

Poster presentations

Sayaka Yasunaka, Yukihiro Nojiri, Tsuneo Ono, Shin-ichiro Nakaoka and Frank A. Whitney

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

Minwoo Kim, Cheol-Ho Kim and Chan Joo Jang

Effects of grid refinement in the global ocean circulation experiments

Cheol-Ho Kim, Chan Joo Jang and Minwoo Kim

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

Olga Trusenkova and Dmitry Kaplunenko

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

SM M. Rahman, Chung Il Lee and Chang-Keun Kang

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

Allison R. Wiener, Marisol García-Reyes, Ryan R. Rykaczewski, Steven J. Bograd and William J. Sydeman

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

Wu Shuangquan, Gao Zhigang, Yang Jinkun and Yu Ting

Numerical simulation of ocean ecological dynamics in Taiwan Strait

BIO/FIS/MEQ/TCODE/FUTURE Topic Session (S8)

Ecosystem indicators to characterise ecosystem responses to multiple stressors in North Pacific marine ecosystems

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

* Jameal Samhoury was unable to attend PICES-2013 due to the U.S. government partial shutdown.

Invited Speakers:

Isabelle Côté (Simon Fraser University, Canada)

Yunne-Jai Shin (Institut de Recherche pour le Développement, France)

Mingyuan Zhu (First Institute of Oceanography, SOA, PR China)

Background

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

The session was deeply saddened by the untimely death of Dr. Mingyuan Zhu, and a moment of silence was held in his honour. He was a very important scientist for PICES.

Summary of presentations

The session was well-attended, and with strong participation in questions and discussions. All of the presenters were congratulated for leaving time for questions after their presentations. The session introduced much new information and new ideas, all of which are relevant for the work of Working Group 28. A number of presentations proposed ecologically-based indicator sets and/or methods to evaluate the efficacy of the indicators. A number of talks also discussed how multiple stressors can interact. One important finding from a meta-analysis was that 35% of studies examined found that multiple stressors interacted synergistically, and that antagonistic interactions occurred in 42% of the studies examined. The conclusion from this analysis was that interactions were not additive in the majority of analyses studied, which is usually the default assumption in frameworks examining the impacts of multiple interacting stressors. An important implication of these results is that management actions may not produce the intended result because such actions may alter the interactions among multiple stressors, in particular if the interactions are antagonistic. Overall, discussions questioned how well existing indicators can address temporal scaling issues and the interactions of processes at larger (and smaller) temporal and spatial scales. The issue of sub-lethal stressors and their effects was also discussed, with the potential for indirect stressors to interact with direct stressors. It was recognised that many indicators can be proposed; when developing indicators of human actions and responses an inclusive process is needed. Overall, the consensus was that a good job is being done currently of beginning to model and evaluate responses of indicators to observed and modelled ecosystem changes, although questions remain as to whether these models can adequately address the three types of stressor interactions (additive, synergistic, antagonistic). Participants felt the current state of the art was doing a better job simulating fishing and climate interactions in models. Participants also concluded that no single indicator will be adequate and the use of multiple models was recommended to reduce model-based uncertainties. But an important question was raised: how, and whether, multiple indicators can be combined into smaller sets of summary indicators. At present, it seems the most common way to assess the impacts of more than two stressors is via expert opinion, and sometimes modelling. These techniques have their own important limitations and biases.

List of papers

Oral presentations

Isabelle M. Côté and Emily S. Darling (Invited)

Testing and predicting synergy between multiple stressors

Stephen Ban

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

Helen J. Gurney-Smith, Catherine A. Thomson, Dan S. Sanderson, Jennifer Kimball and Stewart C. Johnson

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

Andrew Day, Thomas A. Okey, Micha Prins and Stephanie King

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

Joanna Smith, Charlie Short, Steve Diggon, John Bones, Matthew Justice, Andrew Day and Stephanie King

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

Cathryn Clarke Murray, Megan E. Mach, Rebecca G. Martone, Gerald G. Singh, Kai M.A. Chan and Miriam O

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

Rebecca G. Martone, Melissa M. Foley, Megan E. Mach, Corina I. Marks, Carrie V. Kappel, Kimberly A. Selkoe and Benjamin S. Halpern

Groundtruthing cumulative impact models in nearshore ecosystems of the California Current

Yunne-Jai Shin, Jennifer Houle, Alida Bundy, Marta Coll, Penny Johnson, Chris Lynam, Lynne Shannon and Laure Velez (Invited)

A multi-model evaluation of ecosystem indicators' performance

Caihong Fu and Yunne-Jai Shin

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

Vladimir V. Kulik

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

Session Summaries-2013

Kirstin K. Holsman and Stephani Zador

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

Stephen B. Brandt and Cynthia Sellinger

Growth rate potential as a quantitative ecosystem indicator of habitat quality

Doug Hay, Jake Schweigert, Jennifer L. Boldt, Jaclyn Cleary, Thomas A. Greiner and Kyle Hebert

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

Kisaburo Nakata

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

Kyung-Su Kim, JeongHee Shim and Suam Kim

The combined effects of elevated CO₂ and temperature on the survival, growth and skeletal formation of olive flounder larvae *Paralichthys olivaceus*

Skip McKinnell

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

Motomitsu Takahashi and Mingyuan Zhu

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

R. Ian Perry, Jameal F. Samhuri and Motomitsu Takahashi

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

Sarah Ann Thompson, William J. Sydeman, Heather Renner and John F. Piatt

Regionalizing seabirds as indicators of forage fish in Alaska

Yuxue Qin, Yuichi Shimizu and Masahide Kaeriyama

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

Yongjun Tian

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

Poster presentations

R. Ian Perry and Diane Masson

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

Peng Sun, Zhenlin Liang, Yang Yu, Yanli Tang, Fenfang Zhao and Liuyi Huang

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

Guanqiong Ye, Jie Liu and Loke M. Chou

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