Proposal for a SCOR Working Group on

"Evaluating the ecological status of the world's fished marine ecosystems"

Abstract

An Ecosystem Approach to Fisheries (EAF) is being adopted globally. To make progress towards implementing the EAF, carefully selected and appropriate indicators are required to translate ecosystem impacts and changes into management measures that can be assessed for their effectiveness. The scientific community is challenged to provide a generic set of integrated ecological indicators to accurately reflect the effects of fisheries on marine ecosystems, to discriminate these effects from other ecosystem drivers and to facilitate effective communication of these effects to managers, policymakers and the public. Building on the work of SCOR/IOC Working Group 119 on "Quantitative Ecosystem Indicators" (2001-2004), and the IndiSeas Euroceans WG (2007-2009), this ICES SCOR WG proposal, "Evaluating the status of the world's fished marine ecosystems" subject to multiple drivers, aims to provide a concrete framework for evaluating the status of marine ecosystems. We propose a comparative statistical approach to explore and analyse the response of a suite of ecological indicators to ecosystem change across a broad range of ecosystem types; to develop models to explore the combined effects of fishing and climate on indicators trends and to develop rigorous means of testing indicator responsiveness and performance. Furthermore we intend to forge links with other research fields (climate change, conservation biology, sociology and economics) to promote an integrative ecosystem approach to marine resources.

Background and Rationale

Societal and scientific background

After decades focused on the study and management of single species, fisheries management is evolving towards ecosystem-based approaches. These regard the ecosystem as the most relevant unit for management, emphasising that resilient ecosystems are crucial to maintain the sustainability of marine goods and services. Efforts are now being made to measure and alleviate the ecosystem effects of fishing (Hall 1999) and focus is very much on how an ecosystem approach to fisheries may be implemented (Garcia and Cochrane 2005). The FAO Reykjavik declaration of 2001, reinforced at the World Summit on Sustainable Development in Johannesburg in 2002, requires nations to develop and start implementing an Ecosystem Approach to Fisheries (EAF) for reconciling conservation and exploitation objectives by the year 2010. Nations are further required to restore depleted fish stocks by 2015, and to establish representative networks of Marine Protected Areas by 2012.

To fulfil these objectives, a strategy based on innovative and integrated science is urgently needed to translate the complexity of marine ecosystems into comprehensible signals and to propose operational management frameworks (e.g. FAO 2003, Link 2005). The response of the fisheries scientific community has been to develop tools to enable an ecosystem approach to fisheries, a fundamental component of which is the development of ecosystem indicators (Daan *et al.,* 2005), to evaluate the status and dynamics of ecosystems, or components thereof

The groundwork has been established by the SCOR/IOC WG 119 (Cury and Christensen 2005) which reviewed the relevance of a wide range of ecological indicators according to the following criteria:

- ecological significance (i.e. are the underlying processes essential to the understanding of the functioning and the structure of marine and aquatic ecosystems?)
- measurability: availability of the data required for calculating the indicators
- sensitivity to fishing pressure
- awareness of the general public.

It also provided some of the theoretical background to understand which processes and fishing effects are captured by ecosystem indicators. This review categorised ecosystem indicators into three main types: size-based (Shin et al. 2005), trophodynamic (Cury et al. 2005) and species-based indicators.

What is now needed to implement EAF worldwide is a concrete framework to facilitate the application of ecosystem indicators as a tool for diagnosing the ecological state of the world's marine ecosystems and subsequently as a means of initiating appropriate fisheries management responses that would address and alleviate the impacts of fishing on ecosystems. A start has been made by the IndiSeas WG, established under the auspices of the EUROCEANS European NoE (Network of Excellence), to look at "EAF Indicators : a comparative approach across ecosystems". The objective of the IndiSeas WG was to use a comparative approach to evaluate the status of marine ecosystems in a comparative framework and to guide fisheries management in each ecosystem. Ecological indicators from 19 fished ecosystems were assembled, examined and reviewed with respect to several criteria, before agreement was reached on an initial suite of eight ecological indicators consider most suitable to evaluate ecosystem effects of fishing. An IndiSeas website has been created to present part of the results of this work, which includes a "dashboard" of these indicators, developed for visualisation purposes for the non-scientists (see www.indiseas.org, opened to the public in April 2009). A series of 9 scientific papers[1], exploring the behaviour of the suite of the minimal set of 8 ecosystem indicators has been submitted to ICES Journal of Marine Science. One clear result from this WG is that (a) further work is required to select indicators that are robust to ecosystem type, (b) the performance of these indicators can be ambiguous and (c) it can be difficult to discriminate the effects of fishing from environmental drivers. Ecological indicators only tell part of the ecosystem story.

Objectives

The goal of this proposed working group "Evaluating the ecological status of the world's exploited marine ecosystems subject to multiple drivers" is to bring together a broader group of experts to further explore, test and expand the development of a suite of robust ecosystem indicators for detecting ecosystem change in response to fishing and environmental impacts. Specifically we propose to:

(i) to develop rigorous means of testing indicator responsiveness and performance,
(ii) develop reference points for the suite of indicators,
(iii) add climate and biodiversity/conservation indicators, and link with parallel projects undertaking global applications of socio-economic indicators, to a set of integrative ecological indicators developed during the first phase of IndiSeas (see below),
(iv) develop models to explore the combined effects of fishing and climate on indicators trends,
(v) build from the database and working relationships developed through the IndiSeas WG, review further indicators and include more ecosystems in the project, and
(vi) evaluate the exploitation state of marine ecosystems in a comparative framework from all three tiers of an EAF (ecological, social, economic) using a comparative statistical approach.

The following questions will be addressed by the WG:

- Are the analyses and methods of synthesizing information from ecological indicators, as proposed during the first phase of IndiSeas, sufficient and helpful as a means of moving towards ecosystem diagnosis and formulating recommendations for management purposes?
- Which complementary indicators should be used to synthesize and communicate ecosystem status in terms of climatic change, biodiversity/conservation and socio-economics?
- How can we compare the status of exploited marine ecosystems under multiple drivers (fishing, climate) and objectives (ecological, social, economic)?
- How well do indicators reflect actual change?

There are many proposed ecosystem indicators, but in most cases their behaviour has not been explored across different ecosystems. There are several reasons why a comparative approach is adopted in this WG:

- With the difficulty in establishing baseline levels and reference points for most ecosystem indicators, the comparative approach across ecosystems will provide a range of reference

[1] The Indiseas suite of papers will be published in the ICES Journal of Marine Science. See Annex A for details.

values against which each ecosystem can be assessed. These comparative analyses allow the opportunity for taking a broader ecosystem perspective, help to avoid repeating the same fisheries management mistakes as may have been the case in some ecosystems in the set considered (i.e. provide early warning signals), and permit the ability to draw generalizations important to understanding ecosystem response to external drivers;

- The comparative approach will also help in selecting robust ecological indicators that will be meaningful and measurable over a set of diverse and contrasted situations;
- The comparative approach between ecosystems, together with the communication of results to the public at large are also aimed at creating an incentive for politicians to consider their management options, with informed responsibility for the ecological, social and economic quality of marine world ecosystems.

Timeliness and relevance to other international activities

The proposed WG will greatly benefit from the advances made by the SCOR/IOC WG 119 (2001-2004) and the IndiSeas WG. While SCOR/IOC WG 119 focused on theoretical and conceptual studies, the selection of relevant ecological indicators and on local empirical studies, the IndiSeas WG undertook much of the groundwork for the present proposed SCOR WG. It has developed a minimal suite of ecological indicators, a database for 19 ecosystems and working relationships with over 30 scientists from adjacent nations. It is timely to take advantage of this work to expand the range of ecosystems and indicators, to focus on the further development and testing of this expanded suite of indicators and to use this capability to test indicators across a range of ecosystem types with differing fishing histories. This is seen as a substantial step towards implementation of an Ecosystem Approach to Fisheries.

In 2007 and 2008, the European Network of Excellence (NoE) EUR-OCEANS (www.eur-oceans.eu) supported two IndiSeas meetings dedicated to the first stage of a global comparative approach. Yunne Shin and Lynne Shannon were co-leaders of these meetings, which assembled expertise from around the world, and then applied a suite of ecological indicators to 19 ecosystems. These meetings and inter-sessional work have culminated in a suite of papers that evaluate the status of the 19 ecosystems and explore the use, application and interpretation of the indicators (submitted to ICES early June 2009). These results have raised many questions about the performance of indicators, their robustness, the type and number of indicators required and the enigma of ecological reference points.

The proposed SCOR WG will be able to take advantage of the momentum of the IndiSeas WG. The proposed membership is expanded to include scientists from other disciplines and ecosystems to bring new perspectives and necessary expertise. The recently opened IndiSeas website will help to attract experts from other ecosystems to join the analyses and expand the suite of indicators. This expansion of the initial indicator suite based on fisheries and fish surveys data is seen as a major challenge and highly necessary if we are to progress with EAF worldwide. Through associations with experts in these fields, the proposed SCOR WG will undertake analyses of the expanded suite of indicators and attempt to assemble these in a unified approach.

The SCOR "label" will ensure the success of the WG as it will provide an international visibility which will attract top scientists across several fields working on a common ecosystem approach to marine resources and will ensure that the scientific analyses are undertaken with rigour and complete neutrality. This last point is critical as we aim at transferring our scientific knowledge to other spheres. We also plan to build bridges with other research fields (socio-economics and climate change) so again, having the visibility of SCOR will greatly facilitate conducting inter-disciplinary studies.

Finally, there is a growing body of researchers working on different systems and types of ecosystem indicators for EAF for whom the final symposium would be useful (see below). There is a developing need for comprehensive, international scientific discussion of the use, testing and performance of ecosystem indicators for EAF. The ICES SCOR WG will provide the scientific groundwork; the symposium will provide the opportunity for further progress and communication of knowledge and experience.

Terms of reference

The proposed working group would:

1. **Review the protocols developed by IndiSeas to diagnosis the exploitation state of marine ecosystems using ecological indicators.** This stage involves the review and selection of adequate statistical methods for characterizing trends in indicators (autocorrelated regression, GAMs, first and second-order derivatives), for detecting similarities between indicators (PCA analyses, mutual information index) and for establishing a classification of marine ecosystems according to fishing impacts (decision tree analysis, scoring and ranking ecosystems). This step will be enriched by input from new participants (representing new types of ecosystems such as coral reef ecosystems, or new disciplines such as physical oceanography), and on reviews provided for the suite of 9 papers submitted to ICES Journal of Marine Science.

2. **Testing the performance of ecosystem indicators in fisheries management.** How well do ecosystem indicators detect fisheries effects? How sensitive are they to changes in the ecosystem and how well do they guide management decisions? These are crucial questions in the development of indicators and are often ignored. Performance testing is a formal procedure to assess whether an indicator and accompanying decision rule actually guides decision-makers to make the "right" decision. Performance testing scores the ratio of "right" decisions to "wrong" decisions. The suite of indicators developed by the IndiSeas WG provides an initial unique opportunity to test these indicators across a broad range of ecosystem types. Conclusions should be very robust.

3. **Developing reference points for indicators.** Establishing reference points for ecosystem indicators has proven to be a major challenge to implementing EAF, due to the complexity of ecosystems and their response to fishing. A key benefit of the comparative approach proposed for this SCOR WG is that it provides empirical data on ecosystem indicator behaviour across a range of ecosystem types and states. These data will be used to explore whether, minimally, limit thresholds can be identified, and whether possible target reference points can be proposed. The use of simulations using a set of various ecosystem models (EwE, Osmose, Atlantis) can also help in reconstituting pristine states of the ecosystems. There are several candidate ecosystems in which such multi-models comparative approach can be undertaken as the models are already parameterized, and the specialists/developers of the models are part of the present WG: South Africa, North Sea, Australia, West Coast Canada.

4. **Studying the joint effects of climate and fishing changes on the selected indicators.** Time-series analyses will be undertaken of fishing effort and regional climate indices. Ecosystem models will also be used to assess the specificity of ecosystem indicators to fishing effects versus climate effects: EwE, Osmose and Atlantis models will be used in this regard. This task can be done in synergy with actions planned within the FP7 European MEECE project (www.meece.eu) in which some of the participants of the present proposal are involved (Y. Shin, L. Shannon, J. Blanchard), and which can be expanded to other world ecosystems.

5. **Integrating conservation and biodiversity issues in the diagnosis of ecosystem states.** Biodiversity is a key ingredient for resilient, robust and resistant ecosystems. All too often however, species, habitats or even whole ecosystems are negatively affected by fishing and mitigation approaches are necessary in addition to avoiding damage through wise management. We plan to expand the set of eight ecological indicators to add a set of indicators that will quantify the biodiversity and conservation risks in ecosystems.

6. **Integrating socio-economic issues.** EAF has many facets, and one which is too often ignored is the realm of socio-economic indicators of the effects of fishing on ecosystems. As yet, the development of socio-economic indicators lags that of ecological indicators, and thus there is less to work with. However, we aim to link with projects like Questfish, and other regional/local-scale projects addressing the human dimensions of EAF, to review existing socio-economic indicators and then apply the criteria outlined above to select a subset of socio-economic indicators for inclusion in the generic dashboard of indicators.

Working Group Composition

We propose that the WG will have 3 co-leaders, Alida Bundy, Yunne-Jai Shin and Lynne Shannon. The composition of the WG is necessarily international in accordance with its objectives. Participation by an expert from each ecosystem is a pre-requisite for adequate comparative analyses and proper scientific guidance in each ecosystem. With the proposed list of members, at least 22 marine ecosystems will be considered from the first year of the WG. All scientists proposed have comprehensive, expert knowledge of ecosystem functioning and the ecosystem approach to fisheries. The WG also includes scientists having expertise in socio-economic, biodiversity and climate indicators. The geographical coverage ensures that each type of ecosystem is well represented, as well as three major oceans (Pacific, Atlantic, Indian oceans). Among the Full Members, the group has 2 scientists from developing countries and 5 women, providing good geographic and gender balance. Additional breadth will be achieved through Associate Members.

Full members

Name	**Country**	**Institution**	**Expertise**	
			Ecosystem	**indicators**
Alida Bundy, co-chair	Canada	DFO	Temperate	fisheries, trophodynamic
Yunne-Jai Shin, co-chair	France	IRD	Upwelling	size-based
Lynne Shannon, co-chair	South Africa	MCM	Upwelling	fisheries, trophodynamic
Marta Coll	Spain	ICM/CSIC	Temperate	trophodynamic
Jorge Tam	Peru	IMARPE	Upwelling	fisheries, trophodynamic
Nick Dulvy	Canada	SFU	Temperate	Biodiversity
Beth Fulton	Australia	CSIRO	Temperate	fisheries
Jason Link	US	NOAA	Temperate	fisheries
Ian Perry (to be confirmed)	Canada	DFO	Temperate	fisheries, climate
Claude Roy	France	IRD	Upwelling	climate

Associate members

Name	**Country**	**Institution**	**Expertise**	
			Ecosystem	**indicators**
Vera Agostini	US	Nature Conservancy	Upwelling	biodiversity
Icarus Allen	UK	PML	Temperate	climate
Edward Allison	Malaysia	Worldfish Centre	Tropical??	Socio-economic
Kerim Aydin	US	AFSC	high latitude	fisheries, climate
Julia Blanchard	UK	CEFAS	Temperate	size-based
Fatima Borges	Portugal	IPIMAR	Upwelling	fisheries
Ratana Chuenpagdee	Thailand	CDC	Tropical	Socio-economic
Philippe Cury	France	IRD	Upwelling	Fisheries, trophodynamic
Ibrahima Diallo	Guinea	CNSHB	Tropical	fisheries
Sheila Heymans	Scotland	SAMS	Temperate	Biodiversity
Larry Hutchings	South Africa	MCM	Upwelling	Climate, fisheries

Astrid Jarre	South Africa	UCT	Upwelling	socio-economic
Edda Johannesen	Norway	IMR	high latitude	fisheries
Didier Jouffre	Senegal	IRD	Tropical	biodiversity
Pierre Labrosse	Mauritania	IMROP	Tropical	socio-economic
Steve Mackinson	UK	CEFAS	Temperate	fisheries, climate
Hicham Masski	Morocco	INRH	Upwelling	fisheries
Sergio Neira	Chile	U Concepcion	Upwelling	trophodynamic
Henn Ojaveer	Estonia	EMI	Temperate	fisheries
Khairdine Ould MA	Mauritania	IMROP	Tropical	fisheries
Trevor Platt (to be confirmed)	UK	PML	Temperate	Biological oceanography; climate
Jake Rice	Canada	DFO	Temperate	fisheries
Marie-Joëlle Rochet	France	IFREMER	Temperate	size-based
Djiga Thiao	Senegal	CRODT	Tropical	fisheries
Verena Trenkel	France	IFREMER	Temperate	fisheries
Dawit Yemane	South Africa	MCM	Upwelling	biodiversity

Planned activities and Products

If approved, the first task of the working group will be to meet to address TOR 1, and to plan for the other TORs. The intent is to institute 5 task groups to address TORs 2 – 6, and to plan for two more annual meetings. All terms of reference will be addressed at each of the annual meetings. However, the main emphasis of meeting 2 will be on TORs 2 and 3, and the main emphasis of meeting 3 will be on TORs 4-6. In general, the work of this group will involve the group of ecosystem and indicator experts meeting once per year with inter-sessional targeted work being undertaken at their home institutions. Progress reports will be written and sent out to other experts for comment. It is proposed that the first annual meeting takes place between March and May 2010.

Products of the WG will be oriented towards an International Symposium in the final year and a special Journal edition. Furthermore, as ecosystems and indicators are developed and tested, these, and the associated protocols will be made available on the IndiSeas website.

In addition to assuming current coordination tasks (delivering annual reports, searching for additional fundings, distributing documents and data to each participant, organizing annual meetings, coordinating activities between meetings), each co-leader of the WG would assume the main responsibility of each of the following deliverables and TORs as indicated.

- Alida Bundy (TORs 1,3,6) will lead TOR 3 “Developing reference points for indicators”. She will also be responsible for the organization of an **international symposium** at the end of the WG (2012). It will be the opportunity for the worldwide network to present their results on the use of ecosystem indicators in diagnosing ecosystems’ states and implementation of Ecosystem-based fisheries management.

- Yunne-Jai Shin (TORs 1,2,4) will lead TOR 4 “Studying the joint effects of climate and fishing changes on the selected indicators”. She is also responsible for the continued delivery of the **website** dedicated to inform the general public about world’s marine ecosystems.

- Lynne Shannon (TORs 1,3,4,5) will lead TOR 5 “integrating conservation and biodiversity issues in the diagnosis of ecosystem states”. She will be responsible for the edition of a **special Journal issue** following the international symposium (2012).This special issue will include papers from the WG, the International Symposium and solicited reviews and analyses.

It is anticipated that members of the Committee will lead the task groups associated with TOR 2 and 6. Some additional sources of funding are already identified: IRD (Institut de Recherche pour le Développement) for inviting experts from developing countries to annual meetings, and the European project MEECE (2008-2012, www.meece.eu) will provide the persons-month necessary to maintain and expand the website. Other sources will also be explored.

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Annex A

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