The North Sea

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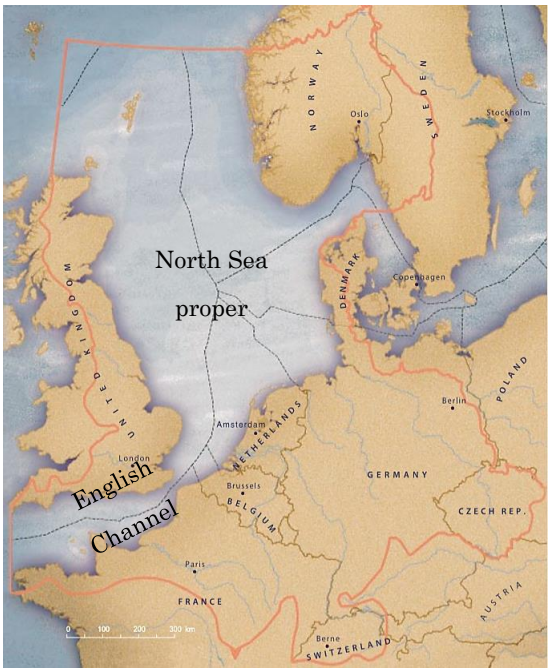
1. *Physical and ecological features*

The Greater North Sea is a large epi-continental marine ecosystem off North Western Europe. These waters include the European North Sea and the English Channel; it is a semi-enclosed shelf sea surrounded by highly industrialised countries, i.e. the United Kingdom, France, Belgium, the Netherlands, Germany, Denmark and Norway. The total catchment area is about 840,000 km², with a total annual input of about 300 - 350 km³ of fresh water. A third of run-off originates from melt water from Scandinavia, but is variable from year to year.

Surface area	Water volume	Average depth	Maximum depth
750,000 km	94,000 km³	90 m	725 m
Higher tidal range	Surface temperature		Salinity
12.40 m	August 12-20°C February 0-8°C		25-35

Main physiographical characteristics of the Greater North Sea

Most of the North Sea is shallow (average depth of 90 m) and coastal but it also includes deeper areas such as the Norwegian Trench (725 m deep). In the English Channel, the tidal range is more than 12 m high. Extensive sedimentary areas characterise the North Sea/Channel complex, including subtidal sandbanks and muddy areas such as the Dogger Bank and estuarine ecosystems. Many of these produce the rich feeding areas necessary for supporting higher trophic levels and their biological systems are rich and complex. Estuarine mudflats and wetlands have a dominant role in their carrying capacity as nursery areas for many fish species and feeding and wintering grounds for birds. Approximately 230 species of fish are known to inhabit the area. Up to 12 million seabirds are present at most times of the year. Marine mammal species occur regularly over large parts of the Greater North Sea.



The Greater North Sea and catchment area (OSPAR)

The Greater North Sea is situated in temperate latitudes with a climate that is strongly influenced by the inflow of oceanic water from the Atlantic Ocean and by the large scale westerly air circulation which frequently contains low pressure systems. In the shallow areas, extreme weather conditions have a direct impact on the general hydrography of the system, which is characterised by substantial water exchange with surrounding ocean areas, and strong tides. The North Atlantic Oscillation (NAO) affects changes in winter extreme high and low waters and storm surges, the frequency, duration, and magnitude of which are linked closely to NAO variability. Approximately 200 million people live in in the catchment area of the Greater North Sea. Population densities differ greatly between areas with over 1000 inhabitants per km² on the coast of Belgium and the Netherlands to less than 50 inhabitants per km² along the coasts of Norway or Scotland. Despite a decreasing birth rate, the population was still increasing in the late 2010s due to immigration which amounted to more than a million in later years. Most estuaries are the sites of major

conurbations and ports, each threatening the integrity of estuarine ecosystems. Tourism also induces large scale seasonal migrations to the coast and the number of visitors amounts to millions of people on a single day.

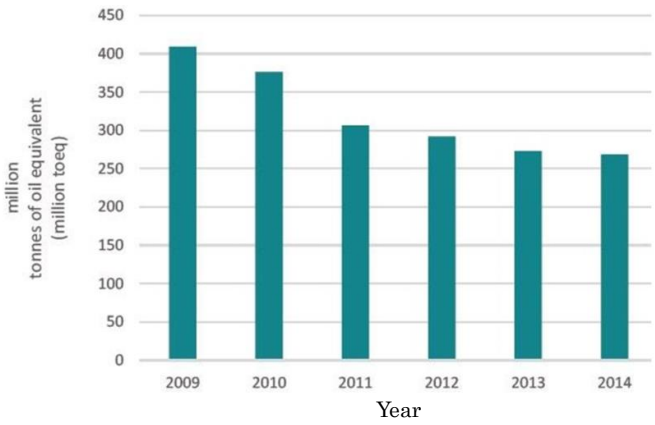
2. Water Quality in the North Sea

The North Sea is an open embayment the geomorphology of which results in considerable flushing water movement. Consequently, pollutants discharged are dispersed, degraded and assimilated rather easily. However, residence times vary in the order of months and are significantly higher in the German Bight where pollution is more pregnant. The anticlockwise currents in the southern North Sea transport nutrients (discharged from the continent) to the Wadden Sea and other German and Danish areas. The two main pollutant nutrients are nitrogen and phosphorus and these have shown the following trends since 1990:

- There has been a reduction in nitrogen inputs via water and air, but the trend is weak. Particularly high nitrogen inputs occurred in 1994, 1995 and 2002, associated with central European flood events. They varied from about 2–000 to 1500 kilotons per year (kt/) from 1990 to2003 and then remained fairly constant. Before 2003, approximately 500 kt/y were from atmospheric deposition (24 –38% of the total). Afterwards, a cut of approximately 150 kt/y was due to measures taken to reduce atmospheric nitrogen pollution.

- Phosphorus inputs to the Greater North Sea have significantly decreased. Annual phosphorus inputs have halved to about 40 kt/y. Prior to 2003, phosphorus inputs varied from 70 to 90 kt/y. The highest inputs occurred in 1995 and the lowest in 1996 and 2001. After 2002, phosphorus inputs of around 40 kt/y became typical. Since 2006, waterborne phosphorus inputs have decreased by about 1.5 kt/y. This compares to a rate of decrease of about 2 kt/y for the entire period 1990–2015.

Hydrocarbons and offshore chemicals are routinely discharged to the marine environment during offshore oil and gas operations. Assessment of the discharges and spills shows that measures have led to decreases in the discharge of both hydrocarbons and the most harmful offshore chemicals.



Total production of oil in the North Sea OSPAR Maritime Area from 2009 to 2014

3. Environmental problems in the North Sea

Long-term inhabitation of the coastal zone over millennia has resulted in a strong anthropogenic footprint causing water pollution, a deterioration of marine habitats and depleted fish stocks. Ongoing and likely future impacts include the combined effects of climate change (e.g. warming, acidification, deoxygenation), and contamination by micro particles and micro plastics. The basins of large estuaries such as the Humber, Thames, Seine, Rhine-Meuse complex, Scheldt, Ems, Weser and Elbe are among the most heavily industrialised and impacted regions in the world. Industries of all types are located in particular in estuaries or in bays rather than along the open coast, especially in the Southern Bight and the Channel. Shipping lanes are among the busiest in the world. Major ports include Rotterdam, the busiest port in Europe and the fourth busiest port in the world by tonnage as of 2013, Antwerp (16th) and Hamburg (27th). Bremen/Bremerhaven, Felixstowe and le Havre are in the top 30 busiest container seaports, as well as Zeebrugge, Europe's leading Ro-Ro port. The Dover Strait alone sees more than 400 commercial vessels a day. Coasts are home to numerous canal systems which facilitate traffic between and among rivers, artificial harbours and the sea.

In the open sea, the following strains have been recognised:

- Sound pressure data from 2015 are available for a limited number of countries and various sound sources. The predominant sources are seismic survey activity in the northern North Sea, explosions and pile driving in the Southern North Sea, and naval sonar activity in the western English Channel.

- A recent increase in the construction of offshore wind farms has initiated many environmental impact assessments and monitoring programs. These focus on sea mammals, seabirds, benthos or demersal fish, but generally ignore any potential effects on the pelagic ecosystem.

- Ocean acidification is still not identified in any of the assessments as a strong driver and is not considered a common indicator of change despite complex responses to changing ocean pH being described in the wider scientific literature.

- Adverse impacts from dumping sediments have been noted. Known effect can be physical (through smothering of habitats and organisms), chemical (through toxicity) and / or biological through increased turbidity, and from bioaccumulation and biomagnification of contaminants through the food web.

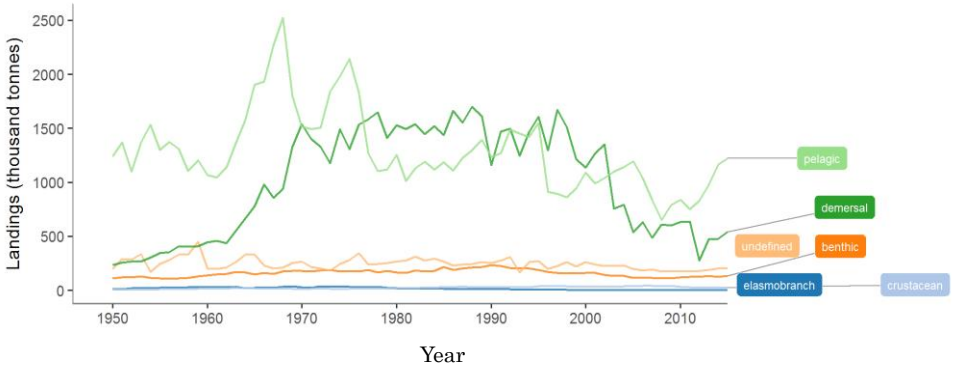
- Fisheries are the main source of litter, essentially ghost nets and rubber balloons. Shotgun cartridges are also of concern. The findings demonstrate the high level of exposure to marine debris and associated risks for large predators, such as the sperm whale. For instance, in 2015, 58% of beached fulmars had more than 0.1 g of plastic in their stomach.

- Microplastic ingestion by fish may be less common than thought initially. In a recent OSPAR (Convention for the Protection of the Marine Environment of the North East Atlantic) study, in 5.5% of all investigated fishes, plastic particles were detected, with 74% of particles being in the < 5 mm size range. Almost 40% of the particles consisted of polyethylene. In 3.4% of demersal and 10.7% of pelagic individuals, plastic ingestion was recorded, with a significantly higher ingestion frequency in the pelagic feeders.

- At the base of the food web, changing environmental conditions are affecting the abundance and distribution of phytoplankton species. Phytoplankton is highly sensitive to changes in physical and chemical conditions (temperature, salinity, available light, nutrients, pH, storminess, currents), as well as oxygen and CO2 availability.

- Fishing has had a major impact on ecosystems for decades. Many of the demersal fish stocks have been declining for several years, but fisheries management is changing for the better, with long-term management plans for certain key stocks.

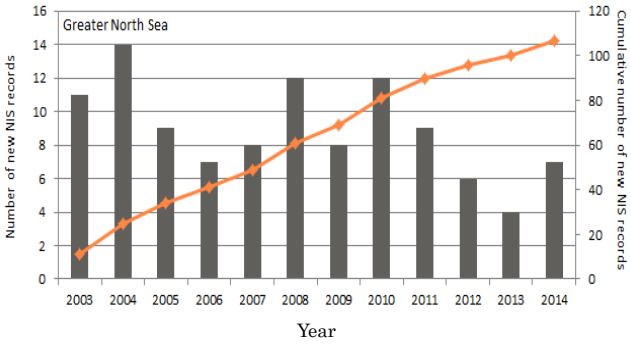
The herring stock used to be at a low level, but harvest control rules have been implemented and the stock is improving. However, according to model simulations, it is not possible for all stocks to be simultaneously maintained above a safe level. For instance, small whiting are subjected to high predation by grey gurnard, and a strong recovery of the cod stock (another significant predator of whiting) increases the probability that the whiting stock will decline below its precautionary biomass reference point. Destructive practices such as beam and otter trawl fishing have decreased in some areas and the excessive discards of fish (by-catch) are beginning to be addressed. There are signs that fish communities near the seabed may be starting to recover. However, physical disturbance still occurs by mobile bottom-contacting gear in the eastern English Channel, in nearshore areas in the south-eastern North Sea, and in the central Skagerrak. Incidental by-catches of protected, endangered, and threatened species occur in several fisheries. The by-catch of common dolphins in the western English Channel may be currently causing irreversible population decline.



Landings (thousand tonnes) from the Greater North Sea in 1950–2015, by fish category.
Historical nominal catches 1950-2010. Official nominal catches 2006-2015. ICES, Copenhagen

- For top predators (mammals and birds), the direct impacts from climate change are not well established and effects are primarily seen through indirect impacts on habitats and prey species. For example, the impacts of changing environmental conditions on food/forage species (e.g. sand eels and sprat), along with historical fishing pressure, are probably limiting the breeding success of some seabird species (e.g. the black-legged-kittiwake). There is no doubt that changes in key aspects of ecosystem function have been observed with consequent effects higher up the food web.

- Non-indigenous species (NIS) are not only a major threat to marine biodiversity, but can also have considerable socio-economic impacts. Excluding a few years with high rates of NIS introduction, new species have been encountered at a relatively constant rate.



Number of new NIS records per year in the Greater North Sea

4. Environmental Conservation of the North Sea

Since 1972, the management of the Greater North Sea has been focused on the land first then fresh waters, then moving out to the estuaries, the coasts, and finally the open sea. It is one of the regions covered by (OSPAR). Contracting parties are required by the Convention to undertake and publish at regular intervals joint assessments of the quality status of the maritime area encompassed in the Convention, in order to evaluate the effectiveness of measures taken and planned for the protection of the area, and to identify priorities for further action. There are more than three hundred European directives or regulations concerning the environment, many of which may relate to estuarine, coastal and marine environments. The framework directives form the basis of this policy but do not expressly prescribe how to fulfil their objectives, which is the responsibility of the Member States and their governments in charge of establishing national laws to do so, for instance, in relation to the protection of the marine environment:

- The Natura 2000 network is a European network of protected natural sites. It aims to preserve biodiversity.

- The Water Framework Directive (2000) focuses on the strategic importance of knowledge of aquatic environments for better community management of water. The assessment of the quality of water bodies is based mainly on an assessment of ecological quality. Monitoring and quality control programs for marine waters were adapted and implemented in 2015. Their application aims to achieve the good ecological status of estuaries and coastal waters, but also the good chemical status of the territorial waters (up to twelve miles from the coast). More generally, the objective is to prevent any degradation of the ecological quality of a body of water and to reach the good ecological and chemical status or a good ecological potential for heavily modified water bodies.

- The Marine Strategy Framework Directive (2008) establishes a framework for community action in the field of marine environmental policy. This directive was the subject of an "ecosystems-based" approach. It introduces the concept of "European waters", which are "waters beyond the baseline used for measuring the breadth of territorial waters and extending to the confines of the area under sovereignty or the jurisdiction of the Member States, including the bottom and the subsoil of all these waters." It aims at the good ecological status of the marine environment and marine biodiversity conservation.

- The Common Fisheries Policy (CFP) is a set of rules for managing European fishing fleets and for conserving fish stocks. Designed to manage a common resource, it gives all European fishing fleets equal access to EU waters and fishing grounds and allows fishermen to compete fairly. The CFP was first introduced in the 1970s and went through successive updates, the most recent of which took effect on 1 January 2014. The CFP seeks to phase in the implementation of the landing obligation from 2015 through to 2019 for all commercial fisheries in European waters and for European vessels fishing in the high seas.

North Sea countries also contribute to global discussions on marine conservation, held in the UN General Assembly, the Convention on

Biological Diversity (CBD) and the International Union for Conservation of Nature (IUCN), among others, and provides a regional approach to protecting the marine environment and managing natural resources.

5. New Directions in Management Policies

The decision by the UK to leave the EU (Brexit) has important implications for the future management of the European marine environment. It will, for instance, impact European fisheries. Difficulties might occur in the sector, arising from privatisation and economic reforms, which may affect the fisheries even years after the establishment of new ruling principles. A number of directives would no longer apply although it is possible that some existing water pollution control regimes would remain in place and wider international obligations would also remain. In the future, nations will face energy-related problems due to the exhaustion of oil resources from the North Sea. Opportunities exist for the production of energy from offshore wind power in shallow areas, wave and underwater current power and underground CO_2 sequestration. With regard to radioactive substances, plans are currently being developed by OSPAR to determine a new methodology for assessing additional concentrations in the marine environment above historic levels.

Understanding and assessing cumulative effects is at the heart of implementing an ecosystem-based approach to the management of human activities in the Greater North Sea. A holistic and integrated science and management system is needed. It is expected that a strategic coordinated approach for marine and maritime research will support the implementation of relevant EU policies to help deliver key Blue Growth objectives across Europe after 2020. In order to foster an understanding of coastal seas and the sustainable use of their goods and services challenges need to be addressed such as: fragmentation among nations and sectors, gaps in interdisciplinary knowledge, inadequate information on potential synergies and trade-offs between different sectors and the environment (including climate change issues), insufficient exchange of knowledge among scientists, industries and policy makers, and a need to increase attention to societal inclusiveness and human well-being. Fragmentation in research and innovation needs attention.

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