

# ICES SYMPOSIUM REPORTS 2010

ICES CM 2010/GEN:01

ICES/PICES/FAO Symposium on "Climate Change Effects on Fish and Fisheries:  
Forecasting Impacts, Assessing Ecosystem Responses, and Evaluating Management Strategies"  
Sendai, Japan, 26–29 April 2010

ICES/DHI/NOAA Third International Symposium on  
"Research and Management of Eutrophication in Coastal Ecosystems"  
Nyborg, Denmark, 15–18 June 2010

ICES Symposium on "Making the Most of Fisheries Information:  
Underpinning Policy, Management and Science"  
Galway, Ireland, 23–26 August 2010

26th Lowell Wakefield Symposium on "Ecosystems 2010:  
Global Progress on Ecosystem-based Fisheries Management"  
Anchorage, Alaska, USA, 8–11 November 2010



**ICES**

International Council for  
the Exploration of the Sea

**CIEM**

Conseil International pour  
l'Exploration de la Mer

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## 1 ICES/PICES/FAO Symposium on "Climate Change Effects on Fish and Fisheries: Forecasting Impacts, Assessing Ecosystem Responses, and Evaluating Management Strategies"

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**Conveners: Anne Hollowed (United States), Manuel Barange (United Kingdom), Shin-ichi Ito (Japan), Suam Kim (Republic of Korea), and Harald Loeng (Norway)**

**Venue and dates: Sendai, Japan; 26–29 April 2010**

In 2009, the North Pacific Marine Science Organization (PICES) and the International Council for the Exploration of the Sea (ICES) formed the first joint working group (the Working Group on Forecasting Climate Change Impacts on Fish and Fisheries, WGFCCIFS). The first task of WGFCCIFS was to convene a symposium to provide a venue for the exchange of scientific information and the discussion of the issues and challenges related to predicting the future impacts of climate change on the world's marine ecosystems. Working group members convened a symposium in Sendai, Japan on 26–30 April, 2010. Selected papers from the symposium will be published in July 2011 issue of the *ICES Journal of Marine Science*. This report summarizes key outcomes of this symposium as relevant to the Terms of Reference for the Working Group.

The symposium and the subsequent publication will advance understanding within the scientific community of the potential effects of climate change on fish and fisheries. The symposium also provided the background information needed to address the following WGFCCIFS terms of reference:

- Identify frameworks and methodologies for forecasting the impacts of climate change on the growth, distribution and abundance of marine life with particular emphasis on commercial fish and shellfish;
- Assess the results of designated case studies to test methods;
- Establish techniques for estimating and communicating uncertainty in forecasts;
- Evaluate strategies for research and management under climate change scenarios, given the limitations of our forecasts;

Key findings from the symposium were distributed using three approaches. First, key outcomes and findings from the meeting were summarized in a volume of the PICES Press: ([http://pices.int/publications/pices\\_press/volume18/v18\\_n2/PICES\\_Press18\\_FULL.pdf](http://pices.int/publications/pices_press/volume18/v18_n2/PICES_Press18_FULL.pdf)). This vehicle provided immediate outreach to scientists within ICES and PICES. Second, Theme Session and Workshop co-conveners prepared more detailed summaries of key findings from their session (this report). Third, selected papers will be published in a special issue of the *ICES Journal of Marine Science* with sufficient time for them to be considered by review panels responsible for the next assessment report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) and other review bodies (e.g. the Millennium Report of the United Nations Development Program).

The response to this symposium exceeded the expectations of the conveners, with more than 350 abstracts submitted by scientists from over 40 countries. A total of 208 oral presentations and 105 posters were presented. Over 60 papers were submitted for consideration by the *ICES Journal of Marine Science* and they are currently under review.

During the symposium the global significance of the issues was highlighted in many discussions and presentations. Scientists from around the world debated the issues stemming from climate change impacts on marine ecosystems during the 3 ½ day symposium. Sound scientific advice on the expected impacts of climate change requires the international research community to work together in an interdisciplinary research setting to identify, forecast, and assess strategies to respond to, the impacts of climate change on fish and fisheries. This symposium provided this type of interdisciplinary exchange of information.

The symposium was made possible by the hard work of the local organizers and professionals at the PICES and ICES Secretariats, by the hospitality of the people of Sendai, and by the generous financial support from sponsors. In addition to primary international sponsors (PICES, ICES and the Food and Agriculture Organization, FAO) and local sponsors (the Fisheries research Agency of Japan and Hokkaido University Global Center of Excellence Program), the following agencies and organizations made financial contributions to the symposium:

- Fisheries and Oceans Canada (DFO)
- Integrated Climate System Analysis and Prediction, Germany (CLISAP)
- Intergovernmental Oceanographic Commission (IOC)
- International Pacific Halibut Commission (IPHC)
- Japan Society for the Promotion of Science (JSPS)
- Korea Ocean Research and Development Institute (KORDI)
- Australia National Climate Change Adaptation Research Facility (NCCARF)
- Japan National Institute of Environmental Studies (NIES)
- National Marine Fisheries Service of NOAA (NMFS)
- North Pacific Anadromous Fish Commission (NPAFC)
- North Pacific Research Board (NPRB)
- Pacific Salmon Foundation (PSF)
- Scientific Committee on Oceanic Research (SCOR)
- Sendai Tourism and Convention Bureau (STCB)
- World Bank (WB)

The symposium was arranged around ten theme sessions, with six workshops preceding the meeting. These sessions and workshops encompassed a broad range of topics that provided a global perspective on climate change and the future of the World's fish and fisheries. Day 1 started with presentations by four plenary speakers: Drs. Kevin Trenberth (U.S.A.), Akihiko Yatsu (Japan), Ussif Rashid Sumaila (Canada) and Edward Allison (Malaysia). The themes for Day 1 included:

- Session P1-D1: Forecasting impacts: from climate to fish (co-chaired by Harald Loeng, Kenneth Drinkwater, Franz Mueter, Carl O'Brien, Graham Philling and Yashuhiro Yamanaka,)
- Session P2: Forecasting impacts: from fish to markets (co-chaired by Manuel Barange, Jacqueline King, Ian Perry and Adi Kellermann)
- Session A2: Species-specific responses: changes in growth, reproductive success, mortality, spatial distribution and adaptation (co-chaired by Richard Beamish, Myron A. Peck and Motomitsu Takahashi)

The themes for Day 2 included:

- Session A2: Continuation: Species-specific responses: changes in growth, reproductive success, mortality, spatial distribution and adaptation (co-chaired by Richard Beamish, Myron A. Peck and Motomitsu Takahashi)
- Session A1: Downscaling variables from global models (co-chaired by Michael Foreman and Jason Holt)
- Session B1: Assessing ecosystem responses: impacts on community structure, biodiversity, energy flow and carrying capacity (co-chaired by Thomas Okey and Akihiko Yatsu)

The themes for Day 3 focused the following topics:

- Session B2: Comparing responses of climate variability among nearshore, shelf and oceanic regions (co-chaired by Jürgen Alheit, Jae Bong Lee, and Vladimir Radchenko)
- Session C1: Impacts on fisheries and coastal communities (co-chaired by Edward Allison, Keith Brander, and Suam Kim)
- Session C2: Evaluating human responses, management strategies and economic implications (co-chaired by Tarub Bahri, Kevern Cochrane and Jake Rice)
- Session D1: Contemporary and next generation climate and oceanographic models, technical advances and new approaches (co-chaired by Jonathan Hare and Shin-ichi Ito)

The final half day session was held in plenary. This session focused on sustainable strategies in a warming climate and it was co-chaired by Michael Schirripa and Anne Hollowed. Dr. Steve Murawski provided a summary of first impressions from the meeting.

#### **Summary of key outcomes from the symposium**

- Long-term ocean monitoring programs are needed to track and understand ecosystem and climate change as they occur.
- Networks of shelf-seas ecosystem models have already been developed within several of the world's LMEs. These models provide a basis for examining structural uncertainty within shelf sea ecosystem models.
- Three sources of uncertainty in Global Ocean Models (GOMs) are under investigation: (1) Parameter uncertainty, (2) Structural uncertainty, (3) Scenario uncertainty. Parameter uncertainty is being addressed to some degree with sensitivity tests, structural uncertainty is being explored via comparison of different coupled physical-biological models, and scenario uncertainty deals with greenhouse gas emissions and economics could be addressed via using ensemble model sets
- There are eight approaches to predicting the effects of climate change on fish and fisheries: (a) Global or basin-scale static models, (b) Global-scale dynamic models, (c) Dynamic downscaling, (d) Statistical downscaling, (e) Deductive approach, (f) Comparative approaches, (g) Statistical/time series approach, and (h) Field and laboratory studies. Each has strengths and weaknesses.
- Fisheries oceanography and laboratory studies are critical to integrating biological and oceanographic models, evaluating species environmental

tolerances and adaptation, and to tracking species responses to long term ecosystem and climate change as it occurs.

- Models that couple marine social and economic responses are needed to evaluate management strategies, however few examples exist.
- Issues of food security and marine conservation may require new approaches to satisfy the growing demand for marine resources.
- Two-way communication is needed with scientists and stakeholders to develop meaningful scenarios on human responses to the impact of ecosystem and climate change.



## 2 ICES/DHI/NOAA Third International Symposium on "Research and Management of Eutrophication in Coastal Ecosystems"

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**Conveners: Jesper H. Andersen (DHI, Denmark), Suzanne Bricker (NOAA, USA), Jacob Carstensen (NERI, Denmark), and Jørgen Erik Larsen (DHI, Denmark)**

The Third International Symposium on Research and Management of Eutrophication in Coastal Ecosystems (EUTRO 2010) took place in Nyborg, Denmark, 15–18 June 2010. The symposium focused on the most recent results and experiences related to research and management of coastal eutrophication. Hence, the target audience was a combination of scientists and managers.

EUTRO 2010 followed two earlier symposia taking place in 1993 and 2006, respectively. The first symposium was organized by the Danish Environmental Protection Agency in collaboration with the European Commission. Although taking place in 1993, this symposium has had a significant influence, mainly via the Symposium Proceedings which were published in a special issue of *OPHELIA* (vol. 41 and 42) and included seminal papers, such as Nixon (1995) "Coastal marine eutrophication: a definition, social courses, and future concerns" and Duarte (1995) "Submerged aquatic vegetation in relation to different nutrient regimes", both highly cited. A follow-up symposium, EUTRO 2006, was organized by the Danish Environmental Protection Agency, Fyn County, the Swedish Environmental Protection Agency and DHI Denmark, again focusing on both science and management of coastal eutrophication.

In 2010, almost 17 years after the first symposium and four years after the second symposium, the problems associated with eutrophication were still far from being solved, although there have been major advances in our scientific knowledge and conceptual understanding of nutrient enrichment and eutrophication in coastal waters. New questions and challenges have emerged - especially in relation to modelling and management of coastal eutrophication. Therefore, ICES, NOAA and DHI Denmark organized a third symposium with the aim of integrating science and management of coastal eutrophication.

EUTRO 2010 was organized by DHI, ICES and NOAA and attended by more than 100 participants sharing an interest in coastal ecosystem science and solutions to address coastal eutrophication. EUTRO 2010 was not intended to be a large conference, like annual meetings of many scientific organisations. The symposium goal was to organise an intimate forum for presentation of novel results and to encourage discussions and facilitate development of future collaboration amongst participants. Hence, the success of the symposium was not based on the number of participants but getting in touch with the right participants. Given the feedback received from many participants after the symposium, we feel comfortable concluding that this mission was accomplished.

Members of the Programme Committee were: Jacob Carstensen (chair), National Environmental Research Institute, Aarhus University, Denmark; Jesper Andersen, DHI Denmark; Andris Andrusaitis, BONUS, Finland; Suzanne Bricker, NOAA, USA; Daniel J. Conley, University of Lund, Sweden; Anna-Stiina Heiskanen, SYKE Marine Research Centre, Finland; Marianne Holmer, University of Southern Denmark, Denmark; Robert (Bob) Howarth, Cornell University, USA; Sif Johansson, Swedish Environmental Protection Agency; Adi Kellermann, ICES, Denmark; Maria Laamanen, HELCOM, Finland; Harley Bundgaard Madsen, Environmental Centre Odense (MCO), Denmark; and Stephen Malcolm, CEFAS Lowestoft Laboratory, United Kingdom.

Members of the Organising Committee were: Jesper Andersen (chair), DHI Denmark; Suzanne Bricker, NOAA, USA; and Jørgen Erik Larsen, DHI Denmark.

An overview of organisers, sponsors and supporters of EUTRO 2010 can be found in Annex 1.

### Programme and themes

The programme for EUTRO 2010 included: 1) Opening Ceremony, 2) nine Plenary Sessions including eight key note presentations, 3) ten thematic session, 4) two workshops, 5) a Symposium Summary, and 6) a Closing Ceremony. An outlined programme can be found in Figure 1 below.

|             | TUESDAY 15/6                            | WEDNESDAY 16/6   |   |   | THURSDAY 17/6              |                              | FRIDAY 18/6  |
|-------------|---|--|---|---|----------------------------|------------------------------|--|
| 07:00-08:30 | Registration                            | BREAKFAST  |   |   | BREAKFAST                  |                              | BREAKFAST  |
| 08:30-09:00 |   | KN 3   |   |   | KN 6                       |                              | Workshop Summaries<br><br>Where are we going?:<br>The EU Marine Strategy Framework Directive |
| 09:00-09:30 |   | KN 4   |   |   | KN 7                       |                              |  |
| 09:30-10:00 |   | KN 5   |   |   | KN 8                       |                              |  |
| 10:00-10:30 |   | Questions  |   |   | Questions                  |                              |  |
| 11:00-11:20 | OPENING                                 | Session 4:   | Session 5:  | Session 6:  | Session 9:                 | Session 10:                  | SYMPOSIUM SUMMARY<br>by<br>"Three Wise Ladies"   |
| 11:20-11:40 | KN1                                     | Phyto-plankton and HABs  | Nutrient availability and dynamics                    | Submerged aquatic vegetation                            | Oxygen, hypoxia and anoxia | Regime shifts and thresholds |  |
| 11:40-12:00 | KN2                                     |  |   |   |                            |                              |  |
| 12:00-12:20 |   |  |   |   |                            |                              |  |
| 12:20-12:40 |   |  |   |   |                            |                              |  |
| 12:45-14:00 | LUNCH                                   | LUNCH  |   |   | LUNCH                      |                              | CLOSING  |
| 14:00-14:20 | Session 1:                              | Session 2:   | Session 7:  | Session 8:  | Workshops                  |                              |  |
| 14:20-14:40 | EU Water Policy: Where are we now?      | Climate change and physical control of the biogeochemical dynamics | Monitoring, modeling and assessment of eutrophication | Linking loads with nutrients concentrations and effects |                            |                              |  |
| 14:40-15:00 |   |  |   |   |                            |                              |  |
| 15:00-15:20 |   |  |   |   |                            |                              |  |
| 15:20-15:40 |   |  |   |   |                            |                              |  |
| 16:00-16:20 | Session 3:                              | Session 2  | Session 7   | Session 8   |                            |                              |  |
| 16:20-16:40 | Assessment and management support tools | (cont.)  | (cont.)   | (cont.)   |                            |                              |  |
| 16:40-17:00 |   |  |   |   |                            |                              |  |
| 17:00-17:20 |   |  |   |   |                            |                              |  |
| 17:20-17:40 |   |  |   |   |                            |                              |  |
| 17:40-18:00 |   |  |   |   |                            |                              |  |
| 19:30       | DINNER                                  | DINNER   |   |   | SYMPOSIUM DINNER           |                              |  |

Figure 1. Outlined programme for EUTRO 2010 – a link to a detailed programme including abstracts can be found in Annex 1.

### Themes and sessions

EUTRO 2010 put special focus on conceptual understanding of eutrophication, loads and cycling of nutrients, reference conditions, primary and secondary effects, trend reversal (oligotrophication), monitoring, modelling, assessment as well as development of adaptive and knowledge-based nutrient management strategies.

The EUTRO 2010 gave room for ten sessions which included:

- Session 1: 'Where are we now?: EU water policy' (chaired by Sif Johansson)
- Session 2: 'Climate and physical controls on the biogeochemical dynamics of the coastal zone' (chaired by Pierre Regnier)
- Session 3: 'Assessment and management support tools' (chaired by Marianne Holmer)
- Session 4: 'Eutrophication, phytoplankton and harmful algae' (chaired by Patricia Glibert)
- Session 5: 'Nutrient availability and dynamics' (chaired by Jørgen Erik Larsen)
- Session 6: 'Eutrophication and submerged aquatic vegetation' (chaired by Dorte Krause-Jensen)
- Session 7: 'Monitoring, modelling and assessment of eutrophication in coastal waters - implications to management' (chaired by Joao Ferreira)
- Session 8: 'Linking loads with nutrient concentrations and effects - implications for management' (chaired by Christiane Lancelot)
- Session 9: 'Oxygen, hypoxia and anoxia' (chaired by Suzanne B. Bricker)
- Session 10: 'Regime shifts, thresholds and shifting baselines' (chaired by Jens Perus)

In addition, EUTRO gave room the following plenary sessions:

- Opening session which included presentations by: DHI (Jesper Andersen), ICES (Claus Hagebro), and the European Commission, DG Environment (Sif Johansson)
- 'Complex phytoplankton patterns where land and sea meet' by Jim Cloern, USGS.
- 'Making science influence environmental policy decisions' by Adrienne Sponberg, ASLO.
- 'Processes affecting the nutrient discharge from land - now and in the future' by Per Stålnacke, Bioforsk.
- 'Eutrophication and harmful algae' by Patricia Glibert, UMCES.
- 'Zoobenthos and benthic-pelagic coupling in relation to eutrophication' by Linda Schaffner, VIMS.
- 'Nutrient management, European Directives and The Ecosystem Approach: lessons learned' by Mike Elliot, University of Hull.
- 'Ecological and economical effectiveness of nutrient mitigation measures in the coastal Southern North Sea: an integrated modelling approach' by Christiane Lancelot, Université Libre de Bruxelles.
- Where are we going?: The EU Marine Strategy Directive, chaired by Jacob Carstensen.

## Workshops

EUTRO 2010 hosted two workshops: 1) "BNI workshop: Assessment of measures for a Baltic Sea environment 'unaffected by eutrophication'" and 2) "Comparison of eutrophication assessment tools" (chaired by Michelle Devlin).

The first workshop was organised by the Baltic Nest Institute (BNI), which is a collaboration between Stockholm University and Aarhus University, and builds upon the results from the Swedish research program MARE. BNI has developed a decision support system, called Baltic Nest, openly available on the Internet and that was used for the estimating country-specific nutrient reduction targets in the Baltic Sea Action Plan (BSAP). Baltic Nest links information on environmental conditions in the entire region with possible measures and their costs through a series of databases and models. Baltic Nest provides useful tools for scientists but the primary objective is to provide management options for international negotiations. The aim of the workshop is to present the different components of Baltic Nest and give participant a 'hands-on' experience of using the system.

The second workshop, focused on a number of approaches developed for assessing the impact and risks of nutrient enrichment in marine waters. In Europe, the main approaches for assessing that status and risks of coastal and marine eutrophication include the OSPAR Comprehensive Procedure, methodologies to support the Urban Waste Water Treatment and Nitrates Directives, the TRIX ranking process, the HELCOM Eutrophication Assessment Tool (HEAT), and the relevant elements associated with eutrophication assessment within the Water Framework Directive. ASSETS and EPA NCA are the two main eutrophication assessment methods in the United States and REEFPLAN outlines the non regulatory approach in the Great Barrier Reef, Australia. These approaches differ in their scope, definitions, spatial extent, and how they lead to regulatory and policy outcomes. Slight differences in approaches, reference conditions and statistical tools can have significant impacts on outcomes of the eutrophication assessment. In particular, the identification of biological response as a measurement of undesirable disturbance can influence outcomes, typically moving the eutrophication rating from indicative of a problem to a rating that indicates there are no significant problems if no biological disturbance can be linked to the eutrophication impacts. This workshop presented a comparison of approaches, and presented data to demonstrate how the approaches align through the use of common indicators and reference conditions. The main differences are shown to be at a waterbody level, with the combining of indicator measurements in the final assessment and the definition of biological disturbance, giving the greatest differences in outcomes. The management approach, through the use of either regulatory triggers that require action or through a non-regulatory approach that recommends management action was also discussed.

## Symposium Summary

The Symposium Summary, based on the above presentations and workshops, was compiled and presented by Anna-Stiina Heiskanen, SYKE; Nancy Rabalais, LUMCON; and Robinson W. Fulweiler, Boston University, collectively known as 'The Three Wise Ladies'. In addition, a Summary of the Symposium introducing "The Ten Eutrophication Commandments" was offered:

- 1) Thou shall protect coastal ecosystems to deliver biodiversity and ecological services (or targets)
- 2) Thou shall remember future generations

- 3) Thou shall use modelling, monitoring and expert judgment for a fully integrated approach to ecosystem management
- 4) Thou shall be responsible
- 5) Thou shall learn to recycle nutrients
- 6) Thou shall eat less meat
- 7) Thou shall not pollute thy neighbours' waters (transboundary effects)
- 8) Thou shall communicate with thy neighbour
- 9) Thou shall be patient
- 10) Thou shall be hopeful

Annex 2 includes "The Eutrophication Commandments" poster presented at OSPAR 2010 in Bergen, Norway.

### **Towards EUTRO 2014**

A fourth symposium is in its planning stages and is expected to take place in the United States in 2014. NOAA will take the lead, supported by DHI. Other organizations are being asked to contribute to the planning of what is hoped to be a series of symposia that will continue the discussions that were started in EUTRO 1993, EUTRO 2006 and EUTRO 2010.

### **Annex 1: Links**

Programme including abstracts:

[http://eutro2010.dhi.dk/EUTRO%202010%20programme\\_rev.pdf](http://eutro2010.dhi.dk/EUTRO%202010%20programme_rev.pdf)

List of participants: [http://eutro2010.dhi.dk/symposium\\_programme.html](http://eutro2010.dhi.dk/symposium_programme.html)

Organisers:

- DHI: [www.dhi.dk](http://www.dhi.dk)
- ICES: [www.ices.dk](http://www.ices.dk)
- NOAA: [www.noaa.gov](http://www.noaa.gov)

Sponsors and supporters:

- Nordic Council of Ministers (Working group on Aquatic Ecosystems); [www.norden.org](http://www.norden.org)
- Naturvårdsverket (Swedish Environmental Protection Agency); [www.internat.naturvardsverket.se](http://www.internat.naturvardsverket.se)
- Environmental Centre Odense; [www.blst.dk/Styrelsen/Organisation/MiljoecenterOdense/](http://www.blst.dk/Styrelsen/Organisation/MiljoecenterOdense/)
- ICES; [www.ices.dk](http://www.ices.dk)
- CERF; [www.erf.org](http://www.erf.org)
- NERI; [www.dmu.dk](http://www.dmu.dk)

- University of Southern Denmark; [www.sdu.dk](http://www.sdu.dk)
- BONUS; [www.bonusportal.org](http://www.bonusportal.org)
- HELCOM; [www.helcom.fi](http://www.helcom.fi)
- OSPAR; [www.ospar.org](http://www.ospar.org)

International organizations and societies:

- HELCOM; [www.helcom.fi](http://www.helcom.fi)
- OSPAR; [www.ospar.org](http://www.ospar.org)
- European Environment Agency (EEA); [www.eea.eu.int](http://www.eea.eu.int)
- DG Environment; [europa.eu.int/comm/environment/index\\_en.htm](http://europa.eu.int/comm/environment/index_en.htm)
- DG Research; [europa.eu.int/comm/dgs/research/index\\_en.html](http://europa.eu.int/comm/dgs/research/index_en.html)
- American Society of Limnology and Oceanography (ASLO); [www.aslo.org](http://www.aslo.org)
- Baltic Marine Biologists (BMB); [www.smf.su.se/bmb](http://www.smf.su.se/bmb)
- Coastal and Estuarine Research Federation; [www.erf.org](http://www.erf.org)
- Estuarine and Coastal Science Association (ECSA); [www.ecsa-coast.org](http://www.ecsa-coast.org)

Eutrophication links:

- ASSETS; [www.eutro.org](http://www.eutro.org), [www.eutro.us](http://www.eutro.us), [www.eutro.org/register](http://www.eutro.org/register)
- HELCOM's integrated thematic assessment of eutrophication in the Baltic Sea region, 2001–2007;  
[http://meeting.helcom.fi/c/document\\_library/get\\_file?p\\_l\\_id=79889&folderId=377779&name=DLFE-36817.pdf](http://meeting.helcom.fi/c/document_library/get_file?p_l_id=79889&folderId=377779&name=DLFE-36817.pdf)
- MARE; [www.mare.su.se/ENG/eng-om/eng-om.html](http://www.mare.su.se/ENG/eng-om/eng-om.html)
- Monitoring and Management of European Seagrass Ecosystems (M&Ms); [www.seagrasses.org](http://www.seagrasses.org)
- Nutrients and Eutrophication in Danish Marine Waters; [eutro.dmu.dk](http://eutro.dmu.dk)
- THRESHOLDS; [www.thresholds-eu.org](http://www.thresholds-eu.org)

## Annex 2: "The Eutrophication Commandments" Poster

# THE EUTROPHICATION COMMANDMENTS

R.W. Fulweiler<sup>1</sup>, A.-S. Heiskanen<sup>2</sup> & N.N. Rabalais<sup>3</sup>

The Eutrophication Commandments are meant to summarize the state of eutrophication science as presented in EUTRO 2010, "The Third International Symposium on Research and Management of Eutrophication in Coastal Ecosystems." Here we define eutrophication as an increase in the rate of carbon production and carbon accumulation in an aquatic ecosystem (Rabalais et al. 2004, modified from Nixon 1995). Unfortunately, multiple

changing factors (e.g. shifts in nutrient ratios, landscape changes, local and global socio-economic pressures) prevent return of eutrophied aquatic ecosystems to some historic status. There is compelling evidence that increased loads of nitrogen and phosphorus lead to increased primary production, shifts in phytoplankton communities, shifts in trophic interactions, and negative impacts such as noxious and toxic algal blooms, hypoxia, and loss

of habitats. Many uncertainties remain including the role of climate change in eutrophication, the results of unbalanced N and P reduction, unintended consequences in food web structures, and increased sensitivity of coastal waters to nutrient loading. Regardless of the uncertainty it is clear that action must be taken. With that in mind we present the following ten eutrophication commandments.

### 1. Thou shalt protect the coastal ecosystems to deliver biodiversity and ecological services (or targets)

Coastal ecosystems are diverse and productive – ranking among the most productive in the world – responsible for half of the seafood (Chiriac & Duarte 2008). In addition, coastal systems provide a sense of wonder to quantify services including nursery habitat for commercially valuable species, nutrient filtering, and carbon sequestration. In terms of ecosystem services it has been estimated that coral reefs, mangrove forests, salt marshes, and sea grass meadows have been estimated to deliver the highest value (\$15.921 billion to \$30.000 billion) of all natural ecosystems (Costanza et al. 1997 as cited in Duarte 2009), increasingly human activities are degrading these environments, decreasing biodiversity and ecosystem functions.

### 2. Thou shalt remember future generation

With the identification of nutrient enrichment as a major driver in eutrophication management interventions have tried to reverse this process and its often negative effects. However, we have learned that the fix is more complicated. Recovery of eutrophied marine systems can take decades and in most cases the disturbed ecosystem will never return to be similar as before degradation as food-web changes, climate change, and socio-economic pressures present a clear trajectory back to baseline conditions. There is no doubt that our children will experience a different environment from the one we know just like our environment is much different than that of our grandparents.

### 3. Thou shalt use modelling, monitoring, and expert judgment for a fully integrated approach to ecosystem management

We might not have all the answers now but it is clear that action must be taken. With that in mind we suggest a three-pronged approach to ecosystem management. First, we must remember the power of data. For example long-term monitoring has helped us better understand how systems respond to management intervention as well as climate change; many of these findings were unexpected. Second, models are a powerful tool that should be used to integrate data, test scenarios, and explore the complex socio-ecological interactions. Finally, armed with the best science available we must act responsibly to mitigate our impact and we need to be open to new data suggesting alternate paths.

### 4. Thou shalt be responsible

All of us are responsible and so everyone can contribute to reduce eutrophication. Collectively, simple life style changes will make a profound impact. For example, we could choose: walking powder or detergent that do not contain phosphorus than reducing nutrient contents in vitamins, public transportation or bicycles to reduce atmospheric emissions from traffic, conserve electricity, recycle, etc.

### 5. Thou shalt learn to recycle nutrients

Over a century ago we faced a major nutrient limitation that threatened our very way of life. With the invention of the Haber-Bosch process we are now able to fix enough nitrogen to sustain – in fact over 40% of the global population is alive today because of this process. In the future, phosphorus will be a scarce resource, and we have no idea what that will produce this element. Even if we did not need to – we should learn to recycle nutrients. By recycling both P and N from manure and other types of waste we would decrease nutrient loading to coastal systems and reduce energy use. Organic farmers are looking for solutions that would make us independent of chemical fertilizers. Research indicates that large scale organic farming would be a cost efficient manner to reduce nutrient emissions.

### 6. Thou shalt eat less meat

In many countries meat consumption has been rising steadily (Glover et al. 2002, Stead et al. 2009). The recommended total daily protein dietary intake is exceeded by many populations. High meat consumption is troublesome not only because of the N excreted by meat eaters but because the production of meat is very inefficient in terms of nitrogen. For example it requires 100 kg of N in corn to produce 9 kg of edible N in beef when averaged across the herd (Peters & Fulweiler 2009). The other 90 kg is lost to the environment leading to eutrophication.

### 7. Thou shalt not pollute thy neighbour's water (transboundary effects)

The old saying we all know down here has perhaps never been more important. Nutrients are highly transportable both in the atmosphere and in water. Nutrients may not cause immediate impacts on the coastal zone where they are discharged. The physical, chemical and biological characteristics of the systems determine how and when it responds. Impacts further away may be difficult to trace and prove. But as we state in commandment four we all are responsible. Coastal waters are a continuum, and loading should be stopped at their source.

### 8. Thou shalt communicate with thy neighbour

Effective communication is a key foundation for all partnerships – even the relationship humans have with their environment. Science and policy do little if the public does not understand why certain criteria are adapted or why laws are imposed. Whether you are a scientist, manager, policy maker, stake holder, or concerned citizen it is critical to learn as much as we can and to take collective action. This was also a major conclusion of EUTRO 2010, "Eutrophication abatement will only be effective when accompanied with changes in public attitudes and consumption patterns. This requires continued efforts for scientific understanding of the drivers of eutrophication problems to be transferred effectively to society." (Diane Duarte, presentation in EUTRO 2010).

### 9. Thou shalt be patient

We cannot expect our management interventions to cause immediate change but this does not necessarily mean our actions are ineffective. Ecosystems did not degrade overnight and they certainly will not recover in a short period of time but rather in timescales of decades to half-centuries. The overall system recovery time for freshwater, landfish and marine systems have been estimated to be between 10 to 20 years (Nixon & Schindler 2002).

### 10. Thou shalt be hopeful

We have made substantial progress in our understanding of eutrophication. We have also made progress in educating the public. We have no reason not to be hopeful and we have numerous examples of documented positive ecosystem change. Many coastal regions have succeeded from serious eutrophication systems, such as Iceland, primarily through reduction of nutrient loads. It is a question of not just of marine and coastal environment we wish to have and leave for future generations.

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EUTRO 2010, or in full "The Third International Symposium on Research and Management of Eutrophication in Coastal Ecosystems", took place 25-30 June 2010 in Hirtsholm, Denmark.

Read more about EUTRO 2010 at [www.EUTRO2010.dtu.dk](http://www.EUTRO2010.dtu.dk).



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Click here to download the poster:  
<http://www.ices.dk/iceswork/symposia/eutro2010posterFinal.pdf>

### 3 ICES Symposium on "Making the Most of Fisheries Information: Underpinning Policy, Management and Science"

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#### First International Conference on the Collection and Interpretation of Fishery Dependent Data

**Conveners:** Norman Graham (Ireland), Richard Grainger (FAO), William Karp (USA), Kjell Nedreaas (Norway)

**Steering Committee:** Jerry Fraser (USA), Steven Kennelly (Australia), Kwame Koranteng (FAO), Philip MacMullen (UK), Martin Pastoors (the Netherlands)

**Contributors:** ICES, Marine Institute of Ireland, Failte IrelandNOAA, Norwegian Institute of Marine Research, Norwegian Research Council, FAO

**Venue and Dates:** National University of Ireland, Galway, Ireland; 23–26 August 2010

**Participation:** 210 Delegates from 30 countries

**Publication:** Special Edition of *ICES Journal of Marine Science* to be published in September 2011 with approximately 36 articles. The Guest Editor is David MacLennan (Scotland)

The overall goal of the conference was to bring together managers, scientists and representatives of the fishing sector to consider contemporary issues relating to fishery dependent information in the ecosystem context. The conveners were also successful in soliciting participation from, and support for, scientists from several developing countries.

Each day of the conference began with a keynote presentation in plenary session. Keynote speakers addressed important themes within the broad concept of the conference:

- News of the Death of Fishery-Dependent Data Has Been Exaggerated - Steve Murawski (NOAA, USA)
- Converging Opposing Perceptions in Fisheries Science – The Importance of Common Language, Mutual Understanding, and Collaboration Between Fishermen and Scientists – Lorcan O’Cinneide (Irish Fish Producers Organization)
- Policy Indicators Based on Fisheries Data Sources – Examples from Norway – Peter Gullestad (Directorate of Fisheries, Norway)
- Fishery Dependent Information and the Ecosystem Approach: What Role should Fishers and their Knowledge Play? – Sebastian Mathew (International Collective in Support of Fishworkers, India)

Following each keynote, concurrent sessions were held. Each session included presentation of several papers, a summary presentation of relevant posters, and a panel discussion which included scientists, managers and other stakeholders. Sessions were entitled:

- The role of technology, data collection, and management in mitigating IUU fishing activity
- Analyzing rare occurrences in fishery-dependent datasets
- Technologies for monitoring and data collection
- Fishery management and policy issues relevant to fishery dependent information



- Data quality, evaluation and control: traditional and novel collection methods
- Data quality, evaluation and control: data collection through observers and self-sampling by fishermen
- Application of fisher knowledge to scientific assessments and fishery management (2 sessions)

Important overarching issues were identified and discussed during the week, and important questions were raised regarding conventional approaches to the collection, analysis and interpretation of fishery dependent information and the manner in which fishermen, scientists and policy makers interact during the process of analysis, drafting of advice and development of policy based on that advice.

The diversity of fisheries covered by the conference was noteworthy and ranged from offshore industrialized fisheries, with high technology data acquisition systems and high levels of observer coverage, to small scale, artisanal fisheries, with very little infrastructure. These small scale fisheries are faced with considerable challenges in terms of structured data collection systems, but in many respects are more advanced in terms of inclusion of the fishing community in decision making and recognizing the importance of strong cultural structures as key components of resource management.

In summarizing the conference, the conveners highlighted the following areas and issues:

#### 1) Inclusivity

- Should scientists ask fishers for information or should scientists ask fishers what services they need for sustainable fisheries?
- Fishers and communities as well as policy makers, managers and scientists should be involved in setting goals and defining data needs;
- Improved communication among industry, policy-makers, managers and other stakeholders is of great importance;
- It is important to build an awareness of the long term benefits to industry of providing data to address sustainability goals;
- Small-scale, artisanal and recreational fisheries have unique management and data collection challenges which require careful consideration;
- Broader participation of stakeholders is essential the planning of future meetings; fora where industry, scientists and policy makers come together are uncommon;
- Economists and social scientists have a significant role in many of the issues considered during this conference, including provision of integrated policy advice and evaluating the effectiveness of regulatory measures. Greater participation from these disciplines should be encouraged in future conferences.

#### 2) Technology

- Impressive technological innovation and development of analytical tools has enabled and enhanced data collection and interpretation;
- Future developments will also be powerful;

- Need to properly link information requirements with appropriate technologies;
- Data integration and management will continue to be challenging and emphasis should be placed on solutions;
- Advanced technology is not always the answer – sometimes basic tools like notebooks and pencils are all that is necessary.

### 3 ) Data Quality, Analysis and Use

- Continued focus on data quality and management is essential;
- Need for data to be appropriate, proportionate and cost effective;
- Information needs should be properly identified and satisfied before implementation of new policies and programmes;
- Challenges associated with analysis and interpretation of conventional and unconventional data are significant: great progress has been made in many areas but appropriate and effective use of unconventional data/information is still uncommon;
- Fishery dependent data is becoming increasingly important for shaping fisheries advice and policy.

The conveners and several key participants met in Bergen, Norway, 4–6 January 2011 to review progress on the conference publication, evaluate the conference, and develop recommendations for future conferences of this type.

Participants were in general agreement that the conference was a success and that future conferences should focus on the broad themes identified above (Inclusivity, Technology, Data Quality, Analysis and Use). The focus on use of fishery dependent data to provide advice to policy-makers should also receive particular attention at the next conference.

While there was general agreement that interaction between scientist, policy makers and fishers during the conference had been productive and worthwhile, there was also a strong feeling that this aspect needs to be emphasized at the next conference and that special efforts should be taken to involve managers, policy makers, fishers, industry representatives, and other stakeholders. Increased participation by social scientists and economists was also considered to be important.

The conveners also noted their success in attracting scientists and managers from developing countries and agreed that this should be a priority for future conferences.

There was agreement that follow up conferences of this type should be held at approximately three-year intervals. A proposal for the next conference will be submitted to SCICOM for consideration at their May 2011 meeting. The venue will be in Europe or North America and the initial plan is to hold the conference in 2013.

#### 4 26<sup>th</sup> Lowell Wakefield Symposium on "Ecosystems 2010: Global Progress on Ecosystem-based Fisheries Management"

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**Conveners/ Steering Committee members:** Dr. Gordon Kruse (Chairman, USA), Dr. Howard Browman (ICES, Norway), Dr. David Christie (Alaska Sea Grant, USA), Dr. Kevern Cochrane (FAO, Italy), Diana Evans (NPFMC, USA), Dr. Glen Jamieson (DFO, Canada), Patricia Livingston (NOAA Fisheries, USA), Dr. Douglas Woodby (ADF&G, USA), and Dr. Chang Ik Zhang (PICES, Republic of Korea).

**Venue and dates:** Anchorage, Alaska, USA; 8–11 November 2010

##### **Background**

Since the 1990s, fisheries managers have been advised to broaden their scope of awareness beyond single-species considerations. Reasons include: typical poor performance of single-species fishery management worldwide, heightened awareness of interactions among fisheries and ecosystems, a growing understanding of the functional value of ecosystems to humans, and recognition of a wider range of societal objectives for marine ecosystems beyond fishery catches. As a result, fisheries management has been shifting toward ecosystem-based fisheries management (EBFM), also called an ecosystem approach to fisheries (EAF). An ecosystem approach strives to balance diverse societal objectives by taking into account the knowledge and uncertainties of biotic, abiotic, and human components of ecosystems and their interactions, and applying an integrated approach to fisheries within ecologically meaningful boundaries. This ecosystem approach forms the foundation of the ICES Strategic Plan, "*A Vision Worth Sharing.*"

Considerable progress has been made by organizations, such as ICES, the Food and Agriculture Organization of the United Nations (FAO), North Pacific Marine Science Organization (PICES) and others to develop the conceptual framework, rationale, and international consensus toward such ecosystem approaches. Efforts have been directed toward developing new modelling tools and ecosystem indicators that can be used for implementation. However, substantial challenges still remain, including the need to develop operational objectives, requirements for more empirical information and associated increased costs of implementation, and practical matters of implementing the ecosystem approach by the very institutions that failed to successfully implement even single-species management.

##### **Summary**

These considerations motivated an international symposium titled "*Ecosystems 2010: Global Progress on Ecosystem-based Fisheries Management*", which was convened 8–11 November 2010, at the Captain Cook Hotel in Anchorage, Alaska, U.S.A. The symposium was co-sponsored by ICES, PICES, FAO, and multiple U.S. regional sponsors, including Alaska Sea Grant, NOAA Fisheries Service, North Pacific Fishery Management Council, North Pacific Research Board, Alaska Department of Fish and Game, and the Pollock Conservation Cooperative Research Center. Other supporting organizations included the Institute for Marine Research (Bergen, Norway), School of Fisheries and Ocean Sciences of the University of Alaska Fairbanks (U.S.A.), and Marine Conservation Alliance (U.S.A.). The symposium was hosted by Alaska Sea Grant, which handled all meeting logistics. This symposium was part of an ongoing Alaska Sea Grant symposium series; specifically it was the 26<sup>th</sup> Lowell Wakefield Fisheries Symposium

<http://seagrant.uaf.edu/conferences/wakefield/index.html>

The symposium attracted broad international interest and was attended by 108 registered participants from 19 countries: Argentina, Australia, Brazil, Canada, Estonia, India, Italy, Japan, Korea, Malaysia, New Zealand, Norway, Pakistan, South Africa, Sweden, Taiwan, Thailand, United Kingdom, and USA. This size and diversity fostered a very collegial atmosphere to discuss and contrast approaches in many regions of the world. The keynote and seven invited speakers further emphasized the international focus of this symposium with presentations on contrasting marine ecosystems of Thailand, Korea, Japan, Australia, Namibia, Norway, and Atlantic Canada.

The goals of *Ecosystems 2010* were to: (1) evaluate global progress toward EBFM by reviewing regional case studies, development of new analytical tools and practical approaches toward future progress, and (2) offer explicit, practical advice for future progress in implementation of EBFM. To meet these goals, oral presentations and posters were organized along four main themes: (1) progress on regional applications, (2) new analytical tools and evaluation of ecosystem indicators, (3) human dimensions, and (4) case studies and practical solutions.

Alaska Sea Grant Director, Dr. David Christie, and Steering Committee Chairman, Dr. Gordon Kruse opened the symposium with welcoming addresses. The keynote speaker was Dr. Howard Browman, who kicked off the symposium with a provocative and challenging “devil’s advocate” position. He questioned the extent to which EBFM can be operationalized, whether ecological principles have been incorporated into EBFM and, in fact, whether ecology is necessary to meet the main objectives of EBFM. Finally, he considered whether we have the resources needed to apply EBFM broadly and completely, and whether EBFM will really improve the sustainable management of marine resources.

All sessions were conducted in plenary to maximize involvement of all participants. The first Topic Session addressed “*Progress on Regional Applications*” and spanned just over one full day. It was chaired by Dr. Douglas Woodby and Dr. Kwame Koranteng (FAO, Ghana). An invited talk was given by Dr. Chris O’Brien (Thailand) on the Bay of Bengal Large Marine Ecosystem (BOBLME) Project. He described the strategies and challenges associated with working simultaneously in eight developing countries to implement the BOBLME Project. They are attempting to integrate ecological, economic, social, and governance aspects into the management of three transboundary fisheries, as well as into an overall strategic plan for coordinated management and remediation of the degraded Bay of Bengal marine ecosystem. The challenge is daunting, as the regional fisheries involve 380 000 fishing vessels, with landings valued at US \$6.0 billion, and 4.5 million people employed in the fishing industry. Lessons learned are likely most relevant to PICES countries in the western North Pacific. This interesting session also included examples of other regional EBFM applications in very diverse regions such as India, Thailand, Sweden, South Africa, west coast of Canada, New England (U.S.A.), and even tropical river systems of Brazil.

The second full-day Topic Session addressed “*New Analytical Tools and Evaluation of Ecosystem Indicators*”. It was chaired by PICES representatives, Patricia Livingston and Dr. Chang Ik Zhang, and included two invited talks. In the first, Dr. Rick Fletcher (Australia) introduced an EBFM framework to set priorities based on risk assessment. The framework integrates individual fishery level risks and outcomes at a regional level so as to develop a practical, prioritized agency planning process. An example of applying this step-wise, hierarchical approach was given for the West Coast Bioregion of Western Australia. Over 600 ecological assets, social and economic outcomes, governance systems, and external drivers were identified. How-

ever, these were consolidated into just 24 department-level priorities ranging from urgent to very low after applying the hierarchical approach, which culminated in a multi-criteria analysis. The approach appears to be remarkably successful, as these EBFM-based assets and priorities now form the basis for all planning and budget setting processes in the agency, plus they are facilitating improved linkages with other government agencies and regional level processes. In the second talk, Dr. Zhang reviewed new analytical tools for EBFM assessment and management. He gave two examples showing how ecosystem-based assessments can assist fisheries management in practice. The first was the Marine Stewardship Council's Fishery Assessment Methodology and the second was the Integrated Fisheries Risk Analysis Method for Ecosystems (IFRAME) developed by Dr. Zhang and colleagues. Other presentations in this session addressed ecosystem indicators, integrated ecosystem assessments, and models ranging from multispecies surplus production models to full ecosystem models.

The third Topic Session spanned a half-day and addressed "*Human Dimensions*". It was chaired by Dr. Glen Jamieson and Diana Evans, and also included two invited talks. In the first, Dr. Anthony Charles (Canada) examined the human context for EBFM, as part of a multi-objective "systems" approach, as well as the human dimensions of implementing ecosystem-based management. He emphasized a number of challenges, including the challenge to scale up or scale down new governance initiatives to fit the multiple scales of fished ecosystems. Dr. Mitsutaku Makino (PICES, Japan) spoke about fisheries in the Shiretoko World Natural Heritage. He pointed out that a key to effective management is the participation of the fisheries sector from the beginning of the planning process. Involvement of stakeholders includes a very large number of frequent public meetings. A notable benefit of this involvement is "buy-in" of the stakeholders to the management actions, resulting in a considerable reduction of the administrative costs for conservation measures. Lessons learned from this case study of co-management may be particularly helpful to other situations in the world where large numbers of small-scale fishers harvest a wide range of species. Other interesting talks in this session covered social aspects of overfishing of small-scale fishery resources in Estonia, governance models in Western Australia, development of spatially explicit, decision-support tools for public involvement along the west coast of the U.S. and Canada, and conflict resolution methods for design of marine protected areas in Taiwan, among others.

The final Topic Session addressed "*Case Studies and Practical Solutions*." It was chaired by Dr. Gordon Kruse and Dr. Howard Browman (Norway). Dr. Johann Augustyn (Namibia) delivered the first invited talk on EBFM in the Benguela Current region. The Benguela Current Commission involves Namibia, Angola, and South Africa. These three countries have established structures and mechanisms to manage their fisheries using an ecosystem approach to varying degrees, and they have also initiated research projects to develop ecosystem indicators to monitor progress. In the second talk, Dr. Robert Stephenson (Canada) reported on progress toward EBFM in the Gulf of Maine. In this region, there have been many advances in the understanding of ecosystem processes and progress in networking of people and information. Remaining impediments include the need for enhanced monitoring and information about this complex ecosystem to support evolving management, as well as the need for changes in governance to support cross-disciplinary and inter-jurisdictional considerations. In other presentations in this session, Dr. Kwame Koranteng discussed the approach to EBFM in a number of developing countries and regions around the world, current progress, and practical obstacles that are being

encountered. The session was concluded with four talks addressing case studies of EBFM involving considerations of marine mammals, fishing, climate, and other factors in marine ecosystems of the Gulf of Alaska and eastern Bering Sea.

### **Discussion**

The symposium was concluded with a panel discussion, which included Drs. Howard Browman, Rick Fletcher, Glen Jamieson (Chairman), Kwame Koranteng, Mitsu-taku Makino, and Patricia Livingston. Panelists offered their perspectives on the take-home messages from the symposium, and meeting participants posed questions and proffered their insights. Based on the panel discussion, it appears that the symposium achieved a general consensus on several aspects of EBFM. There was a convergence on broad ecosystem management objectives, principles, approaches, tools, and involvement of stakeholders. A clear consensus also emerged on the need to conduct risk assessments to set priorities. In general, the greatest risk identified for many of the regions of the world is the lack of effective governance. Rectifying this central problem is a prerequisite for any form of sound fishery management. Other common struggles include the difficulty to obtain clear operational objectives from policy makers and the need to develop practical approaches that can be implemented in developing countries with limited fiscal resources. In developed countries, ecosystem models have been constructed to improve understanding of ecosystem dynamics in many regions, but it remains unclear whether these models are capable of providing explicit management advice, such as prescription of biological reference points and total allowable catches. Symposium participants agreed that this was a very successful collaboration among ICES, PICES, FAO, and regional partner organizations. Participants urged a follow-up symposium on this same topic in the not-too-distant future.

### **Symposium materials and publication**

Details about this symposium, "*Ecosystems 2010: Global Progress on Ecosystem-based Fisheries Management*", including the program, copies of presentations, and book of abstracts are available on the symposium website at <http://seagrant.uaf.edu/conferences/2010/wakefield-ecosystems/index.php>. Accepted papers presented at the symposium will be published in a peer-reviewed, edited book expected to be published by Alaska Sea Grant in late 2011. The book will be available electronically over the Internet for easy and affordable access to the ICES community.