

5 North Sea

Overview

The North Sea is a semi-enclosed sea situated on the continental shelf of northwestern Europe. It opens into the Atlantic Ocean in the northwest, the Norwegian Sea to the north, and the Baltic Sea to the east via the Skagerrak-Kattegat. The North Sea is heavily exploited economically by the surrounding - from fisheries to maritime transport to communication to energy and is one of the busiest seas in the world.¹

Location

Basic information⁹

Surface area : 575,200 km²

Volume : 54,069 km³

Average depth : 94 m

Maximum depth : 660 m

Nature

< Background >

The North Sea has a catchment area of about 850,000 km². The annual freshwater river input is on the order of 300 km³, with one-third coming from the snow-melt waters of Norway and Sweden and the rest from major rivers such as the Elbe, Weser, Rhine, Meuse, Scheldt, Seine, Thames and Humber. In addition, a vast amount of fresh water is supplied through the brackish waters of the adjacent Baltic Sea, which is the dominant fresh water source for the North Sea.²



Climate

The climate of the North Sea is strongly influenced by the inflow of Atlantic Ocean water and the large-scale westerly air circulation, which frequently contains low-pressure systems. These air-flow patterns produce large variations in wind direction and speed, high levels of cloud cover and high precipitation.²

Annual rainfall across the North Sea varies between 340 and 500 mm, averaging 425 mm. April to June tend to be the driest months, with October to January being wetter. Thunderstorms are infrequent, and snow showers vary markedly from as few as 5-7 days per year in the south, to 10-12 days in the central North Sea, and 30-40 days in the north.³

Topography

The continental shelf of northwestern Europe gradually slopes from the North Sea towards the Atlantic Ocean. A large part of the North Sea's bottom topography was shaped during the glacial period, as evidenced by the presence of river-valley systems, and deep fjords.

Although the shallowest regions in the North Sea are generally found off the southern coast, very shallow areas, such as Dogger Bank, are also found in the open waters of the North Sea. The depth at Dogger Bank can be less than 20 m, and this shallow topography significantly influences the surrounding water circulation.

The deepest region in the North Sea is the Norwegian Trench, which runs along the coast of Norway. It reaches its maximum depth of 660 m off the southern Norwegian coast in the Skagerrak.^{2,9}

Hydrology

The hydrology of the North Sea is influenced by inflowing Atlantic waters, strong tidal action, fresh water inputs and climatic conditions.

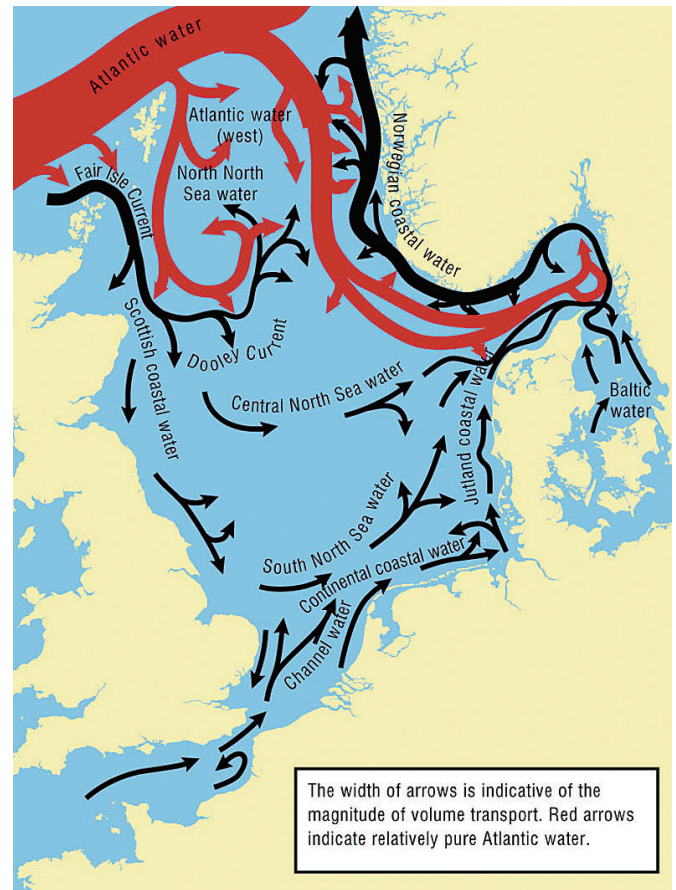
The majority of the North Sea's oceanic (Atlantic) water enters through the northern North Sea and runs south along the western slope of the Norwegian Trench. Smaller amounts also enter east of the Shetland Islands and between Shetland and Scotland. Less than 10% enters the North Sea through the English Channel. Most of these inflows, as well as waters from the Baltic Sea, flow back into the Atlantic Ocean via the Norwegian Trench, creating a general anti-clockwise circulation in the North Sea.

The volume of Atlantic water entering the North Sea shows large annual variation due to the fluctuation of the North Atlantic Oscillation, which is a measure of the intensity and persistence of westerly winds over the North Atlantic. These fluctuations significantly influence the hydrology of the North Sea, as is obvious when observing the interannual variability of the surface salinity distribution in the North Sea.

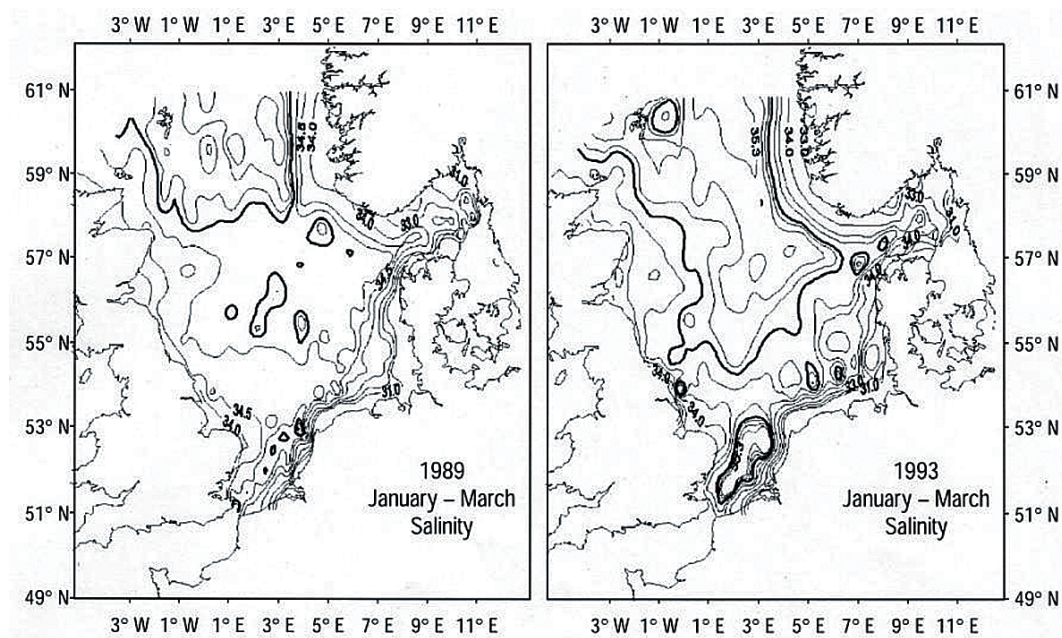
Despite annual fluctuations, salinity in the open waters is around 35 ppt and in the coastal waters is between 32 ppt and 34.5 ppt. However, near the entrance to the Baltic Sea (Kattegat and Skagerrak) and in the Norwegian Trench, salinities are much lower (10 ppt–34 ppt), due to the brackish water flowing from the Baltic Sea and adjacent rivers. Since these regions have low surface salinities, they have stable density stratification that persists throughout the year.

In summer solar heating causes thermal stratification over large areas of the North Sea, but the stratification quickly disappears in winter through wind-induced vertical mixing. No stratification develops in the shallow parts of the southern North Sea, owing to tidal amplitudes of up to 8 m.

The sea-surface temperature in the northern North Sea is quite stable, with an annual mean of about 9.5 °C. The temperature is most stable in the northern entrance. However, seasonal fluctuations are large in the southern region, due to its shallow depth and extensive fresh water inputs.²



Schematic diagram of general circulation in the North Sea¹



Surface salinity distribution for the winters of 1989 and 1993¹

< Surrounding environment >

Habitat

The coastlines of the North Sea display a large variety of landscapes that arise from differences in geology and vertical tectonic movements. The coastlines of Norway and northern Scotland are mountainous, with many rocky islands and deep fjords. The fjords shelter most of the Norwegian mainland from the open ocean. Cliffs of varying sizes are found along the coast of northern England and Scotland and are often intersected by river valleys. Further south, along the east coast of England, are estuaries and expanses of sand and mud flats. In the southeast there are low cliffs and flooded-river valleys. From the Strait of Dover to the Danish west coast, sandy beaches and sand dunes prevail, interspersed with estuaries, tidal flats, tidal inlets, islands and lagoons. The Wadden Sea contains the largest stretch of unbroken mudflat in the world.²

Biota

Perennial fucoids algae, serrated wrack and kelps densely cover the littoral zones of the North Sea. Seagrasses were once abundant along the coasts but now occur only in a few scattered areas.

Approximately 230 species of fish inhabit the North Sea, of which 13 are the main targets of major commercial fisheries.^a Fish species diversity is lowest in the shallow southern North Sea and the eastern English Channel.²

Marine mammals, such as harbor seals, grey seals, harbor porpoises, minke whales, white-sided dolphins and killer whales are found in the North Sea. Currently, the seal population is estimated to be around 36,000 and the population of harbor porpoises, the most common cetacean in North Sea, is estimated to be around 300,000.²

Areas of gravel and coarse sand may be expected to host greater species richness than soft sediments, and beds of structural organisms such as sponges, anemones, soft corals and deep water corals are expected to contain more species still.⁴

History and Culture

< History of fisheries in the North Sea >

The North Sea environment today is very different from that of 200 years ago, before the advent of large-scale industrial fishing. The changes are due to the effects of fish removals by fishing (both capture and killing in situ): the impacts of fishing gears on habitats, oil and gas exploitation: pollution: and, latterly changes in environmental conditions accompanying global warming.

The onset of commercial sea fishing in the North Sea can be traced to within a few decades around AD 1050. At the time, fishers used hook and line to catch cod and allied species, and nets to catch the abundant herring that seasonally entered British coastal waters. Bottom trawling was invented in the 14th century and spread slowly. At the beginning of the 19th century it was still largely confined to the English Channel and south-east England, as well as several ports in continental Europe.

By the middle of the 19th century the English fleet consisted of around 800 sail-powered trawlers working mainly in nearshore coastal areas, and trawling had spread further into the North Sea. But the great expansion of trawling came with the adoption of steam power in the late 19th century. By 1890, virtually the whole of the North Sea was trawled, in many places more than once a year.

Since then fishing techniques has further advanced, though it has led to the current overexploitation of many commercial fish species.⁵

Social Environment

< Population >

Approximately 184 million people live within the North Sea catchment area.⁸ The population is expected to reach a maximum in 2025. The population density is highest along the southern coast, especially along the western and northern coasts of the Netherlands, and least dense along the eastern coast of the North Sea.²

< Industry >

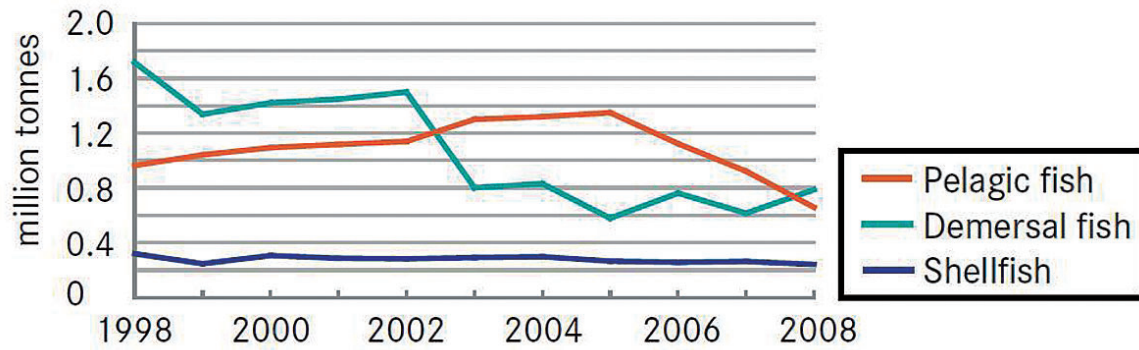
The North Sea is surrounded by densely populated, highly industrialized countries that conduct a wide range of industrial activities. Many of these industries have affected the North Sea environment, with fisheries, agriculture, coastal industries and the oil and gas industry playing major roles.¹

Fisheries

Fisheries have a range of direct and indirect effects on marine ecosystems. Fishing causes the death of many species including those being targeted and a range of other species such as non-targeted invertebrates and fish (including sharks and rays), seabirds, turtles and marine mammals (seals and small cetaceans). Excessive fishing pressure on targeted species may lead to impaired reproductive capacity and a risk of stock collapse. Deep-water species have been shown to be particularly sensitive to fishing pressure. Some unwanted by-catch is discarded at sea, and discard rates have been high in some fisheries. Discards have been shown to affect the structure of biological communities.

In the North Sea, beam and otter trawl fishing effort decreased by 31% and 44% respectively between 1997 and 2004, although Nephrops trawl effort grew by 65%. Beam trawling has been increasingly replaced by twin-rigging and flyshooting, which require less fuel. Demersal landings continued to increase until 2005, but have since declined such that in 2008 the catch was lower than in 1998. Pelagic catch has decreased throughout the decade. Extensive discarding having been reported in many roundfish, flatfish, and Nephrops fisheries in the North Sea. In 2008, the total landing of fish and shellfish in the North Sea countries was about 1.8 million tons, which was a decrease of 1.7 million tons from 1995.⁶

^a Sand eels, Norway pout, sprat, herring, horse mackerel, types of cod fishes (cod, haddock, whiting), saithe, plaice, sole, salmon, rainbow trout, blue mussels, oysters, and scallops



Landings from the North Sea of demersal fish, pelagic fish, and shellfish over the period 1998–2008⁶

Agriculture

Over 40% of the total land area in Europe is used for agriculture, and highly productive agricultural systems operate throughout the North Sea states. Intensive field-crop farming operates in eastern England, northern Germany and most of the Netherlands. Animal, fruit and vegetable farming are extensive in Denmark, the Netherlands, northern Belgium and northern Brittany.²

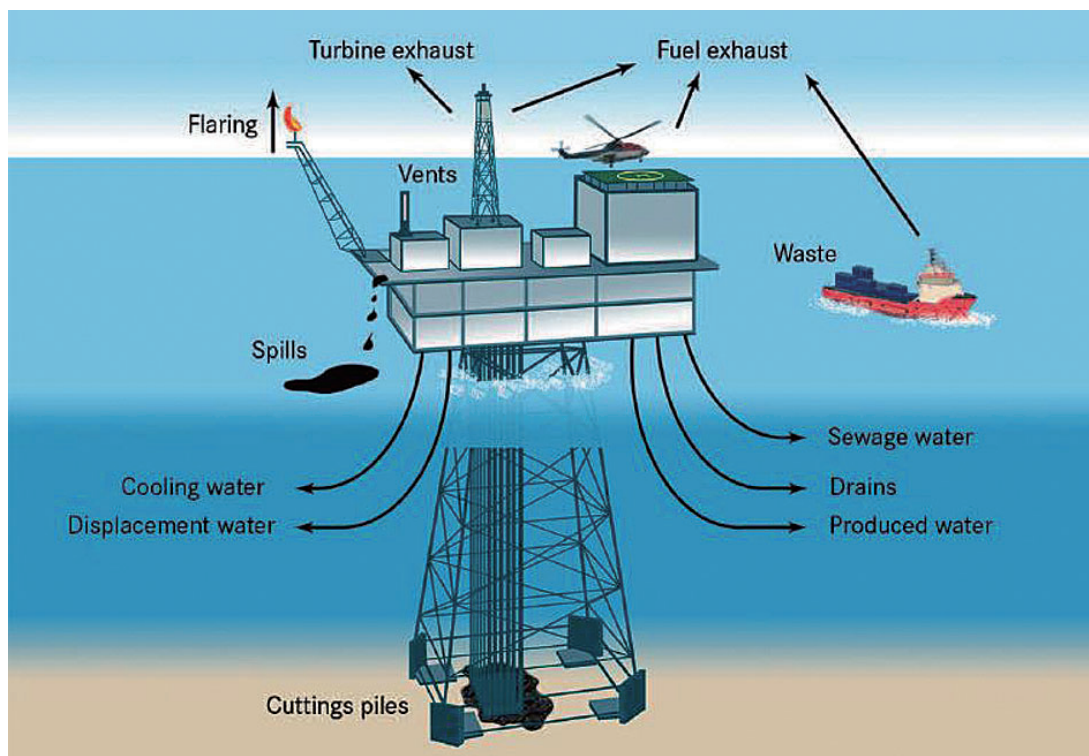
Because of the adverse impacts of pesticides on the environment, the various uses of the six OSPAR (The Convention for the Protection of the Marine Environment of the North-East Atlantic) priority pesticides (dicofol, endosulfan, lindane, methoxychlor, pentachlorophenol and trifluralin) have been phased out progressively since 1998 and have now ceased for almost all substances.⁶

Coastal industries

Metal production, metal processing chemical industries, and shipbuilding industries are located along the coasts of the North Sea. Many of these industries are situated in the innermost regions of fjords (Norway), river banks (Germany) and estuaries (Netherlands, Belgium, France and U.K.).²

Oil and gas industry

Since the late 1960s, the offshore oil and gas industry has been a major economic activity in the North Sea.² The major oil developments have been in the northern parts of the North Sea. In 2007, oil and gas production are 205.4 mtoe (million tons of oil equivalent) and 172.8 mtoe respectively. Environmental pressures from offshore oil and gas operations are large problem in the North Sea. However, oil and gas production has peaked in the North Sea and is now declining.⁶



Substances are released from a range of sources during routine offshore oil and gas production⁶

Environmental Problems

< Water and Sediment Quality >

The water quality of the North Sea has improved since the implementations of the OSPAR Convention and various other programs. Inputs of heavy metals and oil from refineries and cuttings have significantly decreased. The dumping of sewage sludge ceased in 1998 and chemicals used in aquaculture have also decreased. Despite these improvements, the North Sea is still heavily affected by intense human activities. The two most important issues currently identified by the OSPAR Commission are eutrophication and contamination by trace organic compounds.²

Eutrophication

Eutrophication caused by nutrient inputs is a problem along the east coast of the North Sea from Belgium to Norway, and in some small estuaries and bays of eastern England and north-west France. Associated problems include fish dying in the fjords of Denmark and Sweden, and sugar kelp declining along parts of the Norwegian coast. Nitrogen inputs, largely from agriculture, are the biggest cause of eutrophication and few countries approach OSPAR's 50% reduction target for nitrogen inputs to problem areas. It can take decades before reduced nutrient inputs benefit the marine environment because nutrients can be released from soil and sediments.⁶

Hazardous substances

Concentrations of metals (cadmium, mercury and lead) and persistent organic pollutants are above background in some offshore waters of the North Sea, and unacceptable in some coastal areas. Lead levels, for example, were unacceptable at 40% of locations monitored, while PAHs and PCBs were at unacceptable levels at more than half of the monitoring sites.⁶

<Other Environmental Problems >

Marine litter

Over 90% of fulmars have microscopic plastic particles in their stomach and 45% to 60% have more than the Ecological Quality Objective (EcoQO) set by OSPAR. Beach litter in the southern North Sea is at OSPAR-wide average (around 700 items per 100 m of beach), but levels are higher in the northern part of the North Sea.⁶

Impacts of climate change

The pace of warming of the sea is high, with an increase in sea surface temperature of 1 to 2°C over the past 25 years. Plankton and fish communities are already changing in response to warming. Fish like silvery John dory, sea bass and red mullet are becoming more common further north, while North Sea cod stocks seem to be falling faster than would be expected from the impact of fishing alone.⁶

Damage to seabed habitats⁶

Significant damage has occurred to shallow sediment habitats and reefs as a result of bottom fishing practices, especially beam trawling. Thick beds of red calcareous seaweed called maerl declined in extent and quickly, partly as a result of damage resulting from its extraction for use as an agricultural soil conditioner.⁶

< Environmental Protection Measures >

The Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention)

The OSPAR Convention, adopted in 1992, established the OSPAR Commission to implement the Convention. The purpose of the Convention was to merge and modernize the Oslo and Paris Conventions to include the 'precautionary principle', 'polluter pays principle', Best Available Techniques (BAT), and Best Environmental Practices (BEP), including clean technology. The 1992 Convention included a series of annexes to facilitate the prevention and elimination of pollution from land-based sources, by dumping or incineration, and from offshore sources, by the assessment of the quality of the marine environment.

In 1998, the first ministerial meeting of the OSPAR Commission adopted new strategies concerning the protection and conservation of the region's ecosystems and biological diversity. These strategies deal with radioactive and other hazardous substances, eutrophication and the conservation of ecosystems and biological diversity. Also new rules governing the participation of non-governmental organizations in the work of the Commission were adopted. Furthermore, in 1999 the Commission adopted a strategy on environmental goals and management mechanisms for offshore oil and gas industry activities.⁷

Monitoring

In 1995, the OSPAR Commission adopted the Joint Assessment and Monitoring Programme. Under the coordination of the Environmental Assessment and Monitoring Committee, the contracting parties are required to regularly undertake and publish joint assessments of the quality of the marine environment. Based on the findings of the above monitoring programs, a Quality Status Report of the North Sea was published in 2000, which has provided the basis for the future work of the Commission.²

Related organizations and NGOs

- The Bonn Agreement <[http:// www.bonnagreement.org](http://www.bonnagreement.org)>
- Risk assessment for marine pollution in the Greater North Sea and its wider approaches
<<http://beaware.bonnagreement.org>>
- The North Sea Commission <<http://www.northsea.org/>>
- European Environment Agency (EEA) <<http://www.eea.europa.eu/>>
- International Council for the Exploration of the Sea (ICES) <<http://www.ices.dk/>>

References

1. ESPON, 2013. ANNEX 7 to the Scientific Report: North Sea Regional Profile.
http://www.espon.eu/main/Menu_Projects/Menu_AppliedResearch/ESaTDOR.html (accessed March 31, 2015)
2. OSPAR Commission, 2000. Quality Status Report 2000, Region II Greater North Sea.
http://qsr2010.ospar.org/media/assessments/QSR_2000_Region_II.pdf (accessed March 31, 2015)
3. GOV.UK, 2009. OESEA Environmental Report APPENDIX 3f - CLIMATE AND METEOROLOGY.
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/194346/OES_A3f_Climate_Meteorology.pdf (accessed March 31, 2015)
4. FSBI, 2004. Fisheries Society of The British ISLES Briefing Paper 3: Effects of Fishing On Biodiversity In The North Sea.
<http://www.fsbi.org.uk/assets/brief-biodiversity-north-sea-refs.pdf> (accessed March 31, 2015)
5. WWF, 2008. Return to Abundance: A Case for Marine Reserves in the North Sea a report for WWF-UK.
http://www.wwf.org.uk/filelibrary/pdf/marine_reserves_north_sea.pdf (accessed March 31, 2015)
6. OSPAR Commission, 2010. Quality Status Report 2010.
http://qsr2010.ospar.org/en/media/chapter_pdf/QSR_complete_EN.pdf (accessed March 31, 2015)
7. OSPAR Commission < <http://www.ospar.org/> > (accessed March 31, 2015)
8. Vittorio Barale, 2008. Remote Sensing of the European Seas.
<https://books.google.co.jp/books?id=9B3D5-HBTzkC> (accessed March 31, 2015)
9. Hutchinson, S.; Hawkins, L.E., 2007. Oceans: A Visual Guide. Shinjusha Co., Ltd.: China, 2007. Japanese translation.