# 2014 PICES FUTURE OPEN SCIENCE MEETING

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April 13-18, 2014
Kohala Coast, Big Island, HI, U.S.A.

# Table of Contents

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 pleased to welcome you to the PICES FUTURE Open Science Meeting (OSM). This unique event will give the North Pacific Marine Science Organization (PICES) a chance to review progress on the scientific achievements of its ambitious integrated science program **FUTURE** (**F**orecasting and **U**nderstanding **T**rends, **U**ncertainty and **R**esponses of North Pacific Marine **E**cosystems) while providing an opportunity to identify gaps and mechanisms to fill them. We hope this venue will create a relaxed and comfortable environment that will stimulate scientific discussion and debate.

Drastic ecosystem changes have been observed in recent decades in both open and coastal systems. These changes are believed to have occurred in response to climate change and increasing anthropogenic pressures. "*What is the future of the North Pacific given current and expected pressures?*" This is the overarching question to be addressed by FUTURE – a program aimed at synthesizing and disseminating knowledge provided by national and multi-national research programs under the auspices of three Key Scientific Questions related to: a) ecosystem resilience and vulnerability; b) ecosystems response to natural and anthropogenic forcing; and c) future ecosystem change. Further, this program proposes to addresses poorly understood, yet important, issues of interactions between human societies and coastal ecosystems, such as the effects human activities have on the provision of ecosystem services.

Inaugurated in 2009, FUTURE will enter its mid-life in 2014, making it an appropriate time to evaluate what has been achieved and what remains to be addressed. Based on information presented and discussed at this OSM, FUTURE may redirect its course in order to achieve its final goals, and input provided by participants will be essential should the need for change be identified.

We thank the PICES Secretariat for their efforts that have allowed us to gather for this important event. They have worked hard to ensure that the theme sessions and workshops will run smoothly. We also thank all the institutions and individuals who we know will make this symposium a success. This OSM will give us an opportunity to discuss our ongoing research, progress and plans. We hope that you find time to enjoy the Kohala Coast, Hawaii.

*Thomas Therriault and Hiroaki Saito*
*on behalf of all the FUTURE OSM Scientific Steering Committee members, convenors, and coordinators*

## Symposium Scientific Steering Committee

Sinjae Yoo
Korea Institute of Ocean Science and Technology, Korea

Thomas Therriault
Pacific Biological Station, Department of Fisheries and Oceans, Canada

Hiroaki Saito
Atmosphere and Ocean Research Institute, The University of Tokyo, Japan

Phillip Mundy
Alaska Fisheries Science Center, NOAA-Fisheries, USA

Mitsutaku Makino
Fisheries Research Agency, Japan

Fangli Qiao
First Institute of Oceanography, State Oceanic Administration, PR China

Oleg Katugin
Pacific Research Institute of Fisheries and Oceanography, Russia

# Notes for Guidance

## Registration

The registration desk will be located outside Executive Boardroom A (p. X).

## Location for the Sessions and Workshops

All sessions and workshops will be convened at Hapuna Beach Prince Hotel
(Timetable and Floor Plan pp. VIII-X)

## 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 Ballroom Makai from April 15-17 (noon)

## Social events*

*April 15, 18:30-20:30*

**Welcome Reception**
Location: Beach Bar-Poolside area (open-air)

*April 17, 19:00-22:00*

**Banquet**
Location: "The Courtyard" (open-air)

* For all registered participants social events are included into their registration fees
We welcome all spouses and kids to join our events (spouses - CAD$100, kids - CAD$50)
Please contact Christina Chiu (christina@pices.int) at the registration desk

# Meeting Timetable

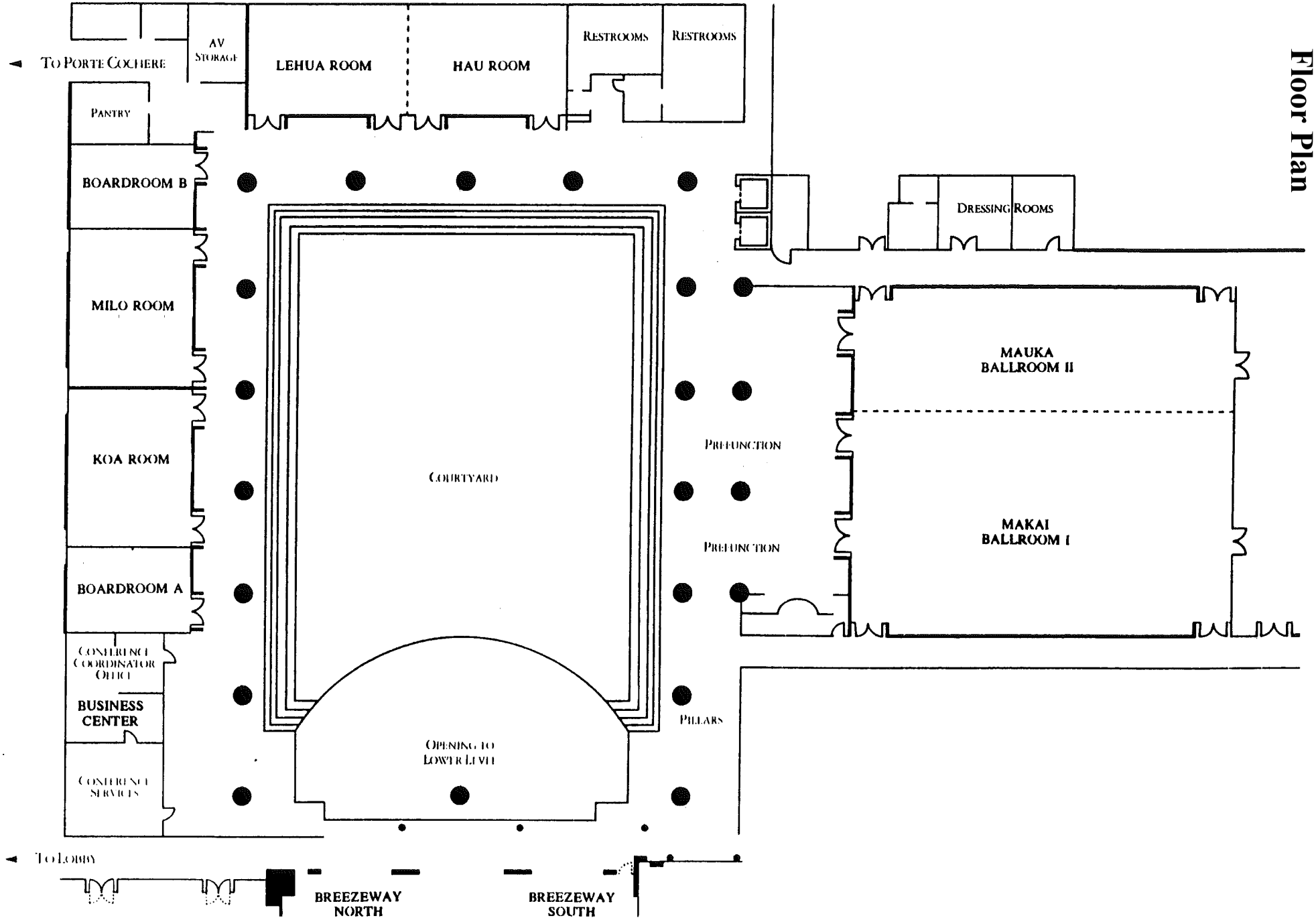
| | | | |
|---|---|---|---|
| **Sunday, Apr 13** | | | |
| 09:00<br>18:00 | W4 Wsh (day-1) [*Koa*] | MarWeb Meeting [*Milo*] | |
| **Monday, Apr 14** | | | |
| 09:00 | W1 Wsh [*Hau*] | 08:45 W2 Wsh [*Milo*] | W3 Wsh [*Koa*] |
| 12:30 | Lunch | | |
| 14:00 | W1 Wsh [*Hau*] | W2 Wsh [*Milo*] | 15:50 W4 Wsh (day-2) [*Koa*] |
| **Tuesday, Apr 15** | **Day 1 Plenary Session** [*Ballroom Makai*] | | |
| 09:00 | Opening Remarks | | |
| 09:15 | **Overview of PICES FUTURE Program**<br>**Sinjae Yoo**<br>(Korea Institute of Science and Technology, Korea) | | |
| 09:45 | Introduction of Theme Session 1 | | |
| 10:00 | **Plenary Speaker for S1**<br>**Isabelle Rombouts**<br>(Université de Lille, France) | | |
| 10:30 | *Coffee/Tea Break* | | |
| 10:50 | Introduction of Theme Session 2 | | |
| 11:05 | **Plenary Speaker for S2**<br>**Michael Foreman**<br>(Institute of Ocean Sciences, Department of Fisheries and Oceans, Canada) | | |
| 11:35 | Introduction of Theme Session 3 | | |
| 11:50 | **Plenary Speaker for S3**<br>**William Peterson**<br>(Hatfield Marine Science Center, NOAA-Fisheries, USA) | | |
| 12:20 | Lunch | | |
| 14:00<br>18:00 | Session 1 (day-1) [*Milo*] | Session 2 [*Koa*] | Session 3 [*Hau*] |
| 18:30<br>21:00 | **Welcome Reception** | | |
| **Wednesday, Apr 16** | **Day 2 Plenary Session** [*Ballroom Makai*] | | |
| 09:00 | **Summaries of Theme Sessions S1, S2, and S3** | | |
| 09:45 | Introduction of Theme Session 4 | | |
| 10:00 | **Plenary Speaker for S4**<br>**Deborah Steinberg**<br>(Virginia Institute of Marine Science, USA) | | |
| 10:30 | *Coffee/Tea Break* | | |
| 10:50 | Introduction of Theme Session 5 | | |
| 11:05 | **Plenary Speaker for S5**<br>**Mat Collins**<br>(University of Exeter, UK) | | |
| 11:35 | Introduction of Theme Session 6 | | |
| 11:50 | **Plenary Speaker for S6**<br>**Elisabeth Fulton**<br>(CSIRO, Australia) | | |
| 12:20 | *Lunch* | | |
| 14:00<br>18:00 | Session 1 (day-2) [*Milo*] | Session 4 [*Koa*] | Session 5 [*Hau*] |

| **Thursday, Apr 17** | **Day 3 Plenary Session** [*Ballroom Makai*] | | |
|---|---|---|---|
| 09:00 | **Summaries of Theme Sessions S4 and S5** | | |
| 09:45 | Introduction of Theme Session 7 | | |
| 10:00 | **Plenary Speaker for S7**<br>**Scott Large on behalf of Jason Link**<br>(NOAA-Fisheries, USA) | | |
| 10:30 | *Coffee/Tea Break* | | |
| 10:50 | Introduction of Theme Session 8 | | |
| 11:05 | **Plenary Speaker for S8**<br>**Jake Rice**<br>(Department of Fisheries and Oceans, Canada) | | |
| 11:35 | **Summaries of Workshops W1, W2, W3 and W4** | | |
| 12:20 | *Lunch* | | |
| 14:00<br>18:00 | | Session 7 [*Milo*] | 14:20 Session 8 [*Koa*] |
| 19:00 | **Banquet** *The Courtyard* | | |
| **Friday, Apr 18** | **Day 4 Plenary Session** [*Ballroom Makai*] | | |
| 09:00 | **Summaries of Theme Sessions S7 and S8** | | |
| 09:30 | **Current and Future Role of National Programs (Canada, China, Japan)**<br>**Robin Brown** (Institute of Ocean Sciences, Department of Fisheries and Oceans, *Canada*)<br>**Fangi Qiao** (First Institute of Oceanography, State Oceanic Administration, *China*)<br>**Hiroaki Saito** (Atmosphere and Ocean Research Institute, The University of Tokyo, *Japan*) | | |
| 10:45 | *Coffee/Tea Break* | | |
| 11:05 | **Current and Future Role of National Programs (Korea, Russia, USA)**<br>**Naesun Park** (Korea Institute of Ocean Science and Technology, *Korea*)<br>**Oleg Katugin** (Pacific Research Institute of Fisheries and Oceanography, *Russia*)<br>**John Stein** (Northwest Fisheries Science Center, NOAA-Fisheries, *USA*) | | |
| 12:20 | *Lunch* | | |
| 14:00 | Discussion on FUTURE Progress, Gaps, Challenges and Identification of a Path Forward | | |
| 17:00<br>17:30 | Closing Remarks | | |

## List of Sessions and Workshops

| | |
|---|---|
| S1 | Identifying multiple pressures and system responses in North Pacific marine ecosystems |
| S2 | Regional climate modeling in the North Pacific |
| S3 | Challenges in communicating science and engaging the public |
| S4 | Ecosystem status, trends and forecasts |
| S5 | Mechanisms of change: Processes behind climate variability in the North Pacific |
| S6 | Ecosystem resilience and vulnerability |
| S7 | Strategies for ecosystem management in a changing climate |
| S8 | Human dimension indicators of the status of the North Pacific ecosystem |
| W1 | Top predators as indicators of climate change: statistical techniques, challenges and opportunities |
| W2 | Bridging the divide between models and decision-making: The role of uncertainty in the uptake of forecasts by decision makers |
| W3 | Climate change and ecosystem-based management of living marine resources: Appraising and advancing key modelling tools |
| W4 | Ecosystem projection model inter-comparison and assessment of climate change impacts on global fish and fisheries |

# Floor Plan


To Porte Cochere
AV Storage
Lehua Room
Hau Room
Restrooms
Restrooms
Pantry
Boardroom B
Milo Room
Koa Room
Boardroom A
Conference Coordinator Office
Business Center
Conference Services
Courtyard
Opening to Lower Level
Pillars
Pre-function
Pre-function
Dressing Rooms
Mauka Ballroom II
Makai Ballroom I
To Lobby
Breezeway North
Breezeway South

# Schedules

# Sunday, April 13 - W4

## Workshop 4 (W4) - Day 1

### Ecosystem projection model inter-comparison and assessment of climate change impacts on global fish and fisheries

***Co-Convenors:***
*Anne B. Hollowed (USA)*
*Kirstin Holsman (USA)*
*Kerim Aydin (USA)*

This workshop will assemble an international team of modeling experts in order to: (1) identify the optimal means of combining global earth system models (ESMs), high resolution regional modeling frameworks, and ecosystem models of varying complexity to provide robust assessments of climate-change impacts on marine ecosystems and fisheries, and (2) coordinate international efforts to assess biological and societal impacts of climate-driven changes to future marine resources.

These experts will discuss the options for interfacing fisheries and ecosystem models with next generation of ESMs. Discussion topics will include: 1) identification of candidate ESMs for use in regional models based on a common set of the most recent IPCC projections, 2) quality and spatial resolution of phytoplankton and zooplankton output from ESMs; 3) identification of which marine ecosystems require dynamic downscaling to address regional ocean processes; and 4) strengths and weakness of simplifying assumptions for higher trophic level projection. Following the workshop, participants will conduct paired simulations using agreed upon climate scenarios and model structures to project climate-driven changes to marine ecosystems. Results will be presented and analyzed at the 3rd PICES/ICES/IOC Symposium on "*Effects of climate change on the world's oceans*" to be held in March 2015, in Santos, Brazil.

**Sunday, April 13 (09:00-18:00)**

| | |
|---|---|
| 09:00 | *Introduction by Workshop Convenors* |
| 09:20 | **Charles Stock**<br>Climate models: Status and future - USA/GFDL |
| 09:40 | **Enrique Curchitser**<br>Climate models: Status and future - USA/NCAR |
| 10:00 | **J. Icarus Allen/Myron A. Peck**<br>Climate models: Status and future - Europe |
| 10:20 | **Michio Kawamiya**<br>Climate models: Status and future - Japan |
| 10:50 | *Coffee/Tea Break* |
| 11:10 | **Elizabeth A. Fulton**<br>Models linking climate to lower tropic levels: Status and future - South Pacific |
| 11:40 | **Michael Foreman**<br>Models linking climate to lower tropic levels: Status and future - Canada |
| 12:10 | **Albert J. Hermann**<br>Models linking climate to lower tropic levels: Status and future - Bering Sea |
| 12:30 | *Lunch* |

| | |
|---|---|
| 14:00 | **Shin-ichi Ito**<br>Models linking climate to lower tropic levels: Status and future - Japan |
| 14:20 | **William Cheung**<br>Models linking climate to fish: Spatial shifts |
| 14:40 | **Kerim Aydin**<br>Models linking climate to fish: Spatially explicit ecosystem model |
| 15:00 | **Melissa Haltuch**<br>Models linking climate to fish: Climate enhanced stock projection model |
| 15:20 | *Coffee/Tea Break* |
| 15:40 | **Kirstin Holsman**<br>Models linking climate to fish: Climate enhanced multispecies stock projection model |
| 16:00 | **Elliott Hazen**<br>Models linking climate to fish: Spatially explicit top trophic level model |
| 16:20 | **Pheobe Woodworth**<br>Models linking climate to fish: Ecosystem model |
| 16:40 | **Nicholas A. Bond**<br>Models linking climate to fish: Short-term projections |
| 17:00 | **Discussion**<br>Best practices for projecting climate impacts on fish and fisheries |
| 18:00 | Day 1 Workshop Ends |

# Monday, April 14 - W1

## Workshop 1 (W1)

### Top predators as indicators of climate change: Statistical techniques, challenges and opportunitiess

***Co-Convenors:***
*Steven J. Bograd (USA)*
*Elliott Hazen (USA)*
*Takashi Yamamoto (Japan)*

***Invited Speakers:***
*Emanuele Di Lorenzo (Georgia Institute of Technology, USA)*
*Jeffrey Polovina (Pacific Islands Fisheries Science Center, NOAA-Fisheries, USA)*
*William J. Sydeman (Farallon Institute for Advanced Ecosystem Research, USA)*
*Kevin Weng (University of Hawaii at Manoa, USA)*

Top predators such as fish, turtles, marine mammals, and seabirds integrate multiple lower trophic level processes and can also exert top-down control of marine food webs. Climate change and variability affect the timing and productivity of pelagic ecosystems. This variability is integrated into the life histories of top predators, potentially affecting their breeding patterns, migration strategies, diets, and ultimately fitness and reproductive success. Pan-Pacific data about top predators are generated by surveys, animal tracking studies, dietary analyses, and measurements of reproductive performance. Environmental and climate data can be synthesized and compared to ecosystem responses in many locations. This workshop invites participants to present and to discuss topics that address: (1) oceanographic and top predator datasets that can be used to examine responses to climate variability and change, (2) statistical techniques that can be used in differentiating top predator responses to climate variability and climate change, (3) identification of sentinel species that respond directly to climate effects and can be used as leading indicators of ecosystem state, and (4) synthetic approaches to understanding how climate variability and change is incorporated in top predator distribution, abundance, or foraging datasets. From the workshop, a pan-Pacific meta-analysis and review paper examining this subject are planned.

**Monday, April 14 (09:00-18:00)**

| | |
|---|---|
| 09:00 | *Introduction by Workshop Convenors* |
| 09:10<br>W1-O1 | **Emanuele Di Lorenzo, Mark D. Ohman and Salvador Lluch-Cota (Invited)**<br>A filtering-hypothesis to explain climate synchrony in fish populations (9365) |
| 09:40<br>W1-O2 | **Gadea Pérez-Andújar, Christina Comfort and Kevin Weng**<br>Deep-water sharks: Their ability to withstand hypoxic conditions provides hints on how animals may respond to climate change (9326) |
| 10:00<br>W1-O3 | **Rachael A. Orben, Rosana Paredes, Daniel D. Roby, Richard Phillips, David B. Irons and Scott A. Shaffer**<br>Annual variation in habitat use of black-legged kittiwakes (*Rissa tridactyla*) wintering in the sub-arctic North Pacific (9320) |
| 10:20 | *Coffee/Tea Break* |
| 10:50<br>W1-O4 | **William J. Sydeman, Sarah Ann Thompson, Julie A. Thayer, Mike Litzow, Marisol Garcia-Reyes, Jarrod A. Santora, Heather Renner, John F. Piatt and Yutaka Watanuki (Invited)**<br>Challenges and opportunities for assessment and attribution of climate change impacts on North Pacific seabirds (9375) |

| | |
|---|---|
| 11:20<br>W1-O5 | **Takashi Yamamoto, Akinori Takahashi, Katsufumi Sato, Nariko Oka and Yutaka Watanuki**<br>Spatial utilization of streaked shearwaters in the Northwestern Pacific (9382) |
| 11:40<br>W1-O6 | **Robert M. Suryan, Amanda J. Gladics, Julia K. Parrish, Elizabeth A. Daly and William T. Peterson**<br>Diet composition and isotopic signatures of sentinel species as indicators of climate change (9370) |
| 12:00<br>W1-O7 | **Chandra Goetsch, Melinda Conners, Yoko Mitani, William Walker, Samantha E. Simmons, Colleen Reichmuth, Suzanne Budge and Daniel P. Costa**<br>Climate variability is linked to diet switching in a marine predator, the northern elephant seal (*Mirounga angustirostrus*) (9316) |
| 12:20 | *Lunch* |
| 14:00<br>W1-O8 | **Jeffrey Polovina, Jason Baker, George Balazs and Denise Parker (Invited)**<br>Loggerhead sea turtles and Hawaiian monk seals as sentinels of climate change in the central North Pacific (9286) |
| 14:30<br>W1-O9 | **Kevin Weng, Gen Del Raye, Christina Comfort, Gadea Pérez-Andújar and Danielle Garcia (Invited)**<br>Fish futures: Observation, adaptation and response to climate change (9395) |
| 15:00<br>W1-O10 | **Briana H. Witteveen, Kate M. Wynne and Lei Guo**<br>Whales as sentinels in a changing marine environment in the Gulf of Alaska (9285) |
| 15:20 | *Coffee/Tea Break* |
| 15:40 | **Kathy Kuletz**<br>Introduction to program: US Fish and Wildlife surveys of birds and mammals at sea in the Gulf of Alaska and Eastern Bering Sea. |
| 15:50 | *Discussion* |
| 18:00 | Workshop Ends |

# Monday, April 14 - W2

## Workshop 2 (W2)

### Bridging the divide between models and decision-making: The role of uncertainty in the uptake of forecasts by decision makers

***Co-Convenors:***
*Hal Batchelder (PICES Secretariat)*
*Kai M.A. Chan (Canada)*
*Edward J. Gregr (Canada)*
*Shin-ichi Ito (Japan)*
*Vladimir Kulik (Russia)*
*Naesun Park (Korea)*
*Ian Perry (Canada)*
*Jameal Samhouri (USA)*
*Motomitsu Takahashi (Japan)*

***Invited Speakers:***
*Georgina A. Gibson (International Arctic Research Center, University of Alaska Fairbanks, USA)*
*Lee Failing (Compass Resource Management Ltd., Canada)*

Uncertainty is a key theme of the FUTURE program. Scientific uncertainty extends beyond the outputs of oceanographic or ecosystem models and has significant consequences on human dimensions ranging from public and stakeholder perception to tactical and strategic decision making by managers and policy makers. The workshop will consider uncertainty along the entire path from data, through model design and implementation to communication and uptake of results by decision makers. Such end-to-end consideration of uncertainty is critical to improve the uptake of oceanographic model results by stakeholders and decision makers in all PICES member countries, particularly as the modeling community moves towards end-to-end models, and faces the challenges of managing multiple stressors. This workshop will thus bridge two central themes of the FUTURE Open Science Meeting: quantification and measurement of uncertainty in observations and projects, and communication and engagement in the development and dissemination of FUTURE products.

The workshop will be centered on two themes. The first of them concerns input data, model structure, and parameterization, and will focus on how sources of uncertainty can be articulated and presented on a technical level. This theme challenges the modeling community to explain the credibility of their results, articulate their assumptions, and generally expose sources of uncertainty. Models of any topic including stock assessment, ecosystem dynamics, and cumulative effects are welcome.

The second theme will consider decision analysis and decision making, including psychological insights into how people perceive, understand, and incorporate complex information into decision-making. Discussions will focus on: (1) how FUTURE can best articulate uncertainty assessments, and develop a communication strategy to broaden the engagement of the public, communities, decision makers and other stakeholders in the results emerging from FUTURE; and (2) how FUTURE products can link to coastal communities, with an emphasis on how and to what degree these products are relevant to the communities whose decisions they presume to affect. This includes the fundamental challenge of how to scale FUTURE scientific outputs with impacts on human dimensions, generally considered at more local extents. This theme in particular will consider approaches to communicate the value of FUTURE products beyond the natural science community. Potential topics of additional discussion include outreach to other disciplines (e.g., psychologists and anthropologists) with the intent of developing more insightful and applicable inter-disciplinary outputs and strategies for presenting FUTURE products to the broader, international stakeholder community.

From this workshop, we plan a primary publication outlining how FUTURE products can be effectively communicated to the intended audiences.

**Monday, April 14 (08:45-12:00)**

| | |
|---|---|
| 08:45 | *Introduction by Workshop Convenors* |
| 09:00<br>W2-O1 | **Edward J. Gregr and Kai M.A. Chan**<br>Uncertainty from observations to decision-making: What we know, what we assume, and what matters (9341) |
| 09:20<br>W2-O2 | **Georgina A. Gibson (Invited)**<br>Ecosystem modeling predictions – How reliable are they? (9346) |
| 10:00<br>W2-O3 | **William T. Peterson**<br>Modelers: Know thy fish (9403) |
| 10:20<br>W2-O4 | **Shin-ichi Ito, Takeshi Okunishi, Michio J. Kishi and Muyin Wang**<br>Uncertainty of fish growth projection caused by uncertainty of physical forcing (9401) |
| 10:40 | *Coffee/Tea Break* |
| 11:00<br>W2-O5 | **Rowenna Gryba and Edward J. Gregr**<br>Evaluation of predictive habitat suitability: Using contemporary sightings and prey data to assess model assumptions (9335) |
| 11:20 | Plenary discussion - Objectives for Joint Session |
| 11:30 | Joint Session with W3 |
| 12:30 | *Lunch* |
| 13:30<br>W2-O6 | **Kai M.A. Chan and Edward J. Gregr**<br>The problem isn't uncertainty, but its monotypic treatment (9342) |
| 13:50<br>W2-O7 | **Lee Failing (Invited)**<br>How decision science can improve the relevance of oceanographic research to managers and stakeholders (9377) |
| 14:30 | Plenary Discussion |
| 15:30 | *Coffee/Tea Break* |
| 16:00 | Risk Panel |
| 17:00 | Next Steps |
| 18:00 | Workshop Ends |

# Monday, April 14 - W3

## Workshop 3 (W3)

### Climate change and ecosystem-based management of living marine resources: Appraising and advancing key modelling tools

***Co-Convenors:***
*Timothy E. Essington (USA)*
*Anne B. Hollowed (USA)*
*Myron A. Peck (Germany)*

***Invited Speakers:***
*J. Icarus Allen (Plymouth Marine Laboratory, UK)*
*Elizabeth A. Fulton (CSIRO, Australia)*

Climate variability and climate change interact with other pressures to affect the productivity and dynamics of marine ecosystems. Managers charged with the stewardship of sustainable living marine resources are challenged to deal with consequences of this variability, and better tools are needed to inform them. Process-oriented research on climate-driven changes in ecosystem dynamics is occurring at the same time that new ecosystem-related tactics to manage species interactions (time/area restrictions-marine spatial planning) and maximum retention allowances (bycatch restrictions) are being explored. These new management tactics, if applied broadly, suggest that international agreements regarding straddling and shared fish stocks and highly migratory species need to be re-visited.

This workshop is organized by the ICES-PICES Strategic Initiative (Section) on the Impacts of Climate Change on Marine Ecosystems (SICCME) to discuss state-of-the-art tools for: (1) calculating biological reference points under changing climate conditions that recognize that equilibrium states no longer apply; (2) assessing the relative ecological and economic costs and tradeoffs of different ecosystem-based management scenarios, and (3) estimating the vulnerability and stability of ecosystems (and their key components) required to make informed, ecosystem-based fisheries management.

The workshop is intended to provide a critical review of modelling tools available for fisheries management needs and to understand what advancements are required to address climate-driven changes in ecosystem dynamics. These goals will be facilitated by inviting fisheries managers as well as members of the ICES Working Group on Integrative, Physical-biological and Ecosystem Modelling (WGIPEM) and PICES modelling expert groups. All issues will be discussed in light of the upcoming release of IPCC's synthesis of impacts on marine ecosystems. A "Dahlem-type" format will require the convenors to pre-define workshop questions and direct participants to background reading material. After a morning of selected short presentations on management needs and modelling tools, break-out groups will discuss a set of pre-determined questions. A plenary discussion will synthesize group discussions leading to the next steps required to deliver specific outputs (one or more review papers to be published in a peer-reviewed journal).

**Monday, April 14 (09:00-15:10)**

| | |
|---|---|
| 09:00 | *Introduction by Workshop Convenors* |
| 09:10<br>W3-O1 | **J. Icarus Allen, Y. Artioli, J. Blackford, J. Bruggeman, L. Polimene and S. Sailley (Invited)**<br>Towards a next generation marine ecosystem model (9407) |
| 09:40<br>W3-O2 | **Elizabeth A. Fulton, P. Johnson and R. Gorton (Invited)**<br>Modelling change (9384) |
| 10:10<br>W3-O3 | **Alan C. Haynie**<br>FishSET: A spatial economics toolbox to better incorporate fisher behavior into fisheries management and ecosystem modeling (9336) |
| 10:30 | *Coffee/Tea Break* |
| 11:00<br>W3-O4 | **Myron A. Peck, Erik Buisman, Momme Butenschön, Jose A. Fernandes, Marc Hufnagl, Miranda C. Jones, Alexander Kempf, John K. Pinnegar, Ana Queiros, Sébastien Rochette, Sarah Simons, Lorna R. Teal and Morgan Travers-Trolet**<br>Current status of integrated bio-physical, economic modeling approaches examining fish stocks in the North Sea: Some results from the EU VECTORS program (9390) |
| 11:20 | Joint Session with W2 |
| 12:30 | *Lunch* |
| 14:00 | Open Discussion |
| 15:10 | Workshop Ends |

# Monday, April 14 - W4

## Workshop 4 (W4) - Day 2

### Ecosystem projection model inter-comparison and assessment of climate change impacts on global fish and fisheries

***Co-Convenors:***
*Anne B. Hollowed (USA)*
*Kirstin Holsman (USA)*
*Kerim Aydin (USA)*

This workshop will assemble an international team of modeling experts in order to: (1) identify the optimal means of combining global earth system models (ESMs), high resolution regional modeling frameworks, and ecosystem models of varying complexity to provide robust assessments of climate-change impacts on marine ecosystems and fisheries, and (2) coordinate international efforts to assess biological and societal impacts of climate-driven changes to future marine resources.

These experts will discuss the options for interfacing fisheries and ecosystem models with next generation of ESMs. Discussion topics will include: 1) identification of candidate ESMs for use in regional models based on a common set of the most recent IPCC projections, 2) quality and spatial resolution of phytoplankton and zooplankton output from ESMs; 3) identification of which marine ecosystems require dynamic downscaling to address regional ocean processes; and 4) strengths and weakness of simplifying assumptions for higher trophic level projection. Following the workshop, participants will conduct paired simulations using agreed upon climate scenarios and model structures to project climate-driven changes to marine ecosystems. Results will be presented and analyzed at the 3rd PICES/ICES/IOC Symposium on "*Effects of climate change on the world's oceans*" to be held in March 2015, in Santos, Brazil.

**Mondy, April 14 (15:30-18:00)**

| | |
|---|---|
| 15:30 | *Coffee/Tea Break* |
| 15:50 | **Discussion**<br>Elements of a model inter-comparison experiment |
| 18:00 | Workshop Ends |

# Tuesday, April 15 - Plenary

## Plenary Session

| | |
|---|---|
| 09:00 | Opening Remarks |
| 09:15 | **Sinjae Yoo**<br>(*Korea Institute of Science and Technology, Korea*)<br>Overview of PICES FUTURE Program |
| 09:45 | Introduction of Theme Session S1 |
| 10:00 | **Isabelle Rombouts and Grégory Beaugrand**<br>(*Plenary Speaker for S1, Université de Lille, France*)<br>Integrative approaches to assess marine ecosystem health |
| 10:30 | *Coffee/Tea Break* |
| 10:50 | Introduction of Theme Session S2 |
| 11:05 | **Michael Foreman, Wendy Callendar, Diane Masson, John Morrison and Isaak Fain**<br>(*Plenary Speaker for S2, Institute of Ocean Sciences, Department of Fisheries and Oceans, Canada*)<br>Regional ocean climate model projections and their ecosystem implications for British Columbia |
| 11:35 | Introduction of Theme Session S3 |
| 11:50 | **William T. Peterson, Jay Peterson, Jennifer Fisher, Cheryl Morgan and Brian Burke**<br>(*Plenary Speaker for S3, Hatfield Marine Science Center, NOAA-Fisheries, USA*)<br>Challenges in communicating science and engaging the public – A case study from the northern California Current |
| 12:20 | *Lunch* |

# Tuesday, April 15 - S1

## Session 1 (S1) - Day 1

### Identifying multiple pressures and system responses in North Pacific marine ecosystems

***Co-Convenors:***
*Vladimir Kulik (Russia)*
*Rebecca Martone (USA)*
*Ian Perry (Canada)*
*Jameal Samhouri (USA)*
*Motomitsu Takahashi (Japan)*

***Plenary Speaker:***
*Isabelle Rombouts (Université de Lille, France)*

Coastal and offshore marine ecosystems of the North Pacific are impacted by increasing temperature, changing iron supply, harmful algal bloom events, invasive species, hypoxia/eutrophication and ocean acidification. These multiple pressures can act synergistically to change ecosystem structure, function and dynamics in unexpected ways that differ from single pressure responses. It is also likely that pressures and responses will vary geographically. A key objective of the FUTURE program is to identify and characterize these pressures in order to facilitate comparative studies of North Pacific ecosystem responses to multiple stressors and how these systems might change in the future.

This session has two primary objectives: 1) to identify key stressors and pressures on North Pacific marine ecosystems, and to compare how these stressors/pressures may differ in importance in different systems and how they may be changing in time; and 2) to identify ecosystem responses to these multiple stressors and pressures, including gaining an understanding of how natural and human perturbations may cascade through ecosystems, and whether there may be amplifiers or buffers which modify the effects of perturbations on marine systems. Papers using conceptual, model-based, observation-based, or experimental-based approaches are welcome, as well as papers which evaluate approaches to linking pressures to ecosystem changes, such as pathways of effects or driver-pressure-state-impact-response models. The overall goal of this session is to obtain an overview of the pressures being experienced by North Pacific marine ecosystems, how these pressures may be changing with time, variation in these pressures (both singly and in combination) among regions, and the combined effects of pressures, both now and in the future, on the marine ecosystems of the North Pacific.

**Tuesday, April 15 (14:00-17:10)**

| | |
|---|---|
| 14:00<br>S1-O1 | **Jameal Samhouri, A.O. Shelton, B. Feist, G. Williams, K. Bartz, M. Sheer and P. Levin**<br>How much city is too much city? Diversity and ecosystem functions along an urban gradient in Puget Sound (9358) |
| 14:20<br>S1-O2 | **R. Ian Perry, Motomitsu Takahashi, Jameal Samhouri, Chang-Ik Zhang, Rebecca Martone, Jennifer Boldt, Baisong Chen and Stephani Zador**<br>Multiple interacting natural pressures and human activities in North Pacific marine ecosystems (9307) |
| 14:40<br>S1-O3 | **Jennifer Boldt, Ik Kyo Chung, Sachihiko Itoh, Rebecca Martone, Ian Perry, Jameal Samhouri and Naoki Yoshie**<br>Development of ecosystem indicators to characterize ecosystem responses to multiple stressors (9302) |
| 15:00<br>S1-O4 | **Stephani Zador and Heather Renner**<br>Red flags or red herrings revisited: Using ecosystem indicators to track ecosystem status in the Gulf of Alaska (9321) |

15:20 **Cathryn Clarke Murray, Selina Agbayani and Natalie Ban**
S1-O5 Current and future cumulative effects of human activities on the Northeast Pacific with climate change and industrial development (9306)

15:40 *Coffee / Tea Break*

16:00 **Rebecca Martone, Erin T.H. Crockett, Allison Thompson and Kai M.A. Chan**
S1-O6 Linking pathways of effects to assess cumulative impacts on ecosystem services: Modeling effects of nutrient run-off on shellfish aquaculture in British Columbia, Canada (9300)

16:20 **Sukgeun Jung**
S1-O7 Fishing *vs.* climate change: An example of filefish (*Thamnaconus modestus*) in the northern East China Sea (9406)

16:40 **Jeffrey Polovina and Phoebe Woodworth-Jefcoats**
S1-O8 Projected responses of the central North Pacific subtropical ecosystem to future pressures of fishing and climate change (9297)

17:00 *Discussion*

17:10 Day 1 Session Ends

## Posters

S1-P1 **Kristin Cieciel and Edward Farley, Jr.**
Changes in jellyfish (*Chrysaora melanaster*) biomass and distribution in response to anomalous climate shifts in the Bering Sea (9349)

S1-P2 **Xinfeng Dai, Douding Lu, Weibing Guan, Hongxia Wang and Piaoxia He**
Newly recorded *Karlodinium veneficum dinofalgellate* blooms in stratified water of the East China Sea (9310)

S1-P3 **Matthew R. Baker and Anne B. Hollowed**
Influence of environmental thresholds on species interactions and ecosystem structure in Northeast Pacific systems (9355)

# Tuesday, April 15 - S2

## Session 2 (S2)

### Regional climate modeling in the North Pacific

***Co-Convenors:***
*Enrique Curchitser (USA)*
*Chan Joo Jang (Korea)*

***Plenary Speaker:***
*Michael Foreman (Institute of Ocean Sciences, Department of Fisheries and Oceans, Canada)*

***Invited Speakers:***
*Arthur J. Miller (Scripps Institution of Oceanography, UCSD, USA)*
*Takashi Mochizuki (JAMSTEC, Japan)*

Regional climate models (RCMs) are vital tools for understanding changes in regional climate. They serve as a good starting point for many socio-economic impact and adaptation considerations to climate changes. Despite their limitations, including systematic errors in forcing fields supplied by global climate models, RCMs are the most promising means of providing information on regional climate changes, mainly through their ability to accommodate much higher spatial resolution. This session invites papers addressing RCM efforts including downscaling techniques, assessment of added values of RCMs in comparison with global climate models, identification and evaluation of regional climate changes in the North Pacific Ocean simulated from global climate models, assessment of RCM uncertainty, and coupling of RCMs to ecosystem models. The goal of the session is to assemble and access existing regional climate modeling efforts, providing a platform to discuss limitation and reliability of RCMs.

**Tuesday, April 15 (14:00-18:00)**

| | |
|---|---|
| 14:00<br>S2-O1 | **Arthur J. Miller, Dian Putrasahan and Hyodae Seo (Invited)**<br>Isolating mesoscale coupled ocean-atmosphere interactions in the Kuroshio Extension region (9373) |
| 14:25<br>S2-O2 | **Takashi Mochizuki, Masahiro Watanabe and Masahide Kimoto (Invited)**<br>Regional information in decadal climate prediction (9354) |
| 14:50<br>S2-O3 | **Enrique Curchitser, Justin Small, William Large, Kate Hedstrom and Brian Kaufman**<br>Downscaling climate simulations for boundary currents (9356) |
| 15:10<br>S2-O4 | **Fangli Qiao, Zhenya Song, Chuanjiang Huang, Changshui Xia and Dejun Dai**<br>How to improve the forecasting ability in the North Pacific? (9371) |
| 15:30 | *Coffee / Tea Break* |
| 15:50<br>S2-O5 | **Chan Joo Jang, Chul Min Ko and Chun Yong Jung**<br>Climate change projection for the western North Pacific: Dynamical downscaling (9334) |
| 16:10<br>S2-O6 | **Angelica Peña, Diane Masson and Michael Foreman**<br>A regional biogeochemical climate model for the British Columbia continental shelf (9379) |
| 16:30<br>S2-O7 | **Jerome Fiechter, Enrique Curchitser, Christopher Edwards, Fei Chai, Nicole Goebel and Francisco Chavez**<br>Impact of horizontal model resolution on air-sea $CO_2$ exchange in the California Current (9293) |
| 16:50<br>S2-O8 | **Francisco E. Werner, Enrique Curchitser, F. Castruccio, G. Hervieux and C. Stock**<br>Downscaled coupled bio-physical projections in the California Current Ecosystem (9357) |

17:10 S2-O9 **Albert J. Hermann, Georgina A. Gibson, Nicholas A. Bond, Enrique Curchitser, Kate Hedstrom, Wei Cheng, Muyin Wang and Phyllis J. Stabeno**
Multiple realizations of future biophysical states in the Bering Sea (9347)

17:30 *Discussion*

18:00 Session Ends

## Poster

S2-P1 **Qi Shu, Fangli Qiao and Zhenya Song**
A global 1/10° eddy-resolving ocean-ice coupled model

# Tuesday, April 15 - S3

## Session 3 (S3)

### Challenges in communicating science and engaging the public

***Co-Convenors:***
*Hal Batchelder (PICES Secretariat)*
*Robin Brown (Canada)*
*Shin-ichi Ito (Japan)*
*Oleg Katugin (Russia)*
*Phillip R. Mundy (USA)*
*William T. Peterson (USA)*
*Chang-Ik Zhang (Korea)*

***Plenary Speaker:***
*William T. Peterson (Hatfield Marine Science Center, NOAA-Fisheries, USA)*

***Invited Speaker:***
*Satoquo Seino (Kyushu University, Japan)*

Communicating scientific findings to the public has never been more important and challenging than in the present era of global climate change unfolding against the backdrop of rapidly accelerating human population growth. Engaging the public in factually based dialogs about environmental change and its impacts on the ecosystems on which we depend is increasingly challenging. The compelling existential nature of the discussion has attracted people of many different professions and cultures who speak a wide variety of mutually unintelligible jargons and many different national languages. As members of the international marine scientific community served by PICES, we are mindful that the first language of most participants is not English and that those from outside our area of specialization do not necessarily share our professional lexicon.

FUTURE is remarkable as a marine scientific program that explicitly addresses the area of public education and outreach within the broader scientific context of identifying major sources of uncertainty and impediments to improving the skill of assessments and forecasts, suggesting research areas for priority development, and providing coordination of potential PICES products through the FUTURE Advisory Panel on Status, Outlooks, Forecasts, and Engagement (SOFE).

Building on expertise and information in workshop (W2) that precedes the session, this session welcomes papers that address challenges presented by uncertainty in the uptake of forecasts by decision makers within the context of communication challenges presented by the diversity of disciplines and languages necessary to address global climate change. We encourage contributions or case study reports that illustrate effective ways of communicating outlooks/forecasts of climate change impacts to specific audiences/communities. The context of communication challenges presented by the diversity of disciplines and languages necessary to address global climate change established during the session will form the basis for setting priorities in FUTURE products.

**Tuesday, April 15 (14:00-18:00)**

| | |
|---|---|
| 14:00 | **Satoquo Seino (Invited)** |
| S3-O1 | Multi-sectoral collaboration through coastal policy evolution (9402) |
| 14:25 | **Nobuyuki Yagi, Kazumi Wakita, Yuhen Lu and Robert Blasiak** |
| S3-O2 | Heterogeneities in human utility of marine ecosystem services and behavioral intentions for marine conservation (9404) |
| 14:45 | **Ekaterina P. Kurilova** |
| S3-O3 | Challenges in communicating science and engaging public in Russia: Large country – different expectations (9408) |

15:05 **Shin-ichi Ito, and Harumi Yamada**
S3-O4 Oceanographic information needs of set net fishermen in the Pacific coast of northeastern Japan (9400)

15:25 *Coffee / Tea Break*

15:50 **Joseph A. Orsi and Phillip R. Mundy**
S3-O5 Challenges in communicating uncertainty of production and timing forecasts to salmon fishery managers and the public (9376)

16:10 **Eric C. Volk, William D. Templin, Christopher Habicht and Andrew R. Munro**
S3-O6 Effective engagement of stakeholders in designing and communicating science: The Western Alaska Salmon Stock Identification Program (9394)

16:30 **Steven J. Barbeaux and Jae Bong Lee**
S3-O7 Broadening stakeholder involvement in fisheries research through the development of cooperative research initiatives in Korean fisheries (9319)

16:50 **Chang-Ik Zhang, Young-Il Seo, Man-Woo Lee, Sang-Chul Yoon, Hee-Joong Kang and Eun-Ji Lee**
S3-O8 Status of IFRAME as an approach for EAF (9415)

17:10 *Discussion*

18:00 Session Ends

# Wednesday, April 16 - Plenary

## Plenary Session

| | |
|---|---|
| 09:00 | **Summaries of Theme Sessions S1, S2, and S3** |
| 09:45 | Introduction of Theme Session S4 |
| 10:00 | **Deborah K. Steinberg**<br>(*Plenary Speaker for S4, Virginia Institute of Marine Science, USA*)<br>Ecosystem comparison of trends in zooplankton community structure and role in biogeochemical cycling |
| 10:30 | *Coffee/Tea Break* |
| 10:50 | Introduction of Theme Session S5 |
| 11:05 | **Mat Collins**<br>(*Plenary Speaker for S5, University of Exeter, UK*)<br>Long term climate change: Projections, commitment and irreversibility |
| 11:35 | Introduction of Theme Session S6 |
| 11:50 | **Elizabeth A. Fulton**<br>(*Plenary Speaker for S6, CSIRO, Australia*)<br>Exactly how resilient are ecosystems? |
| 12:20 | *Lunch* |

# Wednesday, April 16 - S1

## Session 1 (S1) - Day 2

### Identifying multiple pressures and system responses in North Pacific marine ecosystems

***Co-Convenors:***
*Vladimir Kulik (Russia)*
*Rebecca Martone (USA)*
*Ian Perry (Canada)*
*Jameal Samhouri (USA)*
*Motomitsu Takahashi (Japan)*

***Plenary Speaker:***
*Isabelle Rombouts (Université de Lille, France)*

Coastal and offshore marine ecosystems of the North Pacific are impacted by increasing temperature, changing iron supply, harmful algal bloom events, invasive species, hypoxia/eutrophication and ocean acidification. These multiple pressures can act synergistically to change ecosystem structure, function and dynamics in unexpected ways that differ from single pressure responses. It is also likely that pressures and responses will vary geographically. A key objective of the FUTURE program is to identify and characterize these pressures in order to facilitate comparative studies of North Pacific ecosystem responses to multiple stressors and how these systems might change in the future.

This session has two primary objectives: 1) to identify key stressors and pressures on North Pacific marine ecosystems, and to compare how these stressors/pressures may differ in importance in different systems and how they may be changing in time; and 2) to identify ecosystem responses to these multiple stressors and pressures, including gaining an understanding of how natural and human perturbations may cascade through ecosystems, and whether there may be amplifiers or buffers which modify the effects of perturbations on marine systems. Papers using conceptual, model-based, observation-based, or experimental-based approaches are welcome, as well as papers which evaluate approaches to linking pressures to ecosystem changes, such as pathways of effects or driver-pressure-state-impact-response models. The overall goal of this session is to obtain an overview of the pressures being experienced by North Pacific marine ecosystems, how these pressures may be changing with time, variation in these pressures (both singly and in combination) among regions, and the combined effects of pressures, both now and in the future, on the marine ecosystems of the North Pacific.

**Wednesday, April 16 (14:00-16:40)**

| | |
|---|---|
| 14:00<br>S1-O9 | **Gen Del Raye and Kevin Weng**<br>Challenges for peak aerobic metabolism in the future oceans: The effect of multiple climate variables on exercise performance in a model teleost fish (9393) |
| 14:20<br>S1-O10 | **Motomitsu Takahashi, Sachihiko Itoh, Naoki Yoshie, Kazuhiko Mochida, Masakazu Hori, Shigeru Itakura and Mingyuan Zhu**<br>Ecosystem responses to anthropogenic activities and natural stressors among inland, shelf and oceanic waters in the western North Pacific (9383) |
| 14:40<br>S1-O11 | **Nam-Il Won, Min-Gyu Ji, Young-Teck Hur and Jin-Hyeog Park**<br>Freshwater input as multiple stressors on coastal ecosystems under a changing ocean: Implication of possible mitigation effect (9413) |
| 15:00<br>S1-O12 | **Vladimir Kulik**<br>Multiplicative effect of SST variation during spawning period and 1 year after on the catches of walleye pollock 5 years later in the waters off the northeastern part of Sakhalin Island (9327) |

15:20 *Coffee / Tea Break*

15:40 *Discussion*

16:40 Session Ends

## Posters

S1-P1 **Kristin Cieciel and Edward Farley, Jr.**
Changes in jellyfish (*Chrysaora melanaster*) biomass and distribution in response to anomalous climate shifts in the Bering Sea (9349)

S1-P2 **Xinfeng Dai, Douding Lu, Weibing Guan, Hongxia Wang and Piaoxia He**
Newly recorded *Karlodinium veneficum dinofalgellate* blooms in stratified water of the East China Sea (9310)

S1-P3 **Matthew R. Baker and Anne B. Hollowed**
Influence of environmental thresholds on species interactions and ecosystem structure in Northeast Pacific systems (9355)

# Wednesday, April 16 - S4

## Session 4 (S4)

### Ecosystem status, trends and forecasts

***Co-Convenors:***
*Hiroaki Saito (Japan)*
*Thomas Therriault (Canada)*

***Plenary Speaker:***
*Deborah K. Steinberg (Virginia Institute of Marine Science, USA)*

Marine ecosystems are constantly changing. Therefore, researchers need to develop and to communicate information on ecosystem status, trends, and forecasts to ensure that sound management and policy decisions are made for the benefit of the societies that depend on them. Ecosystem indicators are one way to communicate such information, but the selection of the most appropriate indicators can prove challenging, especially given increasingly complex array of audiences. It is likely that different indicators will be needed where the scale of ecosystem responses to different stressors must be reconciled with the scale of the perturbation (e.g., coastal versus oceanic). Forecast ecosystem change demands good understanding of how multiple stressors affect ecosystem structure and function. A key element of the FUTURE program is the ability to convey to diverse audiences, in each of the PICES member countries, ecosystem status, trends and forecasts. This session will explore current and proposed ecosystem status and trend indicators, including some already in use in the North Pacific Ecosystem Status Reports, and attempt to identify metrics required in support of ecosystem forecasts.

**Wednesday, April 16 (14:00-18:00)**

| | |
|---|---|
| 14:00<br>S4-O1 | **Sanae Chiba, Sayaka Yasunaka, Tomoko Yoshiki, Hiroya Sugisaki, Sonia Batten and Tadafumi Ichikawa**<br>Oceanic currents dynamics and zooplankton diversity in the Kuroshio-Oyashio-Extension (KOE) Region (9324) |
| 14:20<br>S4-O2 | **Sonia Batten**<br>Lower trophic level ecosystem indicators from CPR data (9296) |
| 14:40<br>S4-O3 | **Douding Lu and Xinfeng Dai**<br>Evolvement of HAB causative species and possible links during the past five decades in Chinese coastal waters (9317) |
| 15:00<br>S4-O4 | **Ichiro Imai, Masafumi Natsuike, Keigo Yamamoto, Tetsuya Nishikawa and Satoshi Nagai**<br>Long-term trends of red tides by eutrophication and toxic blooms by oligotrophication in the Seto Inland Sea of Japan (9412) |
| 15:20 | *Coffee / Tea Break* |
| 15:40<br>S4-O5 | **Jon Brodziak and Marc Mangel**<br>Understanding ecosystem productivity and predicting population resilience via steepness (9353) |
| 16:00<br>S4-O6 | **Haruka Nishikawa, Yoichi Ishikawa, Shiro Nishikawa and Toshiyuki Awaji**<br>Possible effects of global warming on the neon flying squid winter-spring cohort (9298) |
| 16:20<br>S4-O7 | **Yongjun Tian, Xuhui Xie, Kazuhisa Uchikawa, Jürgen Alheit, Jiahua Cheng and Akira Tomosada**<br>Regime shifts in the fish assemblages around Japan over the last century and their early warning signals (9352) |

| | |
|---|---|
| 16:40 | **Hiroaki Saito** |
| S4-O8 | Wind off Hawaii and fisheries in Japan: Expected benefit from marine science to society (9378) |
| 17:00 | *Discussion* |
| 18:00 | Session Ends |

## Poster

| | |
|---|---|
| S4-P1 | **Jung Jin Kim, Suam Kim Lee Joon-soo Hong Sik Min and Cheol-Ho Kim**<br>Prediction of the spawning ground of *Todarodes pacificus* under IPCC climate A1B scenario |

# Wednesday, April 16 - S5

## Session 5 (S5)

### Mechanisms of change: Processes behind climate variability in the North Pacific

***Co-Convenors:***
*Emanuele Di Lorenzo (USA)*
*Michael Foreman (Canada)*
*Shoshiro Minobe (Japan)*

***Plenary Speaker:***
*Mat Collins (University of Exeter, UK)*

***Invited Speakers:***
*Taka Ito (Georgia Institute of Technology , USA)*
*Nathan J. Mantua (Southwest Fisheries Science Center, NOAA-Fisheries, USA)*

In recent years, much progress has been made in our understanding of the large-scale physical dynamics of Pacific climate variability and change. New modes of ocean and atmospheric variability over the Pacific have been recognized and shown to influence ecosystem processes. The impact that these modes have on marine biophysical interactions in upwelling systems has also become a research focus under a new collaboration between CLIVAR and IMBER, to which PICES is contributing. Diagnosing the mechanisms underlying the statistical correlations between the physical forcing and the ecosystem response strongly relies on our ability to model and synthesize the processes controlling the variability in the climate system, and unveiling the dominant set of physical controls on marine ecosystem dynamics. This synthesis activity is a core component of FUTURE and involves developing low-order (e.g., low number of dimensions) process-models of the climate system, which reduce the complex processes to their most basic and dominant mechanics. Process-models such as these can be used statistically to provide uncertainty estimates of decadal variability in recent historical climate and ecosystem time series, and to provide improved metrics to test the mechanisms of climate variability and change in IPCC models.

This session invites contributions that combine model and observational methods to provide syntheses of the mechanisms controlling North Pacific climate variability, and that show how these improved syntheses enable better diagnosing and predicting of the dynamics of Pacific climate and of the marine ecosystem responses to climate forcing. We also welcome contributions that explore new mechanisms of physical-biological linkages that can only be partially tested with currently available observations, yet provide the theoretical foundation to understand the dynamics of Pacific climate variability and its impact on marine populations, and develop new observational programs. During the session there will be discussion time where the contributors will be asked to participate in developing a synthesis paper on North Pacific climate variability as part of the PICES WG27 activities (http://wg27.pices.int).

**Wednesday, April 16 (14:00-18:45)**

| | |
|---|---|
| 14:00 | **James A. Johnstone and Nathan J. Mantua (Invited)** |
| S5-O1 | Causes and consequences of NE Pacific climate trends and variations from 1900-2012 (9367) |
| 14:25 | **Matthew Newman, Michael A. Alexander and Dimitry Smirnov** |
| S5-O2 | The Pacific Decadal Oscillation, Revisited (9396) |
| 14:45 | **Bo Qiu, Shuiming Chen, Niklas Schneider and Bunmei Taguchi** |
| S5-O3 | A coupled decadal prediction of the Kuroshio Extension system (9381) |
| 15:05 | **Niklas Schneider and Bunmei Taguchi** |
| S5-O4 | The role of spiciness in North Pacific decadal variability (9386) |

15:25 S5-O5 **Andrey Krovnin, Boris Kotenev and George Moury**
Role of North Atlantic climatic variability in recent North Pacific warming (9299)

15:45 *Coffee / Tea Break*

16:00 S5-O6 **Shoshiro Minobe, Curtis Deutsch, Yutaka Hosoya and Hartmut Frenzel**
Secular nutrient changes in observation and numerical modeling in the western North Pacific in the last 50-years (9387)

16:20 S5-O7 **Takamitsu Ito, Yohei Takano, Curtis Deutsch and Athanasios Nenes (Invited)**
Changing oxygen content of the Pacific basin: Anthropogenic trend or natural variability? (9315)

16:45 S5-O8 **Sung Yong Kim and Bruce Cornuelle**
A description of T/S and oxygen variability off southern California using regional- and global-scale climate indices (9283)

17:05 S5-O9 **Mercedes Pozo Buil, Emanuele Di Lorenzo and Steven J. Bograd**
Decadal prediction of hypoxia along the US West Coast (9389)

17:25 S5-O10 **Arthur J. Miller, Hajoon Song and Aneesh Subramanian**
The physical oceanographic environment of the southern California Current during past decade: Changes in climate and concepts (9374)

17:45 S5-O11 **Shin-ichi Ito, Sohsuke Ohno, Takeshi Okunishi, Satoshi Suyama, Masayasu Nakagami Daisuke Ambe and Takahiko Kameda**
A challenge to investigate environmental factors which determine spawning migration variability of small pelagic: An example of Pacific saury (9332)

18:05 S5-O12 **Sukgeun Jung**
Asynchronous responses of fish assemblages to climate-driven ocean regime shifts between the upper and deep layer in the Ulleung Basin of the East Sea from 1986 to 2010 (9405)

18:25 *Discussion*

18:45 Session Ends

## Poster

S5-P1 **Jingsong Guo, Liping Yin, Yeli Yuan and Binghuo Guo**
Formation mechanism of the Kuroshio Loop Current

# Wednesday, April 16 - S6

## Session 6 (S6)

### Ecosystem resilience and vulnerability

***Co-Convenors:***
*Thomas Therriault (Canada)*

***Plenary Speaker:***
*Elizabeth A. Fulton (CSIRO, Australia)*

Marine ecosystems around the globe are affected by a number of natural and anthropogenic stressors. The interactions among stressors are incredibly complex and proving difficult to understand. Ultimately, these stressors will change ecosystem structure and function. This can lead to changes in ecosystem stability and productivity, and impact the societies that depend on them. One of the central themes of the FUTURE Science Plan focuses on ecosystem resiliency and vulnerability to natural and anthropogenic stressors and poses the question how ecosystems around the North Pacific might change in the future. Thus, the ability to understand how resilient marine ecosystems are and to characterize the degree to which ecosystems are vulnerable to change via multiple stressors is critical to advancing the FUTURE program. This session will explore all aspects of ecosystem resilience and vulnerability, including ways to identify and characterize it.

**No contributed papers**

# Thursday, April 17 - Plenary

## Plenary Session

| | |
|---|---|
| 09:00 | **Summaries of Theme Sessions S4, S5, and S6** |
| 09:45 | Introduction of Theme Session S7 |
| 10:00 | **Scott Large on behalf of Jason S. Link**<br>(*Plenary Speaker for S7, NOAA-Fisheries, USA*)<br>Solutions for marine ecosystem-based management in a changing climate |
| 10:30 | *Coffee/Tea Break* |
| 10:50 | Introduction of Theme Session S8 |
| 11:05 | **Jake Rice**<br>(*Plenary Speaker for S8, Department of Fisheries and Oceans, Canada*)<br>Adaptation to climate change requires resilience in governance as well as ecosystems |
| 11:35 | **Summaries of Workshops W1, W2, and W3** |
| 12:20 | *Lunch* |

# Thursday, April 17 - S7

## Session 7 (S7)

### Strategies for ecosystem management in a changing climate

***Co-Convenors:***
*Manuel Barange (UK)*
*Anne B. Hollowed (USA)*
*Suam Kim (Korea)*

***Plenary Speaker:***
*Scott Large on behalf of Jason S. Link (NOAA-Fisheries, USA)*

This session will explore the complex issue of implementing an ecosystem approach to management under changing climate conditions. Climate change is expected to impact the distribution and abundance of fish and shellfish through direct and indirect pathways. The temporal signature of these changes will be dominated by long term trends and thus may necessitate new approaches to setting biological reference points for single species management. Projection models indicate that climate change will affect the distribution and/or abundance of particular species, which in-turn would alter the structure and function of the system. New approaches may be needed to address the complex issues of defining biological and ecosystem reference points under uncertain future states of nature. For fished stocks that are projected to decline under changing climate conditions, it is unclear when or if additional precautionary approaches would sustain the populations or the fishery that depends on them. This session seeks papers that: 1) explore implementations of an ecosystem approach to management under projected climate change, 2) propose techniques that identify how uncertainty in climate and biological responses can be incorporated into biological or ecosystem reference points, 3) evaluate the performance of proposed strategies under changing climate, and 4) define the precautionary approach under changing climate.

**Thursday, April 17 (14:00-18:30)**

| | |
|---|---|
| 14:00<br>S7-O1 | **Samuel Pooley**<br>Distributed governance of marine ecosystems (9309) |
| 14:20<br>S7-O2 | **Jake Rice**<br>What information is really needed to inform adaptation strategies to climate change (9414) |
| 14:40<br>S7-O3 | **Manuel Barange, J. Scholtens, E.H. Allison, G. Merino, J.L. Blanchard, J. Harle, J. Icarus Allen, J. Holt and S. Jennings**<br>So what? How will climate change impacts on fisheries production differentially affect fisheries dependent communities (9410) |
| 15:00<br>S7-O4 | **Paul D. Spencer, Nicholas A. Bond, Anne B. Hollowed, Stephani Zador, Kirstin Holsman and Franz J. Mueter**<br>Projected spatial distributions of eastern Bering Sea arrowtooth flounder under simulated climate scenarios, and their potential impact on predation and stock dynamics of walleye pollock (9301) |
| 15:20<br>S7-O5 | **Kirstin Holsman, Kerim Aydin, Jim Ianelli and André E. Punt**<br>Using multi-species models to evaluate climate and trophic impacts on recommended harvest rates of groundfish in the Bering Sea (AK) (9304) |
| 15:40 | *Coffee / Tea Break* |
| 16:00<br>S7-O6 | **Jacquelynne R. King, Gordon A. McFarlane and André E. Punt**<br>Shifts in fisheries management: Adapting to regime shifts (9366) |

16:20 S7-O7 **Kerim Aydin, Ivonne Ortiz, Albert J. Hermann, Georgina A. Gibson and André E. Punt**
Evaluating long-term climate predictions for the Bering Sea ecosystem using a suite of modeling approaches (9345)

16:40 S7-O8 **Nicholas A. Bond, Sukyung Kang, Jae Bong Lee and Anne B. Hollowed**
Projections of chub mackerel recruitment for incorporation in stock assessment models (9409)

17:00 S7-O9 **Timothy E. Essington, Megan Stachura, Christine Stawitz, Trevor Branch, Melissa Haltuch, Anne B. Hollowed, Nathan J. Mantua and Paul D. Spencer**
Challenges and opportunities for understanding environmental controls on stock productivity: Insights from a meta-analysis of the Northeast pacific (9380)

17:20 S7-O10 **Anne B. Hollowed and Cody Szuwalski**
Setting biological reference points under a changing climate (9329)

17:40 S7-O11 **Maria Rebecca A. Campos**
Economics of adaptation to climate change of sea cucumber fishers in the Philippines (9225)

18:00 *Discussion*

18:30 Session Ends

## Poster

S7-P1 **Aina Wu and Fan Jiang**
Arctic climate change and Arctic standardization

# Thursday, April 17 - S8

## Session 8 (S8)

### Human dimension indicators of the status of the North Pacific ecosystem

***Co-Convenors:***
*Keith R. Criddle (USA)*
*Mitsutaku Makino (Japan)*

***Plenary Speaker:***
*Jake Rice (Department of Fisheries and Oceans, Canada)*

***Invited Speaker:***
*Patrick Christie (University of Washington, USA)*

Forecasting and understanding trends, uncertainty and responses of the North Pacific ecosystem requires an understanding anthropogenic pressures on marine ecosystems, the impacts of ecosystem change on dependent human populations, and social strategies to cope with those changes. This session will present human dimension indicators that have been created or assembled for the next North Pacific Ecosystem Status Report (NPESR). The session will be composed of invited and contributed papers that elucidate commonalities and differences in regional trends of these indicators and their spatio-temporal linkages to ecosystem status indicators and to human well-being.

**Thursday, April 17 (14:20-17:30)**

| | |
|---|---|
| 14:20<br>S8-O1 | **Ron Felthoven, Amber Himes and Stephen Kasperski**<br>Fishing community resilience and vulnerability to changing ecosystems (9362) |
| 14:40<br>S8-O2 | **Kristy Wallmo and Rosemary Kosaka**<br>Marine protected area designations off the U.S. west coast: Mixed-use designs to optimize public economic value (9338) |
| 15:00<br>S8-O3 | **Minling Pan**<br>The linkages between the economic performance indicators and ecosystem status indicators (9322) |
| 15:20<br>S8-O4 | **Patrick Christie and Richard Pollnac (Invited)**<br>Human dimensions research to improve science networks and marine resource management effectiveness (9417) |
| 15:40 | *Coffee / Tea Break* |
| 16:00<br>S8-O5 | **Keith R. Criddle and Mitsutaku Makino**<br>Preliminary analysis of trends in time series observations of human dimension indicator data for the North Pacific ecosystem (9391) |
| 16:20<br>S8-O6 | **Masahito Hirota**<br>A review of the human dimension indicators in the NPESR of Japan (9398) |
| 16:40<br>S8-O7 | **Keith R. Criddle**<br>A review of similarities and differences in fisheries regulatory frameworks across the PICES region (9364) |
| 17:00 | *Discussion* |
| 17:30 | Session Ends |

# Abstracts

# Plenary Session Presentations

# April 15

**April 15, 10:00, Plenary S1**

## Integrative approaches to assess marine ecosystem health

Isabelle **Rombouts** and Grégory Beaugrand

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Assessments of ecosystem health are often based upon individual indicators that measure unique responses to a particular disturbance, such as fishing or pollution. Natural systems usually experience a wide set of interacting stressors, including climate change, however, leading to synergistic and/or additive effects that may be difficult to appreciate. The challenge for ecosystem management therefore, is to identify and quantify these effects so that appropriate and effective management actions can be implemented. This objective can be achieved by combining several attributes, for example diversity and energy flow, that consider important structural and functional aspects of the ecosystem, yet providing an ecosystem-based approach. Taking those biological attributes together with environmental indicators will deliver joint information on the potential sources of pressures and their interactions. Promising approaches with respect to analytical tools include state-space based models that can track changes in ecosystem condition across several dimensions and relate ecosystem responses to changes in pressures. The presentation will use several case studies to exemplify the state-space as well as other integrative approaches and future prospects for their methodological development will be discussed.

**April 15, 11:05, Plenary S2**

## Regional ocean climate model projections and their ecosystem implications for British Columbia

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

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

**April 15, 11:50, Plenary S3**

## Challenges in communicating science and engaging the public – A case study from the northern California Current

William T. **Peterson**[1], Jay Peterson[2], Jennifer Fisher[2], Cheryl Morgan[2] and Brian Burke[3]

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We are contributing to salmon management by studying them during the ocean phase of their life history and through long-term observations of hydrography, zooplankton, a program now in its 19th year. Outlooks have been developed of salmon returns based on analysis of a suite of physical, biological and ecological indicators of ocean conditions that operate during a young salmon's first summer at sea. We make qualitative forecasts of coho and spring Chinook salmon returns (good, fair, or poor returns) and quantitative forecasts (based on PCA and MCA analysis); returns are best predicted by ecological indicators such as biomass anomalies of northern lipid-rich copepods, growth rates of juv. salmon, and catches of juveniles during trawl surveys. Communication of results is through a website and e-mail list-serve. A "stoplight chart" is a qualitative visual aid that illustrates how changes in the PDO and the food web result in differences in salmon returns. Communication through oral presentations to the public and managers is very effective because people enjoy hearing how changes in the PDO affect salmon returns through bottom-up and top-down linkages in the food web. However, managers have been slow to accept our approach (even though they like our stories) because they all have their own "tried and proven" methods (even though their methods fail occasionally). The greatest impediment to adoption of our approach is that most of the data used in the "outlooks" are produced by a research program whose continuation depends on finding research dollars. We need to become operational.

# April 16

**April 16, 10:00, Plenary S4**

## Ecosystem comparison of trends in zooplankton community structure and role in biogeochemical cycling

Deborah K. **Steinberg**

Virginia Institute of Marine Science, The College of William and Mary, VA, USA. E-mail: debbies@vims.edu

Zooplankton play a central role in the structure and functioning of marine pelagic food webs– as consumers of primary production and food for higher trophic levels, and as recyclers and exporters of carbon and nutrients. Cross-comparison of diverse ecosystems can be useful in elucidating the effect of environmental stressors on zooplankton communities and biogeochemical cycling. I use examples of both long-term (increasing temperature, decreasing ice) and sub-decadal scale (El Niño Southern Oscillation, North Atlantic Oscillation) climate-induced changes in zooplankton biomass and community structure in contrasting environments to determine associated changes in biogeochemical cycling, and to predict future changes. I also discuss how shorter-term process studies in regions with distinct physical gradients or boundaries (salinity, temperature, ice cover) can be employed in a similar way, using this spatial contrast to predict future temporal changes. Forecasting ecosystem change is dependent on multiple factors, thus a mechanistic understanding, such as developing indicators of changing animal physiology due to environmental stress, is important as we move forward.

**April 16, 11:05, Plenary S5**

## Long term climate change: Projections, commitment and irreversibility

Mat **Collins**

University of Exeter, College of Engineering, Mathematics and Physical Sciences, Exeter, U.K. E-mail: M.Collins@exeter.ac.uk

This talk will summarize the findings of the recent 5th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5) on long-term changes in climate. Key assessments will be highlighted with an explanation of how the assessment statements were derived. Outstanding research challenges will be put forward. There will be a focus on Pacific-region climate change.

**April 16, 11:50, Plenary S6**

## Exactly how resilient are ecosystems?

Elizabeth A. **Fulton**

CSIRO, Marine and Atmospheric Research, Hobart, Australia. E-mail: beth.fulton@csiro.au

Global change continues to put marine and coastal ecosystems around the globe under pressure. Given that these ecosystems continue to provide billions of dollars of ecosystem services and are a key part of the identity of many people, there is considerable interest in the vulnerability and resilience of the world's marine ecosystems. Examples of system shifts exist for a number of ecosystem types, from tropical reefs to polar food webs. Nevertheless, managing for resilience remains uncertain. All work to date indicates that adaptive management is the most effective approach, though questions remain about what constitutes unacceptable levels of disturbance. While diversity is often discussed as an effective surrogate of resilience, monitoring diversity remains problematic in itself. What shows more promise is to consider system level integrity. Looking at what's needed to understand this – physical state, relative biomass levels, habitat state, trophic structure – indicates that we are likely already collecting the correct information, we may just need to look at it in a new way.

# April 17

**April 17, 10:00, Plenary S7**

## Solutions for marine ecosystem-based management in a changing climate

Scott **Large** on behalf of Jason S. **Link**

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Climate change is occurring and is impacting marine ecosystems. The impacts are increasingly well known across ocean-use sectors and a wide range of species. The challenge is how to account for these impacts as we manage marine resources. If one examines a generalized marine resource management context, there are several entry points at which climate impacts could be considered. Examples from fisheries, conservation (*i.e.* Protected/Endangered/Threatened) species, habitat, aquaculture, and integrated ecosystem assessments demonstrate where in the scientific and assessment process climate can be accounted for to provide modified, climate-savvy advice. Certainly there is much room to advance the science, particularly exploring a full range of now-casts and projections from earth system and climate models as they impact oceans. And subsequently as the changed oceans impact their component biota and biotic processes. Yet there is also a sense that we do know enough to provide climate-savvy advice now, and certainly we do not have the luxury of waiting address these climate impacts as we manage ocean ecosystems.

**April 17, 11:05, Plenary S8**

## Adaptation to climate change requires resilience in governance as well as ecosystems

Jake **Rice**

Department of Fisheries and Oceans, Canada, Ottawa, Canada. E-mail: jake.rice@dfo-mpo.gc.ca

Research on how climate change may affect marine and coastal ecosystems is now moving to applied contexts. Ecological, social and economic scientists now consider how human uses of these ecosystems will be affected by climate drivers. In some cases those collaborations extend to studying adaptive strategies that users can adopt, to increase their community's resilience to climate change impacts.

Identification of potential adaptive strategies is useful, but they can only produce the desired resilience if the governance processes facilitate adaptive responses. Ocean and coastal governance is complex and although there are trends increasingly participatory governance, its basis remains strongly sectoral. This has important implications for how adaptive management can actually be in the face of changing ocean conditions. Moreover, the governance processes themselves have to be resilient to changing drivers, or else they may become impediments to adaptation, rather than facilitating it.

In this talk I will first summarize major trends that have been documented with regard to ocean and coastal governance. Then I will explore the implications of these trends for ability of ocean users to adapt to climate drivers. Finally, I will review properties of governance processes themselves with regard to resilience, and provide observations on how resilient our processes may be. These observations will then be tied back to how well the processes can create conditions to promote adaptation.

# S1 Presentations (Day 1)



**April 15, 14:00, S1-O1 (9358)**

## How much city is too much city? Diversity and ecosystem functions along an urban gradient in Puget Sound

Jameal **Samhouri**, A.O. Shelton, B. Feist, G. Williams, K. Bartz, M. Sheer and P. Levin

Conservation Biology Division, Northwest Fisheries Science Center, Seattle, WA, USA. E-mail: jamealsamhouri.weebly.com

Over half of the world's population resides in urban areas and 44% in coastal areas. As urbanization continues, the ability of coastal marine ecosystems to provide the services people want and need from them is in question. Indeed, the extent of human activity in a region often doubles as an indicator of natural ecosystem responses to multiple stressors. For instance, habitat conversion and reclamation, harvest and hunting, and human population density are frequently assumed synonymous with reductions in the abundance of wild animal populations. However, it is surprising how rarely such assumptions are actually tested against real-world observation of the relationships between stressors and components of ecosystem structure and functions. In this study we investigated how land cover, a potential indicator of stressors such as toxic contaminants, nutrient loads, and extractive uses, related to empirically measured ecosystem responses in freshwater and marine environments of Puget Sound, WA, USA. Specifically, we estimated how four aggregate ecosystem properties varied across 12 watersheds characterized by perennial streams flowing directly into Puget Sound. These properties included freshwater and marine invertebrate diversity, primary production, secondary production, and decomposition. In addition to measuring land cover, which spanned a gradient from highly rural (>80% forested) to heavily urbanized (>80% developed), we also tracked other factors such as water temperature, salinity, stream flow, and nutrient loads. Surprisingly, aggregate properties of freshwater and marine ecosystems did not differ in a systematic way across the urban gradient. These preliminary results provide a contrast to prevailing wisdom that urban ecosystems differ dramatically from pristine ones, and suggest that land cover indicators may not always provide useful information about changes in aquatic and marine ecosystems. Because ecosystem responses can be idiosyncratic, though, this study also highlights the importance of groundtruthing stressor-ecosystem relationships to ensure that indicators are indeed meaningful.

**April 15, 14:20, S1-O2 (9307)**

## Multiple interacting natural pressures and human activities in North Pacific marine ecosystems

R. Ian **Perry**[1], Motomitsu Takahashi[2], Jameal Samhouri[3], Chang-Ik Zhang[4], Rebecca Martone[5], Jennifer Boldt[1], Baisong Chen[6] and Stephani Zador[7]

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The goals of the PICES FUTURE program include understanding how ecosystems respond to natural and anthropogenic forcing, what determines their intrinsic resilience and vulnerability to these drivers, and how these marine ecosystems might change in the future. The objective of PICES' Working Group 28 is to develop ecosystem indicators to characterize ecosystem responses to multiple stressors, as a contribution to understanding these goals of the FUTURE program. This presentation reviews progress by Working Group 28 on achieving these goals, to assist with an assessment of where the FUTURE program is making progress and what remains to be done. Two topics will be discussed: 1) a review of frameworks proposed and in use in the North Pacific for linking natural pressures and human activities to ecosystem responses; and 2) characterisations of multiple pressures and activities on North Pacific marine ecosystems. Frameworks to be discussed include pathways of effects, driver-pressure-state-impact-response (DPSIR), trophic models, probabilistic networks, integrated ecosystem

assessments, integrated fisheries risk analysis method for ecosystems, INVEST, *etc.* Each will be examined for their data needs and applicability to North Pacific situations. For topic (2), characterisations of multiple pressures and activities will include identification of their spatial locations/extents/and overlaps. The presentation is based on literature reviews as well as original work of WG28. A companion presentation by Boldt *et al.* will review progress on developing indicators of ecosystem responses to these multiple pressures and activities.

**April 15, 14:40, S1-O3 (9302)**

## Development of ecosystem indicators to characterize ecosystem responses to multiple stressors

Jennifer **Boldt**[1], Ik Kyo Chung[2], Sachihiko Itoh[3], Rebecca Martone[4], Ian Perry[1], Jameal Samhouri[5] and Naoki Yoshie[6]

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A priority for science in support of ecosystem-based management is to develop ecosystem indicators and reporting systems. Science has developed indicators and suites of indicators to communicate responses to individual stressors, such as fishing pressure. Marine ecosystems, however, are impacted by multiple stressors that can act synergistically to change ecosystem structure, function and dynamics in unexpected ways that differ from single stressor responses. In addition, these stressors can be expected to vary spatially and temporally. There is, therefore, a need to include indicators of multiple stressors when evaluating the state of marine ecosystems. To identify indicators of multiple stressors requires a review of existing indicators, a review of potential sources of data available from national and international programs, identification of indicator-selection criteria, and approaches for evaluating indicators. There are various approaches for evaluating indicators that can provide an understanding of how ecosystems respond to multiple stressors: expert-based elicitation, empirical, and model-based. Each approach has strengths and weaknesses, therefore, there is a need to use multiple approaches to identify and evaluate critical multiple stressors of North Pacific marine ecosystems and indicators to assess their impacts. This talk will summarize these topics with the goal of providing a useful basis for continued work in PICES Working Group 28 - Development of Ecosystem Indicators to Characterize Ecosystem Responses to Multiple Stressors.

**April 15, 15:00, S1-O4 (9321)**

## Red flags or red herrings revisited: Using ecosystem indicators to track ecosystem status in the Gulf of Alaska

Stephani **Zador**[1] and Heather Renner[2]
*Presented by Kirstin Holsman on behalf of Stephani Zador*

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NOAA compiles and synthesizes information about the Alaska marine ecosystem annually into an ecosystem considerations report primarily for fisheries managers, but also the scientific community and the public. The goal is to provide stronger links between ecosystem research and fishery management and to spur new understanding of the connections between ecosystem components. There are more than one hundred time series of physical and biological indicators that are monitored for early signs of ecosystem change. In 2011, the status of a suite of ecosystem indicators cumulatively suggested that anomalous conditions had occurred in the Gulf of Alaska that year. The first indications were noted in upper trophic organisms that experienced reproductive failures and potential nutrient deficiencies. Evidence suggested that upper trophic organisms were influenced by bottom-up forcing that negatively influenced productivity at the lower trophic level. In this presentation, we revisit this chain of events to see if there were similar connections detectable in other years. The same indicators suggest that bottom-up forcing was not as limiting in 2012 and 2013. We conclude that: (1) synthesis of indicators'

status across multiple trophic levels can reveal broad-scale changes in the environment that may have important biological and management implications, and (2) potential mechanisms underlying these changes may be useful for making predictions of future ecosystem state.

**April 15, 15:20, S1-O5 (9306)**

## Current and future cumulative effects of human activities on the Northeast Pacific with climate change and industrial development

Cathryn **Clarke Murray**[1], Selina Agbayani[1] and Natalie Ban[2]

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The diversity and abundance of human activities occurring in coastal and marine environments puts pressure on ecosystems. With single impacts increasing, the possibility of significant cumulative effects becomes more likely. Major drivers of change in the Northeast Pacific include increasing human population density (and increasing demand for seafood, and land-based developments that affect the ocean), industrial development and climate change. Here we present the results of an analysis that models the spatial distribution of cumulative effects, building on the Ban *et al.* 2010 model for British Columbia, Canada. The potential cumulative effects of current marine, coastal and land-based human activities on three broad habitat classes (benthic, pelagic and surface waters) were assessed based on i) the relative intensity of each activity and ii) the vulnerability of each habitat to each activity occurring within it. The resulting maps present the spatial distribution of cumulative impacts. We then examined the potential future cumulative effects given the additional impact of two scenarios climate change and proposed industrial developments. This region is the focus of over 60 major industrial developments such as port expansion, coastal development, mining, and construction of liquefied natural gas facilities. The results of this analysis allow us to identify hotspots of potential cumulative impact, highlight the biggest changes in marine ecosystems, and demonstrate the importance of accounting for future drivers of change in assessing cumulative effects and managing human activities. The results of this research will inform marine spatial planning and effective management of marine protected areas and facilitate ecosystem-based management.

**April 15, 16:00, S1-O6 (9300)**

## Linking pathways of effects to assess cumulative impacts on ecosystem services: Modeling effects of nutrient run-off on shellfish aquaculture in British Columbia, Canada

Rebecca **Martone**[1,2], Erin T.H. Crockett[2], Allison Thompson[2] and Kai M.A. Chan[2]

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[2] Institute for Resources, Environment and Sustainability, University of British Columbia, Vancouver, BC, Canada

Coastal and marine ecosystems face intense and increasing degradation due to overlapping stressors from human activities. In response, marine management and planning efforts have developed frameworks to depict cumulative effects from multiple stressors and the resulting impacts on ecosystem services. Many of these frameworks rely on expert judgment about stressors, and do not consider the mechanisms by which ecosystems or the benefits they provide are impacted. We propose and apply a mechanistic approach that links simple functional relationships between activities, stressors, and ecosystem attributes, resulting in an assessment of cumulative impacts on ecosystem service supply. Using a case study of land-based impacts on commercial shellfish production, we examine the pathways by which nitrogen inputs from agricultural production, forestry, and coastal development impact commercial shellfish harvest closures in British Columbia, Canada. We demonstrate that considering cumulative stressors from multiple activities leads to predicted synergistic increases in aquaculture closures, and, through comparing modeled closures with empirical data, indicates that simple functional relationships can capture the relative magnitude of impacts over regional scales. Incorporating nonlinearities and uncertainties in reference points and thresholds provides further insights into relative impacts from multiple stressors and can reveal where the pursuit of additional scientific research is needed to provide better estimates of impacts on ecosystem service supply. Our mechanistic approach to evaluating effects of human activities on ecosystems presents a simple and transparent basis for examining cumulative impacts on ecosystem services, enabling planning and management for ecosystem health and human well-being.

**April 15, 16:20, S1-O7 (9406)**

## Fishing *vs.* climate change: An example of filefish (*Thamnaconus modestus*) in the northern East China Sea

Sukgeun **Jung**

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The main cause of annual fluctuations in catch and species composition of fisheries is usually uncertain, but a prevailing view has been that fishing effects are more critical than environmental variability. Filefish (*Thamnaconus modestus*) is a good case study: many Korean fisheries scientists have attributed the sudden collapse of Korean filefish fisheries in the early 1990s to overfishing, especially by trawl fisheries in the northern East China Sea (NECS). However, interdisciplinary researches have revealed that climate-driven, multi-decadal variability in oceanic conditions impacts both fish and fisheries around the world. To test the two alternative hypotheses (*i.e.*, fishing and climate) as the major cause of the sudden decline of filefish, I compared fisheries data of filefish from the adjacent countries of the Northern East China Sea (NECS) and analyzed oceanographic conditions in relation to changes in species composition of fish assemblages in the NECS. Results suggested that the basin-wide, 1989 regime shift in the North Pacific and the subsequent shrinkage of habitat range to the southwest were the major cause of the sudden decline of filefish catch in the NECS. Locally, shifts in water temperature and currents were identified in the NECS for the early 1990s, but further physiology-oriented research are required to understand the detailed mechanism of climate-change effects on filefish stocks in the marginal seas of East Asia.

**April 15, 16:40, S1-O8 (9297)**

## Projected responses of the central North Pacific subtropical ecosystem to future pressures of fishing and climate change

Jeffrey **Polovina** and Phoebe Woodworth-Jefcoats

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Analysis of a15-year time series of observer catch and effort data from the Hawaii-based tuna longline fishery documents a decline in large, apex, species and an increase in smaller, mid-trophic, species as fishing effort has increased. Climate model output for the North Pacific subtropical gyre projects increased ocean vertical stratification resulting in a decline in nutrients and large phytoplankton abundance and hence reduced energy transfer to top trophic levels. Thus going forward the North Pacific subtropical ecosystem will be squeezed by high fishing mortality at the top and a longer food web. Two different ecosystem models (Ecopath with EcoSim and a size-based model) are forced by the NOAA Geophysical Fluid Dynamics earth systems model output and a range of fishing mortalities to explore future ecosystem responses. Similarities and differences between the outputs of the two ecosystem models will also be discussed.

# S1 Presentations (Day 2)



**April 16, 14:00, S1-O9 (9393)**

## Challenges for peak aerobic metabolism in the future oceans: The effect of multiple climate variables on exercise performance in a model teleost fish

Gen Del **Raye** and Kevin Weng

University of Hawaii at Manoa, Department of Oceanography, USA. E-mail: gdelraye@hawaii.edu

Climate change induced ocean acidification is likely to be accompanied in much of the ocean with concomitant changes in both temperature and oxygenation. Strong evidence indicates that a warmer, more acidic, and deoxygenated future ocean will challenge the ability of marine animals to carry out high-performance aerobic metabolism. The magnitude of interactions between these simultaneous stressors on exercise performance however is poorly constrained by previous research. Any significant reductions in peak aerobic performance as a result of future climate change could have wide-ranging effects on the ecology of the affected species by limiting the energy budget available for such critical functions as digestion, growth, and reproduction. In this talk, we present experimental data on the peak aerobic metabolism of a widely distributed salt tolerant tilapia *Oreochromis mossambicus* in response to simultaneous changes in multiple climate variables. Furthermore, using the tilapia as a model species, we propose a method for identifying geographical hotspots where projected future conditions are most likely to have a strong effect on tilapia growth and reproduction, and show how similar methods could be used to predict the physiological underpinnings of climate-change based ecosystem effects in a range of other marine species including those targeted in high value pelagic fisheries.

**April 16, 14:20, S1-O10 (9383)**

## Ecosystem responses to anthropogenic activities and natural stressors among inland, shelf and oceanic waters in the western North Pacific

Motomitsu **Takahashi**[1], Sachihiko Itoh[2], Naoki Yoshie[3], Kazuhiko Mochida[4], Masakazu Hori[4], Shigeru Itakura[4] and Mingyuan Zhu[5]

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We assessed ecosystem responses to anthropogenic activities and natural stressors in the Seto Inland Sea (inland water), the East China and Yellow Seas (shelf water) and the Kuroshio/Oyashio waters off northern Japan (oceanic water) using an expert-based screening method. Vulnerabilities of each ecosystem were scored as spatial scale, frequency, functional impact, resistance, recovery time and certainty using a habitats-stressors matrix. Increase in dissolved inorganic nitrogen by water discharge from rivers has resulted in eutrophication, harmful algal bloom and hypoxia in the Changjiang Estuary and the adjacent waters in the East China Sea. For the intertidal and costal habitats, reclamation has led to reduced areas of tidal flats and sea grass beds in the Seto Inland Sea and the East China and Yellow Seas. Heavy industrial fishing influented the rocky shelf in the Seto Inland Sea, the continental soft shelf in the East China and Yellow Seas and the slope in the Kuroshio/Oyashio waters. Decadal changes in water temperature have been associated with population alteration among cold, temperate and warm water fish species in the East China and Yellow Seas and the Kuroshio/Oyashio waters. Increase in lowest temperature allows warm water species to overwinter in the Seto Inland Sea. Our results demonstrate that anthropogenic activities are influential in the inland and coastal shelf waters, but increasing temperature affects the entire ecosystems in the western North Pacific.

**April 16, 14:40, S1-O11 (9413)**

## Freshwater input as multiple stressors on coastal ecosystems under a changing ocean: Implication of possible mitigation effect

Nam-Il **Won**, Min-Gyu Ji, Young-Teck Hur and Jin-Hyeog Park

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Coastal ecosystems have become more important as a buffer or transition zone in river-to-offshore ecological connectivity. As water security has become an urgent global issue and many water management actions are made in coastal areas, freshwater inputs to coastal ecosystems have been recognized as one of the important key stressors. However, there are various types of freshwater discharge into coastal ecosystem and possible local multiple impacts are still left poorly understood, especially in comparison with recent changes in marine ecosystems, *e.g.* due to climate change effects. Many water management actions such as dam construction have been performed in Korea due to restricted large precipitation seasons and poor water security (water shortage). This study aims to evaluate seasonal impacts of dam discharges in two different bays using field observations and numerical modeling. Suncheon Bay has been impacted by year-round continuous freshwater inputs from the Juam Controlled Dam which is located upstream and discharges deep water with low and relatively constant water temperature. Sacheon Bay has been influenced by short but strong freshwater impacts during only rainy season discharge from Nam-gang Dam upstream. Our results indicated that Suncheon Bay could be affected by both cold water input (summer) and warm water input (winter) implying seasonally different thermal impacts. Sacheon Bay appeared to receive heavy freshwater stressor over the whole bay area during short periods. Our study highlights that coastal freshwater inputs can be multiple stressors on marine ecosystems giving possible mitigation effect on local scales.

**April 16, 15:00, S1-O12 (9327)**

## Multiplicative effect of SST variation during spawning period and 1 year after on the catches of walleye pollock 5 years later in the waters off the northeastern part of Sakhalin Island

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Walleye pollock dominates in the pelagic communities (after excluding mid-water forage fish) and in the commercial fisheries in the Sea of Okhotsk including the waters off the northeastern part of Sakhalin Island (10$^{th}$ region). Fisheries independent surveys are not conducted annually in the 10$^{th}$ region. Commercial catch of walleye pollock in the 10$^{th}$ region was 1 to 2 orders less than in the rest of this region over the last 30 years. A very limited number of vessels reported walleye pollock catches in the 10$^{th}$ region during the mid-1990s. Thus 53.32% of deviance in the catches is explained by vessel name and only 5.69% and 3.27% of it is explained by month and years as independent factors of a generalized linear model (GLM) with log-link using a Tweedie distribution with power 1.6. Among many possible additional predictors with -2 to -5 years lag we found that the exponent of the sum of the standard deviation of the sea surface temperature (SST) during May in the northern part of the 10$^{th}$ region with -5 years lag (when the most part of the walleye pollock was spawning) and in the southern part of the 10$^{th}$ region with -4 years lag could explain 1.97% of deviance in the previous GLM without years as factors. Schwarz's Bayesian criterion of the second GLM is lower than that of GLM with years as factors, although the first GLM explained more total deviance (62.3% *vs* 61.0%).

# Posters



### S1-P1 (9349)

## Changes in jellyfish (*Chrysaora melanaster*) biomass and distribution in response to anomalous climate shifts in the Bering Sea

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The eastern Bering Sea has recently undergone periods of anomalously warm and cool sea temperature states. The ecosystem response to these anomalous states suggests that sustained warming in the eastern Bering Sea will lead to reduced fitness and recruitment of groundfish resources. Previous research on Northern sea nettle (*Chrysaora melanaster*) indicates that their biomass in the Bering Sea is increasing, and that they may directly compete with walleye pollock (*Theragra chalcogramma*) for prey resources. We examine biomass, abundance, and habitat characteristics (temperature, salinity, chlorophyll-*a*, and bottom depth) for possible associations between the dominant macro-jellyfish species, Northern sea nettle (*Chrysaora melanaster*) and age 0-1 walleye pollock during warm years (2004-2005) and cool years (2006-2012) in the eastern Bering Sea. To identify these associations, we developed general frequency distributions for each factor by constructing their empirical cumulative distribution functions (cdf) and compared them statistically. All data was supplied by the annual BASIS (Bering-Aleutian Salmon International Surveys) surface trawl surveys.

### S1-P2 (9310)

## Newly recorded *Karlodinium veneficum dinofalgellate* blooms in stratified water of the East China Sea

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*Karlodinium veneficum* is a cosmopolitan species, but has been poorly recorded in the East China Sea (ECS) due to its small size and difficulty in identification. The bloom dynamics of this species is not well understood globally. In this study, we examined its morphological characteristics that suggest the *K. veneficum* is a co-occurring bloom causative species of large scale *Prorocentrum donghaiense* blooms in spring 2011. The epicone of *K. veneficum* recorded in the investigated area is conical or rounded, and the hypocone is hemispherically rounded. The ventral pore is located at the left side of the apical groove. The nucleus is positioned centrally within the hypocone. Four large irregular chloroplasts are equally distributed in the epicone and hypocone. The mean length of cultured cells was 13.6±1.2μm (range 11.0-15.8μm) and the mean width was 10.0±1.1μm (range 8.0-12μm) (*n*=50). Cell abundance of *K. veneficum* population was low, in the region 1040-1600 cells $L^{-1}$, along a transect in the East China Sea on April 19, 2011, when the water column was not distinctly stratified. Cell densities reached $3\times10^7$ cells $L^{-1}$ along the same transect on May 13 2011 when the bloom occurred in the upper 10m layer surface and the water column was distinctly stratified. Cell abundances therefore appear closely related to water column stratification.

**S1-P3 (9355)**

## Influence of environmental thresholds on species interactions and ecosystem structure in Northeast Pacific systems

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The abundance and distribution of marine species varies across time and space, reflecting biological interactions, environmental forcing, and external perturbation. Understanding the relative influence of these drivers requires integrating community ecology with approaches that consider environmental gradients and climate forcing. We use time series of population dynamics and environmental indices in Northeast Pacific systems to explore physical-biological linkages underlying ecosystem structure and to identify mechanisms and integrated pressures influencing stability and change over time. We use diet data to classify species to functional guilds in Alaskan systems and the California Current, identify trends among species within guilds and explore how differential responses to environmental thresholds influence spatial overlap, resource partitioning, and predatory and competitive interaction among species. We use variance ratio tests to examine evidence for compensatory dynamics and external forcing. Using random forest models, we also evaluate the relative influence and marginal effect of various environmental variables on species abundance and quantify environmental thresholds for species distribution. We then integrate analyses of multiple species to explore how environmental gradients define distinct biological communities, quantifying turnover or threshold shifts in community composition along the gradient of select predictors. Using dynamic factor analysis, we distinguish common underlying trends for species within guilds and compare trends to large-scale environmental forcing. We note distinctions in physical and biological structure across systems. Despite common trends among several diet-based guilds, systems differ in response, indicating both fluctuations between benthic and pelagic pathways as well as shifts in system loading based on trophic position.

# S2 Presentations



### April 15, 14:00, Invited, S2-O1 (9373)

## Isolating mesoscale coupled ocean-atmosphere interactions in the Kuroshio Extension region

Arthur J. **Miller**[1], Dian Putrasahan[2] and Hyodae Seo[3]

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The Kuroshio Extension region is characterized by energetic oceanic mesoscale and frontal variability that alters the air-sea fluxes that can influence large-scale climate variability in the North Pacific. We investigate this mesoscale air-sea coupling using a regional eddy-resolving coupled ocean-atmosphere (OA) model that downscales the observed large-scale climate variability from 2001-2007. The model simulates many aspects of the observed seasonal cycle of OA coupling strength for both momentum and turbulent heat fluxes. We introduce a new modeling approach to study the scale-dependence of two well-known mechanisms for the surface wind response to mesoscale sea surface temperatures (SST), namely, the "vertical mixing mechanism" (VMM) and the "pressure adjustment mechanism" (PAM). We compare the fully coupled model to the same model with an online, 2-D spatial smoother applied to remove the mesoscale SST field felt by the atmosphere. Both VMM and PAM are found to be active during the strong wintertime peak seen in the coupling strength in both the model and observations. The atmospheric response to the oceanic mesoscale SST is also studied by comparing the fully coupled run with an uncoupled atmospheric model forced with smoothed SST prescribed from the coupled run. Precipitation anomalies are found to be forced by surface wind convergence patterns that are driven by mesoscale SST gradients, indicating the importance of the ocean forcing the atmosphere at this scale.

### April 15, 14:25, Invited, S2-O2 (9354)

## Regional information in decadal climate prediction

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A near-term (*i.e.*, decadal) climate prediction is a new topic in CMIP5. On decadal timescales, a regional climate change due to internal variability in the climate system is a key issue in addition to global warming, while it is very recent that near-term climate projection experiments have been carried out with initializing global climate models. At this stage, medium-resolution models often exhibit unfavorably large uncertainty in predicting decadal climate changes, particularly in the Pacific. While high-resolution models are able to provide us with regional information explicitly, they require huge computational resources to obtain sets of ensembles for decadal prediction.

To achieve a reliable climate prediction for the mitigation and adaptation efforts in the coming decade, we require not only a realistic estimate of initial and boundary conditions but also a good performance from the models in simulating major climate processes. While global climate models have been commonly used for decadal prediction so far, regional climate modeling can also be an effective approach. A downscaling technique can usually be useful to extract regional information from global climate model integrations. We can directly take into account the contributions of small-scale processes to large-scale climate changes as an issue of scaling-up.

**April 15, 14:50, S2-O3 (9356)**

## Downscaling climate simulations for boundary currents

Enrique **Curchitser**[1], Justin Small[2], William Large[2], Kate Hedstrom[3] and Brian Kaufman[2]

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[3] U. Alaska Fairbanks, USA

We present results from a climate model integration with a multi-scale ocean component capable of locally enhancing resolution. The model is the NCAR Community Earth System Model (CESM), in which the ocean component contains a high-resolution ROMS nest. We will show results from implementations in both eastern and western boundary currents. In this presentation, we will show the latest results from a century-long integration, showing that the better representation of coastal currents has both regional and global ramifications to the climate system. We will present a prototype two-way boundary condition between the global and regional ocean models and distinguish between the role of atmospheric tele-connections and oceanic advection in propagating the upwelling signal.

**April 15, 15:10, S2-O4 (9371)**

## How to improve the forecasting ability in the North Pacific?

Fangli **Qiao**, Zhenya Song, Chuanjiang Huang, Changshui Xia and Dejun Dai

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Improving the forecasting ability for ocean and climate is one of the main streams in oceanic and atmospheric sciences. PICES has mainly focused on the area north of 30°N in the Pacific. To improve the simulation and forecasting ability for ocean and climate is a key scientific issue of the FUTURE, a flagship project of PICES. Incorrect parameterizations of ocean mixing processes essentially render the atmospheric and oceanic dynamics to be either decoupled or coupled incorrectly. We have established a new scheme on the non-breaking wave-induced vertical mixing (Bv) that will correct the systematic error of insufficient mixing in the upper ocean. Meanwhile, the numerical experiments suggest that tidal mixing play a key role in the bottom boundary layer. Based on the above results, here we propose a solution for improving the forecasting ability by setting up a high resolution surface wave-tide-circulation coupled model. The surface wave-induced vertical mixing can much improve the common simulation bias in the upper mixed layers of ocean models, which is important for marine ecosystem and climate system. And the inclusion of tide in a circulation model can improve the bottom structure of temperature, salinity and current. For a high resolution model, we developed a new parallel scheme with high efficiency even in the condition of more than one hundred thousand CPUs.

**April 15, 15:50, S2-O5 (9334)**

## Climate change projection for the western North Pacific: Dynamical downscaling

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This study presents preliminary results of regional climate model (RCM) development and its application to future climate change projection for the western North Pacific. The RCM consists of the Regional Ocean Modeling System (ROMS) for the oceanic component and the Weather Research Forecast (WRF) for the atmospheric component. The ocean model has horizontal resolution of 1/12 degrees, while the atmospheric model, covering the East Asia region, has horizontal resolution of 50km. As a first step for downscaling future climate projection with the RCM for the western North Pacific, for the boundary conditions for RCM, we used future climate changes projected by CanESM2 that well reproduces the East Asian monsoon which largely contributes to ocean circulation variation. Both ocean and atmospheric RCM projections show some prominent features including ocean surface warming concentrated near the Kuroshio-Oyashio front, a dipole pattern in mixed layer depth change, and an opposite trend in precipitation changes between the southern and northern region over the Korean Peninsula. We will also present detailed regional patterns in future changes, compared with global model projections.

**April 15, 16:10, S2-O6 (9379)**

## A regional biogeochemical climate model for the British Columbia continental shelf

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The development of regional climate-biogeochemical models is critical for assessing the likely responses of the marine ecosystem to a climate change. This is particularly important in the coastal region where the coarse spatial resolution of global models is not able to capture the effect of mesoscale patterns such as eddies, coastal jets, and the associated upwelling fronts on lower trophic levels. A first step to address the impacts of climate variability on marine ecosystem is to develop coupled circulation-ecosystem models that simulate the present ecosystem state in relation to the climate record and can be used to examine the influence of a different forcing acting at different scales on ecological processes. This allows us to evaluate the role of specific mechanisms in governing the observed and future variability of the physical-chemical environment, marine populations, and biogeochemical fluxes in a region. This talk will present preliminary results from a coupled plankton-circulation (ROMS) model developed to study the factors determining regional-scale patterns of lower trophic levels and the biogeochemistry of the British Columbia continental shelf. This region is at the northern end of the California Current Systems and is influenced by summer coastal upwelling, mesoscale eddies, and freshwater inputs. The importance of these processes for the biogeochemistry of the region and future work will be discussed.



**April 15, 16:30, S2-O7 (9293)**

## Impact of horizontal model resolution on air-sea $CO_2$ exchange in the California Current

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

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We use a suite of coupled physical-biogeochemical model simulations at 1/3°, 1/10°, and 1/30° to assess the impact of horizontal resolution on air-sea $CO_2$ fluxes in the California Current System (CCS), a relevant issue for downscaling between coarser resolution global climate models and higher resolution regional models. The results demonstrate that horizontal resolution is important to (1) reproduce the sharp transition between near-shore outgassing and offshore absorption, and (2) resolve the regions of enhanced near-shore outgassing in the lee of capes. The width of the outgassing region is overestimated when horizontal resolution is not eddy-resolving, but becomes more dependent on shelf topography for eddy-resolving simulations. Because enhanced near-shore outgassing is associated with local increases in wind-driven upwelling in the lee of capes, sufficient horizontal resolution is needed both in the ocean circulation model and surface forcing. The sensitivity to the wind field is illustrated by running the coupled model with different resolution atmospheric products (COAMPS, CCMPS, MERRA, CORE2, NCEP) and comparing air-sea $CO_2$ fluxes. From a global carbon budget perspective, the model indicates that biological production generates sufficient absorption within a few hundred kilometers of the coast to offset near-shore outgassing, which is consistent with the notion that mid-latitude eastern boundary current upwelling systems act both as a sink and source for atmospheric $CO_2$.

**April 15, 16:50, S2-O8 (9357)**

## Downscaled coupled bio-physical projections in the California Current Ecosystem

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Eastern Boundary Upwelling Systems (EBUS) are among the most productive marine ecosystems of the world's oceans. The EBUS of the west coast of North America, *i.e.*, the California Current Ecosystem (CCE), provides critical habitat for local species (*e.g.*, forage species such as sardine, anchovies, and groundfish) as well as feeding and nursery areas for species that migrate across the Pacific basin (*e.g.*, tuna, turtles, and sharks). As such, understanding the variability of the CCE and its relationship with key species is essential to present and future management practices. We present results from a downscaled projection of coupled bio-physical and biogeochemical models for the California Current Ecosystem (CCE). The global climate simulation is based on the NOAA-GFDL Earth System Model, which incorporates a biogeochemistry model (COBALT). The downscaled regional model uses the Regional Ocean Modeling System (ROMS) coupled to the CoSINE ecosystem model. The simulation covers the historical period since 1970 and transitions to the RCP8.5 scenario to 2050. An analysis of the model simulations shows a general freshening and cooling along the California coast by the middle of the century. Simultaneously, the high-resolution model also shows a decrease in upwelling strength in some locations of the CCE. We consider possible implications of the predicted environmental variations on the communities of the CCE.

**April 15, 17:10, S2-O9 (9347)**

## Multiple realizations of future biophysical states in the Bering Sea

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

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There is considerable uncertainty in projections of global climate over the coming decades; this uncertainty derives from both fundamental limits to predictability of the atmospheric/oceanic system, and our incomplete knowledge of future anthropogenic emissions of greenhouse gases. By extension, there is considerable uncertainty regarding future regional conditions in the Bering Sea. In order to assess probable mean conditions and their uncertainty in the Bering Sea, dowscaling simulations were carried out with a 10-layer regional biophysical model of the area. Regional hindcasts were driven by atmospheric forcing and oceanic boundary conditions derived from reanalyses of past conditions (chiefly CORE, SODA and NOAA's Climate Forecast System Reanalysis [CFSR]). Regional forecasts were driven by three IPCC (CMIP3) global atmosphere/ocean models (CGCM3, MIROC, and ECHO-G). Results were averaged into the standard biophysical domains used in the BEST/BSIERP program. Decadal means of these results indicate a range of 0.5-1.5°C increase over present conditions by 2040 for the south middle shelf domain. On the mid-north middle shelf, a similar increase is observed, with somewhat larger uncertainty. Ice coverage on the southern middle shelf exhibits substantial interannual variability in 2010-2030, but reduced variability thereafter as the mean ice cover disappears. The ECHO-G model, which exhibits the coldest forecast, also exhibits the largest ice cover. Throughout these 10-layer runs, an inverse correlation was observed between spring temperatures and fall production of large crustacean zooplankton (neocalanus and euphausiids). Substantial decadal trends in this production were not observed, however.

# Poster

## S2-P1

### A global 1/10° eddy-resolving ocean-ice coupled model

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A global eddy-resolving ocean-ice coupled model with a horizontal resolution of 0.1º by 0.1º is established on the basis of Modular Ocean Model version 4 (MOM4) and Sea Ice Simulator (SIS). The vertical mixing scheme is K-Profile Parameterization scheme. Non-breaking surface wave induced vertical mixing and tidal mixing are also included in this eddy-resolving model. The model is driven by OMIP (Ocean Model Intercomparison Project) climatological forcing and has been integrated for 20 years. The last 5-year simulation results show that this model can give reasonable features of sea surface temperature, sea surface salinity, sea surface height, sea ice concentration, mesoscale eddies, and the paths and positions of western boundary currents.

# S3 Presentations

**April 15, 14:00, S3-O1, Invited (9402)**

## Multi-sectoral collaboration through coastal policy evolution

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In recent years, multi-sectoral collaboration activities have become more common in the environment and community management fields internationally. Japan is the first country which plunged into rapid modernization taking just over a century, followed by high economic growth for half a century. Almost all environmental and social problems attending modernization have occurred in Japan, whose citizens have suffered and experienced these situations. On the other hand, new international schemes function as a trigger for change in domestic matters that have bogged down. Especially, international conventions and treaties push each country that has promised to adapt its domestic social scheme to these international frameworks. Multi-sectoral collaboration on coastal environment conservation and restoration has progressed in Japan during the last 15 years. Amendments to coastal policies together with international trends, such as global environment and wetland conservation schemes, were reflected in domestic events and policies in the 1990s. International conventions such as those dealing with water problems and biodiversity in the 2000s have included multi-sectoral collaboration schemes. On the other hand, domestic coastal environmental problems have become more and more complicated, and all social sectors are demanding integrated management and ways to overcome sectionalism. Trans-boundary problems such as marine litter, migratory species habitat protection and marine protected area design are also local issues that make local governments and stakeholders aware of national and international schemes. After the Great East Japan Earthquake in 2011, citizen participation and environmental issues came to be discussed related to ecosystem-based disaster risk reduction.



**April 15, 14:25, S3-O2 (9404)**

## Heterogeneities in human utility of marine ecosystem services and behavioral intentions for marine conservation

Nobuyuki **Yagi**[1], Kazumi Wakita, Yuhen Lu and Robert Blasiak

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Human valuation of ecosystems is known to vary depending on factors such as gender or place of residence. Understanding such differences is a first step towards successful decision-making, for instance, in regards to cost sharing for conservation activities. This study looked at coastal and inland areas of Japan to examine heterogeneities in human utility of marine ecosystem services and its influence on behavioral intentions for marine conservation. An online survey was used to collect responses from 814 residents in Japan for analysis using structural equation modeling. The model identified three common hidden factors for perceptions of marine ecosystem services by residents in both coastal and inland areas, namely “essential benefits” (roughly corresponding to the supporting services used in the Millennium Ecosystem Assessment: MA), “indirect benefits” (roughly corresponding to regulating and provisional services in the MA), and “cultural benefits” (corresponding to cultural services in the MA). These three groups of benefits were named in accordance with Wakita *et al* (2014). Among these three, only cultural benefits were shown to have a significant influence on behavioral intentions for marine conservation in inland areas, although cultural benefits and essential benefits both had a significant influence on behavioral intentions in coastal areas. For both coastal and inland areas, cultural benefits had the greatest influence on behavioral intentions for marine conservation. These results imply that in order to increase support from residents of inland areas for marine conservation in Japan, measures aimed at enhancing the cultural benefits of marine ecosystem services would be the most effective. For residents in coastal areas, in addition to developing measures to enhance cultural benefits, emphasizing the essential benefits of marine ecosystem services would also likely have an influence on promoting their behavioral intentions for marine conservation.

**April 15, 14:45, S3-O3 (9408)**

## Challenges in communicating science and engaging public in Russia: Large country – different expectations

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In order to achieve the main task of communicative act in a broad meaning, background knowledge and cultural experience of the addressee should be taken in consideration. Similar approach must be applied in the case of understanding ecosystem services and their impact on people's communities. If we want to engage public to the problems of change in climate and ocean and to evoke people's interest, our priority should take into account such things as expectations, needs and satisfaction level from ecosystem services of a particular social group to which we communicate science products. Understanding the society needs is the basis for successful cooperation and proper drawback. The real challenge with large countries like the Russian Federation is that so many different communities with various expectations and cultural background knowledge exist within one country. Social status issues and distance from ocean or sea of a particular community are among important factors related to ecosystem services values. Therefore, small ethnic groups historically occupying coastline territory consider ocean and its products a source for provision and survival. Climate change and weather conditions, sea level and its temperature are essential for people from coastal communities. For communities in big cities far from the coastline, tendencies in economy, *e.g.*, development of fishing industry, as well as recreational and cultural services are more valuable. People with higher education level have higher expectations. However, both coastal and far from the ocean communities are dependent upon conservation of a marine biodiversity and an opportunity to obtain marine ecosystem products. In order to communicate science products and engage public in a proper way, we should first study community needs and make the data we are distributing relevant for a particular society. The scope and subject as well as means of communication (including language) are essentially important to deliver scientific message successfully and to build fruitful cooperation between science and different socio-economic sectors.

**April 15, 15:05, S3-O4 (9400)**

## Oceanographic information needs of set net fishermen in the Pacific coast of northeastern Japan

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The tsunami caused by the Great East Japan Earthquake on 11 March 2011 seriously damaged the Pacific coast of northeastern Japan. Fisheries in the area were damaged, with the total amount of damage exceeding 1,200 billion yen, including fishing vessels, fishery harbors, aquaculture facilities and products, and facilities for common use. Set net fisheries were not exception. In many coastal villages in the Pacific coast of northeastern Japan, set net fisheries are key industry. Especially, salmon catch by set net is very important income to the coastal villages. To support the smooth recovery of the set net fisheries from the disaster, we researched their needs for oceanographic informations. The set net fishermen are strongly demanding current velocity and direction, wave height and direction and wind velocity and direction. If the current velocity is too high, the set net is sank by the strong drag and difficult to be towed up. In addition the fishes in the set net can escape from the trap. The wave and wind information is also important to determine the departure of the fisheries boat. In the Pacific coastal of northeastern Japan, there are a lot of thermistor observations since the temperature information is important for aquaculture management and the thermistors are easy to maintenance. However, the current observation is limited since the maintenance is relatively difficult. We have equipped current meters and thermistors to several set nets and investigating the value of ocean current information for set net fisheries.

**April 15, 15:50, S3-O5 (9376)**

## Challenges in communicating uncertainty of production and timing forecasts to salmon fishery managers and the public

Joseph A. **Orsi** and Phillip R. Mundy

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Annual forecasts of pink salmon harvest and timing of Chinook salmon migrations were developed to advise fishery managers, members of fishing industries and the public. Although the forecasts were developed independently for different species and widely separated geographic localities, the projects illustrate common challenges in the communication of uncertainty to audiences with a wide variety of interests and educational backgrounds. In both cases, uncertainty is ultimately related to the dependence of annual abundance and timing on multiple factors related to climate. Being climate driven phenomena, both harvest and timing are subject to very large interannual variations, making the effective communication of uncertainty critical to the credibility of the forecasts. To reach the largest possible portion of the audiences, communication of uncertainty is necessarily best done qualitatively. In the case of pink salmon harvest forecasts, an oral presentation and web pages designed to reach industry and fishery managers provide a nine-month ahead quantitative forecast of total pink salmon harvests in Southeast Alaska. The uncertainty associated with the quantitative harvest forecast is communicated by a qualitative ranking of the present values of six significant ecosystem variables in relation to historical harvest levels. A color coding scheme allows the uncertainty of the forecast to be seen at a glance. Values of variables are color coded after the traffic control scheme of red-yellow-green with green meaning large harvests and red meaning small harvests. In the case of the Chinook salmon timing, web pages designed to engage harvesters, managers and the general public provide 2 to 4 week ahead quantitative forecasts of the dates on which key percentage points in the Chinook migration will occur in the lower Yukon River, Alaska. The uncertainty associated with the quantitative timing forecasts is communicated with a qualitative appraisal of the historical timing of the migration (early, average, late) in relation to the histories of key environmental factors, such as sea surface temperature. Examples from ten years of harvest forecasts and four years of operational timing forecasts will illustrate the communication of uncertainty in contrasting climate states.



**April 15, 16:10, S3-O6 (9394)**

## Effective engagement of stakeholders in designing and communicating science: The Western Alaska Salmon Stock Identification Program

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Crafting and modifying fisheries regulations and allocations of fisheries resources in Alaska occurs within the Alaska Board of Fisheries process, where public participation is a guiding principle. As a decision-making body made up of seven knowledgeable lay people, the board is heavily dependent upon a host of increasingly complex material on stock and fishery assessments presented by scientists and engaged stakeholders. Informed decisions affecting broadly divergent interests depend upon clear communication and interpretation of scientific data in an open process. We review a unique example of this exchange using the Western Alaska Salmon Stock Identification Program (WASSIP), a collaboration among stakeholders and scientists to address long-standing questions about harvest patterns of chum and sockeye salmon in Western Alaska fisheries. Born from frustration with widely divergent regulatory decisions based on limited and controversial data, WASSIP created a framework for representatives from affected stakeholders in Western Alaska to collectively design a scientific study to address critical information gaps in a highly contentious commercial and subsistence fishing environment. Against the back drop of the largest salmon genetics study ever conducted, we review development and execution of a process where representatives of major regional fishery interests accepted responsibility to help design scientific investigations that would inform regulatory decisions they must live with. Central themes were creating innovative approaches to deal with data limitations and uncertainty, and designing analytical approaches that considered specific stakeholder needs while maintaining scientific credibility. WASSIP demonstrated how effective engagement of a small group of representatives increased trust among the broader community of stakeholders, regulators and managers. While opinions on application of data to allocative and regulatory decisions made by the Board varied substantially, a measure of success for the program was the broad recognition that methods and data from the study were sound.

**April 15, 16:30, S3-O7 (9319)**

## Broadening stakeholder involvement in fisheries research through the development of cooperative research initiatives in Korean fisheries

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In 2013 the United States/Republic of Korea Fisheries Panel funded an exchange of experts from the Republic of Korea and the United States to evaluate possible cooperative research projects involving the Korean managed fisheries. Besides collecting data useful for fisheries management, the cooperative research projects were aimed at fostering communication among stakeholders and broadening stakeholder involvement in fisheries research. The experts met with each other, Korean and US researchers, Korean fishers, fishing company spokesmen, and fisheries association officers. The experts also visited a number of Korean fishing vessels and fishing ports to evaluate whether cooperative research projects similar to those implemented in US fisheries could be employed in Korean fisheries. This presentation will describe five possible cooperative research projects identified by the Korean and US experts for the Korean eastern Danish trawl, mackerel purse seine, squid jig, crab pot, and multispecies coastal fisheries. The presentation will also discuss the cultural and technological aides and barriers to the possible success of these projects.

**April 15, 16:50, S3-O8 (9415)**

## Status of IFRAME as an approach for EAF

Chang-Ik **Zhang**[1], Young-Il Seo[2], Man-Woo Lee[1], Sang-Chul Yoon[2], Hee-Joong Kang[1] and Eun-Ji Lee[1]

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This presentation will review the current status of an Integrated Fisheries Risk Analysis Method for Ecosystems (IFRAME) framework as an approach for EAF. This IFRAME approach is to assess the ecosystem impacts of resource use and climate change in marine ecosystems. In this approach, resource management scenarios are incorporated into the projection framework by characterizing the action in terms of changes in fishing mortality or availability of resources. An integrated suite of ecosystem status indicators are used to assess the performance of management scenarios relative to the goals of an ecosystem approach to fisheries management. These ecosystem status indicators track four key management objectives of the ecosystem: sustainability, biodiversity, habitat quality and socio-economic status. We will introduce progress in the IFRAME approach and the status of applications to various fisheries and ecosystems.

# S4 Presentations

**CANCELLED**

## NEAR-GOOS Cross-Basin Climate Monitoring Section: First results of a pilot project

Vyacheslav **Lobanov**[1], Sho Hibino[2], Dmitriy Kaplunenko[1], Aleksandr Lazaryuk[1], Toshiya Nakano[2], Satoshi Ogawa[2] and Pavel Tishchenko[1]

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Since 2011 V.I. Il'ichev Pacific Oceanological Institute (POI), Far Eastern Branch, Russian Academy of Sciences and Japan Meteorological Agency (JMA) had started a pilot project on the NEAR-GOOS Cross-Basin Climate Monitoring Section with the objectives to monitor the properties water masses in the Japan Sea and to detect their variability caused by climate change. The section is based on the PM line routinely implemented by JMA from Japanese coast up to Yamato Rise and 134 E section implemented by POI from Russian coast down to Yamato Rise. In total, it consists of 25 stations with CTD observations and water sampling for chemical analyses from surface down to the bottom. Observations have been carried out in October-November periods of every year simultaneously by both sides. When combining the data obtained by different instruments and methods an inter-comparison and validation of data is an important issue. POI and JMA have discussed the causes of differences in CTD salinity and dissolved oxygen as well as some chemical sampling results. Then the data were adjusted using results of salinity measurements by Autosal salinometer and post processing to remove biases caused by temporal changes and pressure dependences specific to each sensor. Coupling of PM and 134E sections allows to analyze water mass structure of the Japan Sea and estimate lateral distribution of intermediate, deep and bottom waters and water exchange between Japan and Yamato basins. Comparison of recent observations with historical data of late 90$^{th}$ shows clear trend of water temperature increase and decrease of dissolved oxygen content in bottom waters of the Japan Basin which should be associated with climate changes and warming tendency of regional winter conditions.

**April 16, 14:00, S4-O1 (9324)**

## Oceanic currents dynamics and zooplankton diversity in the Kuroshio-Oyashio-Extension (KOE) Region

Sanae **Chiba**[1], Sayaka Yasunaka[2], Tomoko Yoshiki[3], Hiroya Sugisaki[4], Sonia Batten[5] and Tadafumi Ichikawa[3]

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[5] Sir Alister Hardy Foundation for Ocean Science, c/o 4737 Vista View Cr, Nanaimo, BC, V9V 1N8, Canada

Zooplankton species diversity has been observed to generally increase as water temperature increases from regional to global scales, thus higher diversity in lower latitude with warmer waters. This would lead to the future projection with more diversity with a global warming trend. However, water temperature is not necessarily a direct cause of the diversity change. Ocean current dynamics could influence local plankton species and functional compositions through advection transport, and regional temperature change is often a consequence of the current dynamics, too. Using the Odate Collection dataset of 1960s to 1990s and Continuous Plankton Recorder Survey data of 2001-2011, this study is to describe the geographical distribution of zooplankton diversity and its interannual variation in the western North Pacific (33-55°N, 140-170°E), particularly in relation to the dynamics of the Kuroshio-Oyashio-Extention (KOE). Consistent to the previous studies, species Richness and Diversity (*H*) gradually increased from north to south and highest around 35°N in the Kuroshio and transition water domain. Meanwhile, the Coefficient of Variation (CV) was highest around 38-42°N, indicating the influence of the interannual latitudinal shift of the Kuroshio Extension (KE) axis on the regional zooplankton community and species diversity. The latitudinal area of high CV well corresponded to the location of the oceanic boundary, which was determined based on the seasonal variation of multiple biogeochemical properties, *e.g.*, DIC, macronutrients, Chl *a* (Yasunaka *et al.*, submitted). The mechanism linking physical/biogeochemical properties and zooplankton diversity will be discussed in the presentation.

**April 16, 14:20, S4-O2 (9296)**

## Lower trophic level ecosystem indicators from CPR data

Sonia **Batten**

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Plankton are the link between oceanographic processes and the upper trophic level marine resources that have a societal value. Plankton respond rapidly to changes in their environment because of short generation times and a limited ability to move independently of ocean currents. These factors have meant that plankton have often been suggested as useful indicators of ecosystem change. The term "plankton" encompasses numerous functionally diverse organisms however, which are difficult to quantitatively measure and monitor over large spatial scales in a systematic way. Some progress has been made towards this with the Continuous Plankton Recorder (CPR) Survey of the North Pacific, now in its 14$^{th}$ year. Summarising the diverse plankton data into comprehensive and meaningful indices is a challenge and such indices generally fall into 3 categories; metrics of abundance, metrics of distribution and metrics of timing or phenology. Variability in some or all of these may influence organisms further up the food chain and can thus be used as indicators of ecosystem change. Examples of lower trophic level indicators are presented here, from both the Pacific Survey and from the much longer North Atlantic Survey to demonstrate what can be achieved as the time series lengthens.

**April 16, 14:40, S4-O3 (9317)**

## Evolvement of HAB causative species and possible links during the past five decades in Chinese coastal waters

Douding **Lu** and Xinfeng Dai

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A remarkble change of harmful algal composition has been occurred during the last half century in Chinese coastal waters. The frequency of harmful algal blooms has shown remarkable increased trend while size spectrum of blooming species has become much smaller since the 70's of last century. More recently, around 60 HAB events occurred each year in China (http://www.soa.gov.cn). Areas with frequent HABs mainly include the Changjiang estuary of the Esat China Sea (ECS), the Zhujiang estuary in the South China Sea (SCS), the Bohai Bay and the Liaodong Bay(the northern sea area of China). Particularly, large scale blooms (over 1 000 km$^2$) have been recorded every year since 1998. *Prorocentrum donghaiense* has become the recurrent bloom species in the East China Sea for more than ten years.Since 1999, *Phaeocystis globosa* has formed massive blooms in the South China Sea and in Tianjing coastal water of the Bohai Sea. A dinoflagellate bloom, caused by *Cochlodinium geminatum* which has not formed blooms elsewhere around the world, occurred recently in the Zhujiang estuary, SCS. Newly recorded blooms caused by *Karodinium veneficum and Cochlodinium polykrikoides* in the East China Sea are also remarkable. Since 1998, nearly 90 blooms caused by *Karenia mikimotoi* have occurred in China. The massive bloom of this species in the East China Sea in 2005, 2012 resulted in the heavy loss of fish and shellfish farming. *Azadinium poporum*, an AZA toxin producer, was rerecorded in the Bohai Sea, the East China Sea as well as in the South China Sea. More recently, brown tide caused by *Aureococcus anophageferense* has been registered in the near shore of the Bohai Sea. A number of species have been detected for the first time in this area. The possible related factors for the shift of causative species of harmful algae in China coastal waters include human activities, ballast water dispersal, climate change and so on. The evolvement of HAB causative species in Chinese coastal waters deserves more attentions and efforts in HAB monitoring and management in future.

**April 16, 15:00, S4-O4 (9412)**

## Long-term trends of red tides by eutrophication and toxic blooms by oligotrophication in the Seto Inland Sea of Japan

Ichiro **Imai**[1], Masafumi Natsuike[1], Keigo Yamamoto[2], Tetsuya Nishikawa[3] and Satoshi Nagai[4]

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The Seto Inland Sea is the largest enclosed coastal sea in Japan and is also a major fishing ground including aquacultures of fishes, bivalves and seaweeds. There were two significant long-term changes in environments; an increase in winter water temperatures of 0.042°C year$^{-1}$, and a decline in dissolved inorganic nitrogen (DIN) from about 10 mM in the 1970s to ~5 mM in the late 1990s to the present due to the reduction in nutrient inputs by virtue of the regulation by law. Along with serious eutrophication in 1960s and 1970s, the red tide incidents had markedly increased in frequency and scale. The maximum incident 299 per year was recorded in 1976, and the incidents showed a clear decreasing trend to reach around 100 per year in late 1980s. However, the toxic dinoflagellate Alexandrium tamarense has become dominant in the Seto Inland Sea in spring, especially in Osaka Bay, and has made manila clams and oysters toxic almost every year from late 1990s. The deposition of abundant cysts of Alexandrium spp. in sediments indicates the establishment of A. tamarense in the Seto Inland Sea. There is a history of anthropogenic transfers of oyster juveniles from A. tamarense blooming areas (Tohoku) to the Seto Inland Sea (no A. tamarense blooms before 1990s), and investigations using microsatellite markers revealed the close relationships between A. tamarense strains of Tohoku and the Seto Inland Sea. The ecosystem resilience was disturbed by anthropogenic activities such as transferring oyster juveniles in the Seto Inland Sea.

**April 16, 15:40, S4-O5 (9353)**

## Understanding ecosystem productivity and predicting population resilience via steepness

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

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

**April 16, 16:00, S4-O6 (9298)**

## Possible effects of global warming on the neon flying squid winter-spring cohort

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Neon flying squid (*Ommastrephes bartramii*) winter-spring spawning cohort stock level depends on zooplankton availability during early life stage. The optimum nursery grounds for this species is defined by a sea surface temperature range of 21°C to 25°C. Zooplankton density in the nursery grounds depends on nutrient supply by winter vertical mixing. Currently, nursery grounds are located at 20–30ºN in the northwestern Pacific that is characterized by moderate wind. In the future, global warming has the potential to push nursery grounds into north region where strong monsoon wind blows. Then, winter mixed layer will develop deeper than now and feeding environment will change. It is difficult to forecast future zooplankton density, however, it is possible to estimate change of feeding environment by using the relationship between current mixed layer depth and chlorophyll-a density. In this study, we discuss how current feeding condition is determined and the possible effects of global warming on the neon flying squid winter-spring cohort in the coming 300 years with mixed layer depth data from major ocean general circulation models (MIROC3.2hires, MRI-CGCM2.3.2, GFDL CM2.1, CSIRO MK3.0) for global warming that are based on CMIP3/SRES A1B scenario.

**April 16, 16:20, S4-O7 (9352)**

## Regime shifts in the fish assemblages around Japan over the last century and their early warning signals

Yongjun **Tian**[1], Xuhui Xie[2], Kazuhisa Uchikawa[1], Jürgen Alheit[3], Jiahua Cheng[4] and Akira Tomosada[2,5]

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The marine ecosystems around Japan which are under the impact of the warm Tsushima and Kuroshio currents and the cold Oyashio current, belong to the most productive regions in the North Pacific. They are typical wasp-waist ecosystems dominated by small pelagic species such as sardine and anchovy which exhibit large low-frequency fluctuations in biomass. Whereas a comparatively large number of studies on the variability of individual species such as sardine and anchovy were carried out, only few studies have focused on the long-term variability of the fish assemblages, particularly for the period before 1950. For this study, thirteen species including small forage and large predatory species, such as sardine and yellowtail, and warm-water and cold-water species, such as skipjack tuna and Pacific cod, were selected as indicators, and essential characteristics of the fish assemblages were analyzed based on fishery, oceanographic and climate datasets during the period from 1901-2010.

Principal component analysis (PCA) of the catch of 13 indicator species showed evident decadal variation patterns with step changes in the first principal component (PC1) in the early-1910s, mid-1930s, early-1960s and late-1980s, and in the PC2 around the late-1920s, early-1940s and mid-1970s. PC3 showed abrupt changes around the early-1910s and mid-1930s, mid-1950 and mid-1960s, closely resembling those in PC1. The tipping points in PC1 and PC3 corresponded well with those of the Arctic Oscillation (AO) (mid-1930s and late-1980) and the Monsoon Index (MOI) (early-1910s, mid-1960s and late-1980s), while the PC2 seemed associated with Pacific Decadal Oscillation (PDO) (early-1940s and mid-1970s). These regime shifts revealed by PCA indicated that the dominant variation modes in the fish assemblages of waters surrounding Japan were forced by decadal climate variability as inherent in AO, MOI and PDO. Ecological indicators such as mean trophic level showed decadal variation patterns which were influenced to a large degree by small pelagic species. The potential possibility of using ecological indicators to detect early warning signals of future regime shifts in the fish assemblages is discussed.

**April 16, 16:40, S4-O8 (9378)**

### Wind off Hawaii and fisheries in Japan: Expected benefit from marine science to society

Hiroaki **Saito**

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Fish species alternation (FSA) between sardine and anchovy is a drastic example of ecosystem regime shift responding to climate change. Sardine stock level off Japan was $>10^7$ ton in 1980's. After 1988, the continuous failure of the recruitment collapsed the stock down to $1\sim2x10^5$ ton (2000's). Japanese interdisciplinary project SUPRFISH (Studies on Prediction and Application of Fish Species Alternation) revealed the stock collapse was a result of the physical oceanographic change in Kuroshio Extension region which was induced by wind off Hawaii. The sudden stock collapse damaged the regional economy depending on sardine fishery, such as Kushiro, Hokkaido. It is expected that the monitoring of the Rossby wave propagation of SSH and sardine larvae/juvenile provides an early warning for fishers and managers. Remaining issue of the SUPRFISH is the response of lower tropic levels, especially zooplankton, to the change in physical oceanographic property. It is suggested poecilostomatoid copepods and appendicularians are key player of energy transfer from primary producer to fish as well as calanoid copepods based on grazing food chain. Further study of the response of lower tropic levels to the physical oceanographic variability is essential for understanding ecosystem response to perturbation and for sustainable use of fisheries production.

# Posters

**S4-P1**

### Prediction of the spawning ground of *Todarodes pacificus* under IPCC climate A1B scenario

Jung Jin Kim[1], Suam **Kim**[2], Lee Joon-soo[1], Hong Sik Min[3], and Cheol-Ho Kim[3]

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In the northwestern Pacific, spawning of the common squid, *Todarodes pacificus*, occurs at continental shelf and slope areas of 100-500 m, and the optimum temperature for the spawning and survival of paralarvae is assumed to be 18-23°C. To predict the spawning ground of *Todarodes pacificus* under future climate conditions, we simulated the present and future ocean circulations, using an East Asia regional ocean model (Modular Ocean Model, MOM version3), projected by two different global climate models (MPI_echam5, MIROC_hire), under an IPCC SRES A1B emission scenario. Mean climate states for 1990-1999 and 2030-2039 from 20$^{th}$ and 21$^{th}$ Century Climate Change model simulation (from the IPCC 4th Assessment Report) were used as surface conditions for simulations, and we examined changes in spawning ground between the 1990s and 2030s. The results revealed that the distribution of spawning ground in the 2030s in both climate models shifted northward in the East China Sea and East Sea, for both autumn and winter populations, compared to that of the 1990s. Also, the spawning area (with 1/6° x 1/6° grid) in the 2030s of the autumn and winter populations will decline by 11.6% (MPI_echam5) to 30.8% (MIROC_hires) and 3.0% (MPI_echam5) to 18.2% (MIROC_hires), respectively, from those of the 1990s.

# S5 Presentations

### April 16, 14:00, Invited, S5-O1 (9367)

## Causes and consequences of NE Pacific climate trends and variations from 1900-2012

James A. Johnstone[1] and Nathan J. **Mantua**[1,2]

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Northeast Pacific coastal sea surface temperatures (SSTs) and landbased surface air temperatures (SATs) exhibit prominent multidecadal variations that have largely been associated with the PDO, in addition to a linear warming trend of 0.6 to 1°C between 1900 and 2012. In order to clarify mechanisms and time scales of temperature variability, we investigate regional coupled atmosphere-ocean variability from 1900 to 2012, with emphasis on the data-rich coastal areas around North America and Hawaii. We use independent records of sea level pressure (SLP), SST, and SAT to identify large-scale patterns of NE Pacific climate at monthly and longer time scales. Using a linear stochastic time series model, we show that the evolution of SSTs in the NE Pacific can be explained by a combination of regional atmospheric forcing and ocean persistence. From 1900-2012, SLP reductions and associated atmospheric forcing over the NE Pacific led to increases of SST and SAT around the NE Pacific margins, with the strongest circulation and warming trends observed from 1920 to 1940. A trend in atmospheric forcing accounts for more than 90% of the 1900-2012 linear SAT warming in the US Pacific northwest. These results illustrate that significant changes in atmospheric circulation warmed the coastal NE Pacific from 1900 to 2012, and suggest more generally that mechanisms of regional multidecadal temperature variability can also extend to century time scales. We hypothesize that much of the observed 20th century warming in the NE Pacific can be attributed to natural variability of the climate system.

### April 16, 14:25, S5-O2 (9396)

## The Pacific Decadal Oscillation, Revisited

Matthew **Newman**[1,2], Michael A. Alexander[2] and Dimitry Smirnov[1]

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Predictability of Pacific sea surface temperature (SST) climate variations and climate impacts on time scales of 1-10 years is discussed, using a global linear inverse model (LIM) as an empirical benchmark for decadal surface temperature forecast skill. A particular focus will be on the predictability of the Pacific decadal oscillation (PDO), which represents the dominant mode of Pacific decadal SST variability. The PDO is shown to represent a few different physical processes, including wind-driven changes of SSTs that can occur either due to daily weather variability or to tropical forcing, and variations in the North Pacific western boundary current region, primarily in the Oyashio SST front. These different processes represent increasingly longer time scales but are largely unrelated, and it is their combination that may produce regime-like behavior. The question of whether the PDO represents a response to climate forcing rather than a forcing of climate variability is thus key to an understanding of what impacts, if any, the PDO has on North Pacific and North American climate. It is shown that while much of the climate signal associated with the PDO has tropical origins, Oyashio frontal variability has a decadal component that drives a significant atmospheric and oceanic response downstream. This result is demonstrated both in observations, and a 25-member ensemble of high resolution (1/4 degree) atmospheric GCM simulations forced with a realistic SST anomaly in the Oyashio region.

**April 16, 14:45, S5-O3 (9381)**

## A coupled decadal prediction of the Kuroshio Extension system

Bo **Qiu**[1], Shuiming Chen[1], Niklas Schneider[1] and Bunmei Taguchi[2]

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Being the extension of a wind-driven western boundary current, the Kuroshio Extension (KE) has long been recognized as a turbulent current system rich in large-amplitude meanders and energetic pinched-off eddies. An important feature emerging from recent satellite altimeter measurements and eddy-resolving ocean model simulations, is that the KE system exhibits well-defined decadal modulations between a stable and an unstable dynamic state. Here we show that the decadally-modulating KE dynamic state can be effectively defined by the sea surface height (SSH) anomalies in the 31--36N and 140–165E region. By 18utilizing the SSH-based KE index from 1977–2012, we demonstrate that the time–varying KE dynamic state can be predicted at lead times of up to ~6 years. This long-term predictability rests on two dynamic processes: (1) the oceanic adjustment is via baroclinic Rossby waves that carry interior wind-forced anomalies westward into the KE region, and (2) the low-frequency KE variability influences the extratropical storm-tracks and surface wind stress curl field across the North Pacific basin. By shifting poleward (equatorward) the storm-tracks and the large-scale wind stress curl pattern during its stable (unstable) dynamic state, the KE variability induces a delayed negative feedback that can enhance the predictable SSH variance on the decadal timescales.

**April 16, 15:05, S5-O4 (9386)**

## The role of spiciness in North Pacific decadal variability

Niklas **Schneider**[1] and Bunmei Taguchi[2]

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Using a coupled model and available of observations, we explore the role of spiciness variations in North Pacific decadal variability. We focus on meridional shifts of North-West Pacific fronts between warm and salty tropical and cool and fresh subtropical waters. Anomalies of North Pacific Ekman pumping induce equivalent barotropic Rossby waves that, upon reaching the western boundary region, generate large spiciness anomalies through anomalous advection. The spiciness anomalies are advected towards the east with the mean circulation, and may be important for the pre-conditioning and generation of higher baroclinic modes in central and western North Pacific.

**April 16, 15:25, S5-O5 (9299)**

## Role of North Atlantic climatic variability in recent North Pacific warming

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The period from the late 1980s to about 2010-2011 has shown the prominent North Pacific (NP) warming, especially strong in its western half. We suppose that this warming was partly associated with changes in patterns of climatic variability in the North Atlantic (NA). Based on climatic datasets for 1950-2013, two modes of interaction between the NP and NA were identified. The first (eastern) mode reflects the NP impact on the NA climate and includes the Pacific/North American and West Atlantic patterns. This mode ensured the strong positive correlation of SSTA variations between the eastern NP and central NA (r=0.74). The data analysis evidenced the inter-decadal eastward propagation of the Azores High from 1950 to 1990. The similar eastward displacement of the Icelandic Low occurred in the early 1990s after it sharp deepening. As a result, the center of the NA climatic variability shifted from the west to its northeastern part. The deepening of Icelandic Low in the late 1980s-early 1990s coincided with transition of the West Pacific pattern to its positive phase, continued until 2011/2012. This period was characterized by strong positive correlation between SSTA variations in the Northeast Atlantic and western North Pacific (r=0.65), while the relationship of anomaly variations between the eastern NP and central

NA became weak. This may denote establishment of the western mode of interaction (East Atlantic and West Pacific patterns), with downstream effects of changes in the leading NA climatic modes on the western NP. In this study, we shall analyze those changes in atmospheric patterns over Eurasia and, especially in its eastern part, which were initiated by the North Atlantic variability and contributed to recent warming event in the NP.

**April 16, 16:00, S5-O6 (9387)**

## Secular nutrient changes in observation and numerical modeling in the western North Pacific in the last 50-years

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Global warming is expected to reduce ocean's productivity generally due to reduced upward nutrient associated with enhanced stratification, consistent with several papers reporting reductions of primary production estimated from satellite ocean-color observations. Also, an analysis of secchi disk observation suggests reduction of phytoplankton concentrations on longer timescales than those for satellite observations. Therefore, nutrient concentration is important in mechanisms how physical climate variability and change influence marine ecosystems. Studies of long-term nutrient concentrations, however, are substantially limited.

In this presentation, we examine observed nutrient changes using a new gridded phosphate concentration dataset for the last 50-years. The analysis of this dataset shows substantial reduction of near-surface phosphate concentration over the western North Pacific. The spatio-temporal pattern of reduction suggests that the mechanism is not the enhancement of stratification, but associated with ocean circulation changes. The hindcast simulation of an ocean biogeochemistry model embedded on a physical ocean general circulation model is examined in order to clarify the responsible mechanism.

**April 16, 16:20, Invited, S5-O7 (9315)**

## Changing oxygen content of the Pacific basin: Anthropogenic trend or natural variability?

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The Pacific basin hosts the largest volume of low-oxygen water in the globe. Observations from the last several decades show a significant expansion of the oxygen minimum zone (OMZ) as well as decadal-scale variability at time-series stations. The long-term warming and associated solubility decease cannot fully explain the observed oxygen trend, and much of the mechanisms that link climate variability and oceanic oxygen remain to be uncovered. We examine physical and biogeochemical mechanisms that alter the intensity of the OMZ and the distribution of dissolved oxygen in the North Pacific using a suite of model experiments. Analyzing hindcast and sensitivity experiments, we find important roles of natural and anthropogenic perturbations to the atmospheric climate, which alters physical circulation and biogeochemical cycling of the upper ocean. Our results suggest that processes that regulate the biological productivity and organic carbon export from the tropical upwelling region likely play crucial role in the future behavior of the Pacific OMZ.

**April 16, 16:45, S5-O8 (9283)**

## A description of T/S and oxygen variability off southern California using regional- and global-scale climate indices

Sung Yong **Kim**[1] and Bruce Cornuelle[2]

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A coastal ocean climatology of temperature, salinity, and oxygen in the Southern California Bight is estimated from conductivity-temperature-depth (CTD) and bottle sample profiles collected from historical California Cooperative Oceanic Fisheries Investigation (CalCOFI) cruises (1950 to 2009; quarterly since 1984) off southern California and quarterly/monthly near-shore CTD surveys (within 30 km from the coast except for surfzone; 1999 to 2009) off San Diego and Los Angeles. The estimation uses multivariate linear regression to optimally separate physical processes affecting the measurements. The four-dimensional temperature and salinity fields are modeled as linear combinations of the annual cycle and five harmonics, a mean and linear trend, selected well-known climate indices – El Nino-Southern Oscillation (ENSO), Pacific Decadal Oscillation (PDO), North Pacific Gyre Oscillation (NPGO) – and the Scripps Pier temperature time series, all without time lags. Since some of the predictor indices are correlated, they are successively orthogonalized in order to reduce the ambiguity in attribution of the contributing variance of each regression basis. The data-derived climatology will provide a tool to evaluate climate signals embedded in coastal observations and to constrain realistic numerical models as boundary and initial conditions.

**April 16, 17:05, S5-O9 (9389)**

## Decadal prediction of hypoxia along the US West Coast

Mercedes Pozo Buil[1], Emanuele **Di Lorenzo**[1] and Steven J. Bograd[2]

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Coastal hypoxia events along the US West Coast are strongly controlled by changes in local upwelling winds. However, the long-term statistics of coastal hypoxia are affected by changes in the oxygen content of the subsurface water masses that feed into the coastal upwelling. Here we diagnose the role of subsurface circulation dynamics in modulating the low-frequency variations of oxygen content of upwelling water masses along the US West Coast. Using the ECMWF ORA-S3 and SODA reanalysis products we develop a subsurface salinity proxy to track the advection dynamics of oxygen on isopycnal 26.5. We show that this salinity proxy tracks the dominant decadal fluctuations of subsurface oxygen observed in long-term records in the California Current, Oregon Shelf and Gulf of Alaska records. Further analysis of the salinity proxy reveals that the coastal low-frequency fluctuations of oxygen originate in the subtropical gyre and propagate downstream into the US west coast upwelling system through the mean gyre circulation. The anomalies in the subtropical gyre lead the ones in the coastal ocean by approximately 8-10 years, and can be used to develop decadal prediction model of coastal hypoxia. Although more in depth analysis are needed to establish the robustness of this forecast model, the current sign of the anomalies in the gyre predicts strong hypoxic conditions by 2020.

**April 16, 17:25, S5-O10 (9374)**

## The physical oceanographic environment of the southern California Current during past decade: Changes in climate and concepts

Arthur J. **Miller**[1], Hajoon Song[2] and Aneesh Subramanian[1]

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The California Current System (CCS) has been studied by CalCOFI for many decades. Since 2004, the Southern California Bight (SCB) and the oceanic region offshore has also been the site for the California Current Ecosystem (CCE) Long-Term Ecological Research (LTER) program, which has established long-term observational time series and executed Process Cruises to better understand physical-biological variations, fluxes and interactions. Since the inception of the CCE-LTER, many new ideas have emerged about what physical processes are the key controls on CCS dynamics. These new perspectives include obtaining a better understanding of what climate patterns exert influences on CCS physical variations and what physical controls are most important in driving CCE ecological changes.

Physical oceanographic and climatological conditions in the CCS varied widely since the inception of the CCE-LTER observational time series, including unusual climate events and persistently anomalous states. These broad-scale climate variations that occurred over the North Pacific and CCS during this time period are discussed here to provide physical context for the CCE-LTER time series observations and the CCE-LTER Process Cruises. Data assimilation fits, using the ROMS 4DVAR framework, were successfully executed for each 1-month period of the Process Cruises. The fits provide information about how the physical flows evolve during the multi-week Process Cruises. Relating these physical states to biological measurements of CCE-LTER will yield vital long-term perspective of how changing climate conditions control the ocean ecosystem in this region and information on how this important ecosystem can be expected to evolve over the coming decades.

**April 16, 17:45, S5-O11 (9332)**

## A challenge to investigate environmental factors which determine spawning migration variability of small pelagic: An example of Pacific saury

Shin-ichi **Ito**[1], Sohsuke Ohno[1], Takeshi Okunishi[1], Satoshi Suyama[2], Masayasu Nakagami[2], Daisuke Ambe[3] and Takahiko Kameda[4]

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Spawning migration is one of the most difficult behavior to represent by a numerical model. Using realistic initial and boundary condition, an Euler-type model of Pacific saury was applied to investigate environmental factors which determine spawning migration variability. The initial distribution of Pacific saury was defined by synoptic surface trawl surveys and satellite derived environmental conditions were used as forcing; sea surface temperature (SST), prey density estimated from surface chl-*a* concentration and surface current speed. Growth of Pacific saury was calculated by a fish bioenergetics model (NEMURO.FISH). A fitness algorithm was applied for feeding migration in which the fish are assumed to be moving towards a place with optimal growth condition. A larvae fitness algorithm was applied for spawning migration in which the spawning fish moves to a place of the optimal growth of larvae. For spawning migration, westward migration was added to reproduce realistic spawning grounds around Japan Islands. Strength of the westward migration was adjusted to realize observed variability of saury migration to fishing grounds. The adjusted westward migration variability showed negative (positive) correlation with eastern (western) side SST. The correlation patter to SST showed PDO pattern distribution and suggested a strong influence of climate to fish spawning migration.

**April 16, 18:05, S5-O12 (9405)**

### Asynchronous responses of fish assemblages to climate-driven ocean regime shifts between the upper and deep layer in the Ulleung Basin of the East Sea from 1986 to 2010

Sukgeun **Jung**

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Past studies suggested that the basin-wide regime shift occurred in 1988-1989, impacting marine ecosystem and fish assemblages in the western North Pacific. However, the detailed mechanisms are still yet unclear. In the Ulleung basin of the East Sea, filefish, anchovy and sardine dominated the commercial fish catches in 1986-1992, but thereafter common squid comprised >60% of the total catch in 1993-2010. To illuminate the mechanisms for this dramatic shift in dominant fisheries species, I related changes in depth-specific oceanographic conditions from 0 to 500 m to inter-annual changes in the fish assemblage structure from 1986 to 2010. In the upper layer of 50-100 m depths, water temperature suddenly increased in 1987-1989, and consequently warm-water epi-pelagic species (anchovy, chub mackerel, and common squid) became dominant, while sardine, relatively cold-water epi-pelagic species, nearly disappeared. An annual index of the volume transport by the Korea Strait Bottom Cold Water, originating from the deep water of the Ulleung Basin, displayed a sudden intensification in 1992-1993, accompanied by decreased water temperature and increased water density in the deep water and replacement of dominant bentho-pelagic species from filefish, warm-water species, to herring and cod, cold-water species. The results suggest that climate-driven oceanic changes and the subsequent ecological impacts can occur asynchronously, often with time lags of several years, between the upper and the deep layer, and between epi-pelagic and deep-water fish assemblages.

# Poster

**S5-P1**

### Formation mechanism of the Kuroshio Loop Current

Jingsong **Guo**[1,2], Liping Yin[1,2], Yeli Yuan[1,2] and Binghuo Guo[1,2]

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Statistical results from satellite altimeter sea level data reveal that the Kuroshio stream belt is a weak disturbance region, while the area west of the Hengchen Submarine Ridge (HSR) is a very active, strongly disturbed region. The Argos satellite-tracked, drifter trajectory diagrams show that the Kuroshio Loop Current (KLC) and its shed eddy (SE) occur only to the west of the HSR. This suggests that these two oceanographic phenomena are induced by instability of the Kuroshio.

To better understand the instability mechanisms in theory, from the governing equations of perturbation instability in a σ coordinate frame, we derive equations in phase space and determine the restraint conditions for solution existence. For a simplified structure of the Kuroshio stream and bottom topography, an analytical solution of the dispersion relation and the exponential growth rate is derived for mesoscale perturbation.

# S7 Presentations

**April 17, 14:00, S7-O1 (9309)**

## Distributed governance of marine ecosystems

Samuel **Pooley**

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"Distributed governance" has been suggested as a way to place the practical elements of rights-based management in fisheries into a regulatory and governance continuum relevant to conditions in particular communities. Some alternatives include co-management, cooperative and corporate institutions that might be ceded the right – or some of the rights – to make management decisions within a conservation and ecological framework monitored by government (the conservation standard). This would redirect many management functions from government to the community, reducing regulatory alienation and increasing the level of information upon which complex fishery management decisions rely. This may be particularly useful in increasing governance flexibility in the face of climate change. However, the choice of management structure for a community-used natural resource, particularly expanded to broad ecosystem concerns with heterogeneous users, even within a limited spatial range, is not obvious. What should also be obvious is that agency costs currently inherent in a government-centered approach to fisheries management can be reduced. Community ownership is one of several alternatives, especially in an ecosystem context, and its advantages should be weighed along with those of other co-management alternatives.

**April 17, 14:20, S7-O2 (9414)**

## What information is really needed to inform adaptation strategies to climate change

Jake **Rice**

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Significant research effort has been devoted to downscaling global climate change models, using the results to predict future ocean temperature and salinity conditions, and in turn using those forecasts to forecasts how distributions of key fish species may change in future. These scientifically challenging tasks can inform policy and management with regard to conditions to which major ocean users, particularly fisheries, may have to adapt in future.

However adaptive capacity is a key aspect of policy making and management as well, and to date has received less attention. In this talk I will argue that the greatest needs for forecasts of changing ecosystem conditions are in near-coastal areas. I will document the pressures on high seas and shelf fisheries and place the expected changes in fish distributions in the context of those other pressures. Coastal fisheries, on the other hand, must adapt to changes in their immediate neighborhoods, and lack the flexibility to follow favoured fishing conditions to new sites. The talk will explore two linked questions. The first is how communities can use different kinds of information in planning adaptation strategies for their livelihoods. The second is how feasible it may be to forecast the various types of information from our current climate forecasting abilities. How answers to those two questions intersect or diverge has important implications for policy, management, and coastal communities.

**April 17, 14:40, S7-O3 (9410)**

## So what? How will climate change impacts on fisheries production differentially affect fisheries dependent communities

Manuel **Barange**[1], J. Scholtens, E.H. Allison, G. Merino, J.L. Blanchard, J. Harle, J. Icarus Allen, J. Holt and S. Jennings

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Growing human populations and changing dietary preferences are increasing global demands for fish, adding pressure to concerns over fisheries sustainability. In addition, climate change is expected to change the productivity, distribution and seasonality of fish stocks, both directly and as a result of underlying food web processes. While recent assessments have discussed the differential expected impacts of climate change on global and regional fish and fisheries resources (Cheung *et al.* 2012; Blanchard *et al.* 2013), the significance of the expected biological impacts to the economies of the countries exploiting them is less known. Here we will answer the "so what?" question by linking models of physical, biological and human responses to climate change in 67 marine national Exclusive Economic Zones (EEZ). We estimated relative 'fisheries dependency' to climate change using quantified indicators of the contribution of fisheries to employment creation, to economic value adding and to food security. Combining "dependency" with projected climate change impacts provides a more complete picture of the consequences of climate change, and possibly an indication of the urgency nations will need when considering their adaptations to climate change in the fisheries sector.

**April 17, 15:00, S7-O4 (9301)**

## Projected spatial distributions of eastern Bering Sea arrowtooth flounder under simulated climate scenarios, and their potential impact on predation and stock dynamics of walleye pollock

Paul D. **Spencer**[1], Nicholas A. Bond[2], Anne B. Hollowed[3], Stephani Zador[3], Kirstin Holsman[2] and Franz J. Mueter[4]

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Empirical relationships between the extent of the eastern Bering Sea shelf summer "cold pool" (bottom water ≤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. This assumption is based on an observed inverse relationship between the area occupied by arrowtooth flounder and the cold pool area. Small cold pool areas and large arrowtooth flounder areas were observed in the warm years of 2003-2005, whereas more recent colder years have exhibited larger cold pool areas and smaller arrowtooth flounder areas. Projections of cold pool area 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 a projected increasing trend in the area occupied by arrowtooth flounder. The projected changes in the spatial distribution of arrowtooth flounder can affect the spatial overlap with their prey species, of which age 1 and 2 walleye pollock (*Theragra chalcogramma*) comprise a large portion. Projected spatially-explicit predation rates of arrowtooth flounder upon walleye pollock under future climate scenarios will be incorporated into a single-species walleye pollock stock assessment model in order to assess the projected impact of predation upon pollock abundance and fishery harvest.

**April 17, 15:20, S7-O5 (9304)**

## Using multi-species models to evaluate climate and trophic impacts on recommended harvest rates of groundfish in the Bering Sea (AK)

Kirstin **Holsman**[1], Kerim Aydin[2], Jim Ianelli[2] and André E. Punt[3]

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Climate change has already altered marine ecosystems around the world and is postulated to cause a 2-4$^{o}$C increase in SST for the Bering Sea (AK). Here we use multi-species food-web and assessment models (MSM) to link climate-driven changes in physical and trophodynamic conditions to recruitment and survival in order to distinguish fishery impacts from large-scale climate pressures. MSM simultaneously runs age-structured stock assessment models and links the models through estimates of predation mortality based on predator abundances in the model. Here we modified an existing MSM for three species of fish from the Bering Sea (walleye pollock, Pacific cod, and arrowtooth flounder) to incorporate temperature dependent predator rations based on bioenergetics models (*i.e.*, TMSM). We fit the model to hindcast-extracted time series then used downscaled IPCC scenario-driven ROMS/NPZ model estimates of temperature, circulation, and zooplankton abundance to project MSM forward to 2050 and derive multi-species biological reference points (MBRPs) for various harvest control rule approaches. Initial results indicate that TMSM estimates of recruitment are higher than those from analogous single species models, whereas harvestable biomass is lower. MBRPs are strongly influenced by harvest rates of predator populations and climate-driven changes to metabolic demand and recruitment. When fishing pressure on predators is attenuated, predation mortality increases and reduces unfished biomass of prey species. Our results demonstrate that prey species populations are strongly influenced by the interacting effects of climate and predator harvest rates, underscoring the importance of considering the interaction of both factors in fisheries management under future climate change.

**April 17, 16:00, S7-O6 (9366)**

## Shifts in fisheries management: Adapting to regime shifts

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For many years, fisheries management was based on optimizing yield and maintaining a target biomass, with little regard given to low frequency environmental forcing. However, this policy was often unsuccessful. In the last two to three decades, fisheries science and management has undergone a shift towards balancing sustainable yield with conservation, with the goal of including ecosystem considerations in decision-making frameworks. Scientific understanding of low frequency climate-ocean variability, which is manifested as ecosystem regime-shifts and states, has led to attempts to incorporate these shifts and states into fisheries assessment and management. To date operationalizing these attempts to provide tactical advice has met with limited success. We review efforts to incorporate regime-shifts and states into the assessment and management of fisheries resources, propose directions for future investigation, and outline a potential framework to include regime-shifts and changes in ecosystem states into fisheries management.

**April 17, 16:20, S7-O7 (9345)**

## Evaluating long-term climate predictions for the Bering Sea ecosystem using a suite of modeling approaches

Kerim **Aydin**[1], Ivonne Ortiz, Albert J. Hermann, Georgina A. Gibson and André E. Punt

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Biological models used to forecast long-term (20+ year) trends for ecosystems using input climate projections necessarily involve large amounts of uncertainty, especially due to nonlinear relationships between biology and the climate/ocean system. In order to best evaluate predictions, a strong approach is to use ensemble modeling; wherein multiple, independent models with differing assumptions produce predictions, and results are compared either qualitatively or quantitatively. As part of the recently-completed Bering Sea Program, a modeling team developed several independent methods of using IPCC climate scenarios run from 2005-2040 to make biological projections, with special attention to forecasting future production of Bering Sea walleye pollock (*Theragra chalcogramma*). These methods include extrapolating fish recruitment correlates from IPCC sea surface temperature results, extrapolating recruitment from temperature-at-depth obtained from a Regional Ocean Modeling System (ROMS) model of the Bering Sea driven by downscaled IPCC results, driving the Ecosim ecosystem model and Multispecies Statistical Models (MSM) with plankton output from a nutrient-phytoplankton-zooplankton (NPZ) model coupled to ROMS, and developing a fully-coupled ROMS model that includes explicitly-modeled growth and movement of fish and simulation of fishing (the FEAST model). Here, we discuss the relative results of each model, the tradeoffs in modeling effort, parameter uncertainty and compute time, and the overall expected utility to scientists, stakeholders and the public, of output of the models individually and as a combined, synthesized set of results.

**April 17, 16:40, S7-O8 (9409)**

## Projections of chub mackerel recruitment for incorporation in stock assessment models

Nicholas A. **Bond**[1], Sukyung Kang[2], Jae Bong Lee[2] and Anne B. Hollowed[3]

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[3] National Oceanic and Atmospheric Administration, USA

Historical time series reveal that wind driven currents (as indexed by spring salinity) influence the transport of chub mackerel eggs and larvae to Korean coastal waters and ultimately the harvest by Korean fisheries. The validity of this relationship is tested using an updated time series of observed recruitment and oceanographic data. The statistical relationship(s) that are derived using the full time series of observed data are used with the output from global climate model output to make projections of chub mackerel recruitment during future decades. These projections will be incorporated in single species stock projection models towards assessing the probable future status of chub mackerel populations in association with changes in regional ocean properties.

**April 17, 17:00, S7-O9 (9380)**

## Challenges and opportunities for understanding environmental controls on stock productivity: Insights from a meta-analysis of the Northeast pacific

Timothy E. **Essington**[1], Megan Stachura, Christine Stawitz, Trevor Branch, Melissa Haltuch, Anne B. Hollowed, Nathan J. Mantua and Paul D. Spencer

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Linking patterns of fish stock productivity to environmental drivers is important for predicting consequences of future climate change and for understanding causes for past dynamics. Identifying causal relationships is made difficult by the possibility of spurious correlations, insufficiently long time series, and the absence of a priori hypotheses. Here we hypothesized that we could better identify environmental drivers of stock production by adopting a hierarchical approach. We first identified stocks that are likely to have similar sensitivity to shared environmental drivers, and then evaluated whether stocks that were grouped together shared similar trends in recruitment or growth, and if so, whether they could be reliably related to hypothesized environmental drivers. We found marginal evidence for synchrony in recruitment dynamics, and grouping stocks based on putative sensitivity marginally improved ability to hindcast recruitment. Evidence for synchrony was strongest in the Gulf of Alaska. Growth dynamics were more difficult to relate to environmental variables. We conclude that limited information about critical life history periods, and the processes that foster high survivorship through those periods, limit our ability to precisely predict groups of stocks that have synchronous production dynamics, and that localized conditions that are weakly related to basin- or regional-scale conditions may play a large role in governing production.

**April 17, 17:20, S7-O10 (9329)**

## Setting biological reference points under a changing climate

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

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Climate change is expected to impact the distribution, phrenology and abundance of commercial fish and shellfish through direct and indirect pathways. The temporal signature of these projected changes will differ from interannual, decadal, and multi-decadal variability and thus may necessitate new approaches to setting biological reference points for management. This issue presents a dilemma because stock projection models must carry forward reasonable harvest control rules that simulate fishers and managers responses to the changing availability and catchability of target species as well as fish responses to changing ocean conditions. To project theses forward, social and natural scientists must work together to identify: (a) the likely policy frameworks that will govern fisheries in the future, and (b) the tactical and strategic measures needed to implement these policies. In this paper we explore the potential impacts of climate change and harvest strategies on key fish and shellfish populations and we introduce a framework for projecting future responses of fish and fisheries.

**April 17, 17:40, S7-O11 (9225)**

### Economics of adaptation to climate change of sea cucumber fishers in the Philippines

Maria Rebecca A. **Campos**

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The Philippines is the second major producer and exporter of sea cucumber in the world. However, climate change has affected this industry and has decreased income for the country's economy, the commercial fishing sector as well as marginal fishermen who rely on it as their source of livelihood. Three types of sea cucumber fishing techniques are: commercial fishing, harvesting sea cucumbers as by-catch and by gleaning. This paper focuses on gleaning because fishermen have no control of the shallow coral reef flats where they catch sea cucumbers. Collection is done by small-scale or artisanal fishers, involving men, women and children. This activity is carried out during low tide in shallow intertidal reef flats. Gleaning is often classified as "informal" work acting as a safety net for the rural landless. The community of sea cucumber fishers in Sorsogon organized themselves and came up with two options, using the marine protected area approach: artificial reef or ranch model. The second is now being implemented with an IRR of 40%, BCR 1.7, NPV of PhP 670,000 and payback in more than a year over the first which has negative NPV and payback in over 50 years.

# Poster

**S7-P1**

### Arctic climate change and Arctic standardization

Aina Wu and Fan **Jiang**

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The Arctic is considered one of the most sensitive regions to climate change in the world. Global warming is intensifying in the 21st century, polar ice is rapidly melting and the Arctic is changing, causing direct impacts on other parts of the northern hemisphere and also indirect effects to the whole world. In order to improve our ability to address climate change issues in the Arctic we need a comprehensive survey of the Arctic environment. A step-by-step plan comprehensive survey and evaluate the Arctic sea must be conducted using standard sampling norms and guidance.

Part of this sampling scheme would involve standardizing survey techniques and regulations in the area of marine seabed sediment investigation and evaluation, inspection and evaluation of marine geophysics, marine chemistry and carbon flux inspection and evaluation, as well as marine biological and ecological survey and evaluation. This would provide a basis and technical specifications for comprehensive survey of the Arctic environment to meet the demands.

# S8 Presentations

**April 17, 14:20, S8-O1 (9362)**

## Fishing community resilience and vulnerability to changing ecosystems

Ron **Felthoven**[1], Amber Himes and Stephen Kasperski

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With the growing emphasis on ecosystem-based management, there is an expanding need for measures of social well-being and sustainability, including resilience and vulnerability, for coastal fisheries and fishing communities. Because primary data collection is time consuming and costly, use of secondary data is a practical alternative that can provide substantial cost savings in developing these measures. This paper summarizes research aimed at using secondary data to develop socio-economic and fisheries dependence indices to measure fishing community well-being in Alaska. Data from more than 300 communities in Alaska were used to create a database of socio-economic and fisheries dependence indices of well-being and adaptability for Alaska that is contextually specific to communities dependent on marine resources. Each index was developed using a principal components analysis to assess the relative position of each community compared to all other communities in Alaska. We find that creating performance measures, such as the indices presented here, in fisheries provides a useful way to track the status of important economic and social variables over time.

**April 17, 14:40, S8-O2 (9338)**

## Marine protected area designations off the U.S. west coast: Mixed-use designs to optimize public economic value

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An ideal suite of socioeconomic indicators for marine ecosystems should reflect the relationship between human well-being and ecosystem state. While a handful of socioeconomic indicators have been proposed (see Lee and Leeworthy 2013 for examples), the relationship between well-being and ecosystem status is typically indirect. Further, the focus has been almost exclusively on primary user groups, with limited attention to economic benefits that accrue to the general public as a result of management and ecosystem health. As a complement to the existing array of indicators, this paper examines how the use of marine protected areas (MPAs) generates positive/negative economic benefits to the general public. Specifically, we examine how the economic benefits of MPAs in federal waters off the U.S. west coast change with different size and use configurations. Use configurations range from recreation/ limited extraction to no-access marine reserves; the current size of permanent area closures in different use regimes serves as the baseline. Based on preliminary model results we find the general public values a 1% increase in the amount of area designated as no-access, no-take, and recreation/limited extraction at $3.50, $2.50, and $1.50 per household/year, respectively. We also examine whether complex models incorporating heterogeneity demonstrate negative benefits from no-access and/or no-take designations, and hypothesize that a mixed-use design will optimize economic values from MPAs. This research, as a complement to other socioeconomic indicators, will help provide a more comprehensive picture of the relationship between human well-being and the state of marine ecosystems.

**April 17, 15:00, S8-O3 (9322)**

## The linkages between the economic performance indicators and ecosystem status indicators

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Linkages between the economic performance indicators and ecosystem status indicators are illustrated in the American Samoa longline fishery. This fishery for albacore tuna, historically one of the main fisheries operating in the western central Pacific, has essentially collapsed. Twenty-two vessels operated in 2013 but only 2-5 are currently operating. This study examines the economic health of the fleet as evidenced by trends in key economic performance indicators and investigates factors that caused the recent collapse. This study is based on both primary and secondary sources of data. In addition, sensitivity analyses were conducted to examine how profitability of the fishery changes in response to the changes in external economic conditions (such as changes in demand for albacore) and changes in ecosystem status (such as declines in stock abundance).

**April 17, 15:20, S8-O4 (9417)**

## Human dimensions research to improve science networks and marine resource management effectiveness

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This presentation of a Puget Sound scientific network study uncovers general trends in collaboration within the Puget Sound marine research community. Survey results showed that natural scientists dominate the network, representing 80% of all actors in the sample. Relational contingency analysis revealed high internal rates of collaboration among social scientists and among interdisciplinary scientists. The lowest rates of collaboration were observed between natural scientists and social scientists ($p < 0.001$). In general, sub-networks focused on human dimensions-related topics had higher fragmentation scores (lower cohesion) than sub-networks focused on ecological, biological, or physical processes. These less cohesive sub-networks are identified as areas of opportunity for strategic network interventions to support and foster new collaborations. Results of qualitative analysis highlight factors that facilitate or inhibit success of collaborative research efforts, such as leadership, incentives, and long-term adequate funding. Additionally, the degree to which a collaborative research model can be linked to 'high-impact', policy-informing research outcomes is addressed.

**April 17, 16:00, S8-O5 (9391)**

## Preliminary analysis of trends in time series observations of human dimension indicator data for the North Pacific ecosystem

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Development and analysis of time series observations (TSO) of human dimension (HD) indicators for the North Pacific ecosystem is one of the principal activities of S-HD. A provisional list of indicators was developed during the S-HD intersessional meeting in June, 2013. This presentation reports on TSOs that have been received from PICES members and exploratory analyses of observed trends in the TSOs as well as patterns of spatial and temporal correlations.

**April 17, 16:20, S8-O6 (9398)**

## A review of the human dimension indicators in the NPESR of Japan

Masahito **Hirota**

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There is fish eating culture, historically, in Japan as well as other Asian countries. In this region, fisheries serve five principal roles for society: a resource endowment and source of environmental services, a source of food security, a means to industrial and economic development, a basic foundation for local communities, and a defining cultural characteristic. However, until recently, policy makers have primarily focused on food and industrial and economic aspects of fisheries. More recently, some attention has been given to a consideration of fisheries from the perspective of human well-being and their intrinsic value as a resource endowment and source of environmental services. Today, local community and cultural aspects of fisheries are attracting increased attention. These changes demonstrate the need for a wide variety of human dimension indicators for fisheries and that the relative importance of some indicators may change in response to social change. At the 2013 S-HD NPESR meeting, we discussed the selection of key indicators. While there was some agreement, we also found that the preferred set of indicators also varied from country to country. In this presentation, I review some indicators of particular relevance to Japan, a fish eating country. I anticipate that this example will add an important nuance to the way the S-HD presents indicators for inclusion in the NPESR.

**April 17, 16:40, S8-O7 (9364)**

## A review of similarities and differences in fisheries regulatory frameworks across the PICES region

Keith R. **Criddle**

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Fisheries are governed by a complex interplay of national regulations and international agreements. These regulations and agreements directly influence the magnitude and distribution of benefits from fisheries. Members of S-HD have shared summaries of their national regulations. This presentation highlights similarities and differences among these national frameworks.

# W1 Oral Presentations

**April 14, 09:10, Invited, W1-O1 (9365)**

## A filtering-hypothesis to explain climate synchrony in fish populations

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Fish population like sardines and anchovies exhibit an apparent temporal synchrony on global-scale that has been documented in the major boundary current systems. The dynamics controlling this synchrony are heavily debated and remain unclear. We present a simple theory to explain why fish populations characterized by inter-decadal variability, like sardine and anchovies, would exhibit a natural tendency to synchrony in their variability, and why this synchrony tends to align with global-scale low-frequency changes of the climate system. Previous work shows that double integration of white noise atmospheric forcing by the ocean (1x integration) and subsequently by the biology (2x integration) can explain the emergence of strong transitions and prolonged state changes in marine population. We expand the double integration model to simulate fish species that are sensitive to multiple independent regional forcing functions. We show that if the different forcing functions have a small imprint (*e.g.* 5-10%) from a global-scale climate variability or climate change signal, the double integration acts as a powerful filter that amplifies the common climate signal leading to synchrony among the fish population.

**April 14, 09:40, W1-O2 (9326)**

## Deep-water sharks: Their ability to withstand hypoxic conditions provides hints on how animals may respond to climate change

Gadea **Pérez-Andújar**, Christina Comfort and Kevin Weng

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As a result of rising atmospheric $CO_2$ levels and increased temperatures, density changes are occurring in the oceans, upper-ocean stratification will increase and the intermediate water ventilation will diminish. These changes are already causing oxygen minimum areas (*i.e.* hypoxic zones) in the oceans to expand. To understand the implications of decreasing dissolved oxygen concentrations, we are studying organisms that are likely to intersect low oxygen environments. The prickly shark (*Echinorhinus cookei*) and the sixgill shark (*Hexanchus griseus*) live in deep slope environments where they may encounter the oxygen minimum layer, a feature of most of the world's oceans. While the sixgill shark's diel patterns have been studied, no research yet exists on the behavior of *E. cookei* and the comparison between both species. We compare the behavior of *H. griseus* and *E. cookei* using acoustic telemetry and popup satellite tags. We then analyze the data with reference to oxygen measurements obtained from the Hawaiian Ocean Time Series and the World Ocean database. Preliminary data reveal that *E. cookei* inhabits mixed layer and pycnocline waters, thus avoiding hypoxic conditions, whereas *H. griseus* enters sub-pycnocline waters during the day, spending much of its time in hypoxic conditions.

**April 14, 10:00, W1-O3 (9320)**

## Annual variation in habitat use of black-legged kittiwakes (*Rissa tridactyla*) wintering in the sub-arctic North Pacific

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During winter migratory movements seabirds utilize distantly located prey resources, however annual variability driven by large-scale climatic processes may alter conditions in these wintering areas. To better understand how seabirds respond to environmental variability in the North Pacific, geolocation loggers were deployed on 165 black-legged kittiwakes (*Rissa tridactyla*) during July of 2008-2010, at the two main Pribilof Island colonies in the Bering Sea resulting in a total of 124 complete winter migration trips and activity budgets. In contrast to the sympatric red-legged kittiwake (*R. brevirostris*) that largely winters in the Bering Sea, black-legged kittiwakes migrated south to the pelagic sub-arctic. Most birds spent some time in the western sub-arctic, while only 5% of birds wintered in the California Current System. During all years there was a high degree of similarity between winter habitats and colony distributions. However, St Paul birds were more likely to be found in the Bering Sea, while St George birds were more likely to be found in the western sub-arctic. In 2009/10, a moderate El Niño, distributions were further north. In 2010/11, during La Niña conditions, migrations were more dispersed and the following breeding season was particularly poor for Pribilof kittiwakes with <3% of nests fledging chicks. It appears that El Niño / La Niña may differentially influence winter migratory routes and habitat use; suggesting a potential mechanistic link between these large-scale climatic processes and Bering Sea kittiwake populations.

**April 14, 10:50, Invited, W1-O4 (9375)**

## Challenges and opportunities for assessment and attribution of climate change impacts on North Pacific seabirds

William J. **Sydeman**[1], Sarah Ann Thompson[1], Julie A. Thayer[1], Mike Litzow[1], Marisol Garcia-Reyes[1], Jarrod A. Santora[1,2], Heather Renner[3], John F. Piatt[4] and Yutaka Watanuki[5]

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We focus on challenges and opportunities for assessment and attribution of climate change impacts on seabirds in the North Pacific. Initially, we review available key datasets on seabirds, demographics and dietary information obtained from breeding colonies, as well as information on seabird distribution, abundance, and spatial organization from shipboard surveys and tracking studies. This will include information from across the North Pacific, including datasets held by the USFWS/Alaska Maritime National Wildlife Refuge, Hokkaido University, North Pacific Pelagic Seabird Database, and the California Cooperative Oceanic Fisheries Investigation. Next, we will examine statistical techniques, such as variance decomposition and wavelet analyses, which may contribute to differentiating seabird responses to climate variability versus unidirectional climate change. The dominant modes of climate variability in the North Pacific (interdecadal) make separation of climate variability vs. long-term impacts a challenge. Third, we will address which genera and species may best serve as sentinels and leading indicators of climatic impacts on North Pacific marine ecosystems. Widespread genera such as murres (*Uria*) provide a holistic perspective, but are likely to be less responsive to climate variability/change than species with more limited distributions and diets. Last, we will address how synthetic, modeling approaches could be used to generate new understanding and hypotheses about how climate has and will impact seabirds. Integration of Global Climate Models (GCM), Regional Ocean Modeling Systems (ROMS), with Individual Based Models (IBM) of prey and seabirds offers a prime opportunity for understanding mechanisms of change as well as predicting seabird population dynamics in the future.

**April 14, 11:20, W1-O5 (9382)**

## Spatial utilization of streaked shearwaters in the Northwestern Pacific

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Future climate change is expected to have a significant impact on spatial and temporal distribution patterns of species. Recently, habitat models have increasingly established using the combination of remotely sensed environmental and animal distribution data, to assess and predict how animals interact with their dynamic environment. However, habitat preference may differ between sexes, among colonies as well as between breeders and non-breeders, and, therefore, their responses to environmental change are also assumed to be different. Here, we applied generalized additive model (GAMs) to project the habitat utilization of a pelagic seabird, streaked shearwaters *Calonectris leucomelas*, in the Northwestern Pacific, and compared models between including and not including individual information (sex, colony, breeding status). Their relative density differed between sexes, among colonies, and also between breeders and non-breeders. For example, males frequently distributed close to the colony from April to June, while females appeared to move northwards in relation to seasonal increase in SST. During the breeding period, breeding activity (*e.g.* incubation and chick provisioning) as well as sex-related difference in parental investment are likely to constrain their foraging range, and, thus, generate differences in distribution and response to marine environmental change. It may imply that effects of climate-related changes in the Northwestern Pacific possibly have a differential impact on shearwaters from different colonies and of different sexes. In this study, we present how the habitat model generates different outputs within a species depending on dataset, and emphasize the importance of considering the biological information when establishing the model.

**April 14, 11:40, W1-O6 (9370)**

## Diet composition and isotopic signatures of sentinel species as indicators of climate change

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Climate change in marine systems will impact food webs with effects propagating to higher trophic levels. Seabirds, in particular, have been suggested as key upper trophic level indicators of environmental change. The use of seabirds as sentinel species, however, can be confounded by time lags, non-linear responses, and top-down impacts, particularly when attempting to decipher mechanisms of their response. Food web impacts of climate change will first directly impact seabird foraging. Therefore, we propose the combined longitudinal analysis of seabird diet composition and isotopic signatures to track climate change impacts through the food web. We demonstrate the merit of this approach using a 9 yr time series of data from a diving piscivore, the common murre (*Uria aalge*). Murres are the most abundant breeding seabird in the northern California Current We studied the diets of breeding common murres using both conventional prey identification and stable isotope analysis to determine their response to annual variation in local and basin scale ocean conditions. Murre diets were dominated by three prey species, with relative proportions changing annually. Stable isotopes of $\delta^{13}C$ and $\delta^{15}N$ varied annually, with variation in $\delta^{15}N$ strongly linked to local drivers and $\delta^{13}C$ linked to basin scale drivers and diet composition. Likewise diet composition varied in concordance with environmental indices at the two scales and reflected warm and cold regimes. Climate impacts on physical forcing and biological production that propagate through the food web can be tracked using diets and isotopic signatures of an upper trophic level predator.

**April 14, 12:00, W1-O7 (9316)**

## Climate variability is linked to diet switching in a marine predator, the northern elephant seal (*Mirounga angustirostrus*)

Chandra **Goetsch**[1], Melinda Conners[1], Yoko Mitani[2], William Walker[3], Samantha E. Simmons[4], Colleen Reichmuth[1], Suzanne Budge[5] and Daniel P. Costa[1]

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Foraging behavior of marine predators can be affected by climate cycles, such as the El Niño Southern Oscillation (ENSO). In response to climate variability, predators may change where they forage, how they forage, and which prey they target. Tracking data show that northern elephant seals have high foraging route fidelity, exhibiting little evidence of changing foraging locations in response to ENSO conditions. During the 2009-2010 El Niño, female seals dove deeper than in previous years, providing evidence that they alter how they forage. However, knowledge of diet is scant due to long foraging migrations, and it is unknown whether seals respond to changes in ocean climate by switching diet. To assess the impact of climate variation on diet, we compared fatty acid signatures of blubber from adult female seals (2009-2012, $n$=119) with respect to ENSO state (positive, negative, or neutral). Blubber samples were processed for fatty acid methyl esters and analyzed via gas chromatography to obtain fatty acid profiles. Several dietary fatty acids increased in positive ENSO conditions, while others decreased, indicating that diet varies with ENSO state. Furthermore, the fatty acid signatures for seals foraging in the 2009-2010 El Niño were significantly different than seals foraging in 2011 and 2012 (Permanova, p=0.001), suggesting a diet switch in response to changes in ENSO state. Therefore, we found that seals alter their diet in response to climate variability, which may be an important indicator of the impact of future climate conditions.

**April 14, 14:00, Invited, W1-O8 (9286)**

## Loggerhead sea turtles and Hawaiian monk seals as sentinels of climate change in the central North Pacific

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Hawaiian monk seals (*Monachus schauinslandi*) at the northern atolls of the Hawaiian Archipelago have been studied for decades, with beach counts going back to the late 1950's. Variations in beach counts appear to follow oscillations in the Pacific Decadal Oscillation (PDO). It appears that during the positive (negative) PDO, the basin-wide frontal feature, the transition Zone Chlorophyll Front (TZCF), reaches (lies above) the northern atolls where these seals reside. A link between the southern position of the TZCF and pup survival has been shown with data since the 1980s.

Since 1997, over 400 loggerhead sea turtles (*Caretta caretta*) in the central North Pacific have been fitted with electronic tags. We've found that the vast majority resides in oceanic habitat and travel east and west along the TZCF.

Climate models project a northward expansion of the subtropical gyre under climate change and hence a northward shift of the TZCF. As a result, we project a decline in monk seal pup survival and a northward shift in the migration path of loggerhead sea turtles. Multiple decades of Hawaiian Monk Seal and loggerhead sea turtle data provide a baseline to test the responses of these sentinels of future climate impacts.

**April 14, 14:30, Invited, W1-O9 (9395)**

## Fish futures: Observation, adaptation and response to climate change

Kevin **Weng**, Gen Del Raye, Christina Comfort, Gadea Pérez-Andújar and Danielle Garcia

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In the future, marine fishes are likely to get squeezed by warming, stratification, deoxygenation at depth, and acidification. Some species may be pre-adapted to habitats that will likely expand in the future, while others may experience a contraction of suitable habitat. We compare the behavior of high trophic level species that have contrasting adaptations to hypoxia, and look at adaptations to their respective habitats. The tunas are 'energy speculators' that require high oxygen environments, and have a range of adaptations to high metabolic rate. In contrast, species inhabiting the oxygen minimum layer, such as the bluntnose sixgill shark, have adaptations to energy conservation and low metabolic rate. Future ocean conditions may favor energy conserving adaptations across large regions. Since hypoxia interacts with temperature and pH in its physiological impact, we develop a model to predict performance under a range of present and future scenarios. This model could potentially be used to incorporate the effects of pH into existing ecosystem models that are driven by temperature, oxygen and productivity.

**April 14, 15:00, W1-O10 (9285)**

## Whales as sentinels in a changing marine environment in the Gulf of Alaska

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With long-term and interrelated studies, the University of Alaska's Gulf Apex Predator-prey (GAP) study has collected environmental, predator, and prey data needed to assess the degree of temporal variability and dietary overlap among sympatric apex predators in the Gulf of Alaska since 1999. Combined, GAP studies have provided both multi-year snapshots and long time-series data demonstrating that Kodiak's apex predators are responding to highly variable marine prey resources. Such multi-year studies are key to monitoring temporal variability and assessing the direction, magnitude and consequences of long-term trends. Because of the removal and subsequent recovery of balaenopterid whales in the Gulf of Alaska across the past several decades, GAP studies have focused heavily on the foraging ecology and population dynamics of baleen whales. Using empirical data from GAP and other regional studies as input into consumption models, we explored the tropho-dynamic impacts of changes in whale populations and their response to environmental change. With this, the secondary and tertiary effects of those changes on prey populations and subsequent changes in the carrying capacity for Steller sea lions and other upper trophic level consumers were explored. Here we will present preliminary results from the modeling effort that takes a top-down approach at exploring the impact of balaenopterid whales on the nearshore marine ecosystem that includes waters of Kodiak and the Gulf of Alaska.

# W2 Presentations



**April 14, 09:00, W2-O1 (9341)**

## Uncertainty from observations to decision-making: What we know, what we assume, and what matters

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Science can be defined as the incremental process of accumulating knowledge through experimentation and observation. With sufficient knowledge, the consequences of particular actions can, in certain contexts, be predicted. However, in contrast to the more typical explanatory role of science, the use of such explanations to project future states can be considerably problematic, particularly when the system under consideration has high complexity and stochasticity. Projections of such complex, adaptive systems contain a significant number of diverse, often implicit, assumptions, both in the initial explanatory models, and around the context of any future projections. Such assumptions can be very specific (*e.g.*, model parameter values) to very general (*e.g.*, trend stability). We argue that as assumptions become less specific, they transition into beliefs, with little empirical support, thereby straying from the positivist view of natural science to the more relativistic view embodied in beliefs. In this contribution, we describe the range of assumptions required to transform empirically-based understanding of process into projections of future state, and discuss the uncertainties associated with each step in the process. We show how evidence-based decision making must therefore be about more than the available evidence: it must also consider the assumptions and beliefs that underpin the projected future alternatives that are the focus of any decision.

**April 14, 09:20, Invited, W2-O2 (9346)**

## Ecosystem modeling predictions – How reliable are they?

Georgina A. **Gibson**

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Ecosystem models are now widely used to predict various aspects of the marine ecosystem. Models range in breath from large scale global climate models to finer scale regional models, and in scope from circulation models predicting physical properties of the environment to the recruitment success of fisheries. A common question relevant to all of these efforts is how much faith can we put in these model predictions? This relates directly to the treatment of model uncertainty, and is rapidly becoming a priority issue as we move from the realm of theoretical modeling to an age in which we use model outputs to inform policy decisions. Uncertainty in ecosystem model predictions stems from a multitude of sources including uncertainty in the physical forcing of the model, to the uncertainty in model structure (*e.g.*, the form of the equations used to describe biological functions) to the parameter values used. I will discuss, through example, the various types of uncertainty that are inherent in ecosystem models and current methods for assessing such uncertainty. Historically, addressing uncertainty has been hampered by the availability of computational resources as efforts to reduce, or at least bound, the uncertainty requires performing multiple realizations of a model projection. Rapid advances in computer technology over the past decade have meant that high performance computers are much more available and affordable; lack of computer resources will soon be no excuse for lack of documentation on the uncertainty of a model prediction. While many of the sources of uncertainty in predictions may never be reduced, as a research community we need to move towards better documentation of the uncertainty such that we can relay our degree of conviction in a model prediction to stakeholders and policy makers, allowing them to make more informed decisions about the extent to which they want to rely on model outputs.

**April 14, 10:00, W2-O3 (9403)**

## Modelers: Know thy fish

William T. **Peterson**

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We produce outlooks on the number of salmon that are expected to return the Columbia River that are based on ocean conditions observed during the year that salmon first enter the ocean, 1-2 years in advance of the year when they enter the fishery. The results of this work are communicated to managers, the media and the general public through a website and an e-mail list-serve. Our work is based on correlations of adult returns with physical and ecological indicator such as the PDO, ENSO, local hydrography, copepod and ichthyoplankton species composition and growth rates of juv. salmon. Our work is effective because salmon year-class strength is set during their first summer at sea during their residence in continental shelf waters. The production of "outlooks" for other fisheries is more difficult because critical life-history information is often missing: it is often unclear where and when recruitment bottlenecks occur, and estimates of recruitment are often derived from models based on age structure of fish caught in annual surveys, thus if recruitment is set in juvenile stages that are not sampled in adult surveys, recruitment failures are not observed. Despite this, oceanographers can still produce indicators of good or bad "ocean conditions" that serve as "early warming indicators" that alert of potential recruitment failures. Although there is a pressing need to understand how indicators of ocean conditions inform recruitment variability, getting managers to use our stuff can be difficult. Why is what we produce better than business as usual?

**April 14, 10:20, W2-O4 (9401)**

## Uncertainty of fish growth projection caused by uncertainty of physical forcing

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To test uncertainty of fish growth projection caused by uncertainty of physical forcing, an ecosystem based bioenergetics model was used for Pacific saury (*Cololabis saira*). The model was forced by the projected sea surface temperature (SST) generated by climate models that formed the bases for the Intergovernmental Panel on Climate Change 4th Assessment Report (IPCC-AR4). Twelve climate models, which reproduced the Pacific Decadal Oscillation well in comparison with observations, were selected and B1, A1B, and A2 emissions scenarios were used. In total, thirty-three ensemble simulations were conducted of which, twenty-four (73%) showed a decrease of wet weight of Pacific saury. The migration pattern was modified in eleven (33%) cases. In these cases, higher SST and size reduction under global warming prevented or delayed the southern migration of saury in winter. As a result, egg production was enhanced by the higher availability of prey plankton in the modified spawning region. A case study to separate the direct temperature effects was conducted, in which prey plankton density was assumed to be the same as the control run. The results suggest that a SST increase will directly reduce juvenile growth while a prey plankton density decrease has an influence on the growth of adults and migration pattern, and hence egg production.

**April 14, 11:00, W2-O5 (9335)**

## Evaluation of predictive habitat suitability: Using contemporary sightings and prey data to assess model assumptions

Rowenna **Gryba**[1] and Edward J. Gregr

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Predictions of habitat suitability and their subsequent validation raises questions about methodology, the nature of the prediction, and the data used for validation. These questions all point to a need to understand the context within which we expect our models to operate and the assumptions underlying the predictions. Predictions of marine mammal habitat suitability are based primarily on correlative relationships between observations of species occurrence and oceanographic variables. For most marine mammal species, the fundamental underlying assumption is that the animals will be distributed according to prey abundance, which is related to particular oceanographic features (*e.g.*, fronts, eddies). To explicitly test this assumption, and explore more fundamental questions about evaluating habitat suitability predictions, we used two different sets of data to evaluate predictive models of North Pacific right whale (*Eubalaena japonica*) habitat suitability. We compared predictions of right whale habitat suitability to contemporary right whale sightings, and used measured distributions of principal prey species (*i.e.*, copepods) to assess how well the predictions met the underlying assumptions of the model. We compared the two datasets to the predictions of right whale habitat suitability using two presence-only evaluation methods: the Boyce Index and adjusted skewness. We found that model evaluation based on the distribution of prey yielded similar results to the more traditional approach of using an independent species observations. Differences in the validation were primarily in the significance level of the results, importantly, at different scales, shedding light on potential differences in abiotic/biotic influences that determine prey distribution, which the models are assumed to be predicting. Our results suggest that using evaluation data that better represents the processes behind the habitat suitability models, such as prey data, may give more informative results. The inclusion of different methods in evaluation, using multiple datasets, allows for assessment of the assumptions involving the processes as well as those related to what the model is actually predicting.

**April 14, 13:30, W2-O6 (9342)**

## The problem isn't uncertainty, but its monotypic treatment

Kai M.A. **Chan** and Edward J. Gregr

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There is increasing attention to a fuller and more appropriate treatment of uncertainty in marine science, and escalating calls for enhanced engagement with audiences of various kinds (including lay, decision-makers, and diverse academics). What appears to be largely missing is a consideration of how the characterization of uncertainty ought to enter into engagement and communication efforts with diverse audiences, and what this means for researchers intent on describing uncertainties. A danger exists that existing approaches to communicating uncertainty are at odds with the needs of various audiences, undermining the successful engagement beyond the marine science research community. In this talk, we describe the different types of audiences associated with different kinds of engagement (informed interested publics, journalists, politicians, staffers, policymakers and policy analysts, and quantitative and qualitative social scientists) and postulate a range of needs and capacities to understand and use information about scientific uncertainties. We suggest approaches to communicating uncertainties to each type of audience. We close by considering what these suggestions imply regarding the underlying modeling and analysis of uncertainty. While following these suggestions might require a dramatic change in practice, it might also enable a much richer and effective marine science.

**April 14, 13:50, Invited, W2-O7 (9377)**

## How decision science can improve the relevance of oceanographic research to managers and stakeholders

Lee **Failing**

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In this presentation I explore how the use of methods and insights from the decision sciences can help inform resource management, with an emphasis on case studies from fisheries management experiences in Canada and the United States. I will demonstrate how framing a resource management problem as a decision - a choice with multiple objectives and alternative courses of action - changes the focus and scope of the necessary scientific studies and modeling. Drawing on recent applied research, I will explore how stakeholders and decision makers respond to complexity and to different ways of representing uncertainty. I will not emphasize the academic aspects. Rather, I will draw lessons from real-world experiences relevant to fisheries scientists and resource managers, providing them with insights and practical tools to help ensure their work is relevant to the coastal communities it is intended to serve.

# W3 Presentations



### April 14, 09:10, Invited, W3-O1 (9407)

## Towards a next generation marine ecosystem model

J. Icarus **Allen**[1], Y. Artioli, J. Blackford, J. Bruggeman, L. Polimene and S. Sailley

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Marine ecosystems provide a range of important services to mankind including food production, climate regulation through the cycling of carbon and other macronutrients, and a range of cultural values (*e.g.* recreation, tourism). They are in serious decline, primarily as a result of over-harvesting, pollution, and the direct and indirect impacts of climate change. Dynamic models that link the physical, chemical and biological processes through food web interactions provide a means of understanding how human impacts on different parts of the ecosystem interact and of predicting the consequences of management actions in one sector on other sectors. One challenge is to how to clearly model the scales of interactions and emergent properties ranging from ecosystem processes (*e.g.* production), through intermediate services (*e.g.* Nutrient cycling), through to final services (*e.g.* fisheries). The traditional approach to modelling marine plankton has generally been to build modelling frameworks by coupling bulk biomass functional type (FT) models to 1D and 3D hydrodynamic models. To enhance our capacity to assess trophic and spatial controls on the structure of marine ecosystems requires the improvement of the representation of biodiversity and ecosystem function in model. To achieve this requires the development of a traceable hierarchy of models of different complexity using a modular approach with consistent process descriptions based on size, function (autotrophy, heterotrophy, decomposition), and biological traits (*e.g.* feeding strategy, motility, physiology). Through species-neutral process descriptions, the approach will allow scalable representation of diversity within and between functionally similar "guilds" of species.

### April 14, 09:40, Invited, W3-O2 (9384)

## Modelling change

Elizabeth A. **Fulton**, P. Johnson and R. Gorton

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Ecosystems are non-stationary systems, something driven home by global change. While most ecosystem modelling tools allow for dynamic ecosystem states, in the last few years the evolution of these tools has taken a number of different routes. Some groups have focused on using new information to revise the representation of ecological groups, others have taken general approaches global, while others have remained broad brush but expanded the number of processes included. In this last group it has been found that the inclusion of acclimation, evolution, trophic and behavioral shifts and human responses are all important for identifying effective management options and judging which are important barriers to adaptation. Projections for eastern Australia indicate that integrated adaptive management is the most effective form of management and that in most cases the ecological processes buffer the effect of climate driven shifts, with the greatest barriers to adaptation consistently sitting with the human components of the ecosystem.

**April 14, 10:10, W3-O3 (9336)**

## FishSET: A spatial economics toolbox to better incorporate fisher behavior into fisheries management and ecosystem modeling

Alan C. **Haynie**

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NOAA Fisheries and partners are developing the Spatial Economics Toolbox for Fisheries (FishSET) to improve predictions about fleet behavior. Since the 1980s, economists have modeled the factors that influence fishers' spatial and participation choices to understand the trade-offs of fishing in different locations. This knowledge can improve predictions of how fishers respond to and are economically impacted by the creation of marine reserves, to changing climate conditions, or to management actions such as the implementation of catch shares.

In this talk, we provide an overview of the modeling approach, details of project implementation, and an introduction to FishSET software. An initial step of the project is the development of best practices and tools to improve data organization. A second core component is the development of estimation routines that enable comparisons of state-of-the-art fisher location choice models. FishSET enables new models to be more easily and robustly tested and applied when the advances lead to improved predictions of fisher behavior. FishSET efficiently organizes statistical code so that leading innovators can build on each other's work and methods can be widely available. Pilot projects that utilize FishSET are underway in different US Regions, ensuring that the data challenges that confront modelers in different regions are confronted at the onset of the project. Implementing pilot projects in various environments also provides insight into how economic and fisheries data requirements for effective management may vary across different types of fisheries. Finally, we discuss how FishSET can be coupled with other ecosystem modeling efforts.

**April 14, 11:00, W3-O4 (9390)**

## Current status of integrated bio-physical, economic modeling approaches examining fish stocks in the North Sea: Some results from the EU VECTORS program

Myron A. **Peck**[1], Erik Buisman[2], Momme Butenschön[3], Jose A. Fernandes[3], Marc Hufnagl[1], Miranda C. Jones[4], Alexander Kempf[5], John K. Pinnegar[4], Ana Queiros[3], Sébastien Rochette[6], Sarah Simons[5], Lorna R. Teal[7] and Morgan Travers-Trolet[6]

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We review and compare four broad categories of modelling approaches currently employed in the North Sea to shed light on the factors responsible for changes in the distribution and productivity of living marine resources. Model categories include: 1) bioclimate envelope and other spatially-explicit statistical models, 2) physiology-based, biophysical models representing single life stages or the whole life cycle, 3) spatially-explicit food web models, and 4) end-to-end models. We also discuss current efforts to include the bioeconomic costs and tradeoffs of historical and projected future changes in stock distribution and/or productivity. Finally, we comment on the ability of these models to assess interactions between key pressures affecting living marine resources including i) climate-driven changes in temperature regimes and acidification, ii) reductions in water quality due to eutrophication (decreased dissolved $O_2$ concentrations and increased turbidity), iii) the introduction of alien invasive species, and iv) reductions in biomass of stocks / populations due to commercial exploitation (fisheries). There are benefits and pitfalls of using each of these different approaches and key sets of assumptions exist when projecting the economic consequences of projected changes in distribution and productivity. Explicit modelling of biological and physical mechanisms, striving for realism in physiological mechanisms shaping individual behaviour and species life history strategies as well as trophodynamic interactions at different spatial scales will be critical for advancing predictive capacity of biological impacts.

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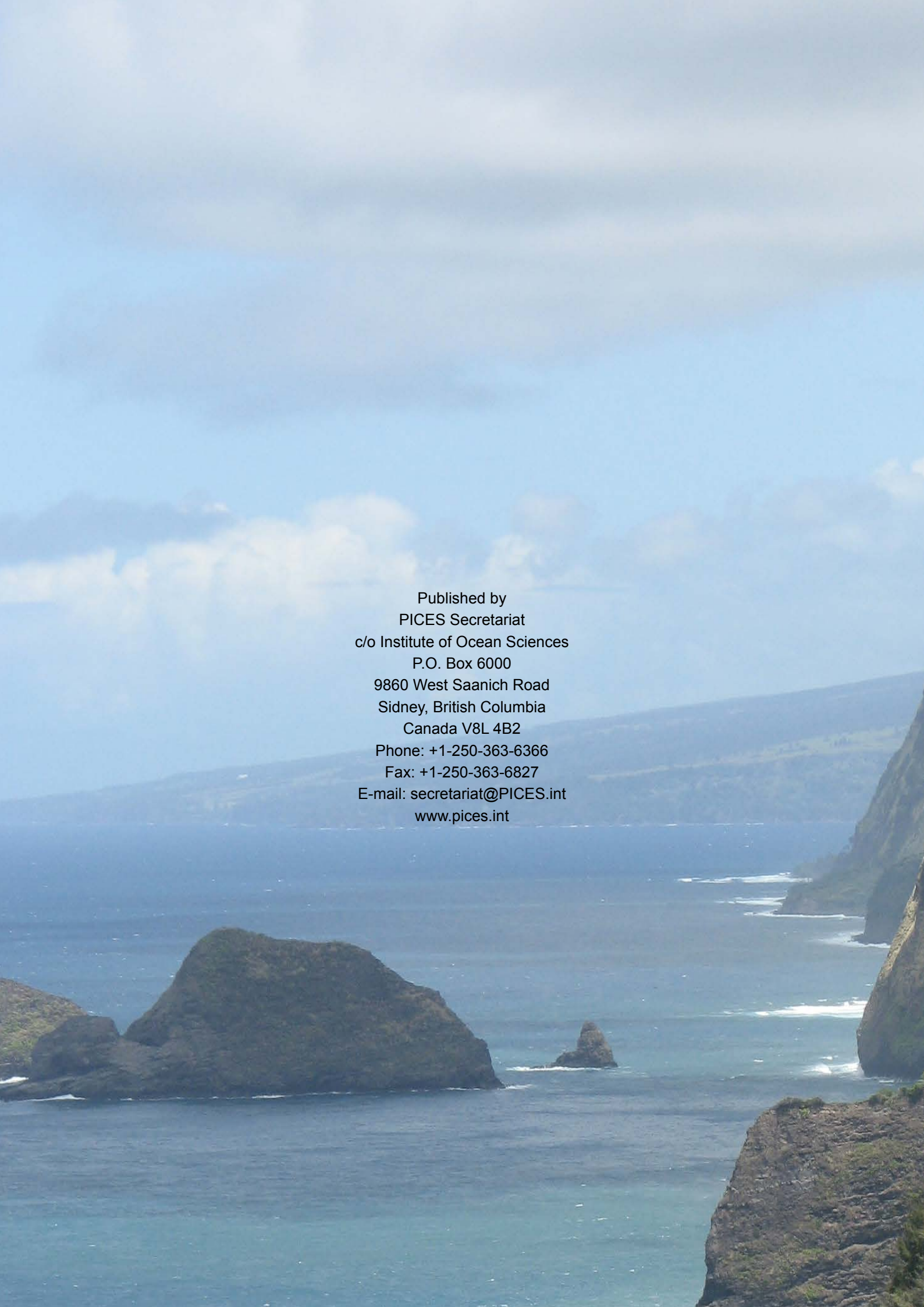

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