ICES Symposium on the "*Ecological basis of risk analysis for marine ecosystems*"

by Alexei Orlov

Fig. 1 Participants of the ICES symposium "Ecological Basis of Risk Analysis for Marine Ecosystems", June 2–4, 2014, at the Art Factory in Porvoo, Finland.

The world's marine ecosystems are facing an increasing number of challenges. Fishing intensity is high, and there are several other threats such as possible oil spills from drilling and transportation, climate change, eutrophication, and risks associated with aquaculture. The aggregate analysis of multiple interacting risk factors is a challenging task for scientists. While risk assessment methods are well established in scientific disciplines like finance, health, and insurance, they are less established in resource management and climate change.

About 80 scientists from 18 countries (Australia, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, New Zealand, Norway, Philippines, Spain, Sweden, Switzerland, Russia, United Kingdom, and USA) gathered near the bank of the Porvoo River in the famous old city of Porvoo, Finland, from June 2–4, 2014, for a symposium on the "*Ecological basis of risk analysis for marine ecosystems*" (Fig. 1).

The ICES symposium was co-sponsored by PICES, the EU Seventh Framework Programme (FP7), Year of the Gulf of Finland 2014, The Federation of Finnish Learned Societies, Maa-ja vesitekniikan tuki ry, and Finnish Cultural Foundation and was convened by Professor Sakari Kuikka (ICES/Finland), Dr. Tony Smith (ICES/Australia) and Dr. Alexei Orlov (PICES/Russian Federation) (Fig. 2).

The aim of the symposium was to support ICES' strategic goal to evaluate the uncertainties related to the sustainability of marine-related industries and production of integrated advice to decision makers. Further, it was to enhance co-operation between ICES and other bodies relevant to risk-based management of marine activities, and to broaden the diversity of scientists participating in these activities. In providing scientific advice, one of the main tasks of ICES advisory and scientific activities is to assess risks and incorporate risk analyses in an integrated and scientifically justified way and to successfully communicate these to scientists in other fields, to managers and to a wider audience. This allows identification of potential risks and leads to better opportunities to manage or control these risks.

The symposium was organized around six overarching themes:

- Fisheries management under uncertainty,
- Decision modelling in fisheries management,
- Probabilistic fish stock assessment,
- Oil spill and eutrophication risk analysis,
- Environmental risk assessment for marine areas,
- Risk analysis in aquaculture.

Fig. 2 Two of the symposium convenors: (top) Prof. Sakari Kuikka, (bottom) Dr. Alexei Orlov.

The symposium (Fig. 3) was opened with a "welcome and opening" speech by the Vice-Rector of the University of Helsinki, Prof. Pertti Panula. This was followed by a presentation by the Vice-Chairman of the ICES Advisory Committee (ACOM), Dr. Carmen Fernandez (Germany), who spoke on Bayesian solutions to ICES responsibilities. The keynote talk by Prof. Samu Mäntyniemi (University of Helsinki), described a Bayesian approach to fisheries stock assessment used in the EU project ECOKNOWS (Effective Use of Ecosystem and Biological Knowledge in Fisheries). Despite their growing popularity, many of the Bayesian stock assessments have only partially followed the logic of Bayesian reasoning. The most notable deviation has been the idea borrowed from statistical data analysis, according to which all the model parameters should be statistically identifiable based on the observed data at hand. This has led to the practice of using different model structures, depending on the amount of data available. A goal of the ECOKNOWS project was to develop a Bayesian stock assessment modelling framework which allows for biologically credible population dynamics and is able to quantify the uncertainty arising from the usual confounding of the model parameters. The General Population Dynamics Model (GPDM) was designed to have a modular structure which describes the essential features of population dynamics. The population can be structured by one or more attributes. For example, age-growth and length-species structures can be specified. The transition of the population from one time step to the next is defined as a probability distribution. This distribution is derived from the assumption that individual fish are correlated due to schooling behavior or patchiness in the environment. Tailoring the GPDM to an assessment problem requires a thorough search for existing information. An important part of the project was to develop ways to formulate the information found from literature, databases and experts into prior probability distributions that describe how well the biology of the population is known. Once the alternative model structures and prior distributions for parameters have been specified, the Bayesian approach is to update these beliefs in light of observed assessment data. Usually, the data are not very informative about most of the parameters but can provide new insights about parameter combinations that pose a difficult computational challenge.

Session 1. Fisheries management under uncertainty. This session dealt with uncertainties from a range of sources that contribute to difficult management processes. Presenters tried to answer the following questions related to data-poor stocks, climate-dependent productivity, complex systems with high numbers of target and bycatch species, and social behaviour by fishers, consumers and policy makers: How can modellers and managers express risks in understandable and practically implementable ways? How can management strategies be developed that are robust to these sources of uncertainty? How can the acceptability of risks be determined in consistent processes? What can be learned from other disciplines applying risk analysis methods?

There was a wide range of presentations regarding analysis of risk assessment for fisheries management that involves various sources of data (life history, environment, ecology, economy, climate, *etc*.). Different methodical approaches, software and databases used in current fisheries management under data-limited conditions were considered and discussed.

Session 2. Decision modelling in fisheries management. This session focused on the following questions: Modelling stocks is an essential component of fisheries management but are models explicitly addressing the decision-making processes used by fisheries managers? How can we integrate ecological, social, economic and institutional aspects? Which variables are relevant for stakeholders? How are model outputs displayed so that management problems and options can be efficiently visualised to support decisions? How may we treat tradeoffs? How do models provide feedback on past decisions? To what extent can fisheries models learn and partially automate decision-making? Are there financial instruments that can deal effectively with ecological risk?

Fig. 3 The symposium in session.

The keynote presentation was given by a member of the ECOKNOWS Scientific Advisory Board, Dr. Robert Stephenson, (Canadian Fisheries Research Network). The ECOKNOWS project represents a major initiative in the challenge of improving fisheries assessment methods by integrating new sources of biological knowledge and the study of the ecological basis for risk analysis for marine ecosystems. An attempt has been made to put the ECOKNOWS experience in context by looking at the developments and progress related to this theme over the past 30 years, and by looking forward at outstanding questions and issues. Looking back, it is instructive to compare the themes and methods of this meeting with those, for example, of the 1998 Symposium on "*Confronting uncertainty in the evaluation and implementation of fisheries-management systems*" (ICES Journal of Marine Science 56:6, 1999). Looking forward, it is important to consider how to address the challenges of evolving domestic and international policies, the move to 'ecosystem' and 'integrated' management, increasing market (and general public) pressure for certification of sustainability, and the need to obtain and maintain 'social license'. The evolving landscape of fishery evaluation and management demands has increased participation in management processes and shared stewardship responsibility, and must adapt to changes in both the ecosystem and in public perception. Additionally, it is important to consider fisheries with other activities in more comprehensive evaluations that can support management decisions in an integrated context. Outstanding research priorities include: (1) more holistic evaluations that take into account the full suite of ecological, social, economic and institutional objectives related to management; (2) methods to support management trade-offs among diverse objectives and activities, and (3) methods that will allow consideration of the cumulative impacts of multiple activities.

Other presentations considered and discussed various examples of decision models with the use of different approaches under different conditions.

Session 3. Probabilistic fish stock assessment. The key questions of this session were: Fisheries assessment now normally include uncertainty as an integral part of the modelling approach, but how consistently is uncertainty applied in the many parameters of complex models, or in the structure of the model itself? While there is an intuitive expectation that reducing uncertainty is desirable, how can priorities be set and the value of reducing relevant individual uncertainties be judged? Are uncertainties on ecological and socio-economic parameters treated the same or differently? Do the assessment models learn from all sources of information effectively?

The session was kicked off with keynote presentation by Dr. Tony Smith (CSIRO, Australia) entitled "*Add a little spice to your life*". Much like cooking, the art of modelling is knowing when to add that little bit of extra spice. The number of foodweb and end-to-end models are growing in number and coverage of the global oceans. While they are an informative means of exploring system dynamics they are not an appropriate risk assessment tool for many applications (such as tactical stock assessments). Nevertheless, experience with such models and other multi-species methods is providing insights into what kinds of ecological idiosyncrasies can undermine the performance of population dynamics with static parameters. Environmental drivers, habitat dependencies, critical predator or prey linkages can shape population trajectories by creating bottlenecks at key points in a stock's life history. In addition, shifting environmental regimes and ecosystem status highlight the importance of considering non-stationary parameters – not just for recruitment, but also size and natural mortality rates. Not all of these additional concerns will always be relevant,

this is not a call for more complexity "just in case". Instead, it is a simple reminder that good model practice is to periodically revise what are key processes, links and feedbacks that need to be considered for the case in point, to check the assumptions. This is something that is being more widely recognized as new hybrid and intermediate model types proliferate and ocean ecosystems change around us. As with any discipline in its early steps, however, a lot can be learnt from sharing lessons to date. Other presentations dealt with various examples of probabilistic stock assessments based on various methods, models, and approaches.

Session 4. Oil spill and eutrophication risk analysis. This session addressed the questions: How are pollution and eutrophication risk analyses formulated? How the risks caused by transportation of oil are linked to ecosystem health? How are exposure and response impacts quantified? How can management at multiple points along an exposure pathway be focused on localized events and endpoints? How are pollution risks built into broader fisheries, coastal and ocean use management models that include multiple, potentially competing, uses of ecosystems? What kinds of advisory and stakeholder groups are needed to link environmental and fisheries risk together?

The session consisted of five presentations by Finnish and German scientists and focused mainly on modelling of oil spills in the Baltic and North Seas under various conditions.

Session 5. Environmental risk assessment for marine areas. This session tried to answer the questions: To what extent are environmental risk assessments in marine areas different from terrestrial systems? How are acceptable endpoints determined in these complex systems? How can the outputs of fishery risk assessments be incorporated into wider marine ecosystem risk assessments?

Eight presentations by scientists from the USA and Europe tried to review current approaches of evaluating environmental risk assessment for various ecosystem components using different tools (marine spatial planning, statistical models, *etc*.).

Session 6. Risk analysis in aquaculture. Production from aquaculture is rapidly overtaking capture fisheries. Simple harvest optimization has been applied to aquaculture modelling but as production becomes more intensive and global, aquaculture must be managed with the expectation of risk. Moreover, aquaculture creates risk for ecosystems. Risks to external (pollution, diseases and parasites, genetic introgression, escapees) and internal (diseases, parasites, genetic deterioration) effects of aquaculture need to be included in aquaculture models. This session was expected to answer two questions: Can general risk models be applied to integrate the range of threats aquaculture faces? How the risks could be incorporated in spatial planning? Unfortunately, these questions did not receive sufficient scientific attention, and the session was cancelled. There was a single poster, dealing with aquaculture-environment interactions in Canada.

The poster session consisted of a dozen of posters that focused on various aspects of risk assessments analysis for marine living resources.

The final event of the symposium was a discussion led by Dr. Robert Stephenson who stimulated participants to formulate key issues that were considered during symposium and those that were missed (Fig. 4). A special issue in the ICES Journal of Marine Sciences has been set to publish the results presented at this symposium.

Fig. 4 Final discussion convened by Dr. Robert Stephenson (Canada).

The steering committee of the symposium included Tapani Pakarinen (Finland), Konstantinos Stergiou (Greece), John Mumford (UK), Robert Stephenson (Canada), Atso Romakkaniemi (Finland), Kirsi Hoviniemi (Finland), Sakari Kuikka (Finland), Tony Smith (Australia), and Alexei Orlov (Russia).

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