Theme session Report

Theme Session O - Impacts of human pressures on ecosystem components assessed by dynamic modelling

Conveners: Solfrid Sætre Hjøllo (Norway), Marie Maar (Denmark), Sonja van Leeuwen (The Netherlands)

Session synopsis The aim of the theme session was to review the latest advances in ecosystem modelling and explore how ecosystem modelling can expand our current knowledge of ecosystem- and stock responses to different pressures and their interactions. The call asked for presentations on all aspects of ecosystem modelling (Figure 1), and specifically on

- Applications of ecosystem models for marine management
- Ecosystem and population responses to different pressures and their interactions
- Quantifying uncertainties
- Evaluating models
- Simulating observational and management strategies
- Formulation of management advice

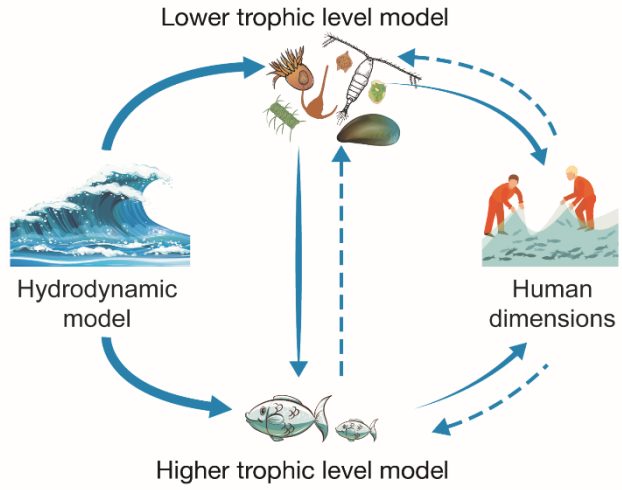

Figure 1. Connections between hydrodynamic and trophic models with human dimensions. Arrow thickness represent frequency of application with arrow direction indication information flow. Dashed arrows represent connections not standard included in ecosystem modelling. Image: ICES Working Group on Integrated, Physical-biological and Ecosystem Modelling

The extent to which the contributions met expectations

The session received 12 oral and 8 poster presentations, covering most aspects of the call and including 7 presentations by Early Career Scientists. In total, 247 participants attended the session. In a poll initiated by the conveners, the attendees (81 answers) reported that their background is ecosystem modelling (50%), management (25%) or observations (25%), and several attendees also identified them in the chat as being Interdisciplinary, a category that was not included in the poll. Anyway, it can be concluded that the session reached out to a wider community than the modelling community alone, which supports ICES' vision to "advance and share scientific understanding of marine ecosystems".

Analytical or thematic overview, grouping the presentations into categories
The session was grouped into 5 categories. The first group included the live keynote talk by Dr Erik Olsen (IMR) with the title 'Impacts of human pressures on ecosystem components assessed by dynamic modelling' and 1 presentation (by Morten Skogen) on the representativeness error in observations and models. The remaining presentations were grouped in four categories:

1. Eutrophication effects on lower trophic levels
2. Climate change and other pressures
3. Food webs - multiple stressor studies
4. Food webs - growth, migration and spatial drivers studies

Presentations of exceptional merit in the session
The presentation by Morten D. Skogen: "Are models better than observations?" discussed to which extent an observation or a model represents the truth, as illustrated by figure 2. Dr. Skogen pointed out that a model will always be limited to the biological understanding we have; thus, a model is recognized with a basic spatial and temporal resolution, but incomplete representation of processes and components of a natural system, while observations on the other hand give an incomplete access to a natural phenomenon where spatial and temporal resolution is a compromise. The presentation won the award "Best Presentation at the 2021 ICES Annual Science Conference".

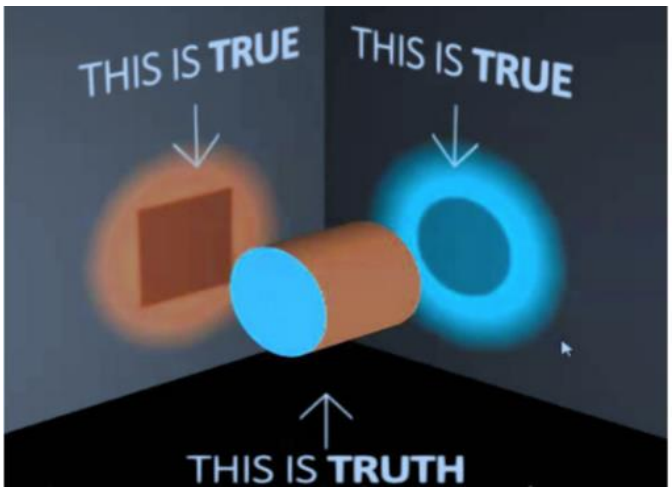

Figure 2. To which extent does an observation or a modelled value represent the truth? Figure from the presentation of Morten D. Skogen (Institute of Marine Research), source is https://medium.com/the-ascent/it-can-all-be-true-e59bacf132b8

The presentation by Sieme Bossier (Denmark) entitled "The effects of climate change & nutrient input on the Baltic Sea ecosystem" won best presentation by an early career scientist. It employs exceptional visualization skills and very clear message delivery to show that climate change and eutrophication results in a decrease in cod and an increase in sprat and herring in the Baltic, while climate change and a reduced riverine nutrient input results in an increase in cod and herring in the Baltic.

Conclusions

Sum up of the session

A wide range of ecosystem models was used to address the impact of the different pressures: coupled hydrodynamic-biogeochemical models, agent based models, dynamic energy budget models, higher trophic level models, size-based models, food web models and end-2-end models. The geographical coverage was dominated by studies in European and Arctic regions (Figure 3), while 1 study covered all European marine waters and 2 were more theoretical.The session addressed single pressures (climate change, nutrient scenarios incl. hypoxia, fisheries, ocean acidification (OA), wind farms, aquaculture) and combinations of these (fisheries x climate change, nutrient loads x climate change, fisheries x climate change x OA). Hence, models are moving in the direction of handling more than one pressure at the time. This can increase our understanding of complex ecosystem responses to multiple pressures and lead to more realistic scenarios for management.

Based on the presentations and accompanying questions, answers and discussions, we find that

- Many complex food web models and end-2-end models are now available for making more holistic scenarios
- Models start to handle multiple pressures (2 or 3) at the same time, but more work is needed
- There is a high gain of following an ensemble approach due the increased robustness and reliability of the derived model results
- Physiological acclimation of phytoplankton should be included in models to simulate and understand ecosystem dynamics, particularly in coastal areas prone to eutrophication
- There is good progress on improving higher trophic level models, for example by including migration algorithms for pelagic species or by inclusion of life history traits in size spectrum models
- Ecosystem modelling allows for drivers of trends and patterns to be identified or eliminated (e.g. the importance of seasonality for body size, or that environmental drivers like food and temperature can explain existing spatial patterns in sand eels, anchovy and sardines but cannot explain migration routes for mackerel on their own)
- Climate change and fishing pressure combined impact is different for different species. Some are additive, some are synergistic and some are antagonistic
- Even under moderate climate scenarios as RCP4.5 large impacts on the food web can be seen

- Better fisheries management can only partially mitigate the large predicted impact climate change will have on commercial species
    - Models and observations should go hand-in-hand to disclose the truth and increase understanding of the natural system

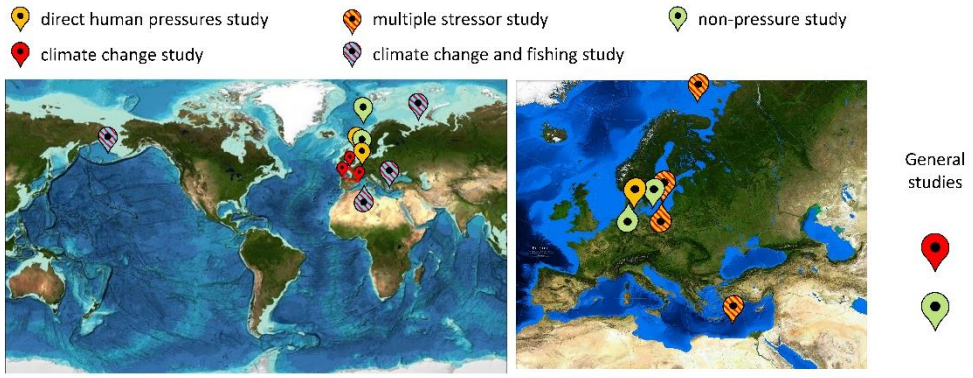

Figure 3. Pressure and geographical location of the papers presented at Theme session O. One additional ensemble study covered all of European waters.

The way ahead

To further advance the field of dynamical ecosystem modelling, the following challenges are identified:

• Quantitative models are limited to a few human activities
• Including more human activities takes time and resources
• Lack of systematic model skill evaluation methods may hamper uptake of dynamic models in management
• Analyses of structural uncertainties and ensemble modelling should be encouraged
• How can (should) we include management objectives in modelling? Stakeholder involvement and public buy-in for complex models need to be further developed
• Limited geographical cover of modelling cases and expertise: international collaboration and resource requirements needed to globally advance marine science, conservation and management by applying dynamical modelling.

The usefulness of the session's conclusions to the ICES Science and/or Advisory function

• Dynamical models can be reliable representations of marine systems, and are instrumental in ecosystem-based management due to the need for tools that can take a holistic approach.
• Dynamical models are able to quantify scenario analyses making them highly suitable management tools.
• Dynamical models are very useful for strategic assessment of possible futures when linked to earth-system models.
• Dynamical models can take food-systems approaches to managing seafood production to achieve United Nations Sustainable Development Goals.