3 CLIMATE CHANGE

Impacts of climate change are now becoming evident, especially in the northern Regions (I and II). While the nature and rate of these impacts are uncertain, rising sea temperature and increasing acidification represent major threats to marine ecosystems in the OSPAR area. Mitigation and adaptation are a necessity and will alter human activities and their pressures on the sea.

OSPAR Contracting Parties should cooperate

→ to reduce existing pressures under OSPAR's Strategies and thereby increase ecosystem resilience;
→ to manage and regulate increasing demand for sea-based renewable energy production and carbon capture and storage through OSPAR so as to minimise their impacts on marine ecosystems;
→ to adapt OSPAR's policies and objectives for the protection of the marine environment to account for changing pressures and increasing vulnerability of marine ecosystems;
→ to enhance OSPAR's knowledge about the vulnerability of species, habitats and ecological processes to climate change and acidification and their interaction with human pressures;
→ to monitor and assess within OSPAR and in cooperation with partner organisations (e.g. ICES, IOC) ocean acidification and climate change, and to develop impact scenarios and indicators to track progression of impacts at regional scales.

Key OSPAR assessments

→ Impacts of climate change on the North-East Atlantic ecosystem
→ Climate change mitigation and adaptation

Atmospheric and ocean climate are closely coupled, with the ocean playing a significant role in regulating global and regional climate and weather patterns. Increased concentrations of anthropogenic greenhouse gases are recognised to have contributed to the rise in globally-averaged atmospheric temperatures since the mid-20th century. Increased concentrations of atmospheric carbon dioxide (CO_2) also make the oceans more acidic. Climate change and ocean acidification are significant threats to marine ecosystems within the OSPAR area and ultimately will affect human well-being, for example, through threats from sea-level rise and changes in biodiversity and fish stocks.

What are the problems?

Climate change is widely recognised but its rates and impacts are uncertain

The UN Intergovernmental Panel on Climate Change (IPCC) has warned that continued emissions of greenhouse gases at or above current rates will cause further warming and will lead to many changes in the global climate system during the 21st century which can be expected to be greater than those observed during the 20th century → FIGURE 3.1. The changes may exceed natural multi-decadal variability and lead to permanent changes in ecosystems.

The changing climate has been linked to a wide range of impacts on marine ecosystems → FIGURE 3.2, either directly (through changes in sea temperature) or indirectly through impacts on the seasonality, distribution and abundance of species. The impacts of future climate trends on marine ecosystems are difficult to predict due to a number of uncertainties, including those in the scenarios for future greenhouse gas emissions. There is also a need for a better understanding of how marine ecosystems will respond to change.

The range of climate change impacts projected for various components of the marine ecosystem are listed in → TABLE 3.1 (physical and chemical environment) and → TABLE 3.2 (biological environment), together with a summary of what has been observed to date.

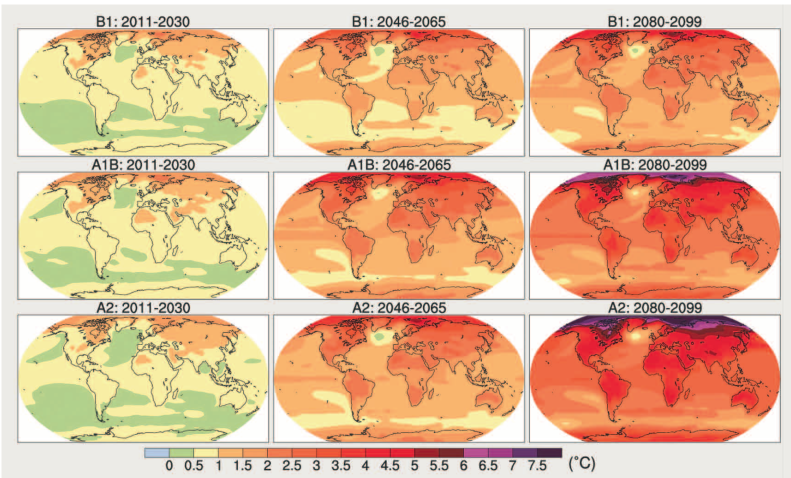


FIGURE 3.1 *IPCC projections of the range of possible changes in surface air temperature for the period to 2100 based on three greenhouse gas emissions scenarios (source: IPCC, 2007 – AR4 WG1, Figure 10.8). The scenarios shown are as follows: B1 – more integrated, and more ecologically friendly growth aimed at global environmental sustainability; A1B – rapid economic development with a balanced emphasis on all energy sources; A2 – a divided world, self reliant nations, continuously increasing population.*

TABLE 3.1 *Projected and observed climate change impacts on the physical and chemical environment.*

Impact	What might happen	What has been observed
Increased sea temperatures	Warming in all OSPAR areas, with strongest warming in Region I	Regions I–IV have warmed since 1994 at a greater rate than the global mean. Warming is most evident in Region II → FIGURE 3.3
Reduced sea ice	Region I: Sea ice may disappear in the summer in coming decades	Region I: Extent of sea ice has decreased in recent decades
Increased freshwater input	Region I: 10 % to 30 % increase in annual riverine inputs by 2100 with additional inputs from the melting of land-based ice Regional precipitation is difficult to project, but Region IV and the southern part of Region V may experience decreases in precipitation	Region I: The supply of freshwater to the Arctic appears to have increased between the 1960s and the 1990s
Changed salinity	Regions I and V: The Atlantic Ocean north of 60° N might freshen during the 21st century	Freshening in the deep waters of Regions I and V over the last four decades of the 20th century
Slowed Atlantic meridional overturning circulation	Slowdown of circulation in 21st century is very likely	No observations, but monitoring is now in place that will be able to observe long-term change in the Atlantic meridional overturning circulation
Shelf sea stratification	Regions II and III: Shelf seas may thermally stratify for longer and more strongly, but in the same locations	Regions II and III: Some evidence for earlier stratification in recent years and onset of the associated bloom
Increased storms	Projections of storms in future climate are of very low confidence	Regions I to V: Severe winds and mean wave heights increased over the past 50 years, but similar strong winds were also present in earlier decades
Increased sea level	Between 0.18 and 0.59 m by 2100 mostly through thermal expansion. There is high uncertainty at the upper range of these projections due to ice sheet processes. A rise of 2 m in a century cannot be discounted as a possibility based upon past change	Global sea level rose on average at 1.7 mm/yr through the 20th century. A faster rate of sea-level rise was evident in the 1990s
Reduced uptake of CO_2	Dependent on water temperature, stratification and circulation	North Atlantic: Reduced flux of CO_2 into surface waters in 2002–2005 compared with 1994–1995
Acidification	In the 21st century, ocean acidity could reach levels unprecedented over the last few million years with potentially severe effects on calcareous organisms	Global: Average decrease in pH of 0.1 units since the start of the industrial revolution
Coastal erosion	Projections are very uncertain and highly location specific	In many areas the combined effects of coastal erosion, infrastructure and sea defence development have led to a narrow coastal zone
Nutrient enrichment	Projections are uncertain and linked to impacts on various factors, such as rainfall patterns on freshwater input and run-off, storminess on turbidity, sea temperature on stratification	Regions I to IV: Drier summers may already be contributing to a decrease in nutrient inputs. Higher nutrient inputs in wet years have caused harmful algal blooms

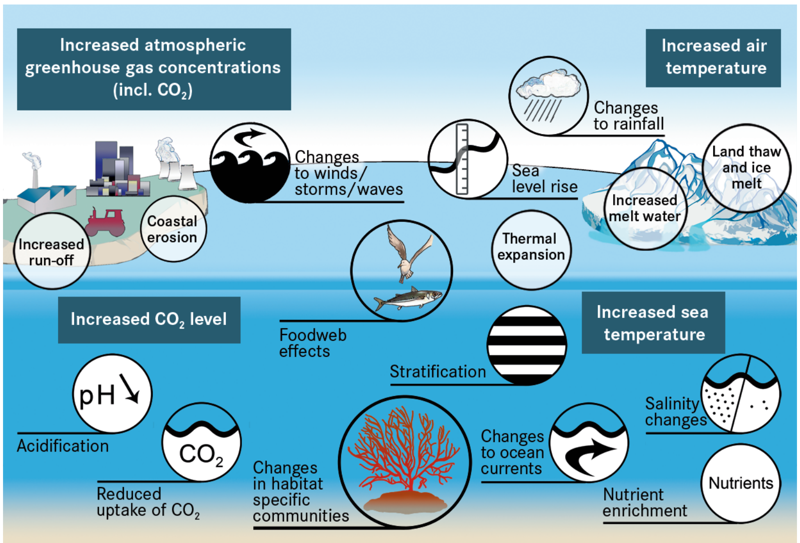


FIGURE 3.2 *Summary of impacts arising from climate change and ocean acidification.*

Many of the observed physical and chemical changes are consistent with increasing atmospheric CO_2 and a warming climate (rising sea temperature, reduced sea ice, acidification), but many of the causative links to climate change are still not well understood. It is difficult to predict the precise rate, magnitude and direction of change, for example for ocean uptake of CO_2, salinity, storminess and nutrient enrichment, and to map impacts at the local level. Physical and chemical changes have been directly linked to impacts on marine organisms (range shifts in plankton, fish and intertidal species communities) and are suggested to have important secondary effects such as on prey availability for seabirds. Uncertainties about physical changes make it difficult, for example, to predict the effects of changes in stratification on primary production, storminess on seabird nesting sites and nutrient enrichment on harmful algal blooms.

TABLE 3.2 *Projected and observed climate change impacts on the biological environment. In all cases, projections are limited by uncertainties in ocean climate projections and species and community responses.*

Impact	What might happen	What has been observed
Plankton	Northward shift of species in shelf and open ocean. Region I: Increased productivity with loss of sea ice	1000 km northward shift of many plankton species over the past 50 years → **FIGURE 3.4**. Changes in timing of seasonal plankton blooms
Harmful algal blooms	Potentially increasing incidence of harmful algal blooms as a result of changes in sea temperature, salinity and stratification	Anomalous phytoplankton blooms (often harmful) in specific habitats affected by lower salinities (e.g. Norwegian trench) or higher temperatures (German Bight)
Fish	Northward shifts in population, but lack of knowledge of the underlying mechanisms make projections uncertain Increased temperature could increase the incidence of disease for farmed species of fish and shellfish	Northward shifts of both bottom-dwelling and pelagic fish species, most pronounced in Regions I and II
Marine mammals	Loss of habitat for mammals dependent on sea ice. Changes in availability of prey species are likely, especially in Region I, due to mismatches in production	Data on distribution, abundance and condition of marine mammals are limited Ringed seals and polar bear may already be affected by loss of sea ice
Seabirds	Impacts on seabirds are likely to be more influenced by changes in their food supply than through loss of nests due to changed weather	Seabird breeding failure in the North Sea has been linked to variations in food availability as a result of increased sea temperatures
Non-indigenous species	Increased invasions and establishment may be facilitated by climate change and pose a high risk to existing ecosystems	Establishment of Pacific oyster and the barnacle *Elminius modestus* has been linked to climate change
Intertidal communities	Continued extension and retraction of the ranges of different intertidal species	Some warm-water invertebrates and algae have increased in abundance and extended their ranges around the UK over the past 20 years
Benthic ecology	Benthic sessile organisms are largely tolerant of moderate environmental change over reasonable, adaptive time-scales but are very vulnerable to abrupt and extreme events	Anomalously cold winter conditions have seen outbreaks of cold-water species and die-offs of warm-water species. Species composition changes have occurred, but not major shifts or changes in gross productivity

Understanding of the links between climate change and impacts on marine ecosystems is also limited due to insufficient data (e.g. relating to marine mammals, benthic ecology, and intertidal communities) and to difficulties in establishing local effects. Synergies and trade-offs between impacts and feedback mechanisms add further to uncertainties in projections.

Clear evidence of physical changes

Annual sea surface temperatures for the period 1999–2008 were warmer than in the period 1971–2000 across the whole OSPAR area → **FIGURE 3.3**. Region II has warmed the most, with temperatures increasing by 1 to 2 °C over the past 25 years. Temperatures in 2002 were the warmest since sea surface temperature records for the North Sea began in 1968. Summers in Region II have generally become longer and warmer while winters have become shorter and less cold. Regional patterns in weather and water circulation reduce the global warming signal in some areas. For example, in Region IV the temperature increase in the south is lower than expected, due to the upwelling of colder water. In the Arctic, both the maximum (March) and

minimum (September) sea-ice extent decreased by around 2.5 % and 8.9 % per decade respectively in the period 1979–2009 → **BOX 3.1**.

The observed decrease in salinity in the deep North Atlantic and the Nordic Seas is likely to reflect higher levels of precipitation in the northern regions as well as higher river run-off, ice melt, advection and an overall speeding up of the global water cycle.

BOX 3.1 Reduction in Arctic sea ice

The Arctic may be ice-free in summer within the next few decades. In September 2009, sea ice in the Arctic reached the third lowest minimum extent recorded since 1979. This follows the lowest minimum extent recorded in September 2007 with ice extent about half the mean minimum observed in the 1950s. The IPCC stated with high confidence in its Fourth Assessment report that continued changes in sea-ice extent are likely to have major impacts on marine organisms and human activities in the Arctic. On the one hand, the increase in open water may increase biological production south of the ice edge, with benefits to important North-East Atlantic fish species such as cod and herring. On the other hand, species such as ringed seals and polar bears that depend on sea ice for feeding and breeding are likely to be adversely affected. Early summer sea-ice melt could exacerbate these impacts by causing a mismatch between the timing of marine mammal breeding and the availability of prey.

Increased accessibility in ice-free periods is likely to allow more shipping and offshore oil and gas production in the Arctic waters. More commercial activity in the open ocean and along the Arctic coasts will inevitably increase the risk of pollution and the risk of introducing non-indigenous species through ships' ballast water. Coastal erosion affects most the soft and historically eroded Arctic coastlines and is more likely as rising seas allow higher waves and storm surges to reach a shore no longer protected by ice. The risk of flooding in coastal wetlands is likely to increase, affecting coastal ecosystems and human settlements. Melting ice and snow may also release stored contaminants and increase their run-off to the sea in melt water.

Data source: NSIDC.

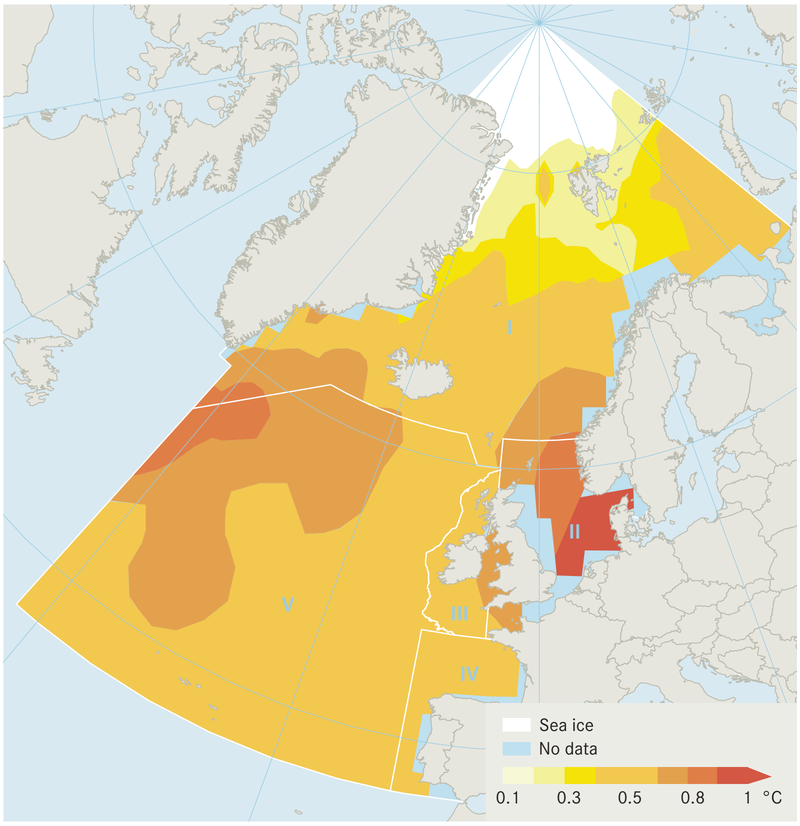


FIGURE 3.3 *Annual mean sea surface temperature anomaly for 1999–2008 relative to 1971–2000. Data source: NOAA.*

These changes have been linked to a possible slowing down of the large-scale circulation in the North-East Atlantic. It is unclear whether the observed increase in storm frequencies and higher sea levels are due to natural variability or whether there is some link with climate change. Rates of relative sea-level rise may be partly compensated in areas where the land rises in response to the loss of ice cover.

Evidence of biological impacts is growing

Climate is an important factor driving changes in the distribution, abundance and seasonality of marine biota → **BOX 3.2**. Evidence suggests that species are expanding their ranges under a warming climate in marine systems. The changes in distribution and abundance, which are expected to continue in the near future, have been sufficiently abrupt and permanent to be termed 'regime shifts' with ecosystems reorganising rapidly in terms of changes in predator-prey relationships and the spread of non-indigenous species.

The seasonal timing of phytoplankton and zooplankton production has altered in response to recent climate change with some species present up to four to six weeks earlier than twenty years ago, which affects predators such as fish. Changes in the timing of planktonic production and the distribution and composition of planktonic communities → **FIGURE 3.4** have been linked to changes in the distribution of many fish species. For example, the earlier occurrence,

BOX 3.2 Changes in the distribution and abundance of marine species in the OSPAR area

Changes in the distribution and abundance of marine biota in a number of long-term datasets (mainly from Region II) are consistent with expected climate effects. While this does not mean that climate is the only cause of the changes observed, it is an important factor in about 75 % of assessed area/taxon groups ('cases'). These include zooplankton (83 cases), benthos (85 cases), fish (100 cases), and seabirds (20 cases). Changes in the distribution and abundance of seabirds showed the weakest link to climate change. For other species, particularly zooplankton and fish, the relationship was much stronger.

Percentage of assessed area/taxon groups for which the observed change matches the change projected to result from climate change (source: ICES, 2008).

Changes in area/taxon groups:	Zooplankton			Benthos		Fish		Seabirds	Change matching projection
	Distribution	Abundance	Other (e.g. seasonality, phenology)	Distribution	Abundance	Distribution	Abundance	Distribution/ abundance	
Region I	4	1				2	13	7	74 %
Region II	3	9	61	40	32	42	15	10	77 %
Region III						9	12	3	83 %
Region IV	1	4		13		2	5		76 %
Change matching projection	100 %	64 %	100 %	66 %	66 %	82 %	71 %	60 %	

■ > 75 % ■ 50–75 % ■ < 50 % ■ No assessment

reduced abundance and increasing dominance of smaller species in zooplankton communities have been linked to the decline in cod in the North Sea. Loss of summer sea ice will have profound implications for ice-associated plankton and the organisms that rely on them.

All OSPAR Regions have experienced range shifts and changes in fish distribution and abundance consistent with what is expected as a result of climate change, with northward shifts in distribution and lower levels of abundance in the southern part of the range. The rate at which cod stocks in the North Sea have decreased cannot be explained by over-fishing alone. Southern species such as the silvery John dory, sea bass, red mullet and European anchovy have all become more common further north. In the UK, expansions in the range of intertidal species have been observed towards previously cooler areas (i.e. eastward and northward).

Climate change is likely to encourage species to spread into and establish in new areas. Several non-indigenous species are now established in the OSPAR area; two of these (the Pacific oyster and the barnacle *Elminius modestus*) as a direct result of regional warming. As Arctic sea ice decreases, organisms may spread into the North Atlantic from the Pacific. The Pacific diatom *Neodenticula seminae* was discovered in the North Atlantic in 1999 and may provide the first evidence of trans-Arctic migration. There is also a risk that loss of sea ice will lead to loss of ice-dependent Arctic species.

Stormy sea on Arranmore Island, North-West Ireland

Ocean acidification is a key threat

With increasing amounts of anthropogenic atmospheric CO_2 dissolving into the sea, the pH of seawater is decreasing and the ocean is becoming more acidic. Decreasing pH reduces the ability of the ocean to take up CO_2 and provides a potential feedback effect on climate change.

There has been an average global fall in ocean surface water pH of 0.1 units since the start of the industrial revolution which reflects a 30 % increase in acidity. The trend is also reflected in the OSPAR area, for

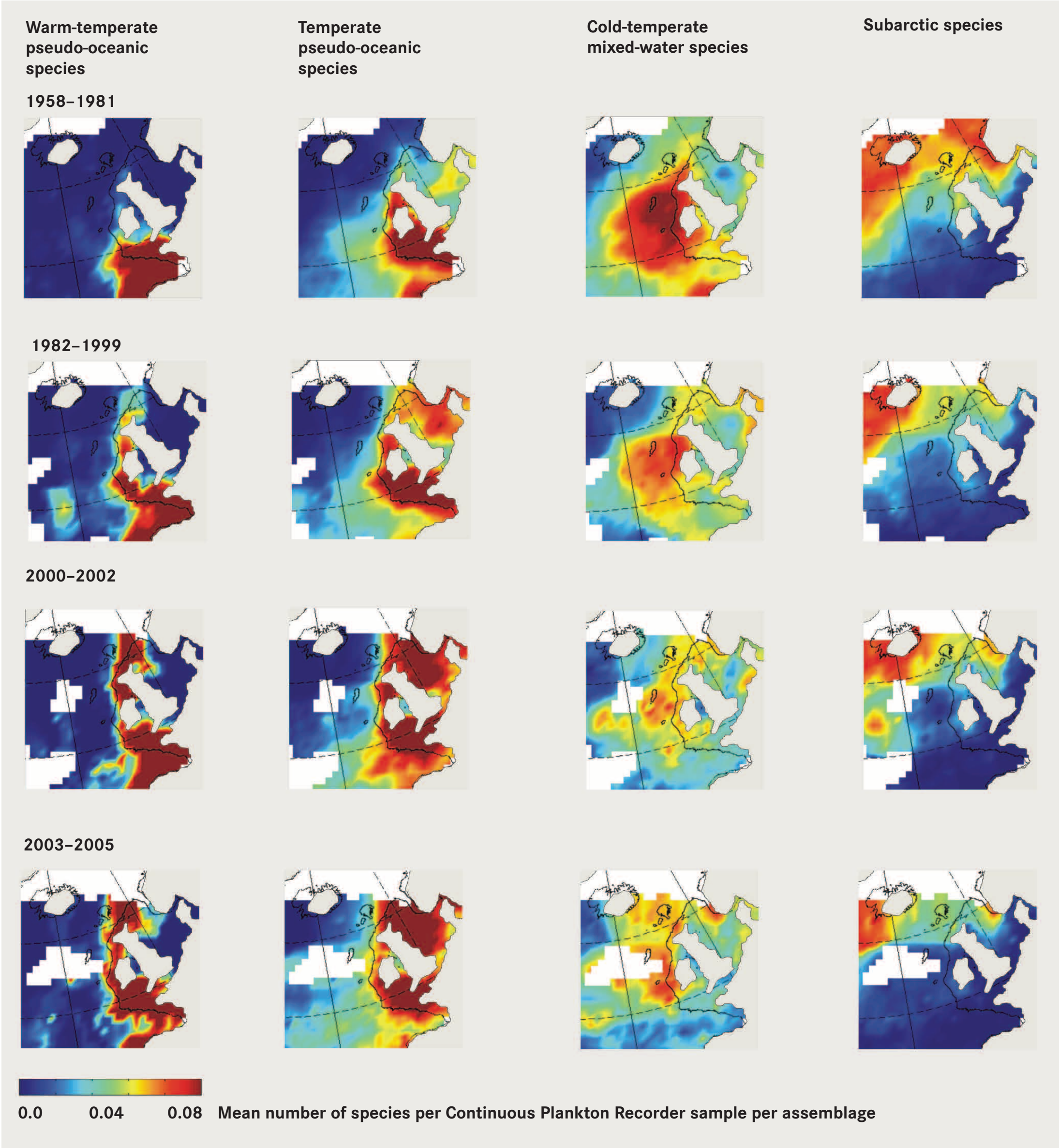


FIGURE 3.4 *Changes in the biodiversity of Calanus copepod zooplankton species in relation to the rise in sea temperatures since the late 1950s. Source: Edwards et al. (2008). Over the past five decades there has been a progressive increase in the presence of warm-water/sub-tropical species into the more temperate areas of the North-East Atlantic and a decline of colder-water species. In the North Sea the warm-temperate species C. helgolandicus has progressively replaced the cool-temperate C. finmarchicus. Overall Calanus abundance in the North Sea has declined. Between 2000–2002 and 2003–2005, subarctic species have declined south-east of Iceland.*

example in the Kattegat and Norwegian Sea → BOX 3.3. Current changes in ocean carbon chemistry are at least 100 times more rapid than any over the last 100 000 years. Little is known about the ecological and economic impacts of marine acidification but they could be severe, affecting the many biologically mediated processes that transport carbon from the ocean surface to the depths. Experimental data indicate that lower pH (at the levels predicted) is expected to have a range of effects on marine organisms, including dissolution of calcium carbonate (aragonite or calcite) shells and skeletons (decalcification) in calcareous plankton and corals, and acidification of body fluids in fish and invertebrates. Many species with critical ecological roles in pelagic and benthic systems will be affected. Ecosystem-wide effects are expected within 50 to 100 years, including the undersaturation of calcium carbonate in seawater – a condition where there is a risk of decalcification occurring. There have been some recent projections that undersaturation of surface water with aragonite may happen in parts of the Arctic by as early as 2016 in winter and 2026 throughout the year. More than 150 scientists under the umbrella of UNESCO's Intergovernmental Oceanographic Commission (IOC) support projections that most regions of the ocean will be inhospitable for coral reefs by 2050 if atmospheric CO_2 concentrations continue to increase. They urged policymakers through the 2009 Monaco Declaration to develop plans to drastically cut CO_2 emissions.

BOX 3.3 Marine acidification in the Kattegat and Norwegian Sea

The trend towards lower pH in the world's oceans is also reflected around Sweden (Region II) and off the Norwegian coast (Region I). Decreases in pH are statistically significant in both surface waters and deeper waters in the Kattegat and projections suggest a decrease in surface pH of 0.2 units by 2050 and 0.4 units by 2100. However, time series are short and geographic coverage limited, making improved measurement of acidification parameters an imperative for the future. Based on current trends, rates of decline in depths over 30 m are projected to be double those for surface water. Given the experimental results obtained to date and the observed trends of declining pH in Swedish coastal waters, it is likely that ecosystem-wide effects will be observed within 50 to 100 years. Similar findings apply for the Norwegian Sea where a statistically significant decrease in pH of 0.03 units was observed in the mixed layer between 2002 and 2007 and projections suggest a further decrease of 0.3 units by 2070 to 7.8.

Observed and projected pH change in the Kattegat

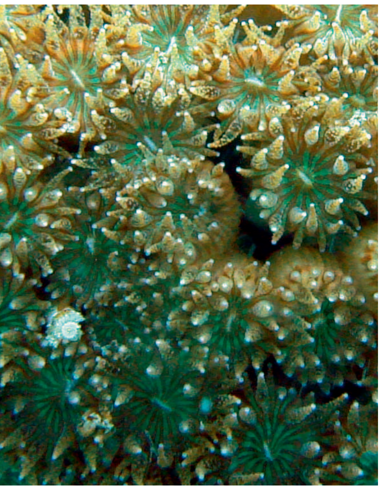
Depth	pH 2007	pH change 1993–2007	pH change per year	Projected pH 2050	Projected pH 2100
0–25 m	8.15	–0.06	–0.0044	7.96	7.74
30 m	8.00	–0.11	–0.0079	7.66	7.24

What has been done?

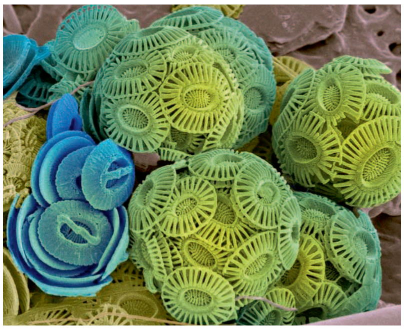
Drastic reductions in greenhouse gas emissions are key to mitigating impacts

The UN Framework Convention on Climate Change leads work at the global level towards stabilising greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. In this context the Kyoto Treaty has committed most industrialised nations to legally binding reductions in greenhouse gas emissions by 2008–2012. Negotiation of a post-2012 framework was initiated by the Copenhagen Conference of the Parties in December 2009.

More than 5000 million tonnes CO_2 equivalent of greenhouse gases were emitted in Europe in 2007. This is 9.3% less than in 1990. Global greenhouse gas emissions must be reduced to less than 50% of 1990 levels by 2050 if the rise in average global temperature is to be kept below 2 °C compared to pre-industrial levels, and specifically, reductions in CO_2 are required to mitigate consequences of ocean acidification. The EU has set a binding unilateral interim target to cut greenhouse gas emissions by 20% over the period 2012–2020 and aims to increase the share of renewable energies in Europe to 20% over this period. Urgent action is needed to achieve these targets, employing a wide range of solutions. Options include improving energy efficiency, reducing energy demand, shifting to renewable energies and carbon capture and storage. All options, whether on land or at sea, can be expected to change the distribution and intensity of pressures on the marine environment.



Impacts of acidification on calcareous organisms. Cladocora caespitosa is a Mediterranean coral, at normal pH (8.1) (left) and with dissolving skeleton in acidified water near CO_2 vents (pH 7.4) (right)



Coccolithophores (coloured scanning electron micrograph) are calcareous microphytoplankton with a major role in the global carbon cycle

Demand for energy from wind, waves and tides is increasing

Most of the existing and planned offshore renewable energy projects are wind farms concentrated in Regions II and III. The number of offshore wind farms in the OSPAR area has grown substantially over the past ten years and if all farms authorised and applied for in 2009 are developed, the number of offshore turbines in the OSPAR area will increase almost ten-fold → CHAPTER 9. More applications have been made and more are expected. In some areas there is potential for harnessing energy from waves, tidal streams and salinity gradients. Commercial-scale development is currently limited.

Tidal turbine, Orkney, Scotland

Wave and tidal power test sites have been operating off Ireland and Scotland for several years, with 0.3 GW total installed capacity in 2008. It will probably be some years before there is large-scale marine energy generation in the OSPAR area, although some countries have set targets for tidal stream and wave energy production. For example, Scotland plans to install 1.3 GW of capacity by 2020. The environmental impacts of these techniques and the necessary mitigating measures are likely to vary depending on the technology and location. Increasing demand for renewable energy from the marine environment suggests that regional cooperation and marine spatial planning could be important tools for managing the competition for space in coastal and offshore areas and for minimising their impacts on the marine environment.

Carbon sequestration can help the transition to a lower carbon economy

Capturing carbon from combustion at source and transporting this to sub-seabed geological reservoirs could help mitigate climate change over century-long time scales and thus help with the transition to a lower carbon economy. Eligible reservoirs include depleted oil and gas fields in the North Sea (Region II) and the Norwegian Sea (Region I). OSPAR and the EU have developed frameworks for managing the risks from carbon sequestration. The main risks to the environment and human health include a risk of re-emitting stored CO_2 to the atmosphere, and local risks from possible releases of CO_2 and other substances in the CO_2 stream to the marine environment. Three projects are currently operating in the OSPAR area, of these the *Sleipner* project provides the longest experience → BOX 3.4. Good site selection,

BOX 3.4 CO_2 capture and storage at the *Sleipner Vest* gas-condensate field

The *Sleipner* CO_2 injection project in the North Sea off the Norwegian coast was the first industrial-scale activity of its kind in the world and has been operating since 1996. Around 1 million tonnes of CO_2 are removed each year from natural gas produced at the *Sleipner Vest* gas-condensate field before it is transported onshore. By 2008, almost 10 million tonnes of excess CO_2 had been injected into a sandy geological layer, called the Utsira formation, which lies 800 to 1000 m below the seabed. The formation is overlain by a thick layer of shales which act as an effective barrier to CO_2 leakage. Selection of an appropriate reservoir and injection location was essential for the success of the storage. Seismic surveys and other monitoring techniques record the spread of the CO_2 and show that the injected CO_2 has remained in place without leaking.

The recent amendment of the OSPAR Convention and the adoption of a package of OSPAR measures make it possible to permanently dispose of CO_2 in sub-seabed reservoirs remote from the source of its capture, subject to agreed standards for risk assessment and management being applied. Placing CO_2 in the water column and on the seabed is banned because it is likely to result in harm to living organisms and marine ecosystems.

Coastal erosion at Happisburgh, eastern England

project design based on risk assessments, and monitoring are essential for avoiding CO_2 leakage and reducing environmental impacts.

Fertilising the oceans with iron to encourage the natural sequestration of carbon has been proposed as a mitigation strategy, but this is unlikely to be feasible within the OSPAR area because the ocean chemistry is unsuitable.

The importance of coastal habitats, such as salt marshes, seagrass meadows and kelp forests, as natural carbon sinks is becoming recognised (Laffoley and Grimsditch, 2009). These habitats may provide a significant contribution to carbon sequestration and this might justify renewed attention to their management and conservation.

Increased risk of floods and coastal erosion requires early response

Whatever level of mitigation can be achieved, it will take years for the ocean to respond and some impacts will inevitably arise even though the precise nature and rate of future climate change are still uncertain. Adaptation strategies for the marine environment will be more challenging than those for land as fewer tools are available.

Sea-level rise and increased storm frequencies will increase the vulnerability of many parts of the coastline to flooding and coastal erosion, especially in the southern North Sea (Region II) and the Bay of Biscay (Region IV), making adaptation of current coastal defence policies and measures imperative. An increase in the occurrence of severe storm surges is projected for the North Sea.

Some adaptation of coastal defence is already taking place. This includes hard-engineering approaches involving the reinforcement of existing coastal defence structures and construction of storm surge barriers, as well as soft-engineering approaches that make use of natural habitats to dissipate the force of waves and tides, for example, large-scale beach nourishment and the conversion of farmland into salt marshes. The effects of these measures, individually and cumulatively, on the marine environment still need to be quantified.

What happens next?

Climate change and ocean acidification add urgency to OSPAR's work

Impacts of climate change are now becoming evident. While the nature and rate of these impacts are uncertain, rising sea temperature and increasing acidification represent major threats to marine ecosystems in the OSPAR area. Even projections based on the more moderate emissions scenarios imply major environmental, economic and social impacts. This adds urgency to OSPAR's work to reduce existing pressures and so increase the capacity of ecosystems to cope under a changing climate. The OSPAR network of marine protected areas (MPAs) will have an important role to play in helping to maintain and restore the capacity of ecosystems to resist and recover from the impacts of ocean climate change.

OSPAR will need to recognise opportunities to mitigate and adapt to climate change. Mitigation and adaptation on land and at sea will alter the distribution and intensity of human pressures on marine ecosystems. OSPAR offers a framework for managing and regulating the increasing demands for new uses of the sea, such as the generation of renewable energy and carbon capture and sequestration. Marine spatial planning and integrated coastal zone management provide additional tools. Attention should be given to conservation and restoration of natural coastal carbon sinks.

To account for the changing pressures on the marine environment and its increased vulnerability, OSPAR will need to adapt its current policies and objectives for the protection of the marine environment and to strengthen its cooperation with other international organisations on the management of uses of the sea (e.g. the North East Atlantic Fisheries Commission and the International Maritime Organization).

Monitoring and assessment are a priority

The nature, rate and impacts of climate change differ across the OSPAR area. The increase in temperature and acidification will be higher in northern areas (Regions I and II) than southern areas (Regions IV and V). Threats to Arctic biodiversity are particularly imminent with sea-ice loss profoundly affecting ice-associated marine life, and projected rates of acidification suggesting adverse ecosystem impacts within the next decade. The differences between the Regions imply a need to understand better the potential climate change impacts at both the regional and local level, as well as the risk of so-called 'tipping points' being reached. These thresholds represent the point at which a change is no longer linear and reversible, but abrupt, large and potentially irreversible over time-scales relevant for the well-being of contemporary generations. Better links between science and the development of local policy on risk assessment are essential. OSPAR will need to undertake the following actions:

- Enhance knowledge about the vulnerability of species, habitats and ecological processes and their interaction with pressures from human activities.
- Work with partner organisations (e.g. the International Council for the Exploration of the Sea and the Intergovernmental Oceanographic Commission) to put in place systems for assessing climate change. This should include scenarios of potential impacts and methods and indicators to monitor and assess the progression of climate change impacts particularly at regional scales.
- Give priority to monitoring and assessment of ocean acidification and its effects on marine ecosystems.

Selected climate driven changes in the OSPAR Regions

→ LEGEND: BACK-COVER FOLD-OUT

OSPAR Region	Observed physical and biological changes	Key observed changes	Outlook for key changes
Region I	Strong changes ***	Sea-ice loss Sea temperature rise Acidification	↑
		Range shifts of fish species Plankton/food web changes	?
Region II	Strong changes ***	Sea temperature rise Acidification	↑
		Range shifts of fish species Plankton/food web changes	?
Region III	Changes ***	Sea temperature rise Acidification	↑
		Range shifts of fish species Plankton/food web changes	?
Region IV	Changes ***	Sea temperature rise Acidification	↑
		Range shifts of fish species Plankton/food web changes	?
Region V	Changes ***	Sea temperature rise Acidification	↑
		No information on species distribution and abundance	?