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Ecosystem modelling in support of the MSFD Hydrography 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.

Hydrography and the MSFD

Hydrographical conditions are the physical properties of seawater (temperature, salinity, depth, currents, waves, turbulence, turbidity) and they play a crucial role in the dynamics of marine ecosystems. In the coastal regions many of these are directly influenced by human activity so can be targeted by policy and management actions.

At the scale of the continental shelf these properties are however largely determined by natural phenomena and so less responsive to management action on human activities. However they are subject to large-scale changes driven both by climate change (including warming and ocean acidification) and natural variability. These can have important and long lasting consequences for marine ecosystems, both beneficial and adverse. GES assessment and targets are based on quantifying the extent, distribution and severity of permanent alterations in hydrographical properties as a result of human activities.

How MEECE science can support this descriptor

MEECE has brought together a suite of scientific tools that can help support the Hydrogrpahy Descriptor. Numerical models can be used to explore past changes and how they affected hydrographical conditions and hence the marine environment. Two important classes of models have been used: global 'Earth System Models' simulate the interactions between the ocean, atmosphere, land surface and marine ecosystems. These models provide an important tool to project climate changes, and are used by the Intergovernmental Panel on Climate Change in their Assessment Reports. However, for continental shelves regional down-scaled models are needed. These can work at much finer scales (1kms rather than 100kms) and also include the important processes controlling shelf and coastal seas, such as tides, coastal upwelling, and the interactions with benthic communities in the sea bed.

A particularly relevant aspect of hydrographical change that these models can explore is global warming, including changes in sea temperature and density stratification, as the surface layers of the open ocean warm much faster than the water at depth. Stratification reduces the vertical mixing of nutrients needed to support the growth of the microscopic plants (phytoplankton) that form the base of the marine food chain. Other effects include changes in nutrient transportation from the open ocean to the shelf seas, the timing of spring blooms and the speed at which organic material is 'recycled' back to the inorganic nutrients that support the growth.

MEECE has made a substantial contribution to the international capability to simulate these effects and explore possibilities resulting from particular climate scenarios, which can include both natural and human induced changes. While we are not yet in a position to make accurate forecasts for these properties, simulations provide important evidence that can be used alongside expert judgement to inform adaptation policies on issues such as the definition of Marine Protected Areas, the level of exploitation of marine living resources and marine renewable energy resources.

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Science in support of policy

An important example of altered hydrographical conditions is the warming of the North West European continental shelf. Recent studies have shown this is happening at ~3 times the global rate since 1985. Analysis using sustained time series observations and the North West shelf downscaled model run in hindcast mode (figure 1) shows that, while there have been periods of increased and decreased warming over the past 100 years, the period of intense warming in the 1980s is of longer duration and a higher rate than any previously seen in this record.

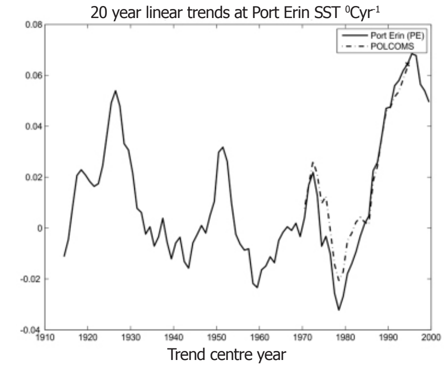

Figure 1. 20-year warming trends (change in seas surface temperature per year) from Port Erin Station (Isle of Man, UK) and corresponding POLCOMS model simulations.

The POLCOMS-ERSEM model has been used to explore the implications of these changes through a series of model experiments forced by both the UK (HadCM3) and the French (IPSL-CM4) climate models. As an example figure 2 shows two views of the possible change in primary production (total phytoplankton growth) comparing future conditions under a particular scenario of greenhouse gas emissions with a present day reference. While the two maps show quite major differences, they do have some similarities which can be used to build up evidence of what effects future changes may have. For example, the coastal regions west of the UK, in the Celtic Sea and the coast of continental Europe show a consistent increase, whereas deeper water west of the UK and the northern North Sea show a consistent decrease. In contrast the central North Sea, Biscay and west of the Iberian Peninsula show ambiguous results indicating higher uncertainty here. By repeating experiments such as these under multiple forcing conditions a detailed picture of possible change can be built up, including some measure of the uncertainty. Also other factors of the marine ecosystem can be considered, for example, figure 3 shows how the timing of the start of the phytoplankton growing season might change in one of these cases. This in turn has implications for fish production.

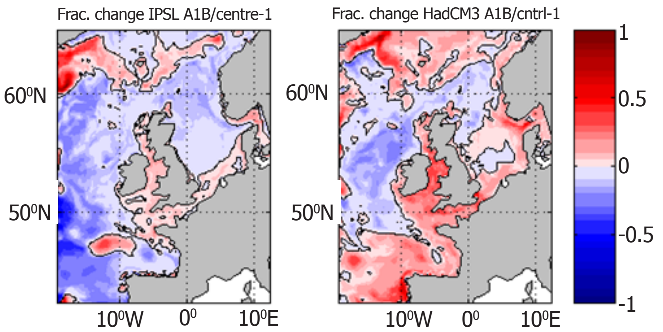

Figure 2. Fractional change in phytoplankton growth for POLCOMS-ERSEM forced by two different global climate models. Future conditions possible in 2080-2100 are compared with conditions typical of 1980-2000. Red indicates an increase and blue a decrease.

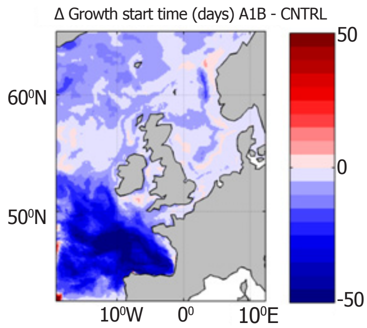

Figure 3. Change in time of the year (days) of the start of the phytoplankton growing seas (blue is earlier) between the same future and past period as in figure 2.

Statement of confidence

As demonstrated above there is still a high degree of uncertainty in projecting future change in marine ecosystems resulting from changes in hydrographical conditions. However, many of the principles are well established and by relating the output of models such as these to well-founded scientific concepts, such as the increase in growth rates with temperature or reduction of mixing with density stratification, these simulations can build a body of increasingly reliable evidence.

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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