

# WORKING GROUP ON INTEGRATING ECOLOGICAL AND ECONOMIC MODELS (WGIMM)

ICES IEASG COMMITTEE

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REF SCICOM AND ACOM

## Report of the Working Group on Integrating Ecological and Economic Models (WGIMM)

December 2017

via Correspondence



**ICES**

International Council for  
the Exploration of the Sea

**CIEM**

Conseil International pour  
l'Exploration de la Mer

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## Executive Summary

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WGIMM worked intersessionally on the review paper published in *Fish and Fisheries*. This work followed the diverse meetings and theme sessions at a number of conferences since 2015. The extensive work on compiling material for a scientific report on “Integrated Ecological-Economic Fisheries Models – Evaluation, Review and Challenges for Implementation” has been partly presented in initial form in the last reports and in several conference symposia and presentations. This work is for a major part a product and the results of the work under ICES WGIMM. The white paper produced under and directly addressing TORs a, b, c, d, e and f under WGIMM was published in a top ranking scientific peer reviewed journal and has been made available through full open access paid to the publisher. This was conducted through extensive work in WGIMM by correspondence during 2017.

The group has accordingly worked on the scope of the group (ToRs a-f) and a new set of ToRs have been proposed to continue to align with the Strategic Initiative on the Human Dimension (SIHD) in Integrated Ecosystem Assessments and the IEA groups.

### Summary of Fish and Fisheries white paper

In the paper “Integrated Ecological-Economic Fisheries Models – Evaluation, Review and Challenges for Implementation” (Nielsen et al. 2017/2018) there is presented a global review and comparative evaluation of 35 integrated ecological–socioeconomic fisheries models (IESFMs) applied to marine fisheries and marine ecosystem resources to identify the characteristics that determine their usefulness, effectiveness and implementation in fisheries advice. The focus is on fully integrated models that allow for feedbacks between ecological and human processes. The review covers selected IESFMs representing a broad range of approaches and perspectives rather than providing a comprehensive analysis of all existing models worldwide.

The white paper produced as a part of the WGIMM report provide potential users an overview of when and how IESFMs can be and have been used worldwide. The review serves to identify some common features and failings of models and hence may guide researchers in selecting existing models and further developing them rather than creating a completely new model. It also highlights modelling challenges and future directions of research especially when it comes to implementation of the models.

The analyses and evaluations of the models cover several phases. Initially, the models are listed with relevant references for their development. Second, the analysis methods and tools used for evaluation of the models are described. The tools are used to describe, categorize and evaluate the different type of models according to a set of specific criteria covering the above issues. This categorization and evaluation is summarized in semi-quantitative spider-web plots to compare the focus and capability of the different models and what main directions of development the different models represent. The review evaluates model design choices such as scope, spatial and temporal dimensions and scales, functions and processes included, level of complexity and realism, the ability to model uncertainty and stochastic process impact, and the type and robustness of advice that can be provided as well as the data and expertise needed to develop and parameterize IESFMs. Model linking, coupling and level of integration of biological-economic-social components in the models are also considered. The results of this meta-analysis are discussed with a focus on use and

characteristics that contribute to effective implementation. Needs for further research are identified with emphasis on specific needs for further model implementation.

The specific objectives of the study are i) to provide a set of tools and criteria to make a comparative evaluation of IESFMs, ii) to evaluate use and implementation of different types of IESFMs through selected examples from around the world, iii) to elucidate limitations and progressions of IESFM implementation and the governance process including necessary stakeholder involvement, iv) to provide potential users with an overview and framework that can be used to guide in selection of the most appropriate models according to their specific needs, purpose, and questions to be answered, i.e. providing guidelines for good practice in selection, use, and communication of the models according to requirements and trade-offs.

The review demonstrates that modellers face inevitable trade-offs between complexity and comprehensiveness, flexibility, and user-friendliness. These trade-offs affect model design, performance and model acceptance, and also must be considered in determining the best approach to communicate model results. No model design fits all cases and uses, but the review provides insights that may help both developers and users of models to determine the model characteristics that best suit their intended implementation, uses and how to more effectively communicate model results to ensure uptake in management advice and decisions. The results show that Modellers must invest more time to make models user friendly and to participate in management fora where models and model results can be explained and discussed. Such involvement is beneficial to all parties, leading to improvement of models and more effective implementation of advice, but demand substantial resources, which must be built into the governance process. It takes time to develop effective processes for using IESFMs requiring a long-term commitment to integrating multidisciplinary modelling advice into management decision-making.

This work was conducted under the ICES WGIMM (ICES Working Group for Integrated Management Modelling). The work is original and is published with paid full open access in Fish and Fisheries. In this report the full paper addressing thoroughly WGIMM ToRs a-f is given, and its appendices are attached, as this paper is mainly produced under WGIMM and full open access have been paid with a high amount to allow it to be published in the current report and make it accessible anywhere. Accordingly, this paper provides the full reporting of ICES WGIMM 2014-2017.

## 1 Administrative details

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**Working Group name**

Working Group on Integrating Ecological and Economic Models (WGIMM)

**Year of Appointment**

2014

**Reporting year within current cycle (1, 2 or 3)**

3

**Chairs**

Eric Thunberg (USA)

J. Rasmus Nielsen (Denmark)

Jörn Schmidt (Germany)

**Meeting venue**

By Correspondence

**Meeting dates**

Continuously by Correspondence

## 2 Terms of Reference a) – f)

ToR	DESCRIPTION	BACKGROUND	SCIENCE PLAN TOPICS ADDRESSED	DURATION	EXPECTED DELIVERABLES
a	Collect globally available coupled ecological-economic models and characterize them with respect to their applicability (academic, advice, evaluation)	Serves as the basis for further work of WGIMM and provides deliverables for the wider community		1 <sup>st</sup> year, will be continued over all 3 Years	Online Repository with explanation of the different models
b	Develop a framework for evaluation and comparison of these models	Models are a method to evaluate or explore specific hypotheses within systems and such need to fulfil the requirements of every other method of reproducibility		2 <sup>nd</sup> year	White paper of good practice, manuscript for peer reviewed journal
c	Analyse the potential, capability and performance of the models and frameworks with respect to spatial and regional explicit bio- economic evaluation of fisheries management in context of marine spatial planning and broader cross sector marine management on regional basis	Fisheries is increasingly competing for space, especially in coastal areas, but also for the high seas marine spatial planning will become the basis for decision-making in future		3 years	White paper, manuscript for peer reviewed journal
d	Identify further the data and information required as well as expertise needed for integrated bioeconomic modelling of fisheries and application of socio-economic evaluation methods on short and long term basis enhancing the above	The models are increasingly data demanding and the collection and access needs to be harmonized. It will be of crucial importance with respect to limited resources to identify the data, which will be needed to feed the models and to serve as a sound scientific basis for decision-making	3 Years		White paper

ToR	DESCRIPTION	BACKGROUND	SCIENCE PLAN TOPICS ADDRESSED	DURATION	EXPECTED DELIVERABLES
e	Discuss how different stakeholder groups can be incorporated in the process of model development. These participatory processes will be of increasing importance to “answer the right questions” and to make these models usable beyond the academic sphere	This is also part of ToR a, but needs to be taken explicitly, because it will influence future developments		2 <sup>nd</sup> year	Nested workshops with stakeholders
f	Develop innovative ways of communicating the increasingly complex results from these models to decision-makers, but also the wider public	A transparent communication of complex results is the basis to increase literacy of fisheries related issues both for decision-makers and the public		3 <sup>rd</sup> year	Schemes for decision support systems



### 3 Summary of Work plan

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Year 1	Repository set up, general planning of white paper and conference contributions
Year 2	Workshops with stakeholder involvement, preparation of contributions to special sessions under ICES ASC 2016, IIFET 2016, and continued work on peer reviewed publication with white paper on evaluation schemes addressing ToRs a-f.
Year 3	<p>Publication of white paper including decision support schemes to finalize work on ToRs a-f.</p> <p>The final considerations under the WGIMM group have been to produce a draft set of future ToRs for the group conforming to ICES SIHD initiative as well as its links to the new ICES WGECON, and the continued links to other related initiatives and groups, ICES/IIFET/NAAFE/NEAFE, etc.</p> <p>WGIMM worked extensively by correspondence during all of 2017 to finalize and publish the white paper and the associated ToRs a-f under the working group. This was based on the final plans and agreements made during the December 2016 WebEx WGIMM meeting.</p>

## 4 Summary of Achievements of WGIMM during 2014-2017

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WGIMM worked extensively by correspondence during all of 2017 to finalize and publish the white paper and the associated ToRs a-f under the working group. This was based on the final plans and agreements made during the December 2016 WebEx WGIMM meeting.

WGIMM worked intersessionally on the review paper published in *Fish and Fisheries*. This work followed the diverse meetings and theme sessions at a number of conferences since 2015. The extensive work on compiling material for a scientific report on “Integrated Ecological-Economic Fisheries Models – Evaluation, Review and Challenges for Implementation” has been partly presented in initial form in the last reports and in several conference symposia and presentations. This work is for a major part a product and the results of the work under ICES WGIMM. The white paper produced under and directly addressing TORs a, b, c, d, e and f under WGIMM was published in a top ranking scientific peer reviewed journal and has been made available through full open access paid to the publisher. This was conducted through extensive work in WGIMM by correspondence during 2017.

The group has accordingly worked on the scope of the group (ToRs a-f) and a new set of ToRs have been proposed to continue to align with the Strategic Initiative on the Human Dimension (SIHD) in Integrated Ecosystem Assessments and the IEA groups.

### 4.1 Summary of Fish and Fisheries white paper

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The white paper produced as a part of the WGIMM report provide potential users an overview of when and how IESFMs can be and have been used worldwide. The review serves to identify some common features and failings of models and hence may guide researchers in selecting existing models and further developing them rather than creating a completely new model. It also highlights modelling challenges and future directions of research especially when it comes to implementation of the models.

The analyses and evaluations of the models cover several phases. Initially, the models are listed with relevant references for their development. Second, the analysis methods and tools used for evaluation of the models are described. The tools are used to describe, categorize and evaluate the different type of models according to a set of specific criteria covering the above issues. This categorization and evaluation is summarized in semi-quantitative spider-web plots to compare the focus and capability of the different models and what main directions of development the different models represent. The review evaluates model design choices such as scope, spatial and temporal dimensions and scales, functions and processes included, level of complexity and realism, the ability to model uncertainty and stochastic process impact, and the type and robustness of advice that can be provided as well as the data and expertise needed to develop and parameterize IESFMs. Model linking, coupling and level of integration of biological-economic-social components in the models are also

considered. The results of this meta-analysis are discussed with a focus on use and characteristics that contribute to effective implementation. Needs for further research are identified with emphasis on specific needs for further model implementation.

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Paper reference: Nielsen J.R., Thunberg E., Holland D. S., Schmidt, J. O., et al. 2018. Integrated ecological-economic fisheries models – Evaluation, review and challenges for implementation. *Fish and Fisheries* 19(1): 1-29 + App I-IV, <https://doi.org/10.1111/faf.12232>.

## 5 Final Report on ToRs, Workplan and Science Implementation Plan

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The below final WGIMM report addresses and provides the final results on all WGIMM ToRs a-f. Concerning the Science Implementation Plan then this has been completed and achieved as planned during the working group. This has been done by publishing the below paper produced under ICES WGIMM in one of the world highest ranking fisheries scientific journals to be made available not only to the full ICES society for further implementation in the scientific and advisory process, but also to a worldwide audience of fisheries scientists and fisheries management advisory bodies.

The following paper has been published under WGIMM: Nielsen J.R., Thunberg E., Holland D. S., Schmidt, J. O., et al. 2018. Integrated ecological-economic fisheries models – Evaluation, review and challenges for implementation. *Fish and Fisheries* 19(1): 1-29 + App I-IV, <https://doi.org/10.1111/faf.12232>.

The paper is fully available in full open access form from the above link <https://doi.org/10.1111/faf.12232>) including the electronic appendices I-IV (Supporting Information):

<https://doi.org/10.1111/faf.12232>.

[faf12232-sup-0001-TableS1.doc](#) Word document, 875.5 KB

[faf12232-sup-0002-TableS2.docx](#) Word document, 63.7 KB

[faf12232-sup-0003-TableS3.docx](#) Word document, 42.5 KB

[faf12232-sup-0004-SupInfo.docx](#) Word document, 25.5 KB

The full open access has been paid with a high amount to allow it to be published in the current section through the above paper link where the paper and its annexes provides the full reporting of ICES WGIMM 2014-2017.

## 6 Cooperation

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The working group have had a broad cooperation among other through:

Continuous dialogue with complementary coverage of tasks with the ICES WGIPEM;

A special session arranged under the IIFET (International Institute of Fisheries Economics and Trade), July 2014 in Brisbane, Australia: Evaluation of integrated ecological-economic models - What are they used for?

A special session arranged under the ICES ASC in September 2015, Copenhagen, Denmark: ICES ASC 2015 Theme Session M: Social, economic, and ecological impact assessment across marine sectors;

Concerning the operation with management and advice, the white paper provide direct recommendations on the application, implementation and use of the IESFMs in the fisheries management advisory process: The review provides insights that may help both developers and users of models to determine the model characteristics that best suit their intended implementation, uses and how to more effectively communicate model results to ensure uptake in management advice and decisions. The results show that Modellers must invest more time to make models user friendly and to participate in management fora where models and model results can be explained and discussed. Such involvement is beneficial to all parties, leading to improvement of models and more effective implementation of advice, but demand substantial resources, which must be built into the governance process. It takes time to develop effective processes for using IESFMs requiring a long-term commitment to integrating multidisciplinary modelling advice into management decision-making.

## **7 Summary of WGIMM Self-Evaluation and Conclusions**

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The working group have achieved its objectives addressing all ToRs a-f and published the planned white paper. Accordingly, the self-evaluation of the working group through the chairs is positive with recognition of the objectives have been fully achieved.

## Annex 1: List of participants

Name	Address	E-mail
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## **Annex 2: Recommendations from WGIMM**

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The white paper provide direct recommendations on the application, implementation and use of the IESFMs in the fisheries management advisory process: The review provides insights that may help both developers and users of models to determine the model characteristics that best suit their intended implementation, uses and how to more effectively communicate model results to ensure uptake in management advice and decisions. The results show that Modellers must invest more time to make models user friendly and to participate in management fora where models and model results can be explained and discussed. Such involvement is beneficial to all parties, leading to improvement of models and more effective implementation of advice, but demand substantial resources, which must be built into the governance process. It takes time to develop effective processes for using IESFMs requiring a long-term commitment to integrating multidisciplinary modelling advice into management decision-making.



### Annex 3: WGIMM draft follow-up Terms Of Reference

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#### **Preliminary suggestions of focus areas, tasks and issues to be included into potential new ToRs for a potential continued WGIMM (not finally evaluated in the working group)**

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- 1) Provide concrete examples and outlines on form, contents and levels of integrated economic-ecological ICES Tactical and Strategic Advice (and the associated advisory process) integrating disciplines and output from integrated management evaluation tools and modeling:
  - a. Review and evaluate existing types and examples of provided interdisciplinary/integrated advice on a global basis and institutional set-up of this (including EU STECF advice);
  - b. On this basis provide realistic examples for ICES Advice covering the needs in the ICES region;
  - c. Evaluate how this interact with existing economic advice in the ICES region (EU STECF, North American Regional Management Body economic advice, etc) taking into account complexity in existing (current) national and international advisory systems in different regions;
    - i. Product (form, contents, levels, etc... – resulting in actual suggested advice on a very explicit and concrete basis);
    - ii. Process and needs (including institutional setup) for providing this – listing paths and obstacles to achieve this;
    - iii. How far will we take it (same challenges as in mixed fisheries advice) – to which extent do we want to provide a fully integrated advice and on what levels (among other in relation to the below challenges according to objectivity in the advice...);
    - iv. Review, evaluate and discuss risks and trade-offs in relation to objectivity in providing the advice (and hereunder potential controversial issues and conflicting economic interests in some instances) as well as in the process of providing the management advice if economic consequences of the advice become too transparent in the advisory process on different levels;
- 2) Review, evaluate and make recommendations on key processes, needs and challenges in increasing implementation and use of integrated economic-ecological management evaluation models by increased stakeholder involvement – e.g. how and what institutional set-up - with focus on the fish, fisheries and aquaculture sector;
  - a. Processes and institutional set-up enabling increased and more formalized engagement of stakeholders;
  - b. Risks and trade-offs in increased stakeholder involvement and integrated management evaluation and modeling - advantages and potential drawbacks;
- 3) Review, evaluate and make recommendations on implementation of broader system integrated management evaluation tools, models and methods as well as challenges herein – global basis with relevance for ICES;

- a. Broader socio-economic models and evaluation tools in the fish and fishery sector (going beyond only the capture sector);
- b. Broader cross sector economic-ecological models and evaluation tools including marine spatial planning models where fishery/aquaculture is one of the sectors (MSP models);
- c. End-to-end life cycle assessment models (LCA models);
- d. Economic-ecological ensemble modeling;
  - i. Aspects of running different models on the same issue;
  - ii. Account for the uncertainty range for all models;
  - iii. Problems in averaging results from different models;

## **Annex 4: Copy of WGIMM Self-Evaluation**

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There was not made a comprehensive self-evaluation process among all working group members and in the full working group. The summary of the self-evaluation is based on self-evaluation by the working group co-chairs:

The working group have achieved its objectives addressing all ToRs a-f and published the planned white paper. Accordingly, the self-evaluation of the working group through the chairs is positive with recognition of the objectives have been fully achieved.