2 THE NORTH-EAST ATLANTIC

A common sea with varied ecosystems and management challenges

The OSPAR Convention covers most of the North-East Atlantic and its adjacent seas. This is a vast area of about 13.5 million km^2 which includes a diverse range of environmental conditions and different ecosystems. These play a key role in the types and patterns of human activity in the North-East Atlantic and associated impacts on the marine environment. Knowledge about the biodiversity of the marine ecosystems of the OSPAR area and its interactions with ocean dynamics and human activities is still limited.

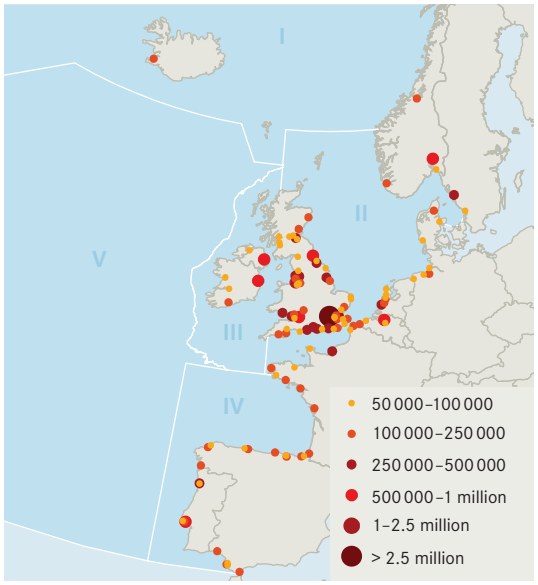
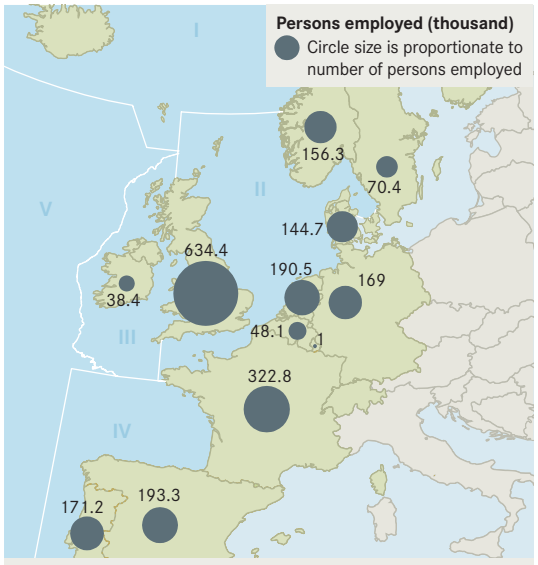


FIGURE 2.1 *Population in coastal urban areas in 2001. Data source: EEA (2006).*



Percentage of sea-related employment in national employment

Belgium	1.08	Ireland	1.82	Spain	0.94
Denmark	4.96	Luxembourg	0.30	Sweden	1.54
France	1.25	Netherlands	2.17	UK	2.19
Germany	0.42	Norway	5.97		
Iceland	n.d.	Portugal	3.33		

FIGURE 2.2 *Employment in all sea-related sectors in OSPAR countries. Data for Iceland are not available. Data source: Policy Research Corporation (2008).*

Much of the coastal area in the North-East Atlantic is densely populated, highly industrialised or used intensively for agriculture. Population density is much higher on the coasts than inland, with most of the population in some areas of Northern Europe being concentrated in coastal settlements. Population density is highest on the Iberian and North Sea coasts (with over 500 inhabitants per km^2) and lowest in Region I (with fewer than 10 inhabitants per km^2 in some remote areas) and Region V, which covers more than half of the OSPAR maritime area, dominated by High Seas. Even in areas with low population density, large coastal settlements can exert pressures on the sea → **FIGURE 2.1**.

Marine and coastal ecosystems provide a range of goods and services

The OSPAR maritime area provides the basis for a wide range of goods and services including food, transport, energy and amenities for millions of people. Marine-related industries and services contribute roughly 1.8% to the Gross Domestic Product and 2.1% to employment opportunities in the OSPAR area → **FIGURE 2.2**. More than a third of the value of the maritime sector in the North-East Atlantic is generated by coastal tourism and shipping, with tourism and the fishing industry being the largest employers. Fishing is a key industry for some of the economies in Region I (Iceland, Norway, Faroe Islands, Greenland) and is also highly significant in certain parts of other OSPAR countries. Norway's offshore oil and gas industry ranks among the largest in the world. Economically, oil and gas production in the North Sea is also important for Denmark, the Netherlands and the UK. Some of the main European seaports are situated along the eastern coast of the North Sea with world-leading shipbuilding and shipping related industries. The maritime transport and seafood sectors are important for Ireland (Region III), and in France,

Portugal and Spain (Region IV) coastal tourism is the largest employer of the maritime industries. The low-lying areas of the southern North Sea maintain an important coastal engineering industry, especially in the Netherlands. Across the OSPAR area new industries are also developing, with marine renewable energy (wind, wave and tidal energy production) the fastest growing activity in coastal and offshore waters. The intense human activities in the OSPAR area place considerable pressure on the marine environment.

Variations in the physical system affect the biology

The bathymetry of the seabed → **FIGURE 2.3** and the ocean circulation → **FIGURE 2.4** exert a strong control on the ecosystems of the OSPAR area, including the occurrence of species and habitats and their interactions. The distinction between waters that are mixed (where most conditions are the same from the surface to the seabed) and waters that are stratified (where conditions vary stepwise with depth) is important biologically, influencing the distribution of habitats as well as the structure of pelagic and benthic ecosystems. The areas where these water types meet ('fronts') are regions of intense biological activity and often provide productive fishing grounds.

Most of the North-East Atlantic is well-mixed to depths of up to 600 m during winter with a deep, permanent thermocline in deep oceanic waters. In spring, a strong vertical temperature gradient develops that separates warm surface water from cold deeper water. In shallow shelf areas strong tidal currents keep the water mixed throughout the year.

Local variations in temperature and circulation can be important in terms of the ecology of an area. The known range of these naturally occurring variations is now being exceeded, and this is a key factor in understanding how human-induced climate change is affecting marine ecosystems. For example, in the North Sea the monthly average sea surface temperature has exceeded the long-term average since the late 1980s. The rising temperatures have already affected the plankton and allowed new species to colonise → **CHAPTER 3**.

Detailed information on the physical environment of the North-East Atlantic may be found in the previous quality status assessment, the QSR 2000.

Regional ecology varies widely

The ecology of the OSPAR area includes a wide range of species and habitats, from the ice-bound and fjord coastlines of Region I, to the estuaries, sea lochs, rias and open bays of Regions II, III and IV, and to the deep-ocean ecosystems of Region V → **BOX 2.1**.

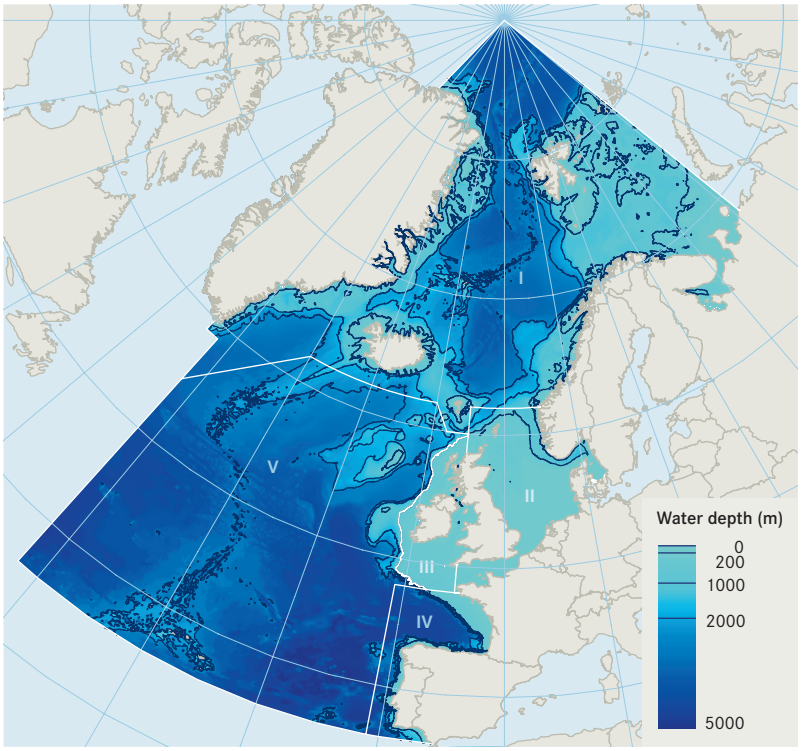


FIGURE 2.3 *The seabed can be divided into three distinct zones: the shallow continental shelf region to 200 m depth, the zone of rapidly increasing depth known as the continental slope, and the deep ocean basin. The main features of the deep ocean basins are the Mid-Atlantic Ridge (the Azores and Iceland are its highest points), and the Greenland-Scotland Ridge (which separates the Atlantic Basin from the Nordic Seas). Seamounts (underwater mountains) are also present, individually and in chains. The abyssal plain, the deep flat ocean floor extending beyond these features, is about 5000 m deep.*

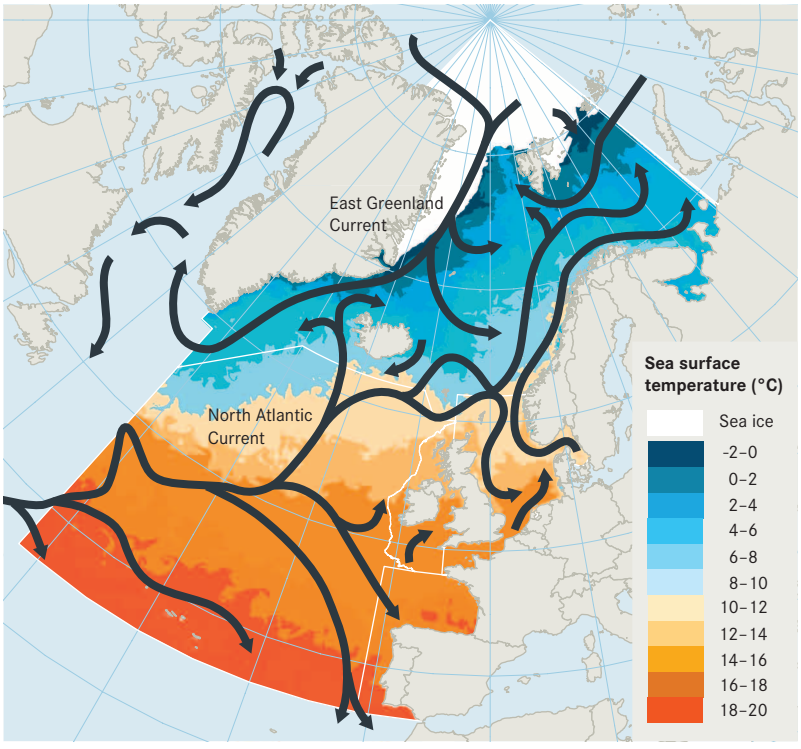


FIGURE 2.4 *Sea surface temperature within the North-East Atlantic from global high resolution Mercator ocean forecasting system for 13 October 2009 (source: Mercator Océan) and circulation patterns. The general ocean circulation in the North-East Atlantic is dominated by the north-eastward extension of the Gulf Stream, known as the North Atlantic Current. This is a part of the global ocean circulation – the 'Great Ocean Conveyor' – which transports relatively warm, nutrient-rich and oxygen-rich water from the north-western Atlantic towards the European coasts. One of the factors driving this flow in the North-East Atlantic is the cooling and sinking of this water in the polar region, from where it flows southward at depth. This general pattern of northward flow at the surface and southward flow at depth can be affected by freshwater inputs from the European landmass. Inter-annual variations in the North Atlantic Current control the temperature and salinity regimes in the OSPAR Regions.*

Tasiilaq, East Greenland (upper); Walrus (lower)

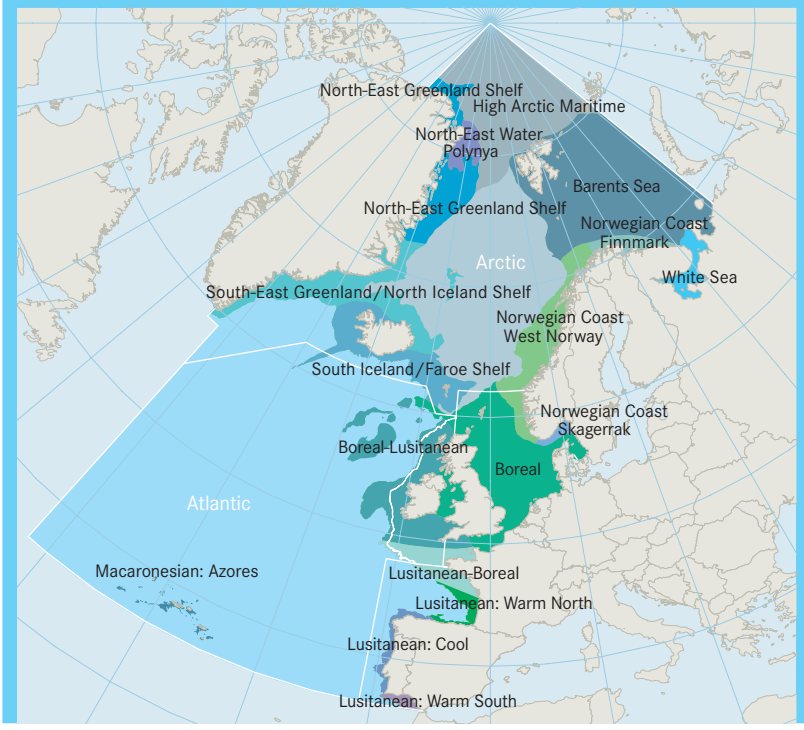
Large parts of Region I are permanently ice-bound, but the Region is warmed by the North Atlantic Current and there is a large area of sea which is ice-free in summer. To the east, Atlantic water is diluted by mixing with the northward-flowing Norwegian Coastal Current, which carries fresher water flowing out from the Baltic Sea and the North Sea. In the Greenland Sea and Iceland Sea, winter cooling of the surface water and the release of water vapour to the atmosphere both increase the density of the surface water which then sinks to the bottom.

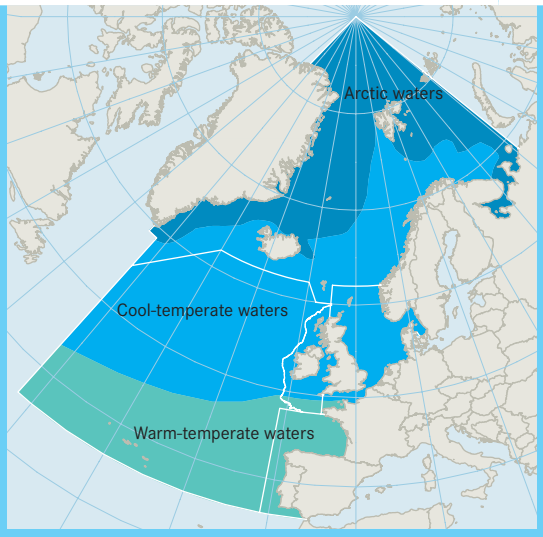
Melting of the seasonal sea ice in spring has an enormous impact on the ecology of the Region. Immediately after the ice melts there is a burst of primary productivity which is conveyed, often through short food chains, to the higher trophic levels that in turn support large stocks of fish, marine mammals and seabirds. The ecosystems are characterised by high natural variability due to a highly variable recruitment of fish stocks, strong biological interactions within simple food webs, and many species being near the edge of their distribution range.

Region I includes the transition between the Boreal and the true Arctic biogeographic zones, which in some areas is very sharp with a distinct polar front. The southern part of Region I supports some of the world's most important fisheries (herring, capelin, cod) as well as substantial populations of marine mammals (whales and seals) and seabirds, notably auks and guillemots. The Arctic supports many endemic species and Region I also contains Europe's entire population of polar bear, narwhal, walrus and beluga. Other notable features include cold seeps (areas of the ocean floor where the release of hydrogen sulphide, methane and other hydrocarbons from the seabed supports endemic species), as well as a large number of extensive cold-water coral reefs and numerous cold-water sponge aggregations. To the south, the Greenland-Scotland Ridge is a major biogeographical boundary for deep-sea benthos, acting as a barrier between warm-water and cold-water species.

BOX 2.1 The Dinter Biogeographic Classification

The Dinter Biogeographic Classification divides the seafloor, the deep sea and open oceanic waters into a series of representative biogeographic zones, each having a specific oceanography which supports characteristic biological communities. Source: Dinter, W.P. (2001).





Top: The water column less than 1000 m depth is divided into three characteristic biogeographic zones for the pelagic environment.

Left: Biogeographic zones for the benthic and deep-sea environments. The deep-sea benthos and deep-sea environments (>1000 m) are separated into two broad zones: Arctic and Atlantic, separated by the Iceland-Faroe Shelf. The benthic environment less than 100 m depth is separated into a series of characteristic zones.

Region II – Greater North Sea

Wadden Sea, Germany

In Region II, North Atlantic water mixes with freshwater run-off and river discharges within a roughly anti-clockwise circulation. Residual currents move southward along the east coast of the UK and northward along the continental west European coast. In the Kattegat, salty oxygenated water flows into the Baltic Sea at depth and brackish water enters the North Sea in a surface counter-flow. Shallower areas of the North Sea (<30 m) are normally fully mixed by tidal action. In deeper areas, the upper 30 m are usually mixed by wind action.

With the exception of the deeper waters along the Norwegian coast, Region II corresponds to the cool-temperate Boreal biogeographic zone. The Channel forms the border with the Boreal-Lusitanean zone. Shallow rocky areas are colonised by extensive forests of kelp. Most of the seabed is covered in sandy sediment habitats which support large populations of flatfish. The Fladen Ground in the northern North Sea is a large area of muddy seabed with abundant Nephrops. The extensive estuaries with mudflats and salt marshes are globally important areas for migrating waterfowl and waders. The south-east of Region II comprises the Wadden Sea, the largest area of intertidal mudflat in the world with abundant shellfish, including mussel beds, and patches of sea grass. It is a crucial stopover for millions of migrating birds. In the north-west of the North Sea, offshore islands support major colonies of seabirds. Benthic and pelagic processes in the North Sea are strongly coupled and work together to make the Region highly productive. Region II has supported large commercial fish stocks, as well as substantial populations of key prey species such as sandeels that are the main food item for many seabirds. Region II contains a great number of habitats considered to be threatened or in decline, including most of the North-East Atlantic's littoral chalk communities.

Bird colonies on Farne Island, north-east England

The Seven Sisters cliffs in southern England

Region III – Celtic Seas

Isle of Harris, Scotland

Region III ranges from being fully oceanic at the shelf break to the west of Ireland, through the relatively shallow semi-enclosed Irish Sea, to the brackish estuarine systems along the west coast of the UK. The overall movement of water is from south to north, continuing the North Atlantic Current flow into the North Sea and Norwegian Sea.

Region III mainly corresponds to the Boreal-Lusitanean biogeographic zone, but with the Irish Sea more closely aligned to the Boreal zone. This is reflected by the spring bloom in the Irish Sea taking place about a month earlier than in the open shelf waters to the north and south, although there is strong variability between years. The Region has a wide range of coastal and seabed habitats, including sea lochs and estuaries, with diverse biological communities that include many commercially important species. The Region is at the southern limit of the distribution range for some cold-water species, such as herring and cod, while some warm-water species, such as sea bass and sardine, come up from the south. There are also important seabird areas and the waters to the south and west of Ireland support a variety of cetaceans, including common dolphins and a resident population of bottlenose dolphins in the Shannon Estuary. Region III, and with the northern part of Region II, supports a high proportion of the North-East Atlantic's sea-pen and burrowing megafauna communities, where soft coral sea-pens coexist with large shrimps burrowing in muddy sediments. These occur in sheltered areas such as sea lochs or on the deeper parts of the shelf.

Short-beaked common dolphin

Cliffs of Moher, western Ireland

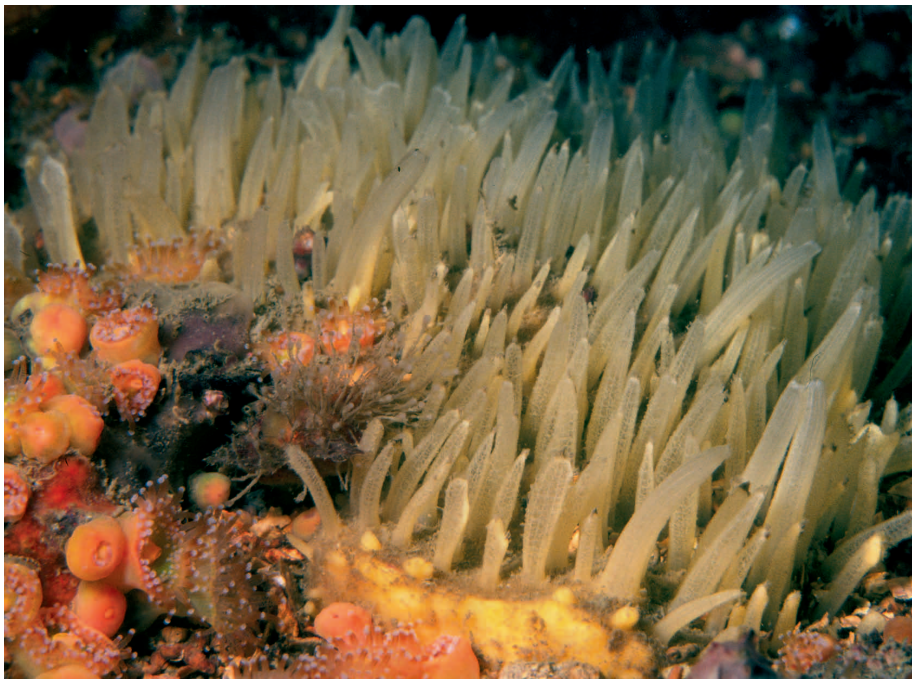
Region IV – Bay of Biscay and Iberian Coast

Cabo Vidio, Asturias, Spain

In Region IV, branches of the North Atlantic Current bend round towards the south. Beyond the shelf break, Atlantic water interacts with salty Mediterranean water, which then moves northward along the continental slope. Off the Iberian Peninsula, northerly winds cause an upwelling of cold and nutrient-rich deeper water to the surface during summer.

Region IV corresponds to the Lusitanean zone and is highly diverse with many different types of coastal habitat, such as rocky cliffs, shingle, sandy and muddy shores, rias, coastal lagoons, open bays and estuaries. The waters of the shelf host maerl beds and sea-pen and burrowing megafauna communities. Many northern species reach the southern limit of their distribution in Region IV and many southern species reach their northern limit of distribution. Mediterranean species occur in the south. Areas of upwelling off the Iberian coast are responsible for the spring bloom occurring earlier than in the other Regions. These areas are highly productive and have supported large populations of pelagic fish such as sardine. The continental shelf hosts cold-water corals and deep-sea sponge aggregations and is dissected by large submarine canyon systems which provide a pathway to the deep sea for sediment and nutrients and contain diverse biological communities with many endemic species.

Ria Ferrol, Galicia, Spain



Sponges, Rade de Brest, France

Region V – Wider Atlantic

Azorean barnacles

Cory's shearwater (left); Punta Delgada, Azores (right)

Region V is dominated by the North Atlantic Current. The northern sections divert into the North Sea and Norwegian Sea, while a more southerly branch forms the easterly Azores Current that coincides with the southern boundary of the OSPAR area.

Region V is sub-divided into two biogeographic regions. To the north of 40° N, the deep mixing of the water column during winter and its stratification in summer results in a strong seasonal cycle of primary production. To the south, the upper water column is stratified throughout the year and so the annual productivity is both lower and less variable seasonally. This causes major differences in the pelagic and benthic ecology, with biological activity almost totally dependent on production in the upper layers of the ocean that receive enough sunlight for photosynthesis. The benthic communities are too deep to be directly supported by photosynthesis, except within the coastal fringes of the Azores, and depend on organic matter sinking or being transported downward.

Biodiversity in Region V is less well-quantified than in the other Regions, particularly in the deep waters. Many deep-sea species have an extensive geographical range due to the small environmental variations in their habitat. Top predators such as sharks probably play an important role in maintaining the structure and diversity of fish communities, which include several long-lived and slow-growing species. Large pelagic predators (tuna and marlin) are highly migratory, ranging far beyond the boundaries of Region V. Region V is also important for Europe's threatened sea turtles and some oceanic seabirds such as Cory's shearwater. The main benthic habitats are the flat, featureless abyssal plains, but rising out of these the Mid-Atlantic Ridge, the continental slope and seamounts support vulnerable deep-sea habitats, such as cold-water coral reefs and deep-sea sponge aggregations. These have highly diverse biological communities with many endemic species. Hydrothermal vents along the Mid-Atlantic Ridge support particularly specialised and largely endemic communities.

Many challenges but common pressures

Although the vast waters of the OSPAR area and its diverse ecosystems present many challenges for management and environmental protection, there are many commonalities within each of the Regions, including common oceanic and open sea characteristics that are strongly influenced by the dynamics of the North Atlantic Current. The degree of pressure from the different human activities varies between and within Regions. The much greater concentrations of human population in catchments draining into Region II produce a significantly different level of pressure to that affecting Region V, where the only human populations are associated with the Azores archipelago. Nevertheless, important pressures, such as fishing and climate change, are of concern in all Regions. Other common types of pressure also exist, particularly from intensive (and sometimes conflicting) uses of the coastal zone. OSPAR provides a common framework for managing the impact of these pressures on the North-East Atlantic.