Drivers of change
Fact sheet series

VECTORS

Climate change and related impacts

Vectors of change in European Marine Ecosystems and their Environmental and Socio-Economic Impacts

The VECTORS project seeks to develop integrated, multidisciplinary research-based understanding of changes taking place in our marine environment, the mechanisms for them and the ecological impacts expected from them. VECTORS will examine how these changes may affect the range of goods and services provided by the oceans, the ensuing socio-economic impacts and some of the measures that could be developed to reduce or adapt to these changes.

Regional seas vectors and drivers

This is a report which identifies and disseminates the current understanding of drivers, pressures and vectors of change that could be affecting the main areas of concern to VECTORS: outbreaks, invasives, changes in species distribution and productivity.

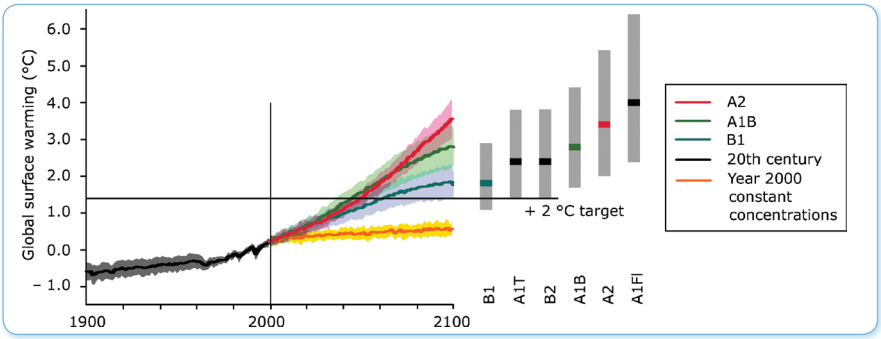
The full 220 page report, created through a desktop review exercise, is available to download from the VECTORS website, www.marine-vectors.eu. A series of twelve fact sheets, including this one, have been produced to summarise the key findings for each of the nine drivers studied and each of the three Regional Seas (Western Mediterranean, North Sea and Baltic Sea) that act as case studies for the VECTORS project.

Key points

There is now indisputable evidence that the planet is experiencing a period of rapid climate change, mainly driven by anthropogenic activities.

The three European sea investigated in VECTORS, the Mediterranean Sea, the Baltic Sea and the North Sea, have all undergone continuous warming during the second half of the twentieth century.

- Climate change is considered to be a major threat to biodiversity as well as to ecosystem structure and functioning, thereby also affecting marine resources and global fisheries potential (Cheung *et al.*, 2008).
- The Intergovernmental Panel on Climate Change (IPCC) assessed observations since 1961, which show that the average temperature of the world's oceans has increased to depths of at least 3000 m.
- Due to temperature-dependent expansion of sea water, sea level has risen at a global average rate of 1.8 mm per year from 1961 to 2003 (Solomon *et al.*, 2007).
- More frequent extreme weather events have been predicted for Europe. Therefore the IPCC expects that coasts will be exposed to increasing risks (Parry et al., 2010).
- Climate change alters sea water salinity, biogeochemistry, UV radiation, as well as atmospheric and hydrographic circulation patterns, and the pH of seawater (see Ocean Acidification fact sheet).



Observed and projected global mean surface temperatures from 1900, for three scenarios calculated by the IPCC and the 'Year 2000 constant concentration' pathway. If global greenhouse gas emissions are not reduced, the 2°C target will be exceeded towards the middle of the 21st century (Solomon et al. 2007).

General effects

Marine ecosystems are vulnerable to climate change as several key processes are governed by temperature. A notable advance of warm-water adapted organisms against the retraction of cold water species has occurred in several European seas (ICES, 2011). Climate change has various implications for marine fish, including direct mortality of sensitive life stages and alterations in hydrodynamically driven transport of fish larvae to their nursery grounds, which may lead to a mismatch between the timing of reproduction and to the occurrence of prey (Pörtner and Peck, 2010). Generally, intense fishing is expected to increase the vulnerability of fish populations to climate effects.

Overall, the increase in temperature has been higher in northern than in southern European seas, and higher in enclosed than in open seas (Philippart *et al.*, 2011). If the Mediterranean, as a semi-enclosed system, were to lose endemic species their ecological niches would probably be filled by species from adjacent waters or by species introduced through shipping via ballast water or directly through the Suez Canal. Effects leading to deterioration of the coastal zone would severely affect the tourism industry in all three regional seas - with the most intense losses in areas highly frequented by tourists, such as the Western Mediterranean coast line.

In the Baltic Sea, overfishing of cod has during previous decades amplified climate-induced changes in zooplankton and fish communities. In regions most enclosed and highly influenced by river runoff, increased rainfalls could support a shift from marine to more brackish and even freshwater species. The North Sea ecosystem has been through phases of different climatic conditions over the last 50 years, which were distinguished by the amount of Atlantic inflow. In recent decades, warming has led to elevated abundances of Lusitanean (southern) species and to a shift in the seasonal occurrences of key species, which has resulted in a mismatch in traditional predator-prey interactions which also contributed to a low recruitment of cod.

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Western Mediterranean

For the Mediterranean Sea, models predict that due to its confined nature it will be one of the regions most impacted by climate warming and more frequent extreme weather events.

Mediterranean biota appear to be strongly affected by the rapid physical changes at the species or community level: range shifts, alteration of reproduction patterns, mass mortalities (two major ones occurred in the past decades due to heat waves), frequent population outbreaks and trophic shifts (e.g. gelatinous and microbial taxa) and invasions of alien species, to the disadvantage of sensitive indigenous species. These changes cause a progressive homogenisation of the marine biota across regions in the Mediterranean.

The comparatively colder areas of the Mediterranean, such as the northern Adriatic and the Gulf of Lion, appear to be more sensitive to climate change. These areas host a number of endemic species and concern has been expressed regarding their conservation in view of increasing temperatures and the advance of warm water-adapted organisms.

Baltic Sea

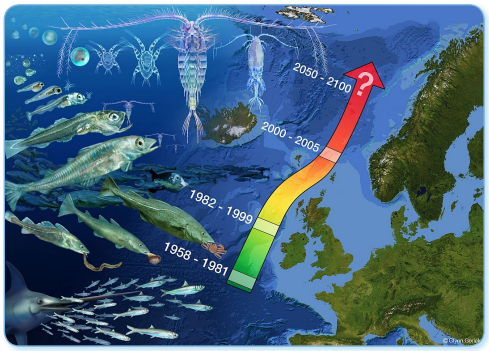
The Baltic Sea has experienced warming of around 0.08°C/decade over the last century, exceeding the global trend of 0.05°C/decade. Since the late-1970s, the frequency and intensity of major inflows of saline water from the North Sea have decreased. This contributed to a major change in the Baltic ecosystems in the late 1980s, when the dominance of a predator species (cod) was lost to the benefit of plankton-feeding fish (sprat and herring). However, since 2007, the eastern Baltic cod stock has increased again, largely due to improved recruitment, likely related to more favourable hydrological conditions (Eero *et al.*, 2012).

The abundance and/or biomass of several invasive alien species have shown a sharp increase over recent decades. While the timing of these shifts is species-specific, changes in the thermal regime have been identified as a common significant forcing factor regulating the population dynamics of the alien species studied (Ojaveer *et al.*, 2011). In addition, there is further evidence, such as intensified blooms of benthic macroalgae, shifts in Atlantic benthic species range, increased frequency and extent of hypoxia, all largely associated to climate change.

North Sea

In the North Sea, water temperatures in winter on the bottom of the sea have over the past four decades increased by 2 to 3°C in shallower southern regions (the German Bight and along the Dutch coast) and, to a lesser extent, in northern areas. Simultaneously, several North Sea fish species have altered their distribution (Perry *et al.*, 2005). While higher temperatures appear to have been profitable for warm-water species such as sea bass, red mullet and anchovy (Petitgas *et al.*, 2012), the productivity of cold-adapted species such as cod has declined (O'Brien *et al.*, 2000). The general warming of the North Sea has been occasionally interrupted by exceptionally cold winters, e.g. in 1996.

At present, probably the greatest challenge in analysing climate effects on North Sea ecosystems lies in the simultaneous effects caused by fishing activities and efforts are underway to separate the combined impacts of fishing and climate. Future projections suggest an increase in the frequency of extreme wind events leading to increases in storm surges along the North Sea coast, especially in Holland, Germany, and Denmark.



Higher temperature and changes in currents at the edge of the European shelf have caused plankton more characteristic of warmer water to extend their range to the north of Shetland, a shift of 1000 km between the 1970s and 2000/2005. At the same time, the shrimp-like Calanus finmarchicus*, abundant in colder water and an important food for fish – especially the larval stages of cod – has retreated towards the pole.*

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Further information

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