxa, *Amphora* and *Navicula* were the most abundant genera. The MPB biomass and species composition showed seasonal and spatial variation in response to main environmental factors, such as light, sediment temperature and sediment property (composition of the grain size of sediment). With lower biomass and diversity, MPB in the sandiest sediment exhibited a positive relationship of biomass with sediment temperature, where biomass was highest in summer and lowest in winter. The light intensity influenced significantly on species composition, but not on the biomass. The effects of pore water nutrients and salinity were not significant on MPB biomass or species composition. Adapting to intertidal environments, MPB migrated rhythmically in sediment according to the light and tidal cycles. The rhythm presented as migrating down into the sediment during submersion and at night, and up to the surface before sunrise and before the incoming tide. However, when the visible thick biofilms formed, the migratory rhythm changed with cells remaining for longer periods in the surface sediment even at night and during high tide submersion. It indicated that light is the more important controlling factor on MPB vertical migration than tidal cycle.

S5-P3

The effect of geochemical characteristics and climate change on the growth of cultured clams at Taean tidal flat on the west coast of Korea

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To assess the effects of environmental factors and seasonal variation on the sustainability of cultured production of *Ruditapes philippinarum*, we investigated the habitat characteristics of a tidal flat (Namhae-po in Taean). We measured physiochemical variables (temperature, salinity, dissolved oxygen, nutrients, chemical oxygen demand and chlorophyll *a*) and geochemical characteristics (grain size of sediments, chemical oxygen demand, ignition loss, C/N ratio and C/S ratio). Surface sediments and benthos were collected from several sites of the tidal flat to examine both the geochemical characteristics and species of benthos in the benthic environment and habitat pollution. The grain sizes for the research area of the tidal flat were similar in the ratio of silt and clay in comparison with other sites. The C/N ratio was more than 3.0, reflecting the range arising from the mix of marine organisms and organic matter. The C/S ratio (less than 1.0) showed that the survey area had normal bottom conditions. The enrichment factor (Ef) and the index of accumulation rate (Igeo) of the metals showed that the research areas can be classified as heavily polluted, heavily to moderately polluted, or more or less unpolluted, respectively. We suggested that the growth of *Ruditapes philippinarum* in the tidal flat was affected by the various environmental conditions and seasonal variation, so an improvement in the culture method was needed.

S5-P4

Dynamic feature of eukaryotic plankton biodiversity in the Nakdong River system, Korea

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Eukaryotic plankton play a major role in primary production and the carbon cycle in aquatic ecosystems. The species diversity and community composition of plankton are important to monitor fluctuations of biological components reflecting environmental change, because the organisms have adapted to their best fitness for a particular environment. Metagenomics, a direct DNA analysis from environmental samples without isolation, is emerging as a good alternative tool to the traditional approach using microscopes and morphological characteristics, and many cryptic species have been revealed by metagenomic studies. In this study, we analyzed the species diversity of eukaryotic plankton in the Nakdong water system by the 18S rDNA clone library construction, colony PCR, PCR-RFLP and sequencing. In total, 434 clones were selected and 98 phylotypes were found from three clone libraries. We found tremendous species diversity in the freshwater and brackish water, previously unreported in this region. New taxonomic entities were also found at the level of new species and genera, and even at higher taxonomic ranks. Therefore, metagenomics can provide more detail and digitalized information about species diversity, and open a new window to evaluate species diversity and the role of species in aquatic ecosystems.

S5-P5

Impact of ocean acidification on five species of macroalgae

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Concerns about the responses of marine organisms to ocean acidification have increased. However, little study is focused on the macroalgae, and most previous studies were conducted within limited laboratory conditions because it is hard to install *in situ* experimental systems. Our outdoor continuous-flow experiment was designed for applying *in situ* conditions with natural seawater and daily irradiance fluctuations. Target CO_2 concentrations were manipulated by CO_2 saturated seawater, slowly added into the seawater pumping system. Five species of macroalgae (*Ulva pertusa, Codium fragella, Sargassum horneri, Sargassum thunbergii* and *Prionitis cornea*) were exposed to different CO_2 conditions (*ca.* 400, 1000 and 1500 ppmv CO_2) for 2 weeks. Varying growth rates were shown between the species under ambient conditions, but these were significantly changed under acidified seawater. Growth of *S. thunbergii* was accelerated by high CO_2 concentrations. In contrast, growth of *P. cornea* was inhibited. Our photosynthetic O_2 production results showed similar patterns with growth rates. According to our results, we suggest that macroalgal physiology could be changed by preferences for carbon species in the future, and it will lead to changes in macroalgal community structure.

S5-P6

A 6-month *in situ* ocean acidification experiment at Heron Island

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Anthropogenic CO_2 is increasing rapidly in the atmosphere, driving major changes to the CO_2 concentration, carbonate chemistry and pH of ocean waters, posing significant challenges for calcifying marine organisms. These challenges are particularly serious for carbonate coral reef systems where reduced calcification rates may decrease calcification rates relative to physical and biological erosion. Previous experimental studies on the impact of future predicted pH levels on coral reefs, however, have mostly used highly artificial enclosed aquarium systems where coral fragments have been removed from nature and placed under artificial light, flow, temperature, microbial and other conditions. To avoid these potential experimental artifacts, we developed and deployed the Coral–Proto Free Ocean Carbon Enrichment System (CP-FOCE), the first *in situ* CO_2 enrichment system for coral reefs, and present results from a 6-month deployment on the Heron Island reef flat. Four replicate experimental chambers were used, two that were maintained as controls (ambient seawater) and two chambers in which CO_2 was added, gradually reducing pH by 0.3 units below controls. Five replicate living and five recently dead *Porites cylindrical* colonies were placed in each chamber and the calcification rates (inside and outside the chambers) monitored daily along with diurnally-varying carbonate chemistry and other environmental variables. Our results confirm that ocean acidification drives reduced growth rates in living colonies and promotes greater dissolution of the recently dead colonies. This study represents an important step in understanding and verifying the impacts of ocean acidification on a range of critical coral reef processes.

S5-P7

Developing a biochemical index to track physiological adaptations of cetaceans to environmental changes

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In order to track the physiological adaptation of minke whales (*Balaenoptera acutorostrata*) to environmental changes, we investigated a new biochemical approach, called compound-specific isotope ratio, because the carbon isotopic ratio of individual fatty acids could be changed via the modification of compounds for physiological requirements. Preliminary results showed that carbon isotope ratios of some fatty acids varied vertically throughout the blubber layers. In particular, the isotope ratios of 16:1(n-7) became lighter from the outermost layer to the innermost layer, whereas the isotope ratio of 18:1(n-7) was heavier in the innermost layer than in the outermost layer. 16:1(n-7) was transformed via the desaturation of longer carbons (>16 carbon fatty acids) but 18:1(n-7) was transformed via the elongation of shorter carbons (<18 carbon fatty acids). However, among PUFAs, the isotope ratios of 20:5(n-3) and 22:6(n-3), generally used as dietary indicators, didn't show any significant changes. It confirms that long-chain PUFAs can't be synthesized in cetaceans. We could infer that only specific fatty acids (*i.e.* MUFAs) were modified and transformed in the blubber for physiological needs (*i.e.* insulation, buoyancy and streamlining). These approaches may provide a history of physiological adaptation of cetaceans experiencing any environmental changes during their life span.

S5-P8

Gene expression of cytochrome P450 in *Euplotes crassus* (Ciliophora, Hypotrichida) under conditions of ocean acidification: Lab trial

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According to climate change scenarios, the pH of seawater is expected to decrease from 8.05 to 7.65 in 2100 due to increasing atmospheric carbon dioxide. In order to predict the adaptations of organisms living in the intertidal zone to ocean acidification, we investigated the pH response of the ciliate, *Euplotes crassus*, under controlled conditions. *E. crassus* is a dominant ciliate species in the intertidal zone, has high resistance to various environmental changes, and is easy to culture. We treated *E. crassus* with different pH conditions ranging from 7.65 to 8.05, adjusted with hydrochloric acid. At pH 7.65, cell motility significantly decreased after 30 minutes, and 1 hour later the fatality rate reached over 30%. Gene expression profiling of cytochrome P450 (CYP) of *E. crassus* is also underway to understand the molecular level responses of ciliates to pH stress using real-time reverse transcription-PCR (RT-PCR).

S5-P9

Marine species' latitudinal distributions conform better to their thermal tolerance than terrestrial species: Implications for range shifts

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The redistribution of life on earth has emerged as one of the most significant biological responses to anthropogenic climate warming. Predicting the response of species' ranges to climate warming requires a fundamental understanding of how geographic distributions are influenced by temperature. Here we use thermal tolerance data of 169 species to show that marine and terrestrial ectotherms differ in the degree to which they fill their potential thermal ranges. Marine ectotherms fully occupy the extent of latitudes tolerable within their thermal niche and are consequently predicted to expand at their poleward range boundaries and contract at their equatorward boundaries with climate warming. By contrast, terrestrial ectotherms are excluded from the warmest regions of their latitudinal range, thus the equatorward, or 'trailing' range boundaries may not shift consistently towards the poles with climate warming. Using 603 observations of climate-induced range shifts, we test this prediction and show that in the ocean, shifts at both range boundaries have been equally responsive, while on land, equatorward range boundaries have lagged in response to climate warming. These results indicate that marine species' ranges conform to their limits of thermal tolerance, and thus range shifts will be easier to predict from niche modelling approaches. However, on land, warmer range boundaries are not at equilibrium with heat tolerance and understanding the relative contribution of other factors controlling their range limßits is critical for predicting local extinctions and invasions.

S5-P10

Evaluation of fatty acids as trophic indicators for the anchovy population in the southern coastal waters of Korea

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Abundance and proportion of specific fatty acids change among fundamental groups of the lower trophic levels. Part of prey fatty acids are directly translated to the predator fatty acids. In this study, fatty acid compositions of juvenile, young and adult anchovy *Engraulis japonicus* were evaluated as trophic indicators for the feeding environment in four regions (Tongyeong, Namhae, Yeosu, Jindo) of the southern coastal waters of Korea. C14:0, C16:0, C18:0, C16:1, C18:1, C20:1, C20:5 and C22:6, among other saturated fatty acids (SFA), monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA), were predominant fatty acids in juvenile, young and adult anchovy. C14:0, C16:1 and C20:5 fatty acids increased while C22:6 decreased significantly in adult anchovy ($p < 0.05$). C14:0, C16:1 and C20:5 fatty acids increased while C22:6 decreased as sampling areas were shifted eastwards. As an indication of *Calanus*-specific copepod lipid biomarkers, MUFA 20:1(n-9) and 22:1(n-11) were high in the upwelling area of the southwestern sea but low in the southern coastal area. High MUFA 18:1(n-9) and fatty alcohol 16:0 in all areas suggests a significant dietary input from non-calanoid copepods in the southern sea of Korea. These results indicated that life stage and area-dependent specific fatty acid composition may be ascribed to the regional feeding environment, influencing growth for juvenile and young fish and maturation for adults. We will discuss influences of climate-driven fluctuations in river-water discharge and oceanographic conditions on primary and secondary productivity, and on the trophodynamics of anchovy in southern Korean coastal waters.

S6 Poster Presentations

S6-P1

State of plankton community of the Zernov's Phyllophora Field (Black Sea) in 2010-2011

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Zernov's Phyllophora Field (PF) is the unique ecosystem on the North-Western Shelf of the Black Sea. Shallow waters of the PF are a habitat for many marine organisms, a kind of "maternity home" for the Black Sea. Nevertheless, despite the obvious importance of this area, expeditions to the PF were sporadic, and focused mainly on the benthic community. For the first time a comprehensive study of this area was made during two cruises of RV "*Professor Vodyanitsky*" in 2010-2011 covering all ecosystem levels, including plankton. It was shown that the highest biomass of plankton (up to 452 mg/m^3) was in the shallow zones with maximum oxygen concentration, located opposite of the Danube and the Dnieper estuaries. In these zones the phytoplankton species (mainly *Coscinodiscus* sp.) dominated. In the central and northeastern parts of the PF, the plankton biomass decreased (to a minimum 50 mg/m^3) with increasing depth, salinity and decreasing oxygen concentration. Copepoda, in particular *Paracalanus parvus* (90%), dominated the plankton. In a small area of PF with increasing depth to 55 m and a sharp decrease of water temperature, blooms of *Noctiluca scintillans* were observed. Causes of a sharp spatial heterogeneity are discussed.

S6-P2 - *Cancelled*

Responses to climate change: Past, present, and future

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Our past, present and future as human beings was, is and will be shaped by prevailing climatic conditions. Climate is the one global variable which has a direct and profound impact on every aspect of human existence. Our natural environment, economics, political and power structures, cultures, social interactions and development are all shaped by climate. Of particular importance is the fact that disaster risk reduction strategies are already being implemented into recent scientific studies on climate change.

In the Nigerian context the context indications are that we have been experiencing discernable temperature changes since the nineteenth century. Warming has taken place at an alarming rate in the central interior Nigeria over a number of decades. At the same time there has been a decline of about 1°C along the southern and western coastal regions of Nigeria in the same period of time. These measurements are based on the increase in Nigerian surface rock temperatures derived from borehole temperatures profiles. By 2050, it is estimated, the average temperatures will have risen in many parts of Nigeria.

In this paper, there are a number of indicators suggesting that within the next two decades there will be more remarkable changes. The paper is based on questions of this nature, asked in early 2008 on the occasion of an informal meeting about climate change and the level of preparedness for potential and anticipated natural hazards. In an attempt to form an impression of public views on the imminent changes to take place, two floods laden areas in Nigeria were selected, with their diverse climate conditions, to compare the relative levels of awareness amongst locals about climate change. To what extent have the local authorities prepared themselves with disaster risk reduction strategies? And, what town planning alternatives deserve serious consideration?

S6-P3

Spaceborne investigation of the long-term variations of primary productivity and sea ice conditions in the Arctic Basin

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Presented by Dmitri A. Petrenko on behalf of Vitaly I. Sychev

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The spatial and temporal dynamics of primary productivity (PP) was investigated by applying PP recovery algorithms and numerical simulation data (mixed layer depth). The database (1998-2009) of satellite and modelled data for the Arctic Basin for the open water period was composed on monthly data (mostly from SeaWiFS and MODIS). Known PP retrieval algorithms and our algorithm (called BOREALI) were applied to retrieve phytoplankton chlorophyll concentration in optically complex waters (for the shelf seas). Satellite data SSMI/DMSP, from 1987 and AMSR-E/Aqua (2002-present) were used to determine a Sea Ice Index (Sea Ice Extend, Concentration and trends) and ice-free periods. These investigations showed a decreasing tendency of sea ice surface. From 2007 to 2009 sea ice surface in September increased to about $7\times10^5 km^2$. During this period there was a maximum in June-October for the East Siberian, Laptev, Kara, and Chukchi seas. Results were compared with trends in sea ice characteristics. Using models/algorithms for ice-free months, PP showed multi-year variations across the pelagic zone of the Arctic Basin. In both cases a positive trend for the entire Arctic, and some appreciable increase of PP were found over the period 1998-2010. Comparison of PP trends with trends drawn by other authors for open ocean waters without shallow areas conditions showed some significant differences. Thus, the cumulative trends for the entire Arctic Basin obtained in this study may be developed for the practical use.

S7 Poster Presentations

S7-P1

Adaptation strategies in coping with the impacts of global climate change on the coastal environment and resources of Bangladesh

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Rapid global warming has caused fundamental changes to our climate. No country and people know this better than Bangladesh, where millions of people are already suffering. Increased climate variability makes significant changes in rainfall patterns and intensities which lead to more serious floods and droughts. Sudden, severe and catastrophic floods have intensified and take place more frequently owing to increased rainfall during the monsoons. In recent years Bangladesh has been ravaged by floods of catastrophic proportion in 1998, 2004 and 2007. This has forced the population to change production methods and eating habits, putting the people of Bangladesh at enormous risk of food shortages. Bangladesh's economy strongly depends on agriculture and natural resources, both of which are highly sensitive to climate change impacts. Fresh water availability will be sharply reduced as the sea level rises. By 2050 a 45-cm sea-level rise may submerge 11% of the total landmass, create 5.5 million "climate refugees", reduce GDP by 57% and reduce the already meagre crop by. 40%. Bangladesh must move on in its pursuit to develop and strive as a nation, taking into account its vulnerability, susceptibility and capacity to manage climate risks and adaptation. Possible impacts of climate change on Bangladesh and the planning and implementation of adaptation measures will be described.

S7-P2

A numerical simulation of storm surge and coastal inundation under the future climate condition

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According to the Fourth Assessment Report of the IPCC the rate of sea level would be increased by thermal expansion and the melting of glaciers and ice caps and the intensity of typhoon would be also intensified, resulting in frequent inundation and flooding in the coastal area. From a long-term perspective on natural disaster protection, inundation prediction by severe weather under future climate change is necessary to establish the disaster protection plan, local emergency managements, advisories and a flood insurance rate map. Typhoon Maemi (0314) made landfall at Kyeongnam province with a pressure 950 hPa in its centre and wind speed of 60 m/s on 13 September 2003. This typhoon produced storm surges of about 2.3 m in Masan Bay, which inundated the Bay causing extensive damage to coastal and inland structures and port systems. It was one of the most destructive typhoons to ever hit the Korean peninsula. We simulated the typhoon Maemi under the projected climate change and compared its influence on the storm surge and inundation area with the real case. We used the fully nonlinear Finite-Volume Coastal Ocean Model (FVCOM) forced by a Weather Research and Forecasting (WRF) model output that considered sea surface temperature by global warming. The FVCOM is driven at the open boundary by TPXO tidal data (M2, S2, K1, O1) with a high-resolution unstructured grid that the resolution remains less than 20m, and it then diminishes to about 25 km along the open boundary. A Digital Elevation Model (DEM) by the National Geographic Information Institute (NGII) was used for model bathymetry data and it covered Masan, Busan, Yeosu, Gwangyang and Mokpo area with 1m and 10m resolution.

S7-P3

Black Sea hot-spot environments and ecosystems: Future of deltas and riverbeds flooded by sea

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Presented by Kateryna Ivanova on behalf of Maksim Gulin

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A series of ancient coastal lines (paleo-terraces) are found in the Black Sea and located at depths of 120-130, 100, 80, 60 and 20-25 m. Also, paleo-riverbeds within the marine shelf were discovered in recent years including submerged fragments of Dnieper, Chernaya and Belbek rivers in northwestern Black Sea, close to the Crimea Peninsula. Ecological parameters of paleo-riverbeds were studied by hydrobiological, hydrochemical and hydroacoustic methods as well as remotely operated vehicles (ROVs) and manned submersibles. In the Dnieper Canyon maximum density of zoobenthos (52,600 individuals per square meter) has been detected in an area of intense methane bubble seepage covered by massive methane-oxidizing microbial mats (220-250 m depth). Meiobenthos was represented mainly by Ciliata, Nematoda, and Foraminifera. The largest abundance and biomass of benthic organisms (2,675 individuals per square meter) which inhabit the Chernaya paleo-riverbed were found at the sea-floor depths of 28 m. Polychaeta and Nemertini were the most numerous macrozoobenthos groups. The location of specified biological maximum in the Chernaya riverbed coincides with the field of methane gas seeps. Within the all seepage sites, the organic matter content was 7-50 times higher than adjacent areas. At the suboxic seep areas dense demersal fish shoals were observed. The hypothesis is that the relict river sediments are related to the formation of present-day benthic environment and associated zoobenthos communities. Expressed migration of organic carbon from relic freshened deposits through seabed sediments can be carried out in form of biomethane bubble seepages (gas seeps).

S8 Poster Presentations

S8-P1

Oxygen intrusions into anoxic fjords: Positive and negative effects

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Studies of the water column biogeochemical structure of the Norwegian Fjord Hunnebunn were performed in 2008, 2009 and 2011. The Fjord Hunnebunn is an isolated 11 m deep, permanently anoxic inlet with a redox interface positioned in the euphotic zone (6 m). It is connected with the sea through a narrow and shallow straight (2 m) without any influence of a riverine discharge. Autumn flushing events lead to both positive and negative effects on the ecosystem state in Hunnebunn. The oxygenated water intrusions lead to a decrease of the deep layer concentrations of hydrogen sulfide, ammonia, phosphate and silicate. On the other hand the intrusion causes an uplift of the hydrogen sulfide boundary to a shallower depth (4 m), an increase at this depth of nutrients and a decrease of pH levels. The environmental consequence of this flushing is the appearance in the surface water of toxic methylmercury formed in the anoxic layer. Methylmercury is easily bioaccumulated in organisms and can be transported from anoxic fjords to the surrounding waters.

S8-P2 - *Moved to Oral, May 17, 12:15*

Seasonal hypoxia of Amurskiy Bay (Japan/East Sea)

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On the base of detailed hydrochemical surveys carried out in four seasons during 2008, the seasonal variability of hypoxia in Amursky Bay of the Japan Sea is described. Hypoxia forms mainly due to microbiological degradation of the "excess" amount of diatoms in the bottom layer and weak circulation dynamics. Existence of phytoplankton "excess" is caused by a bloom which results from the eutrophication of Amurskiy Bay. The phytoplankton bloom might be caused by an enhanced supply of nutrients into the upper layer due to increased discharge of the river on short-time scales. Just after settling of suspended matter, perfect conditions for a phytoplankton bloom are formed because of a strong stratification of the water column, a nutrient enriched surface layer and a low biomass of zooplankton. Therefore, blooming phytoplankton dies and sinks to the bottom in a large amount. Microbiological decay of dead diatoms under conditions of light deficiency (at depth more than 15 m) intensively consumes dissolved oxygen and produces phosphates, ammonium, silicates and dissolved inorganic carbon. This causes a formation of hypoxia in near bottom waters. Its regular occurrence over recent years, and even an increase of its intensity, is a prominent signal of change which may cause serious negative consequences. In the middle of September 2008, many small fishes were found dead in Amursky Bay. We believe sulfate reduction occurred in near-bottom waters and shallow sediments. Subsequently, during a strong wind event in the middle September, the poisoned bottom water was mixed upward which killed fishes. Our data suggest that hypoxia varies seasonally, with a peak at the end of summer. Upwelling of the Japan Sea water in the early fall, and its advection across the shelf, destroys the hypoxia. The ecosystem of Amursky Bay completely recovers in winter because of intense ventilation.

S8-P3

Oxygen decrease in the western Pacific along 165°E

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We made a comprehensive analysis for the trend of dissolved oxygen (DO) in the repeat section of Japan Meteorological Agency (JMA) at 165°E in the western North Pacific since 1996, combining with data from WOCE P13 in 1990's and other cruises. After controlling data quality, the rates of DO change were analyzed at an interval of $0.1\sigma_\theta$ at each 1-degree of latitude for the period 1987-2011. We also analyzed the data of DO that have been acquired by JMA in the Oyashio region over the last nearly 50 years since 1963. In the northern subtropical and the subtropical to subarctic transition zones between 25°N and 42°N along 165°E, long-term trends of DO (-0.77 μmol kg^{-1} y^{-1} on the average) were significantly detected between $26.5\sigma_\theta$ and $27.2\sigma_\theta$. These layers include the North Pacific Intermediate Water (NPIW) and the upper DO minimum layer below the NPIW. At around 40°N, bi-decadal oscillations of DO have also been observed. Their phases of periodicity are a few years behind those found in Oyashio region. It suggests that the long-term decrease of DO, as well as bi-decadal oscillation in this zone, has a close connection with those in the Oyashio region. We think that the long-term decreases of DO at 165°E and in the Oyashio are ascribed to the increase in the contribution of the water from the western subarctic gyre. It is also likely that the deepening of isopycnal surfaces due to warming is contributing to the DO decrease around the NPIW.

S8-P4

Understanding the role of bacteria in the oxygen minimum zone (OMZ) in the carbon cycle

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In order to understand the role of heterotrophic prokaryotes (hereafter bacteria) in the carbon cycle, we investigated bacterial biomass and production in an oxygen minimum zone (OMZ), the NE equatorial Pacific. Field sampling was conducted over the period from July 10 to August 14, 2011. The OMZ (< 30μmol O_2) extended vertically ranging from the depth of 400 to 700m. Bacterial biomass (based on Adenosine tri-phosphate conc.) and production (estimated by the ^{3}H-thymidine incorporation) was very high in the euphotic zone (mean = 36.78 ng L^{-1} and 1.82 mg C m^{-3} d^{-1}, respectively) and decreased with the depth (mean = 4.88 ng L^{-1} and 1.00 mg C m^{-3} d^{-1}, respectively). Interestingly, the second peak of these values was found in the deeper layer of the OMZ (mean = 17.00 ng L^{-1} and 2.06 mg C m^{-3} d^{-1}, respectively). This suggests different types of electron acceptors may be active in the deeper layer of the OMZ. Furthermore, the increased rate of production was higher than that of the biomass in the deeper layer of the OMZ. This discrepancy may be due to the grazing effect by protozoa. These results indicate that bacteria in OMZ could be an important contributor to secondary production and carbon cycling in the ocean. Further genetic investigation will provide more detailed information on diversity and identify key functional groups of bacteria in the OMZ.

S8-P5

Black Sea Holocene gas seeps as hot-spot environments with opposing natural properties: Zoobenthos high-activity and strong hypoxia coupled by H_2S contamination

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Methane gas seepage through Black Sea sediments (age-dated 8,500-36,500 yrs, *i.e.* originating in the holocene and pre-holocene) occurs in all three environmental zones of the Black Sea: oxygenated upper layer, redox–chemocline and H_2S deep zone. A present knowledge gap is the response of seep located zoobenthos assemblages to environmental conditions at various seafloor depths. Benthos fauna studies and chemical analysis were collected in different Black Sea sites: seepage areas in the uppermost H_2S zone and also small-size shallow seep spots. Massive microbial mats are formed in all seepage sites. In the Dnieper Canyon, maximum zoobenthos density (526 individuals dm^{-2}) has been detected in an area where intense methane seeps are covered by methane-oxidizing microbial mats (220-250 m depth). In the shallow seep-spots (1-5 m depth) zoobenthos were also found to be diverse. Benthos abundance varied between 480-7,450 individuals dm^{-2}. During periods of gas seepage intensification and/or anoxia expansion, associated zoobenthos (Annelida, Malacostraca) avoided the seep fields. At suboxic seep areas, dense benthic fish shoals were observed. Fishes could consume live benthos inhabiting the upper mat layer. Abundance and availability of organic food materials in redox-spots of the gas seeps are probably the strongest factors determining both shallow and deep-water benthic associated fauna. At the same time, daily and seasonal changes of oxygen regime and redox-conditions, as well as natural hydrostatic pressure, can make significant impacts on productivity and migration strategies of zoobenthos in gas seep areas.

S9 Poster Presentations

S9-P1

The Baltic Sea regime shift, can it flip back?

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An ecological regime shift has been previously described in the central Baltic Sea during the late 1980s. Biologically, the pre and post shift phases may be summarised as being dominated by cod or clupeids, respectively. This presentation explores the type of interactions between trophic levels and the environment based on time series collected in the system over the last 30 years, with particular focus on detecting non linear and non additive (threshold) relationships. The identification of these two types of relationships is important as they could have arisen as a consequence of the shift or –as an intrinsic property– could have contributed to push and block the system into a contrasting regime. The defined empirically estimated models are then used to evaluate the resilience of the two observed phases by running them under different scenarios.

S9-P2

East-west regime shifts in the Japan/East Sea

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Interannual variability in the southern Japan/East Sea has been related to path variations of the Tsushima Warm Current (TWC), resulting in warmer or colder southwestern area (Hirose and Ostrovskii, 2000; Choi *et al.*, 2004; Lee and Niiler, 2010). However, it is documented from infrared satellite imagery that warmer or colder conditions can also occur in the northwestern area north of the Subarctic Front (Nikitin, 2006). To analyze this variability, we use AVISO 1/4°-gridded weekly sea level anomalies (SLA) for the period from October 1992 onwards, eddy kinetic energy (EKE) computed from SLA, and 1/4°-gridded Merged Satellite and In Situ Data Global Daily Sea Surface Temperature (MGDSST) product by the Japan Meteorological Agency for the period from October 1993 onwards. Multivariate analysis of SST, SLA, and EKE revealed the east – west seesaw between two major pathways of the warm water transport from the Korea Strait towards the northern Japan/East Sea. During the positive phase the entire western Sea is colder, with negative SLA and decreased EKE, and warm water is advected northward within the TWC along the Japanese coast, while during the negative phase sea level rises and EKE increases in the western Sea and warm water is transported towards the Russian coast through systems of warm eddies (Nikitin *et al.*, 2002). This variability evolves on semiannual, annual, quasi-biennial, and interannual time scales. Regimes of the positive phase occurred in 1993, 1996, 2000, 2004-2006 and regimes of the negative phase occurred in 1997-1999, 2001-2003, 2007-2009.

S9-P3

Investigation of common temporal trends in the major demersal fish populations in the Benguela Current Large Marine Ecosystem, 1985-2010

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Future climate change is expected to result in changes to the available environmental niches of many fish species. Such effects are likely to be differential in that the environmental niches of some species would be expanded, and of others, reduced. Changes in the available environmental niche, combined with varying levels of exploitation in the case of certain fish species, can result in changes in abundance of fish populations that are too complex to be explained by simple population dynamics. For this reason, comparative studies may provide a better understanding of the important processes driving the dynamics of fish populations. In this study, we conducted a comparative analysis of the temporal trends in the major demersal fish populations between different geographical areas of the the Benguela Current Large Marine Ecosystem (BCLME). We applied Dynamics Factor Analysis (DFA), a multivariate time series analysis technique that is able to extract a few common trends from a set of time series data incorporating additional covariates that can potentially influence the temporal trend (in this case index of exploitation pressure and some environmental variable). Results showed that there was a degree of similarity between the major trends extracted for those parts of the BCLME that coincide with South Africa and Namibia, whereas the overall trend in Angola was distinctive.

S9-P4

El Niño change associated with subsurface ocean in greenhouse gas forcing scenarios

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Relationship between El Niño and global warming is still unclear. In order to examine this issue, sea surface temperatures from Geophysical Fluid Dynamics Laboratory Climate Model version 2.1 and Earth System Model 2M under the various scenarios of greenhouse gas forcing are compared with those of the pre-industrial control run in the tropical Pacific. Cyclostationary empirical orthogonal function analysis identifies two principal modes of sea surface temperature variability in the tropical Pacific, which explain respectively about 50% and 10% of the total variability. The corresponding subsurface temperature anomalies are also obtained to understand the physical and dynamical processes associated with the two modes. The first mode captures the typical El Niño pattern, while the second mode a dipole pattern in the tropical Pacific. The respective ranges of fluctuations for the two modes do not significantly change in the first 100 years; interestingly, however, the amplitude of fluctuations shrinks after that. The surface temperature increases rapidly in the first 100 years but slows down after 100 years; the subsurface temperature particularly in the depth of 200-350 m, on the other hand, increases rapidly after 100 years in the eastern Pacific. Because of this temporal lag between the surface and the depth, difference in the thermocline depth between the eastern Pacific and the western Pacific decreases and the development of El Niño is suppressed significantly.

S10 Poster Presentations

S10-P1

Quantitative estimation of an annual inorganic carbon production in the Arctic Ocean by coccolithophore during 1998-2010 from synergistic remote sensing data

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This study has been carried out as part of an international project on monitoring and evaluation of regional climate changes in high latitudes and the Arctic (MONARCH -A [http://monarch-a.nersc.no]). An investigation of the spatial and temporal dynamics of primary productivity was conducted with our algorithm BOREALI. The first version of the BOREALI algorithm was developed for retrieving major water colour producing agents: chlorophyll *a*, suspended minerals and dissolved organics specifically for coastal/optically complex waters experiencing significant impacts of land and river run-off. We have modified the BOREALI algorithm for retrieving: a) *Emiliania huxleyi* chlorophyll (as an indicator of the biomass of the alga), b) coccoliths (plates of calcium carbonate, separated from the cells of *E. Huxleyi*, and c) diatom chlorophyll which is usually present on the periphery *E. Huxleyi* blooms. The algorithm is based on a Levenberg-Marquardt multivariate optimization method.

All potential areas of *Emiliania huxleyi* blooming were investigate by applying the BOREALI algorithm using MODIS monthly mean Level 3 data. The main, or only, area of coccolithophore blooming was in the Arctic, between Greenland in the west and Novaya Zemlya in the east and from ~60°N to Spitsbergen. Furthermore, extensive statistical analysis of remote sensing data indicates that the main area of *E. huxleyi* blooms is the Barents Sea. However, because some (not large in number or area) areas of the Arctic Ocean are persistently cloud screened in the characteristic time of *E. Huxleyi* blooms (June-September), at least during the period studied (2002-2010), assessing the *E. huxleyi* generated fluxes of inorganic carbon may slightly underestimate their true values as well as their inter-annual variability. A trend for the period 2002-2010 shows (contrary to some opinions expressed in the literature) that the generation of inorganic carbon by *E. huxleyi* decreased by 61% over this period.

S10-P2

Total alkalinity and calcium of the Japan/East Sea

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Presented by Vyacheslav Lobanov on behalf of Pavel Tishchenko

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Using total alkalinity (TA) and dissolved calcium (Ca) data obtained in 1999 (R/V *R.Revelle*, Prof.Khromov cruises) and 2009 (R/V *Akademik Lavrentjev*) the main features of spatial and vertical distributions of TA and Ca are discussed. It is shown that normalized TA (TA*35/S) has no temporal shift during these ten years. The most important feature in distribution of TA and Ca in the Japan/East Sea is considered: increase potential alkalinity with depth for conditions where water is supersaturated with respect to calcium carbonate. It is demonstrated that this cannot be explained by formation and dissolution of calcium carbonate. A new concept explaining the alkalinity distribution in the sea is offered, according to which the basic process responsible for alkalinity transport from the euphotic layer into interior of the sea is the biological pump. The active element transporting alkalinity is Extracellular polysaccharide (EPS) which is produced by phytoplankton. EPS binds calcium and other cations forming Transparent Exopolymer Particles (TEP). Settling and decay of TEP releases alkalinity and calcium in deeper horizons of the sea. This explains: a) a vertical flux of calcium carbonate independent of the supersaturation/undersaturation state with respect to calcium carbonate of the surrounding water; b) a flux of calcium carbonate occurs via plankton without calcium carbonate skeletons; c) nonstoichiometric relations between alkalinity and calcium fluxes.

S10-P3

Change in oceanic emissions of light alkenes due to monsoon circulations over northern Indian Ocean

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Shipboard measurements of ethene (C_2H_4) and propene (C_3H_6) were made in the marine boundary layer (MBL) of the Indian Ocean during the summer and winter monsoon seasons. The trends in the levels of alkenes were similar to that of wind speed, while no clear relationships were observed with other meteorological parameters. The short term variations of ethene and propene show correlations with the intensity of sunlight, as in summer their daytime values were ~45% higher than the nighttime measurements. In winter, measurements of alkenes did not show any local time dependencies. The concentrations of alkenes were higher during cyclones and episodes of convective activity in the summer season. The uptake rate of nutrients showed similar trends to those of mixing ratios of alkenes in summer, and measurements of phytoplankton indicate high primary production during the episodes of elevated alkenes over central Bay of Bengal (BOB). The concentrations of alkenes showing minima in winter and maxima in summer are similar to the seasonal patterns reported for the global ocean, however their variability over the Indian Ocean was less pronounced compared to the extratropical oceans. The ratios of ethene/propene were comparable to a mean ratio of 2.3 pptv/pptv derived from the database for global oceans confirming fresh oceanic emissions of alkenes over the BOB. The emissions of these reactive hydrocarbons were mainly controlled by the distribution of dissolved organic carbon in sea water and the action of wind in the presence of sunlight. This study is an important step towards understanding the processes controlling the emissions of alkenes from tropical oceans and improving global budget estimates.

S10-P4

Preliminary study on sedimentary organic matter variations in the East/Japan Sea

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Four piston cores (DD08-22, DD08-48, DD09-21, and DD09-39B) from the East/Japan Sea were examined to assess past variability of primary productivity and related paleoclimate changes. Biogeochemical parameters such as $CaCO_3$, C/N ratio, TOC (%) and carbon and nitrogen stable isotope ratios are important to determine natural carbon transport and cycling processes related to global climate changes. In the DD09-21 core, the lowest C/N ratio and the highest concentration in $CaCO_3$ were observed during the Last Glacial Maximum (LGM). DD08-39B and DD08-48, on the other hand, showed $CaCO_3$ content decreasing at the start of LGM and increasing gradually after. DD09-21 revealed the greatest fluctuation in all measured biogeochemical parameters, especially at core depths of 80 cm and 260-300 cm (20 ka, 61 ka, and 70 ka BP respectively). Increases in TOC and C/N ratio in the latter depth range may indicate input of terrestrial organic matter and/or enhanced ocean surface productivity as revealed by increased $CaCO_3$ content. In DD08-48 and DD08-22, heavier ^{15}N ratios were found with increasing depth while in DD09-21, the ratios fluctuated having the lightest value at 280 cm and the heaviest at 50 cm. This study requires further research to provide strong evidence for the major fluxes of organic matter as well as other biogeochemical proxies that are potentially helpful to reconstructing the paleoclimate variations in the East/Japan Sea.

S10-P5

Paleoclimate and paleoceanographic variations based on foraminiferal isotope study in shelf sediment of the East/Japan Sea, Korea

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To understand the paleoclimate and paleoceanographic evolution of the western continental slope area of the East/Japan Sea, we conducted a planktonic and benthic foraminiferal isotope study as well as carbon and nitrogen isotopes of organic matter. The oxygen isotopic compositions of planktonic foraminifera were approximately 0‰, but became heavier toward the core top. Oxygen isotope compositions in benthic foraminifera do not show significant variations, but remain constant throughout the core with an average of approximately 4‰. This difference of oxygen isotope ratios between planktonic and benthic foraminifera (about 4‰) was caused by the temperature difference between surface and bottom water. Biogenic carbonate content and carbon and nitrogen isotopes of organic matter provide valuable information on biological productivity and related climatic variations including ocean environmental changes. Total organic carbon (TOC) content (%) increased during the Holocene and decreased during glacial periods with small fluctuations. Also, carbonate content seem to show clear variation between glacial and interglacial period: glacial increase and interglacial decrease. These opposing trends of TOC and carbonate may be caused by either biogenic productivity changes or climate variations. Carbon and nitrogen isotope ratios ranged from -21.75‰ to -25.75‰, and from 2.7‰ to 6.2‰, respectively. Strongly negative $d^{13}C$ at the core bottom (glacial time) may result from input of terrestrial organic matter. Lower $d^{15}N$ in corresponding periods may indicate anoxic bottom water conditions generated by absence of active ventilation.

General Poster Session Presentations

GP-P1

Change of seasonal rhythms of ice processes by the Peter the Great Bay (Japan Sea) in the second half of the 20th - beginning of the 21st centuries

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Study ice conditions Sea of Japan, especially Peter the Great Bay, is of particular relevance in connection with the plans of economic development in the region of active (APEC summit in 2012, construction of resort and recreational area, the Far Eastern Federal University and the Aquarium on about. Russian, pipeline: Taishet - Skovorodino - Kozmino, *etc.*).

Based on all available information about the state of ice cover the Sea of Japan and the Gulf of Peter the Great immediately performed an analysis of seasonal and long-term variability, as well as space-time conjugation of the formation of ice conditions in the Gulf and across the Sea of Japan. The initial data used information about the state of the ice cover during the period from 1960 to the present time. In general, occur fairly close relationship between ice processes in the Sea of Japan.

Statistical analysis of the series did not show a regular (for the whole of the period), the presence of significant linear trends in long-term distributions of ice conditions, directly in the Gulf, and in general across the sea. However, the presence of different probability assessments of the existence of a trend in the ice season indicates the direction of change in the nature intraseasonal processes. This decrease in the intensity of the destruction of ice and ice sheets for initial and final stage, respectively.

The resulting estimates of conjugacy and long-term variability of ice conditions in the Gulf of Peter the Great and the Sea of Japan as a whole can then be used for a number of probabilistic and statistical models of the evolution of the system.

GP-P2

Influence of Asian dust storms on the state of phytoplankton communities

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Asian dust storm (ADS) is a seasonal meteorological phenomenon which affects much of East Asia sporadically during the springtime months. ADS involves strong winds that blow a large quantity of the dust and fine sand particles away from the ground and carry them over a long distance with severe social and environmental impacts along its way. Although ADS as a natural phenomenon has a history of more than thousands of years, statistics indicate an increased frequency, expanded geographic coverage, and accelerated damage intensity over the past 50 years (GEF 2002).

In this work the spatio-temporal distribution of Asian dust storms is analyzed on the basis of stationary and ship-borne lidar observations, satellite data, model RIAM-CFORS data. The main trajectories and seasons of dust storms are identified in the north-western Pacific. The influence on the concentration of phytoplankton communities is estimated for both individual events, and the entire region. It is shown that in most cases the passage of a dust storm leads to increasing of chlorophyll *a* concentrations. Corresponding reaction times and concentrations increasing are estimated. Possible explanations of the observed phenomena are given.

GP-P3

The fate of floating macroalgal bloom in Yellow Sea during late July of 2011

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A floating macroalgal bloom, which mainly consisted of *Ulva linza*, reoccurred in the Yellow Sea in the July 2011. We observed satellite images using MODIS (250 m resolution) data to reveal the distribution of algal bloom, and measured *in situ* photosynthesis to evaluate the ecophysiological status from chlorophyll *a* fluorescence measurements and short-term incubation at two stations. The floating macroalgal bloom of 2011 covered about 557 km^2 along the southwest coast of the Korea, which is a larger extent than earlier bloom events. Effective quantum yield of PSII (ΦPSII) was shown from 0.22 to 0.51 at both stations, depending on daily irradiance fluctuation. Maximum gross photosynthesis rates (P^B_{max}) of *U. linza* in St. 1 and St. 2 were 107.1 and 102.5 μmol C g^{-1} ww h^{-1}, respectively. Dissolved inorganic carbon and surface pCO_2 concentrations decreased with distance from the coast. Nevertheless, there were no differences in DIC and pCO_2 concentrations between inside and outside of floating macroalgal patches. We ascertained the macroalgal bloom was nearly in its extinction stage in July 2011 from satellite images, and our field observation data indicated that bloom species maintained physiologically healthy status in this period. The carbon chemistry of seawater was not affected by the floating macroalgal patches.

GP-P4

Investigation of interactions between temperature and precipitation on Kamchatka Peninsula

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Interactions between air temperature and precipitation on the territory of Kamchatka have been investigated using monthly mean temperature and monthly precipitation totals for 1951-2010. Synchronous communication between the temperature and precipitation are characteristic of the east coast in January, February, April and October, for the west coast - in March, May and November. The warmer months on the west and east coasts are characterized by greater moisture. Significant asynchronous relationships between precipitation and temperature were found for different parts of the peninsula, but a definite pattern in the nature of their distribution have been identified. For instance, in the north of Kamchatka, the nature of the anomalies of precipitation in August and October appear to directly determine the temperature anomaly in February and January, respectively. In mountainous areas the precipitation during October, November and December, appear to be linked to the temperatures of the following January, February and March, respectively. In general, analysis of temperature and precipitation reveals the following relationship: the temperature anomaly is determined by the anomaly of precipitation in the preceding months with a shift of 1, 2, 5, 6 and 9 months.

GP-P5 - *Cancelled*

Summer and winter zooplankton abundance and biodiversity in two oligotrophic areas of the Central Western Mediterranean Sea

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The Balearic Sea located in the Central Western Mediterranean encompass major spawning areas of pelagic fish, possibly due to the 'island stirring' effect that may produces an increment of planktonic biomass around the islands as a result of presence/absence of intense oceanic front and other mesoscale features. Although generally oligotrophic, the Balearic area is a pertinent site to track the dynamics of water exchanges and mesoscale hydrographic variability and their consequences on the structure of pelagic ecosystems. In this study we have investigated the zooplankton communities (micro, meso and macrozooplankton) abundance and biodiversity and its relationship with the environment in north and south waters off the Balearic islands. Winter and summer seasons were chosen at different depths (200 and 900m) for the comparative studies (*), founding that both communities showed important differences in biomass and composition. They characterized the mixing and stratification season of the pelagic area ecosystem where the copepods and their nauplii were the most abundant group, following the appendicularians in importance. During the mixing period the northern frontal area exhibited a greater biomass where the largest fraction (>500 um) was more important. Microzooplankton, however, was found of higher abundance during the stratified period due to the small copepod nauplii. Major zooplankton groups but also main copepod species were identified, characterizing main assemblages in both periods and oceanographic areas. Other minor groups, such as siphonophores, chaetognaths, jellys and thaliaceans were also valuable indicators of the pelagic ecosystem. Their pattern distributions were discussed in relation to the climate change in open waters of the Western Mediterranean Sea.

(*) Framework of the National IDEA 2 project

GP-P6

Influence of ocean water quality on diversity of marine fauna resources in the Gulf of Guinea, off Ogun State Southwest Nigeria

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Man and environment interact with each other. The effect of one on each other can either be positive or negative. Development is an increasing ability to obtain from the environment the resources required to meet man's need. Marine fauna especially fish resources are highly important in meeting the fish food needs of Nigerian populace. Marine artisanal fishery is one of the important fisheries sectors in Nigeria; which contributes over 50% of the total fish production. The artisanal fishermen operate within 5 nautical miles non-trawling zone of the Exclusive Economic Zone (EEZ) using gillnets as major fishing gears. Based on direct catch assessment, analyses of surface water quality parameters and questionnaires surveys carried out along the coast of the Gulf of Guinea, off Ogun State, Southwest Nigeria, the species are not only reducing in size but also in diversity. Species such as *Xiphias gladius* and *Trachinotus goreensis* are absent in the catches while species like *Tarpon atlanticus*, *Trichiurus lepturus*, *Mugil* spp are low in abundance compared with what was obtainable in the past. Exploration of the study was carried out by using canonical correspondence analysis in PAST package (Paleontological Statistics, version 2.08). This study aims to evaluate the diversity and influence of the water quality parameters on the distribution of marine fauna species in Nigerian coastal waters in the Gulf of Guinea.

GP-P7

Preliminary plans of marine biodome for the studies of climate change and ecosystem management in Korea

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Marine biodome is a large scale mesocosm, an experimental tool that brings a small part of the natural environment under controlled conditions. In this way mesocosms provide a link between observational field studies that take place in natural environments and controlled laboratory experiments that may take place under somewhat unnatural conditions. Mesocosms have been used to evaluate how organisms or communities might react to environmental change, through deliberate manipulation of environmental variables, such as increased temperature, carbon dioxide or pH levels *etc*. Marine biodome in this study is a large scale habitat based mesocosm representing real costal ecosystems. Current plans are to build five the most representative habitats spread throughout the Korean coastal waters; tidal flat, estuary, seagrass bed, subtropical coral reef and permanent shallow coastal waters based on the Ramsar coastal habitat classification criteria. This preliminary study proposed the three major components of marine biodome; general laboratory and supporting facilities, semi-closed and open marine ecosystem connected as one system. Four suggestions were made to operate the large facility as establishment of independent national organization, incorporated association, a consortium of local universities and research institutes, or direct operation by Korea Marine Environment Management Corporation (KOEM). This facility must be a major test bed for the studies of fate of pollutants, ecosystem responses by climate changes, ocean acidification, air-sea interactions, biogeochemical cycling, ecosystem modeling, and ecological risk assessment *etc* at ecosystem level. Also, the marine biodome can be used for the multi academic purposes, public awareness and education to arouse the people to the importance of marine ecosystem services.

GP-P8

Evaluating the effect of climate changes on marine biodiversity: The ReBentos (Network for Monitoring Coastal Benthic Habitats) initiative in Brazil

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The implementation of the Network for Monitoring Coastal Benthic Habitats (ReBentos) took place in 2011 within the Subnet Coastal Zones of the Brazilian Climate Network and the National Institute of Science and Technology for Climate Change, aiming to evaluate the effects of regional and global environmental changes on biodiversity of coastal benthic habitats (sandy beaches, coral reefs and rocky shores, vegetated bottoms, estuaries, and mangrove and salt marshes). The ReBentos is part of the Program SisBiota Brazil (CNPq/FAPESP), with resources to articulation between research groups and fieldwork, with an environmental education branch. Additional sources of funds are being requested to structure and strengthen the research team and the participating laboratories. The project started in January 2011 and the I Workshop was held between 28 and 29 July 2011, when the first attempts to define basic sampling strategies and protocols to establish data series for each habitat were done. After that, an interactive portal (www.rebentos.org) was created to converge communications, documents, references, and discussions. In the II Workshop, 7 to 9 November 2011, the sub-groups consolidated summaries

of the state of knowledge of each habitat and defined the methodological approaches to start data collection in 2012. This structuring process stimulated a strong mobilization of the Brazilian benthic scientific community around the theme of global changes, in which 87 scientists from 39 institutions from the whole Brazilian coast are involved in research activities, capacity building, and environmental education.

GP-P9

The model of catastrophe theory to apply to the possible climatic trends

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The examples of the application of the catastrophe theory to ocean climatic system are shown. The simple model of the fold catastrophe is used. Climatic control parameter is the spatial density gradient of the sea surfaces water. This is shown that a slow accumulation of control parameter may result to fast changing of the system structure. There are two examples of oceanic nonlinear dynamic systems - a jet current, a large-scale vortex. The control parameter for the jet current is the density gradient across the axis of the jet. The control parameter for the large-scale vortex is the spatial density gradient between the centre and at the periphery. The estimations of the critical value of the controlling parameters to lead the system collapse are demonstrated. The variational model interpretation of the steady condition as the minimum of entropy production is considered. The stationary steady condition of a system describes as the variational technique of the local potential. The application of the energy method to lose the steady state as a point of a bifurcation is presented. The purpose is to find some temper the impact of climate change.

GP-P10

Analysis of tropical cyclones influence on phytoplankton communities in the North-western Pacific in 2002-2011 on the basis of satellite ocean color data

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Results of author's research into the impact of tropical cyclones on phytoplankton communities functioning and into processes of seawater dissolved organic matter reproduction by phytoplankton cells are presented in the presentation. Research was conducted on the base of ocean color data (obtained by SeaWiFS and MODIS-Aqua). Investigated tropical cyclones were born in western equatorial Pacific and passed through Philippines Sea, Southern-Chinese Sea, Eastern-Chinese Sea, Yellow Sea, Japan (East) Sea. It has been shown that tropical cyclones usually lead to phytoplankton concentration increasing in the upper Ocean layer and that the reproduction rate of seawater dissolved organic matter by phytoplankton cells generally decrease and become almost constant when chlorophyll *a* concentration are high (more than about 8 μg/l). Phytoplankton cells growth are connected with nutrients concentration increasing in the upper ocean layer (due to tropical storm induced upwelling). Numerical estimations for response time of phytoplankton communities on tropical cyclones passing and estimations of corresponding chlorophyll *a* concentration increasing are obtained. Also relevant questions of satellite data using problems are considered in the work.

GP-P11

Seasonal and inter-annual variation of volume and heat transport in the Northwest Pacific marginal seas based on high resolution regional reanalysis

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This study introduces the reanalysis which is useful in understanding the climate and the climate change in the Northwest Pacific marginal seas. The reanalysis of ocean state was produced for the period of January 1980 to December 2009 using Ensemble Kalman Filter (EnKF). The reanalysis system used the Regional Ocean Modeling System (ROMS) with $0.1° \times 0.1°$ degree horizontal spacing and 20 vertical levels. The ocean circulation was forced with the surface forcing from the European Centre for Medium-Range Weather Forecasts (ECMWF) atmospheric reanalysis dataset. Open boundary data were provided from data assimilative global ocean models (SODA and ECCO). The model had spin up for 2 years starting from SODA initial conditions of 1979. All available temperature profiles from observations including field surveys, the Argo float and remotely sensed sea surface temperature were assimilated. The assimilation improved the temperature and heat transports of the straits among the marginal seas. This study focuses on the linear trend and seasonal variation in volume and heat transports through the major straits among the marginal seas over a 30-year period. Relatively large seasonal variation of volume and heat transports was reproduced through the Taiwan and the Korea Straits and across the continental shelf of the East China Sea. Seasonal variation of transports in the Tsugaru and the Soya Straits was relatively small. There was significant increase of transports through the Korea Strait and across the continental shelf of the East China Sea while decrease of transport through the Taiwan Strait. Linear trends of transports have good correlation with the change of the wind stress in the East China Sea.

GP-P12

Temporal and spatial variation of phytoplankton communities in the Nakdong River, estuary and coastal areas

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Nakdong River is the second largest river in Korea, and it forms a typical estuary. The Nakdong barrage has been in operation since 1987. It provides many benefits to the community, including a source of water for industrial complexes and agricultural areas. However, the natural flow of the river estuary has been divided into two water columns (freshwater and saltwater) and the unique estuary ecosystem has been functionally damaged since operation of Nakdong barrage. In this study, we observed the variation of the phytoplankton communities as a part of the plankton research in the Nakdong River, estuary and coastal areas. Samples for this study were collected from the Gangseo Nakdong Bridge to the eastern Gaduk-do bimonthly from January to December, 2011. We have determined that the river water column was from the Gangseo Nakdong Bridge to the Nakdong barrage (salinity, 0.0), the estuary section was from the Nakdong barrage to the mouth of the river (salinity, 0.1-30.0), and the coastal area was the zone in which salinity is more than 30.0. In addition, we studied on the relationship among the precipitation, the amount of discharge of water from the barrage, and the variation in phytoplankton communities in the rainy season (from July to August). These results, (1) the figure of the general plankton ecosystem and (2) the change of ecosystem by a discharge of water from the barrage opening in the rainy season, will suggest the time needed for recovery of the ecosystem to the normal state after a sudden change.

GP-P13

Effect of air exposure on hemocyte parameters of abalone *Sulculus diversicolor supertexta* from Jeju Island, Republic of Korea

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Effect of air exposure on immune parameters, including hemocyte concentration, phagocytosis activity, and hemocyte DNA damage of the abalone *Haliotis diversicolor* Reeve 1846 was examined in this study using flow cytometry. All abalones exposed to air for 12 hrs of exposure in air died, while 20% of abalones placed in a moisture chamber survived after 30 hrs. In contrast, no abalone in the water tank as a control died during the experiment. Granulocyte, hyalinocyte and blast-like hemocytes were confirmed in *H. diversicolar* and hyalinocyte was most abundant. After 30 hrs, these 3 types of hemocyte significantly reduced in the moisture chamber, while only concentration of granulocyte decreased in the control. Flow cytometry indicated that among the 3 types of hemocyte, the granulocyte was mainly involved in the phagocytosis. It was noticeable that the phagocytosis rate of abalone in the moisture chamber reduced significantly over 30 hrs of exposure, from 36.98% to 21.31%. The phagocytosis rate of abalone exposed to air also decreased, from 36.9% at the beginning to 19.27% after 12 hrs of exposure. The data indicated that the physical stress caused by air exposure reduces immune capacity of abalone and these immune parameters can be used as an indicator of air exposure stress in abalone.

GP-P14

Molecular diagnostics of the ovarian parasite *Marteilioides chungmuensis* in wild Pacific oysters *Crassostrea gigas* on the south coast of Korea

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Marteilioides chungmuensis is a protozoan parasite infecting oysters and clam in Korea and Japan. In the present study, we first surveyed infection of *Marteilioides* in wild oysters collected from Gwangyang Bay and Masan Bay on southern coast of Korea using histology and PCR. Histology revealed that oysters from 3 of 8 sites in Masan Bay and 2 of 7 sites in Gwangyang Bay were infected with *Marteilioides* and the prevalence in both bays ranged 3.3-26.7% and 3.3-6.6%, respectively. In histology only female oysters were identified to be infected and the egg size of infected oyster was significantly smaller than the uninfected ($p<0.05$). Contrary to histology, the *Marteilioides* infection was confirmed both female and male oysters in the PCR, with the prevalence ranging 10-83.3% in Gwangyang Bay and 16.6-86.6% in Masan Bay. It was remarkable that the infection prevalence was highe in male oyster in both bays. Our data suggested that PCR is more sensitive and accurate technique in diagnosis of Marteilioides infection and the south coast of Korea is *Marteilioides* epizootic area.

GP-P15

Impacts of *Hebei Spirit* oil spill on wild Pacific oyster, *Crassostrea gigas,* two years after the accident in Taean, Korea

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We investigated the physiological activities of wild Pacific oysters, *Crassostrea gigas* collected from the oil spill area after two years of a *Hebei Spirit* oil spill accident and compared with those from controlled sites. Microscopic observation revealed a similar atrophy level in digestive cells with some seasonal fluctuations both the spilled and the controlled site oysters. Tissue dry weight of the standard animal was significantly higher at the spilled area and seasonally fluctuated as with condition indices. Proximate composition showed seasonal fluctuations in accordance with gametogenic cycle and the absolute protein content was significantly higher in spilled oyster than the control one. Both of the oysters become ripe in June and spawned during July-October with one spawning peak in August-September. During the spawning season the spilled oyster produce more eggs than the control one. This study results indicate that the effects of oil spill could no longer be sustained after two years of accident and the oysters might be recovered their physiological status. A Long term monitoring is required for better understanding of crude oil on the biological process of oyster.

W2 Poster Presentation

W2-P1

Changes in Structure of Teuthocenosis (Cephalopoda) of the Arctic due to climatic changes of the last decades

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The mid-annual temperature of the last decades in the Arctic has increased on 1.32°C in the inflow zone of the West Spitsbergen Current, and the average increase all over the Arctic regions is by 0.8°C (Hassol, 2005; Walczowski, Piechura, 2006). There is even a disappearance of cold halocline layer (Frolov, 2011). The new data on distribution and biology of cephalopods in the Arctic were obtained on basis of samples of the research cruises of IMR (Norway) and PINRO (Russia) in 2006-2011.

Todaropsis eblanae was found for the first time in the Arctic near the Murman coast in 2006 (71°13′N, 36°38′E) (Sabirov *et al.*, 2009). The next years it was caught in the Barents Sea a few times. Previous known northern border of its range was located almost on 2 thousand km southward (Zumholz, Piatkowski, 2005). *Teuthowenia megalops* was found for the first time in the Greenland Sea in the Spitsbergen Trench (79°20′N) in 2009. The northern border of its range is moved on 1.5 thousand km northward. The feeding shoals of *Todarodes sagitatus* were registered in the northern part of the Norwegian Sea in 2010. The range of aborigine arctic species *Gonatus fabricii* is expanded to the eastern part of the Barents Sea and the western part of the Kara Sea.

The structure of arctic teuthocenosis is changing due to warming of the Arctic waters. The expansion of ranges and the changes of reproductive characteristics and other signs were observed in aborigine and new cephalopod species in the Arctic.

W6 Poster Presentations

W6-P1

Climate-mediated diseases affecting habitat-forming seaweeds: Complex environmental effects on hosts and pathogens

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Disease is emerging as a major factor in the decline of many species worldwide. The impacts of disease are arguably more severe when habitat-forming organisms are affected, as any negative effects of disease could cascade throughout other levels of the food web. On temperate rocky reefs, macroalgae are the dominant habitat-formers and evidence of their decline is being reported worldwide. Often, diseases are implicated in these declines, but this is rarely followed-up or confirmed experimentally. Here, we present descriptive evidence of disease-like symptoms affecting three habitat-forming seaweeds (*Delisea pulchra*, *Ecklonia radiata* and *Phyllospora comosa*; the latter two of which are in decline) from the south-eastern Australian coastline, a global-warming 'hot-spot'. We also present novel, experimental evidence of the involvement of bacterial pathogens in these seaweed symptoms and the complex influence of the environment (*e.g.* temperature, nutrients and light) on these macro-micro interactions. We also discuss the effects of proximity to urbanised areas on seaweeds and microbial pathogens. Generally, high temperatures lead to higher incidences of disease-like symptoms in these algae. Additionally, proximity to localised anthropogenic stressors (*e.g.* sewage outfalls) also affects the severity of stress and disease phenotypes in monitored macroalgae and can affect population structure. Understanding the mechanisms behind declines of important ecosystem engineers such as macroalgae is essential for their conservation and management in warming oceans.

W6-P2

Latitudinal shifts in catch distribution of fisheries species in Korean waters during the past 30 years in relation to climate change

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Sea surface temperatures in Korean waters have increased by *ca* 1°C during the past 40 years, but the warming trend diminishes with water depths, becoming not significant at < 100 m depths. We analyzed spatially-explicit catch data of major fisheries species in Korean waters collected from 1983 to 2010 to evaluate and predict their range shifts in relation to climate-driven hydrographic changes. Preliminary results suggested that more than half of the 36 species, especially for bluefin tuna, small yellow croaker and Korean blue crab, showed a northward shift, but there were some exceptions. Small pelagic species such as anchovy, mackerel and sardine showed a stationary trend in their latitudinal ranges in catch. Distribution of Pacific cod, known as cold-water demersal species, extended southward since the late 1990s, which seems to be related with intensified episodic penetration of deep waters from the Japan/East Sea to the Korea Strait. Catch-weighted mean latitude of largehead hairtail, a most important commercial species in Korea, showed a significantly negative correlation with winter salinity in the East China Sea. Water temperature and salinity, particularly in the mixed layer, showed significant correlations with the mean latitude in catch of some species, suggesting variation in the Tsushima warm current also could be important in range of fish species, together with temperature. Results implied that artisanal coastal fisheries, which have benefited from their ability in quick supply of live or unfrozen fishes, will become less competitive than industrialized fisheries in adapting to possible climate-driven range shifts of their target species.

W6-P3

Range shifts in the North Sea: Why is life so complicated?

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The North Sea has been identified as a 'hot spot' of marine climate change, and has demonstrably warmed by more than 1°C over the past 100 years. Several highly-cited studies have indicated that the recent warming trend has coincided with an apparent northward shift in the distribution of some fish species by distances ranging from 48 to 403 km over the past 30 years, and that the whole fish assemblage has also 'deepened'. However, closer examination of reported distribution changes at the individual species level has revealed many different and confusing responses with some species moving northwards, some moving southwards and some hardly responding at all.

In the present study we have used a unique 97 year (1913-2010) spatial time series of fish catch-per-unit-effort data to examine whether locations where peak catches of species such as cod, haddock, whiting, plaice and sole are obtained, have shifted throughout the 20th Century. We show that high sole catches seem to have retreated away from the Dutch coast, southwards. High plaice catches have moved steadily north-westwards, while cod catches seem to have shifted north-eastward into deeper water. Haddock and whiting catches have moved very little in terms of centre of distribution, but their southern boundary has shifted, in the case of haddock - by approximately 130 km over the past 94 years.

Factors other than climate have played an important role in determining observed fish distribution patterns, including: fishing pressure, depletion of discrete sub-stocks, habitat modification and predator-prey interactions.

W6-P4

The future of Arctic zooplankton: Interplay between advection, life history traits and trophodynamics

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Ongoing and expected climate change will affect zooplankton in the Arctic Ocean through advection of Atlantic water, temperature increase and changing conditions of primary production. The three copepods *Calanus hyperboreus, C. glacialis* and *C. finmarchicus* dominate zooplankton biomass at least in the Eurasian basins. Changing environmental conditions, but also interspecific dynamics will influence their future in the Arctic in a different way.

Recent biological and oceanographic observations showed different gateways of North Atlantic Calanus congeners into the Arctic Ocean, with *C. finmarchicus* mostly advected through the Barents Sea, and *C. hyperboreus* through Fram Strait. Models and oceanographic data suggest that, as a consequence, these populations will have different drift tracks and hence regional distributions, which will finally determine their survival in the Arctic Ocean. Clearly climate effects on the source regions will also affect advected populations. Modelling indicates strong interannual variation in volume and pathways of inflowing waters, which will make early identification of ongoing faunistic changes difficult.

The reproductive traits of the three Calanus congeners differ mainly in the timing of spawning and the resources utilized for oogenesis. Therefore spatial changes, but also changes in timing and magnitude of primary production will decide on colonization or expatriation of advected species. Furthermore, by using observations made in the central Greenland Sea, we demonstrate the importance of interspecific predation for survival in the Arctic Ocean. Our results show, that climate change effects are species specific and imply a variety of mechanisms.

W6-P5

Spatial patterns in zooplankton communities across the eastern Canadian sub-Arctic and Arctic waters: Insights from stable carbon (δ13C) and nitrogen (δ15N) isotope ratios

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This study defined the status quo of biogeographic domains and examined spatial patterns of stable isotopes (SIs) of carbon and nitrogen in relation to biophysical groupings to gain greater insight into how mesozooplankton may respond to continuous environmental change in the Canadian Arctic and sub-Arctic regions. Mesozooplankton communities were sampled during the summer of 2007 along a transect from Belle-Isle Strait, NFL, to Kugluktuk, NU (Canada), and during the early autumn of 2009 along a transect extending from Pelly Bay to Hall Beach, NU. Five broad water mass types corresponded to geographical regions. In general, we found relationships between water mass and species composition; however, this relationship was not always straightforward. Mesozooplankton community composition varied along the transect, revealing eight species assemblages. *Calanus finmarchicus* was abundant in the warmer and saltier Atlantic waters of the Labrador Sea, whereas *Calanus hyperboreus*, *Calanus glacialis and Metridia longa* were most abundant in the cold Arctic waters of Central Baffin Bay and in the eastern portion of the Canadian Arctic Archipelago. Nitrogen and carbon SI analysis revealed that δ15N (but not δ13C) varied spatially for *C. glacialis*, *C. hyperboreus*, *Paraeuchaeta* spp. and *Themisto libellula*. δ15N values were less enriched in Davis Strait and more enriched in the Gulf of Boothia. Seasonality, oceanic fronts and changes in the trophic structure at the base of each regional food web may explain some of the observed variability. This study represents the first broad-scale characterization of the composition and isotopic signatures for mesozooplankton communities ranging from the sub-Arctic Atlantic to the western Central Arctic Archipelago. Our study provides a baseline of the zooplankton community for monitoring species biogeographical range.

W6-P6

Changes in the South Atlantic-Indian Ocean super-gyre due to poleward shift of the southern hemisphere westerlies

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In the past few decades the southern hemisphere westerlies have been showing a poleward shift in response to the positive trend of the southern annular mode (SAM). To access the impact of this change of the atmospheric forcing on the Atlantic-Indian Ocean Subtropical Super-gyre, an implementation of the HYCOM, forced with monthly means of NCEP/Reanalysis since 1948 was run. In the Agulhas Current Retroflection region, the results show a positive trend in sea surface height, salinity and temperature from, 1970 to 2010. The model also shows a poleward shift of the Subtropical Front, south of Africa. The positive trends of these fields in the Agulhas System region and the displacement of the Subtropical Front follow the positive trend of the SAM index, with higher values during austral summer months. These changes reflect a southward drift of the wind forced ocean gyres, and a widening of the connection between the two basins.

W6-P7

Risk-based approach to manage the impacts of climate change on Canada's aquatic resources

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Risk is the combination of the probability of a hazardous event occurring, and the impact or consequence of that event. Climate Change poses a risk to Canadian aquatic resources, and hence the ability of Fisheries and Oceans Canada to deliver on its mandate. The 2005 National Climate Change Risk Assessment identified risks to ecosystems and fisheries as well as those associated with safety and accessibility of waterways. In order to build institutional resilience to climate change, risks need to be assessed and findings integrated with programming. The Department's Aquatic Climate Change Adaptation Services Program's risk-based approach seeks to assess impacts and vulnerabilities based on projected future states of Canada's aquatic resources; the assessment framework includes socio-economic considerations. Initial actions focus on four large basins, consisting of Canada's three oceans and its inland waters. This process will identify vulnerable regions within the large basins for further study, and establish priorities in research and tool development.

W6-P8

Potential impact of global warming on ranges of commercial fish species in the Northwest Atlantic

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Rising sea surface temperatures can cause changes in species' distributions with some species retreating northward to colder temperatures, while other benefitting from sea surface warming and expanding their range. We have assessed the potential for distributional shifts of commercial marine species along the Northwest Atlantic. The study focuses on 33 marine species harvested in the US and Canadian waters and includes macroalgae (*e.g.*, kelp and rockweeds); shellfish (*e.g.*, clams, mussels, oysters, crabs, and lobster); and finfish (*e.g.*, cod, halibut, and salmon). Current sea surface temperatures associated with each species' geographical distribution are used to identify its thermal limits in a bioclimate envelope approach. Future distributions are determined using sea surface temperatures projected by Atmosphere Ocean General Circulation Models and Earth System Models prepared for the upcoming IPCC fifth assessment report (the Canadian Centre for Climate Modelling and Analysis CanESM2, the Met Office Hadley Centre HadGEM2-ES, the NASA Goddard Institute for Space Studies GISS-E2-R, the Australian Commonwealth Scientific and Industrial Research Organization CSIRO-Mk3.6). The output of runs from representative concentration pathways RCP4.5 and RCP8.5 are used to predict the potential geographic distribution of the target species for the year ~2100. The shift of species ranges in response to climatic change has major implications for the management of marine resources and we assess how species assemblages will shift in areas presently designated for management.

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