5 North Sea

Overview

The North Sea is situated on the continental shelf of northwestern Europe. It is surrounded by England and Scotland on the west, Sweden and Norway on the east, and Denmark, Germany, the Netherlands, Belgium and France on the south.

The North Sea is heavily exploited by the surrounding, highly industrialized countries and is one of the busiest seas in the world. It has the largest oil and gas reserves in Europe.

Location

Basic information

Surface area : 750,000 km^2
Volume : 94,000 km^3
Average depth : 95 m
Maximum depth : 700 m

Nature

< Background >

The North Sea has a catchment area of about 850,000 km^2. The annual freshwater river input is on the order

of 300 km^3, 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.[1]

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. The annual precipitation of the Sea is around 425 mm, with the highest rainfall occurring along the Norwegian coast (about 1,000 mm/year), because moist air is uplifted against the high, steep mountain ranges.[1]

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.

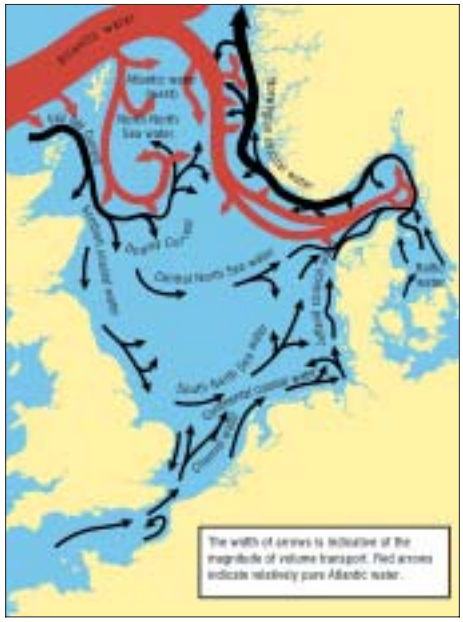
The deepest region in the North Sea is the Norwegian Trench, which runs along the coast of Norway. It reaches its maximum depth of 700 m off the southern Norwegian coast in the Skagerakk.[1]

Hydrology

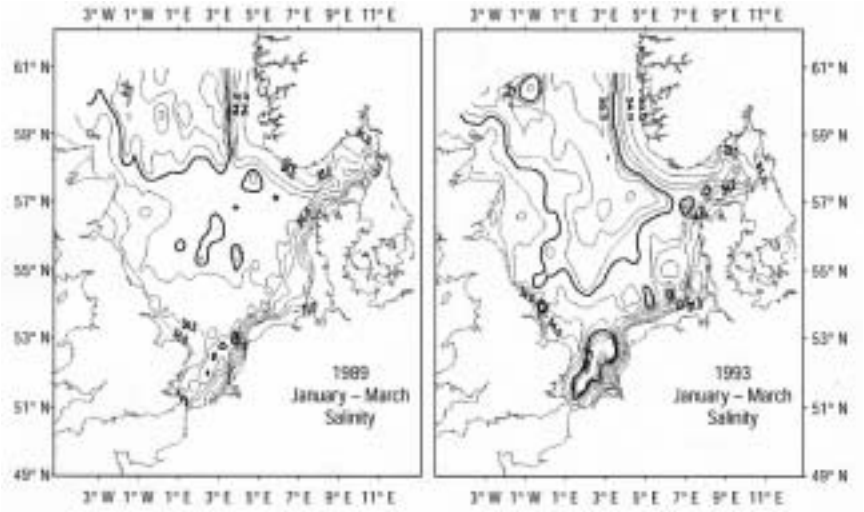
The hydrology of the North Sea is influenced by inflowing Atlantic waters, strong tidal action, fresh water inputs and climatic conditions.

The majority of the North Sea's oecanic (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 per cent 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.



Schematic diagram of general circulation in the North Sea[1]



Surface salinity distribution for the winters of 1989 and 1993[1]

Despite annual fluctuations, salinity in the open waters is around 35 and in the coastal waters is between 32 and 34.5. However, near the entrance to the Baltic Sea (Kattegat and Skagerrak) and in the Norwegian Trench, salinities are much lower (10—34), 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 ℃. 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.[1]

< Surrounding environment >

▶Diverse coastline

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.[1]

▶Marine Biodiversity

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 (see section on social environment for more details). Fish species diversity is lowest in the shallow southern North Sea and the eastern English Channel.

Marine mammals, such as harbour seals, grey seals, harbour 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 harbour porpoises, the most common cetacean in North Sea, is estimated to be around 300,000.[1]

History and Culture

< History of fisheries in the North Sea >

In the North Sea, fishing communities were established as long ago as the 1500s, and fishing have since been an essential activity for the North Sea countries. These ancient fishing communities mainly operated only to serve the local needs, and fishing were mainly restricted close to the shore.

In the mid-1500s, the Dutch revolutionized the fishery industry by introducing large-scale vessels. These vessels were large enough for processing the fish onboard, which enabled for more longer and distant voyages. This consequently lead to the dramatic increase in fish catch for the Dutch fishermen. They also incorporated the concept of fishery management by introducing restriction on net size and moratorium periods. Other fishing nations such as Scotland and England were behind the Dutch and still used small vessels and were not able to exploit the North Sea on the same extent.

Then with the advent of the steam trawler at the end of the 19th century, a massive exploitation of the North Sea fish stock began by many North Sea countries. By 1910, sailing ships were almost completely replaced by steam trawlers and the high catch capacity of these vessels gradually reduced the fish stocks in the North Sea. During this period, fish landings at some ports increased 30 fold compared to the mid 1800s level, and

in 1914 the U.K. total annual landing stood at over 450,000 tons. Since then fishing techniques has further advanced, though it has led to the current overexploitation of many commercial fish species.
<http://www.stonehaven.org.uk/history/fishing/genfish.htm>

Social Environment

< Population >

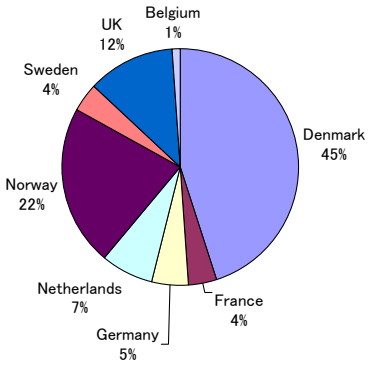
Approximately 184 million people live within the North Sea catchment area. The population is expected to reach a maximum in 2025. The population density is highest along the southern coast, especially along the western and northern coasts of the Netherlands, and least dense along the eastern coast of the North Sea.[1]

< 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.

▶Fisheries

Fishing is an extremely important industry in the North Sea, but its degree of importance for the bordering countries varies. In 1995, the total landing of fish and shellfish in the North Sea countries was 3.47 million tonnes, which was an increase of 1.1 million tonnes from 1990, and with Denmark (45%) and Norway (22%) recording the largest landings. Landings from industrial fisheries, accounted for about 55% of the above total landing with major species consisting of sand eels, Norway pout and sprat. The major fish species caught for human consumption are herring, horse mackerel, cod, haddock, whiting, saithe, plaice and sole.



Landings of fish and shellfish by the North Sea countries in 1995 (% by weight of total)[1]

Reflecting the increasing trend in landings, fishing effort in the North Sea has steadily increased since 1983, mainly due to the increase in beam trawl effort in the southern and central regions. In 1995, the total fishing effort was approximately 2.25 million hours.

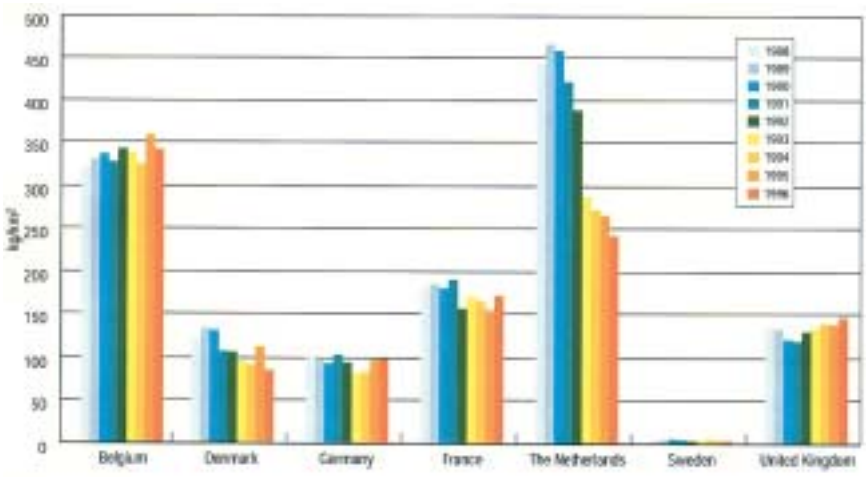
Aquaculture occurs in many of the North Sea states, but is negligible in Belgium and Sweden. Major fish and shellfish products are salmon, rainbow trout, blue mussels, oysters and scallops.[1]

Aquaculture production in the North Sea countries[1]

	Rainbow trout (t)	Salmon (t)	Blue mussel (t)	Oysters piece (p) or tonnes (t)	Scallops piece (p)	Clams (t)
Denmark (1996)	667	-	59,602	-	-	-
France	589	650	41,000	48,000 t	-	-
Germany (1996)	-	-	38,028	75 t	-	-
Netherlands	-	-	95,000	17,000,000 p	-	-
Norway (1996)	12,000	120,000	180	530,000 p	90,000	-
UK (1996)	11,400	27,700	7,700	14,000,000 p	3,000	12
Sweden (1996)	< 100	-	1,800	-	-	-

Agriculture

Over 42 per cent 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. Despite the known adverse impacts of pesticides on the environment, they are still widely used in the North Sea countries. There has been little reduction in their usage, except in the Netherlands, though its usage is still second highest next to Belgium.[1]



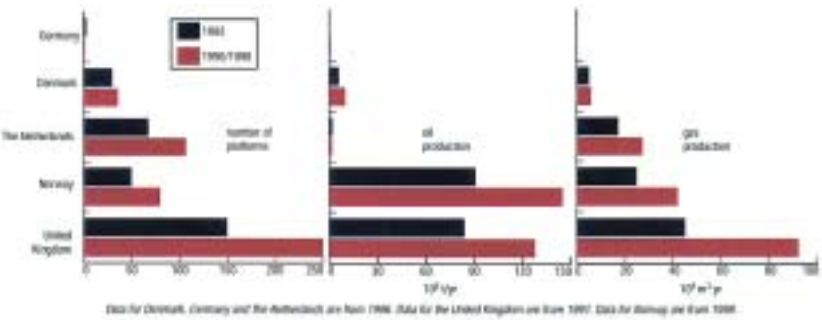
Trends in agricultural pesticides use in North Sea countries from 1988 to 1996[1]

Coastal industries

Metal production, metal processing and chemical 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.).[1]

Oil and gas industry

Since the late 1960s, the offshore oil and gas industry has been a major economic activity in the North Sea. During the mid-1990s, the number of platforms increased from 300 to 475 and oil production almost doubled. The major oil developments have been in the northern parts of the North Sea, in the U.K. and Norwegian regions. In fact, Norway is the third-largest oil exporter in the world. Gas is mainly exploited in the shallow southern regions of the Sea, in the U.K., Dutch, Danish and Norwegian regions.[1]



Comparison of offshore oil activities during the mid-1990s[1]

Environmental Problems

< Water and sediment quality >

The water quality of the North Sea has improved since the implementations of the Oslo and Paris Conventions on the Protection of the Marine Environment of the Northeast Atlantic (OSPAR) 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.[1]

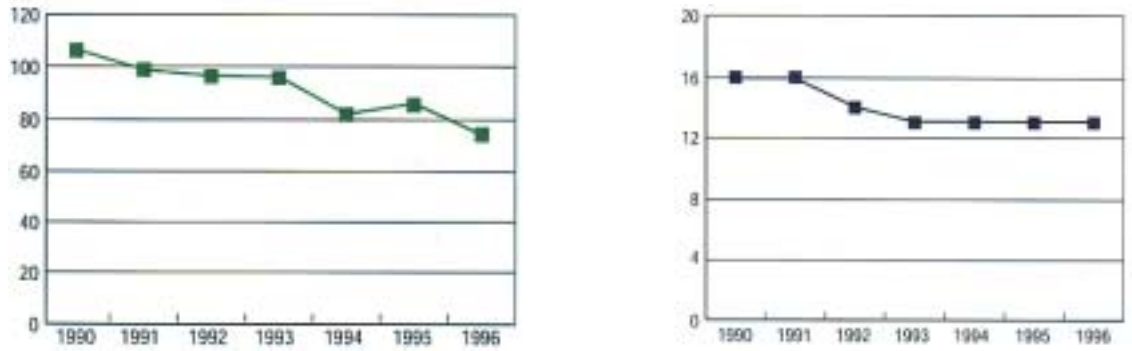
Eutrophication

The amount of land-based nutrient input into the North Sea is minor compared to the inputs from the

Atlantic Ocean, but land-based inputs still have considerable impacts on the coastal waters of the North Sea. This is especially true in areas with restricted water circulation and stratified water columns, such as in the Kattegatt, eastern Skagerrak, Wadden Sea, German Bight and various Norwegian fjords. These areas frequently suffer from eutrophication and periodic low oxygen levels, which affect the mortality, abundance and diversity of the resident benthic organisms. As a consequence, fishing for Norwegian lobsters has almost ceased in the Kattegatt region.

The majority of nutrient inputs from land-based sources are discharged into the North Sea via large rivers, accounting for 65 to 80% of total nitrogen and 80 to 85% of total phosphorus. Leaching from agricultural soil and discharges of urban wastewater are the main sources of nutrient inputs into these rivers. Other significant sources of land-based nutrients are discharged into the sea via the atmosphere, from domestic and industrial combustion processes and exhaust from vehicles, or directly into the North Sea, from the coastal urban and industrial areas.[1]

Overall, nutrient levels have not improved much along most of the North Sea coast, mainly due to the poor reduction of riverine nitrogen input from agriculture. On the other hand, according to the survey conducted between 1990 and 1996, the direct discharge of nutrients has been reduced significantly, with reductions of 30 and 20% for nitrogen and phosphorus, respectively. Furthermore, due to improvements in sewage and industrial facilities, the input of phosphorus has dramatically reduced since 1985, which is reflected in the significant decline in phosphorus concentration along the southeastern coast of the North Sea since 1989.[1]



Direct discharge of total nitrogen (left) and total phosphorus (right) into the North Sea, 1990—1996 (kt/yr)[1]

▶Contamination by trace organic compounds

Trace organic contaminants, such as PCBs, various pesticides (e.g. lindane, DDT and toxaphene), TBT and dioxins are found throughout the North Sea. These substances are transported into the North Sea via rivers, direct discharge, the atmosphere, dredge materials and shipping.

High PCB levels are detected along the Norwegian fjords and in the river mouths of Germany and Belgium. As a consequence, there are advisories that restrict the sale of fish and shellfish from several Norwegian fjords.

Although, concentrations of pesticides show a decreasing trend in most areas, elevated levels of DDT and toxaphene are still found in some marine species. Dioxin levels have been decreasing since 1990, following the implementation of reduction measures at industrial sources. However, high concentrations are still detected in the sediments of the Norwegian coast and in several seafood species, which has led to warnings against the consumption of some species from these areas.

High concentrations of TBT are mostly found in frequently-used waterways, since this chemical originates from the paint of large vessels. Very high levels are present in the waters and sediments of the harbors in Germany, the Netherlands, France and Denmark. In extreme cases, TBT levels in these harbors have reached 3,500 times (in water) and 30 million times (in sediment) the safe level for the environment or biota. There are many other synthetic compounds in the North Sea. The ecological effects of these substances are largely unknown and stronger measures are required to reduce the possible risks.[1]

< **Other Environmental Problems** >

▶Adverse impacts of fisheries

The main impacts of fisheries are overexploitation of target species, seabed disturbance and discarding and mortality of non-target species.

Due to overexploitation, many commercial fish species such as herring, cod, haddock, whiting, saithe, plaice and sole, are now outside or close to their safe biological limits. The stock of mackerel (*Scomber scombrus*) has completely collapsed since the mid 1960s. Fishing of these commercial species will certainly not be sustainable at current catch levels.

Seabed disturbance is caused by trawl fishing, notably beam trawlers. The fishing grounds of trawl fisheries are concentrated in certain areas, with some areas being visited more than 400 times a year and other areas not being visited at all. Most of the popular areas have high biological activity, and intense trawling has led to the destruction of important biological habitats, such as mussel beds, cold-water coral, *Sabellaria* reefs and seagrass beds. Trawling has also altered the composition of infaunal and epifaunal species. Nowadays, the benthic community is dominated by small, opportunistic species rather than larger, long-lived species.

The discarding and mortality of non-target species by fisheries has various effects. Certain fishing practices lead to the discarding of more than half the weight of all species caught. Estimates of discarded fish in the North Sea amount to 0.55 million tonnes per year, which is quite substantial compared to the total landings of around 3.5 million tonnes per year. Also, marine mammals and seabirds often become tangled in gill and fixed nets. More than 7,000 harbour porpoises are killed each year posing a significant threat to their populations.

Various measures are being implemented to reduce fishing pressures on commercial species to protect the North Sea ecosystem and to reduce the adverse impacts mentioned above. The most obvious method for doing this is to use the Total Allowable Catch (TAC) system, with quotas allocated to each country. However, for reasons of socio-economics and inaccurate stock assessment, TAC levels have not always been set at levels that facilitate sustainable fish populations.[1]

Other popular measures include the reduction of fishing-vessel size, improvement of fishing equipment and techniques, and establishment of closed areas and seasons (e.g. the restriction of the cockle fishery in the Dutch Wadden Sea and protection of juvenile cod in the German Bight). These measures have been successful to a certain extent, but further considerations and cooperation between the North Sea countries are still required[1].

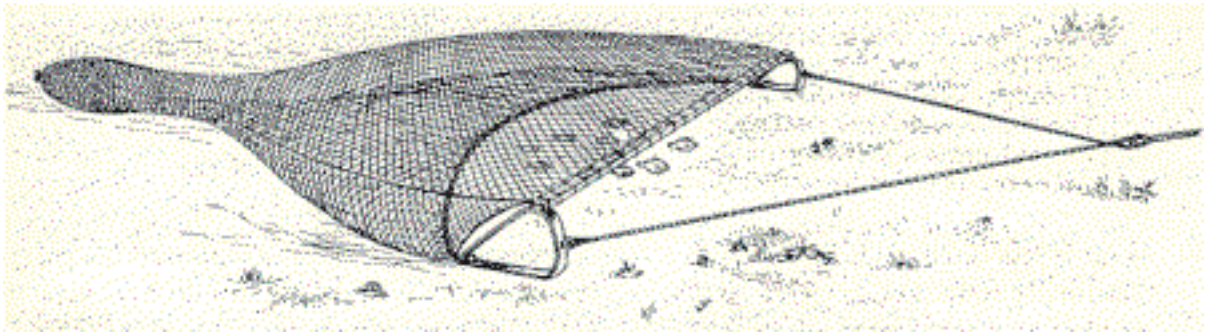


Diagram of beam trawl

< http://www.cefas.co.uk/fishinfo/western%20stocks/Beam%20Trawl.htm >

< **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 activities.

< http://www.unep.ch/seas/ospar.html >

▶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 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.[1]

▶Related organizations and NGO

- Common Wadden Sea Secretariat — Implementation of the Trilateral Wadden Sea Cooperation (Joint organization of the Netherlands, Denmark and Germany to protect the Wadden Sea) < http://cwss.www.de/ >
- The Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS) — An organization dedicated to protecting small cetaceans < http://www.ascobans.org/ >
- The North Sea Commission < http://www.northsea.org/ >
- The International Commission for the Protection of the Rhine (ICPR)
  - < http://www.iksr.org/hw/icpr/ >

References

1. OSPAR Commission 2000. Quality Status Report 2000, Region Ⅱ — Greater North Sea. OSPAR Commission, London.