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Ecosystem modelling in support of the MSFD food webs Descriptor

MEECE is an EU FP7 project which has developed regionally-focused ecosystem models. The new European Marine Strategy Framework Directive (MSFD) provides a transparent, legislative framework to apply an ecosystem-based approach to the management of human activities in the marine environment. The Directive aims to achieve 'Good Environmental Status' (GES) across Europe's regional seas by 2020. The MEECE Descriptor fact sheets highlight how MEECE science can be used in support of the MSFD.

Food webs and the MSFD

Climate change will exacerbate the impacts of human activity on the structure and function of marine ecosystems, and the services they provide. The combined effects of climate, fishing, nutrient loading and pollution impacts at both organismal and population levels, influencing the competitive ability and dominance of key marine species, which in turn reorganises the structure of marine food webs. The MSFD states that GES is achieved if the integrity of food webs ensures the long-term abundance and reproduction of its species.

The MEECE project provides climate and ecosystem (from plankton to fish) response scenarios, to support decision making for marine policy and management. MEECE has created a Model Atlas which provides model outputs and information to help answer key questions such as: how fish stocks are expected to change? Which species will migrate and how far?

How MEECE science can support this descriptor

Food webs are networks of feeding interactions between consumers and producers (see figure 1). The objective of the MSFD, with respect to the food webs descriptor, is to ensure the long-term abundance of key species and the retention of their full reproductive capacity. Key species include both exploited and non-exploited fish and shellfish species. In particular, it includes three aspects:

1) Productivity of key species or trophic groups

2) Proportion of selected species at the top of food webs

3) Abundance and distribution of key trophic groups or species

Assessing the status of food webs will include elements of the web with fast turnover rates (e.g. phytoplankton, zooplankton, bacteria), and thus fast response to systemic change, as well as longer lived organisms, such as exploited fish. Habitat-locked groups and charismatic or sensitive groups, which are often found at the top of the food web, such as dolphins, are also important.

The interactions between species in a food web are complex and constantly changing, making it difficult to assess what would or would not constitute "good" environmental status. By representing the whole food web and by accounting for both human induced and climate drivers, "end-to-end" models can provide a framework to better understand the combined effects of drivers. In MEECE, end-to-end models are used to evaluate the marine food web response to future scenarios of climate change, ocean acidification, and human pressures such as fishing, eutrophication, and pollution across the European regional seas.

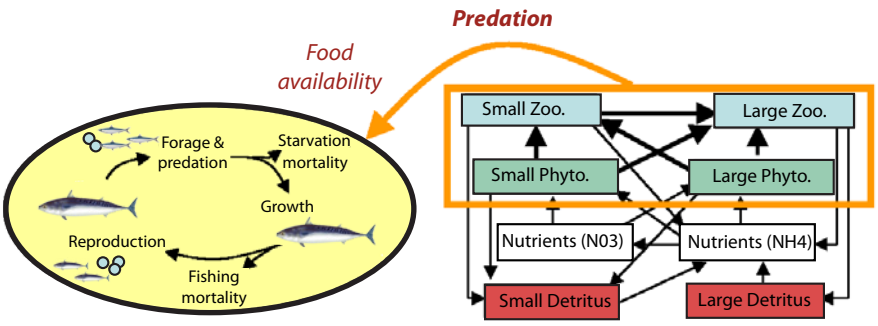

Figure 1. Schematic marine food web considered in a model coupling. Source: modified from Travers et al. (2009).

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Science in support of policy

Changes in a number of climate drivers as a result of a high CO_2 world is likely to influence food webs and cause changes in marine ecosystems already altered by human activities (e.g. pollution and coastal eutrophication) and marine resource exploitation (e.g. overfishing).

In MEECE, coupled physical to ecosystem models are used to evaluate the marine food web responses to climate scenarios in the medium (2030-2040) and long-term (2080-2100). In these scenarios, oceanographic circulation models are forced by climate drivers, which in turn, are coupled with lower trophic models (phytoplankton and zooplankton) to evaluate changes in oceanic primary production. For instance, zooplankton biomass is expected to dramatically change in the Bay of Biscay by the end of the century (figure 2), with increases expected near the continental shelf and likely decreases offshore.

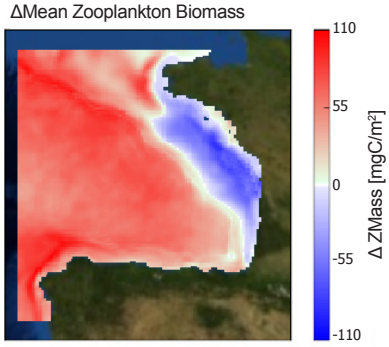

Figure 2. Zooplankton biomass change between present state (1980-2000) and future projections by the end of the century (2080-2100), within the Bay of Biscay. zooplankton biomass is expected to increase within the continental shelf and decrease in offshore.

At the top of the food web (figure 1), the dynamic interactions between fish predators (e.g. tuna) and preys (e.g. sardine, anchovy), are modelled to evaluate the impacts of climate change and human pressures on the integrity of marine food webs and fish stocks. Primary and secondary production of plankton will lead to changes in fish biomass, such as those shown in figure 3 for the North Aegean Sea (Mediterranean Sea). The outputs of the MEECE project, particularly the climate and ecosystem response scenarios for European regional seas are displayed in the Model Atlas, in support of the MSFD and can be used for marine spatial planning.

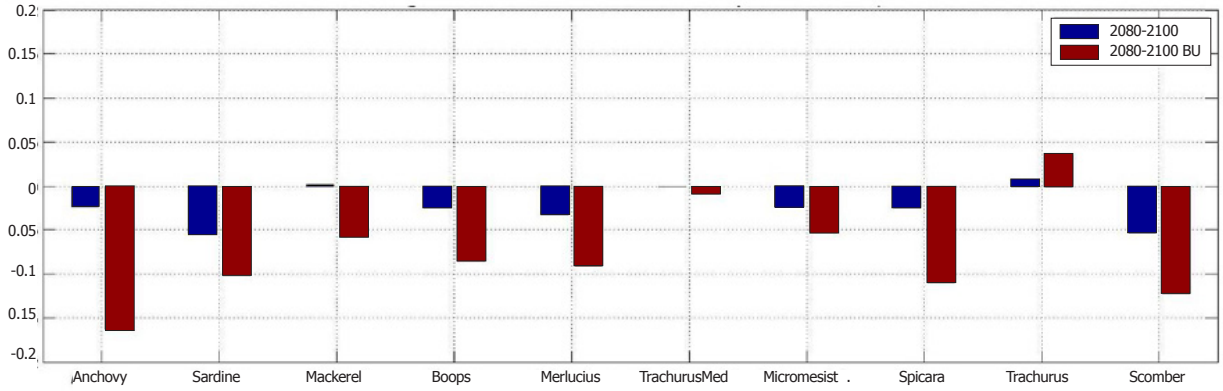

Figure 3. North Aegean fish biomass fractional change (between 1980-2000 and 2080-2100), simulated by OSMOSE model for present and future (A1B climate scenario, with present river loads and Business as Usual (BU) with future river loads. Explanation of scenarios given below). A decrease of a majority of fish species is expected by the end of the century.

Statement of confidence

The reliability of projections increase with trophic level because of error propagation, hence, top-predator projections are subjected to more uncertainty than lower trophic levels such as plankton, which in turn, is less accurate than ocean climatology. Projections provided by the Atlas consider only one greenhouse gases emission scenario of the Intergovernmental Panel on Climate Change, termed A1B which assumes increasing emissions during the first half of the present century that turn to decreasing in mid-century due to the use of more efficient technologies.

MEECE Links

The full suite of models developed in MEECE can be viewed through the Model Library with accompanying user guides. Outputs from the models applied across European regional seas during MEECE are available through our web based Model Atlas. This interactive website allows visitors to view and compare model projections per region for different variables affected by a range of scenarios including future climate and human induced drivers of change.

www.meece.eu/Library.aspx | www.meeceatlas.eu

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