

# Managing marine ecosystems in a changing environment

MEECE explores a wide range of climatic and direct human influenced drivers which may affect the marine system. Policies related to marine resources and environments today require the development of management strategies that are robust to changes in the drivers affecting ecosystem productivity, such as climate change. The successful implementation of an ecosystem based approach to management requires evaluation of management strategies which take into account biological processes such as species interactions and their variability over space and time.



To meet the goals of MSFD to achieve GES of the ecosystems a holistic view considering all ecosystem components beyond those of commercial interest is needed. MEECE has made substantial progress in these aspects through developing tools for Management Strategy Evaluation.

## Drivers of change

Climate change may lead to large scale changes in climate patterns, ocean circulation and climatic variables such as temperature and light. Enhanced atmospheric CO<sub>2</sub> levels will lead to acidification of the oceans with significant impacts on ocean biogeochemistry, calcareous organisms and potentially the reproductive success of fish species. At the same time combinations of direct human drivers such as fishing, eutrophication and pollution can impact individual organisms and entire populations affecting the structure of marine ecosystems. Finally, the introduction of alien invasive species has the potential to restructure marine ecosystems.

It is important to recognize that only a few of these drives (the ones directly related to human pressures) can actually be influenced by direct management actions. The simplest example is fisheries where management decisions have direct impacts on the ecosystem at a relatively small spatial and temporal scale. In contrast, for example, the drivers of eutrophication, pollution and acidification in the marine environment mostly require land based management solutions, with possibly long time lags in response in the environment. Whereas climate as a natural driver acts at a more global scale over extreme timescales, and is arguably beyond management possibilities (see figure 1) but may be a factor to consider when developing management of the direct impacts.

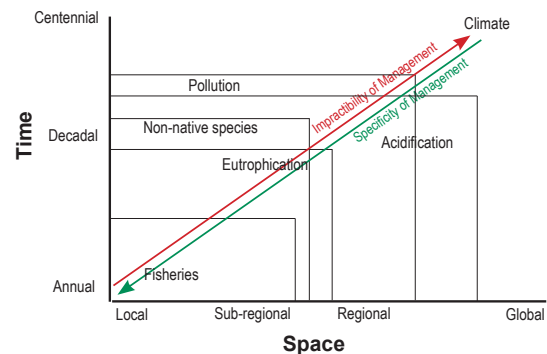


Figure 1. Schematic illustration of differences in time and spatial scales involved in the impact and management of drivers.



Marine ecosystems are subject to numerous multiple pressures including, pollution, climate change and fishing

## Management strategy evaluation

Management Strategy Evaluation (MSE) in a broad sense involves assessing the consequences of a range of management strategies or options and presents tradeoffs in performance across a range of management objectives. An MSE framework generally includes a model of a virtual ecosystem where parts are affected by human activities; data is feed in from monitoring programs to calculate indicators to help form scientific advice which is later translated into management measures with a feedback to include the influence of human activities. Feedback loops ensure the system is dynamic and responsive to changes in human and ecosystem response (Figure 2).

The new important developments in MSE frameworks within MEECE include incorporating natural drivers and ecosystem interactions between multiple species, supporting their application beyond the requirements of Common Fisheries Policy and towards the goals of the MSFD.

## Case study: developing a Management Strategy Evaluation framework for short-lived species

Small pelagic fish are short-lived species with high and variable natural mortality. The population size is very dependent on incoming recruitment, which is also extremely variable and affected by environmental conditions. The size of the next incoming recruitment is a major source of uncertainty when trying to manage short lived species of fish. Anchovy in the Bay of Biscay are currently managed according to the long term management plan (LTMP) launched by the European Commission in 2009. However, it has not yet been investigated how this LTMP proposal could be affected in the future by climate change.

MEECE investigated: (i) how the harvest control rule under the current draft LTMP would perform under a climate change scenario and (ii) how environmental drivers could be included into this harvest control rule. To do this, first, a MSE simulation framework was developed, including a relationship between

the recruitment and environmental factors. Then, the current LTMP was tested under various climate scenarios.



The results demonstrated that taking into account environmental impact on recruitment in the MSE simulations generally resulted in larger average catch and reduced the probability for stock collapse.

### Implications for management

The MSE framework allows the effects of monitored environmental drivers to be taken into account, making it particularly useful for evaluating management strategies for populations highly influenced by environmental drivers, such as small pelagic fish. Development of management strategies robust to changes in environmental drivers is a step forward for the ecosystem approach to management, and beneficial for achieving or maintaining Good Environmental Status.

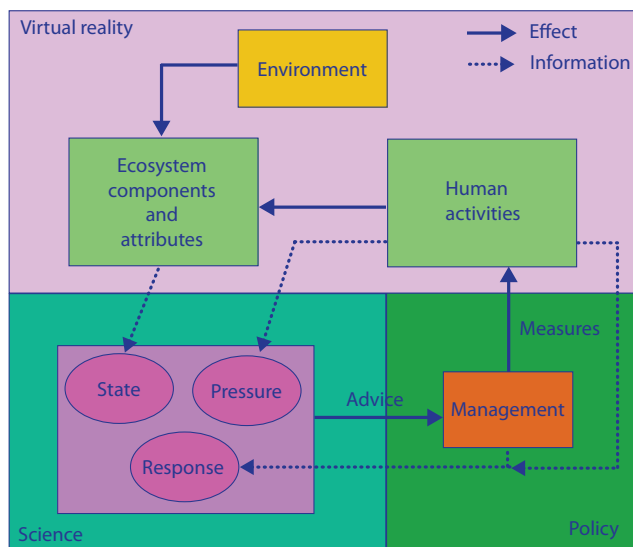


Figure 2. Outline of the MSE framework in its most generic form. It includes an operating model representing a virtual ecosystem in which the "natural" ecosystem components and attributes are affected by human activities and environmental pressures (i.e. climate), a representation of the scientific domain where information from monitoring programs is used to calculate indicators. Together these form the basis for the scientific advice which then translates to management measures that, in turn, affect the human activities.

### MEECE's Management Strategy Tool Box

MEECE has developed a number of bespoke MSE frameworks and models to address management questions, including:

- Forecasting changes in productivity
- Assessing potential spatial expansion of habitat of Non-Indigenous species
- Assessing the extent of spawning habitat of key fish species and distribution of fish in relation to climate change
- Quantifying spatio-temporal overlap between ecosystem components and pressures
- Evaluate management strategies for fisheries (Bay of Biscay, Baltic and North Seas), taking into account species interactions and/or environmental drivers

For further information about the MSE developed in MEECE please contact GerJan Piet (GerJan.Piet@wur.nl) IMARES, The Netherlands or Margit Eero (mee@aqua.dtu.dk) DTU-Aqua, Denmark. Full details including results of all tools and strategies developed by MEECE can be found in Deliverable 5.3 on the main website, [www.meece.eu](http://www.meece.eu)