SCOR/IOC Working Group 119 on Quantitative ecosystem indicators for fisheries management

Villy Christensen

Fisheries Centre, University of British Columbia, 2204 Main Mall, Vancouver, BC, V6T 1Z4, Canada
E-mail: v.christensen@fisheries.ubc.ca

Working Group 119 on Quantitative ecosystem indicators for fisheries management was established in 2001, with 32 members from 19 countries. The working group, co-chaired by Drs. Philippe Cury and Villy Christensen, was designed to support the scientific aspects of using indicators for an ecosystem approach to fisheries, to review existing knowledge in the field, to demonstrate the utility and perspectives for new indicators reflecting the exploitation and state of marine ecosystems, as well as to consider frameworks for their implementation.

The Working Group met first in October 2001, in Reykjavik, Iceland, to plan and report on progress; and then in December 2002, in Cape Town, South Africa, to organize its efforts with a series of task forces working in parallel on:

- environmental indicators including habitat changes,
- species-based indicators,
- size-based indicators,
- trophodynamic indicators,
- integrated indicators,
- selection criteria,
- data sets and reviews, and
- frameworks for implementing indicators.

As part of their work, the task forces reviewed the current status of using indicators for ecosystem approaches to fisheries, as well as seeking to develop new theory, applying it, and evaluating the performance of indicators. The major results of these endeavours formed the core of the presentations at an international symposium held at the UNESCO headquarters in Paris, in April 2004. The symposium received wide interest with more than 200 abstracts submitted for presentation, and 160 of these presented.

The symposium was organized with two major themes. Theme 1 discussed how indicators synthesize the structure and functioning of ecosystems in time and space, and, in turn, how fisheries influence them. It considered how the indicators have been, or should be, applied to different types of ecosystems or fisheries exploitation, and covered the following topics:

- Environmental indicators that quantify climate change or environmental variability and their ecosystem effects (*e.g.*, regime shifts) as well as the quantification of habitat modification induced by fisheries;
- Ecological indicators that characterize the functioning and the dynamics of marine-exploited ecosystems on the basis of species composition, size distribution, and trophodynamics;
- Fisheries indicators that quantify the impact of fishing on exploited and unexploited components of ecosystems. The session presentations outlined a vast array of well-defined indicators for fisheries management, described their properties, evaluated how they can be used at an ecosystem level to describe the impact of fisheries, and also evaluated the relative contribution of environmental and fisheries impacts. Given the number of available, applied indicators, it is also clear that emphasis must be given to methodologies for selecting indicators and evaluating how capable they are of detecting trends in a noisy environment.

Theme 2 addressed the evaluation, implementation, communication, and use of indicators. Quantitative indicators of ecosystem status have many uses, and ecosystems have many properties that are critical to conservation and management. As a consequence, a large number of indicators have already become available within

a relatively short time. Evaluating indicators relative to management objectives needs to be achieved by defining appropriate criteria. Several contributions presented methodologies for evaluating and comparing various indicators, as well as methods for elaborating and constructing data sets for evaluation of indicators.

To implement an operational ecosystem approach to fisheries, selected indicators have to be assembled into frameworks within which they can be aggregated and combined. Institutional frameworks may include indicators of the exploitation and state of ecosystems, and indicators relating to social and economic aspects. Contributions showed how such frameworks can facilitate indicator development and implementation. Studies of trade-offs between frameworks that tend to make incremental improvements to conventional methods *versus* the more difficult design and implementation of completely new approaches for aggregating indicators were also debated. Communicating the relevance of indicators among stakeholders is an important aspect of their usefulness, and means for achieving this were addressed. Contributions reviewed how indicators can be communicated efficiently in practical situations. These reviews include aspects of decision-making, and of how ecosystem indicators are currently, or may be, used.

Recognizing that communication is an important aspect of scientific work, the symposium was organized with only plenary sessions for oral presentations, and with ample time set aside for poster sessions. Approximately three-quarters of the 160 symposium presentations were displayed as posters, indicating the important role posters play in international symposia.

Some of the findings from the symposium are listed below:

- Defining, selecting, evaluating, and implementing indicators is an achievable task given present knowledge, available data, and existing frameworks;
- Environmental and low trophic-level indicators (*e.g.*, for plankton) capture environmental change and bottom-up effects in a spatially explicit manner. However, the global effect of environmental change on higher trophic levels in the foodweb is not well captured by most indicators (*e.g.*, regime shifts);
- Top predators or high-trophic-level indicators (*e.g.*, birds and marine mammals) summarize changes in the fish communities which are most often (but not always) related to exploitation. Top-down effects, such as trophic cascades, that occur in several ecosystems can be quantified using trophodynamic indicators;
- Several trophodynamic indicators are needed to measure the strength of the interactions between the different living components, and of structural ecosystem change resulting from exploitation. Those indicators are sometimes sensitive to the choice of trophic level made for certain species;
- Size-based indicators have received considerable scientific attention and are perceived as promising for characterizing fish community dynamics in a context of overexploitation;
- An ecosystem approach to fisheries (EAF) requires integration of the spatial dynamics of the various components (including fishers). It also requires quantification of the interactions between different components of the ecosystem. Spatial indicators are currently developed in many ecosystems and are key to understanding the interaction between the different components of the ecosystem and human activities;
- No single indicator (or single ecosystem model) describes all aspects of ecosystem dynamics; we need a suite of indicators (covering different data, groups, and processes), because indicator performance may differ (with ecosystem, history of exploitation, and other pressures, *e.g.*, pollution);
- Aggregated indicators can provide a quick evaluation of the state of marine ecosystems; they should be used simultaneously with a suite of indicators to understand the mechanisms and processes that are acting;
- Ecosystem-based indicators are conservative in the sense that they only show if the ecosystem is strongly affected, so trends and rapid changes must be acknowledged in, and evaluated by, management, even if reference points are lacking;

- Interpretation of indicators requires scientific expertise because of potential, often subtle, error and bias in their analysis;
- Considering both target reference points (TRP) and limit reference points (LRP) in the same framework or model represents a promising way to reconcile constraints and objectives when exploiting natural resources. This may be a promising way also to reconcile the principles of conservation and exploitation;
- Several indicators are better used for surveillance than for prediction. Regime shifts, a feature often associated with the North Pacific Ocean, illustrates a situation where surveillance indicators may be useful;
- In an EAF, the objective is not to find the best indicator, but rather a relevant suite of indicators with known properties; developing methodologies for selecting indicators forms an integral part of the process. Guidelines for how to test indicators and develop frameworks for their application are essential;
- Analysis of single-species *versus* ecosystem harvest strategies shows that we need to provide explicit protection for those species whose value derives, in part, from support of other species as well as from harvesting. Harvesting all species at their single-species maximum sustainable yield may lead to ecosystem erosion;
- Reinforce (or start) the process of implementing ecosystem-based indicators (TRP and LRP) and a framework for fisheries worldwide. Pragmatic approaches need to be taken to move towards an EAF. This may be viewed as a stepwise process that needs to integrate scientific results (data, models, and indicators) and management expertise in a spatially explicit manner;
- A strong feedback between scientific expertise and management is necessary to ameliorate indicators and their practical use. The conclusion of the symposium as expressed through a closing panel discussion is clear: with regard to ecosystem indicators, the science that is needed to make an ecosystem approach to fisheries operational is in place.

The proceedings from the Paris symposium is published as a special issue of the *ICES Journal of Marine Science* **62**(4), and it was published within a year of the symposium, thanks not the least to the dedicated effort of the guest editor, Professor Niels Daan.