PICES Twenty Second Annual Meeting

Nanaimo, Canada

October 12 (09:00-18:00), 2013

WORKING GROUP ON
*DEVELOPMENT OF ECOSYSTEM INDICATORS TO CHARACTERIZE ECOSYSTEM RESPONSES TO MULTIPLE STRESSORS (*WG-28)

Provisional Agenda

1. Welcome, Introduction and sign-in (all) – including introductions of new Working Group members (co-chairs; see Appendix 2 for list of WG members)
2. Review of activities during the 2nd year of WG-28
   a. General review of Terms of Reference (see Appendix 1) plus discussion of expectations for the Working Group by PICES, and what we expect to be able to deliver (all)
   b. Report on participation and presentation by WG28 in NOWPAP Workshop (Kulik); [see PICES Press July 2013 article: http://www.pices.int/publications/pices_press/volume21/v21-n2/pp_28-29_NOWPAP-Wsh.pdf , also meeting report on WG28 web page: http://www.pices.int/members/working_groups/materials/WG-28-2013-Report-from-NOWPAP-MPA-Workshop.pdf .
   c. Report on participation and presentation by WG28 to PICES Science Board Intersessional meeting, and at ICES/PICES workshop on Climate Change Effects on Marine Ecosystems (SICCME) (Takahashi-san)
   d. Report on additional WG28 session proposals, at 2014 PICES FUTURE Open Science Meeting (Perry; Appendix 3), and submitted for 2014 PICES Annual Meeting (Martone/Samhouri; Appendix 4)
   e. Brief outline of WG28-convened session at 2013 Annual Meeting later in the week (Session S8, titled "Ecosystem indicators to characterize ecosystem responses to multiple stressors in North Pacific marine ecosystems")
   f. Report on the project MEcoPAM, which focuses on the impact of multi-stressors on the sustainability of marine ecosystem production in China (discussion led by Takahashi-san, with input from Chinese WG members)
   g. Other related WG28 activities?
3. Review of progress on Terms of Reference
   a. General discussion of how far we have progressed in addressing our ToR – which have we covered, which have we still to do? To include brief reports from each country of activities of importance to WG28.
4. Presentations on outlines for each of the draft report chapters, and plans for moving these ahead (see Appendix 5 for draft report outline and lead authors, as discussed at our meeting in Hiroshima) Lead authors for the various chapters in our draft report outline are requested to present and lead a discussion of their proposed chapter outline, i.e. contents, contributors and task assignments, timelines. Additional contributors (in particular among new WG members or those not able to participate in Hiroshima) are welcome:
   a. Chapter 2 "Frameworks linking pressures to impacts and changes in North Pacific marine ecosystems", and "Multiple pressures on North Pacific marine ecosystems" (discussion leads: Perry, Takahashi)
   b. Chapter 3 "Ecosystem indicators" and "Indicators for ecosystem responses to multiple pressures" [discussion leads: Boldt, Samhouri, Itoh, Yoshie, Chung, others (?)]
   c. Chapter 4 "Case study examples" :
      Inland seas, e.g. Salish Sea (Strait of Georgia; Puget Sound), Seto Inland Sea (discussion leads: Samhouri, Perry, Takahashi)
      High latitude seas, e.g. possibly Sea of Okhotsk, Bering Sea (discussion leads: Kullik, Zador, Lukyanova)
5. Discussions of report outline continued

   d. Re-look at proposed report chapter outline – are any topics missing (e.g. reference points/tipping points – or could that be added to Chapter 3)?
   e. Conclusions and recommendations – can we begin to identify any of these now? (discussion leads: co-chairs)

6. Discussion of interactions with other PICES groups (co-chairs)
   a. Relationships between WG28 and other Working Groups and Committees
   b. Contributions to FUTURE
7. Discussion of plans for primary publications resulting from the WG28 report (Samhouri)
8. Any other business

Appendix 1

Terms of Reference

1. Identify and characterize the spatial (and temporal) extent of critical stressors in North Pacific ecosystems both coastal and offshore and identify locations where multiple stressors interact. Identify trends in these stressors if possible.
2. Review and identify categories of indicators needed to document status and trends of ecosystem change at the most appropriate spatial scale (e.g., coastal, regional, basin).
3. Using criteria agreed to at the 2011 PICES FUTURE Inter-sessional Workshop in Honolulu, determine the most appropriate weighting for indicators used for:
   a. documenting status and trends
   b. documenting extent of critical stressors
   c. assessing ecosystem impacts/change
4. Review existing frameworks to link stressors to impacts/change, assessing their applicability to North Pacific ecosystems and identify the most appropriate for application to North Pacific ecosystems.
5. Determine if ecosystem indicators provide a mechanistic understanding of how ecosystems respond to multiple stressors and evaluate the potential to identify vulnerable ecosystem components.
6. For 1-2 case studies, identify and characterize how ecosystems respond to multiple stressors using indicators identified above. Are responses to stressors simply linear or are changes non-linear such that small additional stressors result in much larger ecosystem responses? Do different parts of the ecosystem respond differently (e.g., trophic level responses)? How do stressors interact?
7. Publish a final report summarizing results with special attention to FUTURE needs. This WG will focus primarily on delivery of FUTURE Questions 3 and 1 (outlined below).

Linkages to the FUTURE Science Plan:

1. What determines an ecosystem's intrinsic resilience and vulnerability to natural and anthropogenic forcing?
2. How do ecosystems respond to natural and anthropogenic forcing, and how might they change in the future?
3. How do human activities affect coastal ecosystems and how are societies affected by changes in these ecosystems?

Appendix 2. Working Group 28 members as of September 2013

Dr. Jennifer L. Boldt (Canada)	**Dr. Ian Perry (Canada)** **WG-28 Co-Chairman**
Prof. Min Chao (China)	**Dr. Baisong Chen (China)**
Dr. Honghui Huang (China)	**Dr. Chaolun Li (China)**
Prof. Cuihua Wang (China)	**Dr. Heng Zhang (China)**
Dr. Shigeru Itakura (Japan)	**Dr. Sachihiko Itoh (Japan)**
Dr. Motomitsu Takahashi (Japan) **WG-28 Co-Chairman**	**Dr. Naoki Yoshie (Japan)**
Prof. Ik Kyo Chung (Korea)	**Dr. Jaebong Lee (Korea)**
Prof. Chang-Ik Zhang (Korea)	**Dr. Vladimir V. Kulik (Russia)**
Dr. Olga N. Lukyanova (Russia)	**Dr. Rebecca G. Martone (US)**
Dr. Jameal F. Samhouri (US)	**Dr. Stephani G. Zador (US)**

Appendix 3. WG28-sponsored session at PICES FUTURE Open Science Meeting, Hawaii, April 2014

Identifying multiple pressures and system responses in North Pacific marine ecosystems

Co-convenors (alphabetically): Vladimir Kulik (Russia), Rebecca Martone (USA), Ian Perry (Canada), Motomitsu Takahashi (Japan)

Marine ecosystems of the North Pacific, both coastal and offshore, are impacted by multiple pressures, such as increased temperature, change in 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 PICES FUTURE program is the identification and characterization of these pressures 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) identify key stressors and pressures on North Pacific marine ecosystems, including comparisons as to how these stressors/pressures may differ in importance in different systems and how they may be changing in time; and 2) identify ecosystem responses to these multiple stressors and pressures. Objective 2 includes understanding how natural and human perturbations may cascade through ecosystems, and whether there may be amplifers or buffers which modify the effects of perturbations on marine systems. Papers using conceptual, model-based, observation-based, or experimental-based approaches are welcome. Also welcome are 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.

Appendix 3 (continued).

WG28 Proposal for Workshop at PICES FUTURE Open Science Meeting, Hawaii, 2014
(1/2 day workshop proposal)

Communicating and Presenting Indicators of Ecosystem Responses to Multiple Stressors in North Pacific Marine Systems

Co-Convenors: Ian Perry (Canada), Motomitsu Takahashi (Japan), Vladimir Kulik (Russia), Jameal Samhouri (USA)
[convenors from other PICES member nations are welcome]

Ecosystem responses to the cumulative effects of multiple natural and anthropogenic stressors in the North Pacific can be varied and complex. 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. Several programs in the North Pacific and elsewhere are working on the development of such indicators, including PICES' Working Group 28. Identification of indicators which capture this complexity is a difficult problem; it is most likely that multiple indicators and suites of indicators will be necessary. Once such potential indicators have been identified, there is an additional problem to resolve: how to "simply" and "effectively" present and display these indicators to quickly convey their meaning and to describe the current state and trends of the ecosystem features. Users should also be able to "drill down" through these displays to identify which natural and anthropogenic stressors have the greatest leverage on the current value of the indicators. This feature is necessary so that management actions which may result from these indicators can be directed at the leading causes of changes in the system.

This workshop invites presentations and discussions of how to portray and communicate indicators of ecosystem responses to multiple stressors in North Pacific marine systems. The emphasis is on the presentation of such indicators rather than development of the indicators themselves. The results will contribute to the report of WG28; a primary paper on how such complex ecosystem indicators may be presented to convey information will also be considered. We welcome presentations which include psychological insights into how people perceive and understand complex information, leading to action.

The workshop will include selected invited and contributed presentations, plus time for discussion.

Appendix 3 (continued)

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

Co-convenors: Edward Gregr, Institute for Resources, Environment, and Sustainability
University of British Columbia, Vancouver, Canada
Hal Batchelder, College of Earth, Ocean, and Atmospheric Sciences
Oregon State University, Corvallis, Oregon, USA
Shin-ichi Ito, Tohoku National Fisheries Research Institute
Fisheries Research Agency, Shiogama, Japan
Naesun Park, Korea Institute of Ocean Science and Technology (KIOST)
Ansan, Korea
Ian Perry, Fisheries and Oceans Canada
Fisheries and Oceans Canada, Nanaimo, Canada
Kai Chan, Institute for Resources, Environment, and Sustainability
University of British Columbia, Vancouver, Canada

Topic:

Uncertainty is presented as a key part of the FUTURE program. However, the consequences of uncertainty extend beyond the outputs of oceanographic or ecosystem models. Scientific uncertainty 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 uptake of results by decision makers. We posit that such end-to-end consideration of uncertainty is critical to improve the uptake of oceanographic model results by stakeholders and decision makers in all member countries, particularly as the modeling community moves towards end-to-end models. 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.

Format:

We are proposing a full day workshop with the morning consisting of a mix of 15-20 minute talks and discussions centred on two themes: 1) Input data, model structure, and parameterization; 2) Decision analysis and the psychology of decision-making. The afternoon will be devoted to a discussion of how FUTURE can best articulate uncertainty assessments, and the development of a communication strategy to broaden the engagement of the public, communities, decision makers and other stakeholders in the results emerging from FUTURE.

The first theme is intended to highlight how sources of uncertainty can be articulated and presented on a technical level. The session will challenge the modeling community to explain the credibility of their results, articulate their assumptions, and generally expose sources of uncertainty. The second theme will focus on 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 effect. This includes the fundamental challenge identified in PICES (2011) of how to scale FUTURE scientific outputs with impacts on human dimensions, generally considered at more local extents.

The afternoon will consider a variety of approaches to communicating the value of FUTURE products beyond the natural science community. Potential topics of discussion include outreach strategies to social scientists such as psychologists and anthropologists with the intent of developing more insightful and applicable inter-disciplinary studies, and strategies for presenting FUTURE products to the broader, international stakeholder community.

Outputs:

1) A PICES Press newsletter article written by the convenors summarizing the workshop.

2) An article prepared for a peer-reviewed journal by interested workshop participants (e.g., PLoS ONE, Marine Policy) outlining how FUTURE products can be effectively communicated to the stakeholders for which they are intended.

Number of participants:

We expect the workshop to have broad interest among meeting attendees and therefore hope to attract 15-25 participants. While this will depend on what other workshops are running concurrently, we hope the importance of discussing uncertainty in FUTURE products will be recognized by meeting participants.

Appendix 4. WG28 proposal for a scientific session at 2014 PICES Annual Meeting (Korea)

Tipping points: defining reference points for ecological indicators of multiple stressors in coastal and marine ecosystems

R. Martone (USA), rmartone@stanford.edu; J. Samhouri (USA), jameal.samhouri@noaa.gov; R.I. Perry (Canada), Ian.Perry@dfo-mpo.gc.ca; C.I. Zhang (Korea), cizhang@pknu.ac.kr; M. Takahashi (Japan), takahamt@fra.affrc.go.jp

Many coastal and marine ecosystems, ranging from reefs to estuaries to pelagic systems, are exposed to multiple stressors, which can lead to rapid changes with significant, long-term consequences that are often difficult to reverse. Changes in ocean climate, the abundance of key species, nutrients, and other factors drive these shifts, which affect ocean food webs, habitats, and ecosystem functions and people's livelihoods and well-being. Determining indicators of ecological changes due to multiple stressors and defining reference points for those indicators are key steps for managers to avoid ecological degradation and loss of keys goods and services. Setting ecological reference points in ecological systems presents a challenge to resource managers because (a) reference points are often difficult to determine due to the complexity of natural systems, including the presence of thresholds, tipping points, and non-linearities; (b) the paucity of theoretical modeling and empirical understanding needed to address these complexities, identify ecological thresholds and develop early warning indicators means managers must make decisions based on high levels of uncertainty; and, (c) many institutional and governance structures do not allow managers the necessary flexibility to take up this information and react within relevant timeframes. This session will address these pressing challenges, and explore promising approaches to tackling them with the goal of catalyzing new research and management innovation. In particular we invite presentations that (i) define the conceptual basis for reference points and management objectives surrounding reference points; (ii) use theoretical, modeling and observational approaches to identify potential reference points for indicators of changes in marine ecosystems; (iii) incorporate risk and sources of error (measurement, model, process) in such analyses; (iv) discuss how reference points may be used in helping to manage marine ecosystems, specifically in relation to the decision-making process related to evaluating and deciding on acceptable levels of risk. These discussions will be guided by the FUTURE science themes, with special attention to examining climate and anthropogenic drivers of ecological change, and identifying early warning indicators to enable forecasting to avoid crossing ecological thresholds. The outcomes will contribute to the work of PICES Working Group 28 on the Development of Ecosystem Indicators to Characterize Ecosystem Responses to Multiple Stressors.

Potential Invited Speakers include:
Dr. Jason Link, NOAA, U.S.A., jason.link@noaa.gov;
Dr. Carrie Kappel, National Center for Ecological Analysis and Synthesis, U.S.A., kappel@nceas.ucsb.edu;
Dr. Marten Scheffer, WU Environmental Sciences, The Netherlands, marten.scheffer@wur.nl
Additional suggestions are welcome.

Appendix 5. Draft report outline as developed at WG28 2nd business meeting, Hiroshima, 2012

DRAFT Final Report Table of Contents
(Note all WG members are expected to contribute to each main chapter; names listed are those who will likely take the leads for each chapter)

1. Introduction (Co-Chairs)
- background to the WG
- Terms of Reference / Objectives (see Appendix 1)
- brief overview of the issue of multiple activities/stressors on marine ecosystems
- **e.g. use of the phrase "activities/stressors (or "pressures") to indicate both natural and anthropogenic pressures, and that not all of these are always "bad" for the ecosystem**
- **Include definitions for "stressors", issue that information to construct indicators is often available at multiple but different time and space scales, etc.**

2. Frameworks linking pressures to impacts and changes in North Pacific marine ecosystems (Perry, Takahashi, Samhouri, Zhang, Lee)
- **brief review of potential frameworks that could be used to link activities and stressors to ecosystem responses**
- **assessment of their applicability to North Pacific marine ecosystems**
- **recommendations for applications**
- **e.g. Pathways of Effects and Driver-Pressure-States-Impact-Response models; simulation and other analytical modeling approaches, e.g. Ecopath with Ecosim, probabilistic (Bayesian) networks; Integrated Ecosystem Analyses; IFRAME, others?**
- **addresses ToR 4**

Multiple pressures on North Pacific marine ecosystems
- **identification of the spatial (and temporal, if available) extent of important activities and stressors in North Pacific marine ecosystems**
- **identify habitats and general locations (if possible) where multiple stressors overlap**
- **identify trends in these activities/stressors if possible**
- **sub-sections of this chapter for each PICES country, preferably using a common approach, plus a synthesis section**
- **e.g. PICES Session S10 at 2012 Annual Meeting (Hiroshima)**
- **addresses ToR 1**

3. Ecosystem indicators (Boldt, Ito?, Samhouri, Yoshie, Kulik, Chung – re filing W1 tables)
- **brief review of indicators proposed in the literature to document status and trends of ecosystem conditions.**
- **present criteria proposed for the selection of indicators, e.g. Rice and Rochet (2005. ICES J. Mar. Sci. 62: 516–527), PICES 2011 FUTURE Workshop.**
- **focus in particular on indicators relevant for assessing multiple pressures**
- **addresses ToR 2 and 3**

Indicators for ecosystem responses to multiple pressures

- **identify ecosystem indicators which might be used to provide an understanding of how ecosystems respond to multiple stressors**
- **(could use Case studies to provide mechanistic understanding where these are known)**
- **evaluate their potential to identify vulnerable ecosystem components**
- **e.g. PICES Session W1 at 2012 Annual Meeting (Hiroshima)**
- **Include tables produced in W1 regarding available data**
- **addresses ToR 5**

4. Case study examples (or embed in above chapters??) (Samhouri, Perry, Boldt, Takahashi, Itakura?)

- **which areas:**
    - **Salish Sea (Strait of Georgia; Puget Sound)**
    - **Seto Inland Sea**
    - **Possibly: Sea of Okhotsk, Bering Sea (?Lukyanova, Kullik, Zador?)**

5. Conclusions and recommendations (drafted by Co-chairs but developed by all WG28 members)

Appendices
1. Terms of Reference
2. Membership
3. Reports of sessions held by WG28
etc.