XIII-42 North Sea: LME #22

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The North Sea LME is situated on the continental shelf of northwestern Europe. It covers an area of 694,000 km², of which 1.94% is protected (Sea Around Us 2007). Besides the North Sea with an area of 575,000 km^2 and average depth of 94 m, this LME includes a part of the deep-water basin between the Faroes and Shetland Islands. The North Sea LME includes one of the most diverse coastal regions in the world, with a great variety of habitats (fjords, estuaries, deltas, banks, beaches, sandbanks and mudflats, marshes, rocks and islands). Among its many river systems and estuaries are the Thames, Rhine, Elbe, Sheldt and Ems. A temperate climate and four seasons characterise this LME. Great Britain, Norway, Sweden, Denmark, Germany, the Netherlands, Belgium and France are the countries bordering the North Sea. LME book chapters and articles pertaining to this LME include Daan (1986, 1993) and McGlade (2002). There is a wealth of data on the North Sea. Information on climatology, and physical, chemical and biological oceanography was published by McGlade in 2002. ICES issued a report on the fisheries and fish of this region in August 2008.

I. Productivity

The North Sea LME is a Class II, moderately productive ecosystem (150-300 $gCm^{-2}yr^{-1}$). Primary production varies considerably across the LME. The highest primary productivity occurs in the coastal regions, influenced by terrestrial inputs of nutrients, and in areas such as the Dogger Bank and tidal fronts. For more information on plankton communities, benthic, fish and shellfish communities, as well as for food web dynamics and information about bird communities and marine mammals see McGlade (2002). The Sir Alister Hardy Foundation for Ocean Science has been conducting Continuous Plankton Recorder surveys, collecting data from the North Atlantic and the North Sea on biogeography and ecology of plankton since 1931. The Foundation website reports on plankton abundance in the North Sea (www.**sahfos**.ac.uk/).

Oceanic fronts (after Belkin et al. 2009): Up to ten fronts have been distinguished in the North Sea LME from satellite data (Belkin *et al*. 2009) (Figure XIII-42.1). The North Atlantic Current enters the North Sea from the north. Its branches are associated with the Fair Isle Front (FIF) and Shetland Front (ShF). The Norwegian Coastal Current Front (NCCF) extends along the Norwegian Coast and separates the low-salinity near-shore waters from Atlantic waters. Tidal mixing fronts form around Dogger Bank (DBF) and off Flamborough Head (FHF). The Atlantic waters entering the North Sea via the English Channel form two fronts, western (WECF) and eastern (EECF) fronts at their contact with resident waters; these fronts flank the Atlantic inflow. The Frisian Front (FF) origin is related to the fresh outflow from the Rhein River and Scheldt River. The Skagerrak Front (SkF) is located at the boundary with the Baltic Sea waters.

North Sea LME SST (Belkin, 2009)(Figure XIII-42.2)
Linear SST trend since 1957: 0.88°C.
Linear SST trend since 1982: 1.31°C.

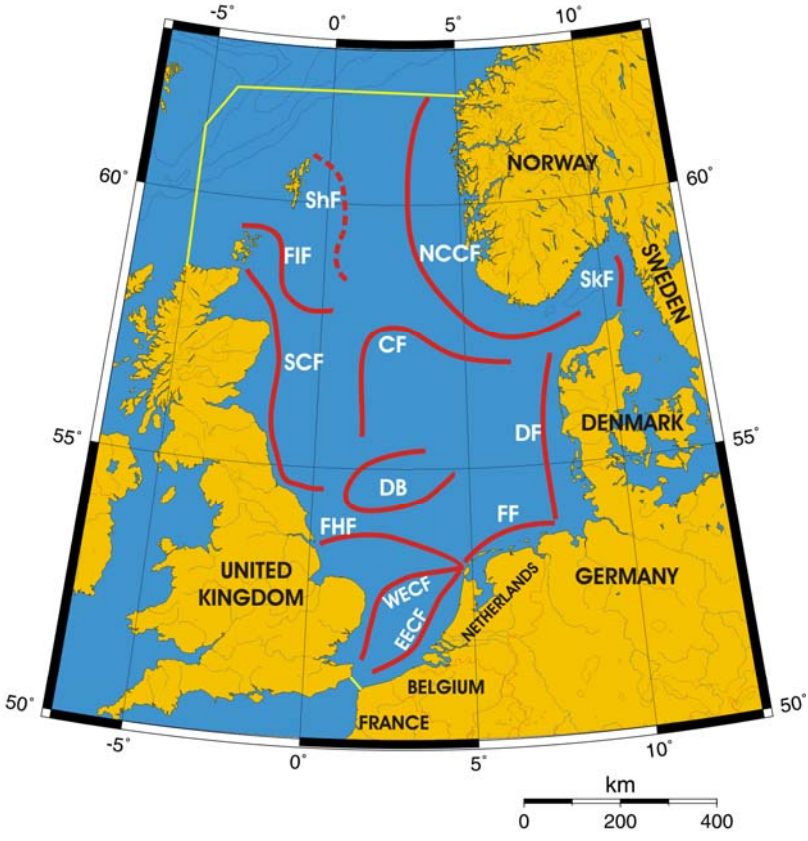

Figure XIII-42.1. Fronts of the North Sea LME. CF, Central Front; DBF, Dogger Bank Front; EECF, East English Channel Front; FF, Frisian Front; FHF, Flamborough Head Front; FIF, Fair Isle Front; NCCF, Norwegian Coastal Current Front; ShF, Shetland Front; SkF, Skagerrak Front; WECF, West English Channel Front. Yellow line, LME boundary. After Belkin et al. (2009).

The 50-year long-term warming of this LME was not uniform. In fact, the North Sea cooled in 1957-1986; this cooling culminated in two cold events of 1979 and 1986 linked to two consecutive Great Salinity Anomalies, GSAs (Dickson et al., 1988; Belkin et 1998). The cold event of 1986 was followed by a dramatic rebound by 1.3°C over the next three years. The third cold event of 1996 was linked to the GSA of the 1990s (Belkin, 2004). The above decadal-scale events were likely associated with the North Atlantic Oscillation, NAO. The cold event of 1962-63 may have been associated with a previous GSA, which is not fully documented because of scarce hydrographic data. The post-1982 warming of 1.31°C makes the North Sea the 2nd fastest warming LME of the last 25 years (after the Baltic Sea LME).

The ongoing rapid warming of the North Sea will likely have an adverse effect on recruitment and catches of boreal fish species (Stenevik and Sundby, 2007). In particular, water temperature in coastal areas of the North Sea is inversely correlated with cod recruitment and catches (Hannesson, 2007). At the same time, warm-water species are expected to become more abundant (Stenevik and Sundby, 2007).

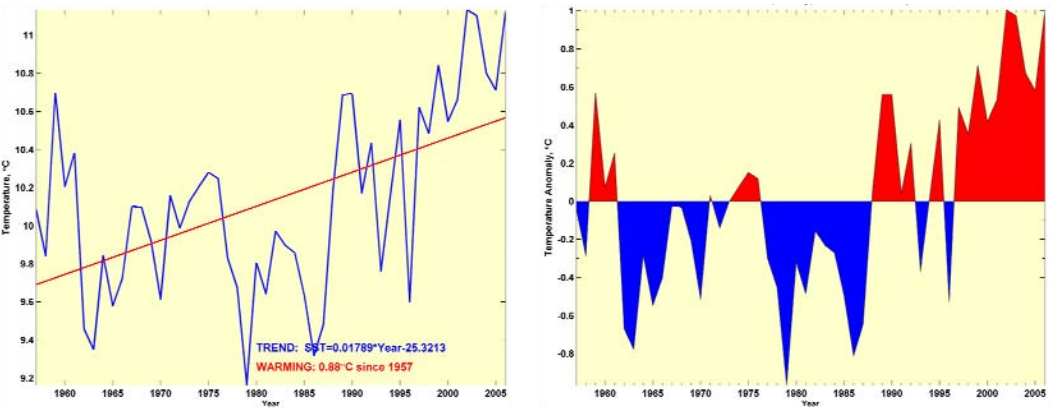

Figure XIII-42.2. North Sea LME annual mean SST (left) and SST anomalies (right), 1957-2006, based on Hadley climatology. After Belkin (2009).

North Sea LME Chlorophyll and Primary Productivity: The North Sea LME is a Class II, moderately productive ecosystem (150-300 $gCm^{-2}yr^{-1}$) (Figure XIII-42.3).

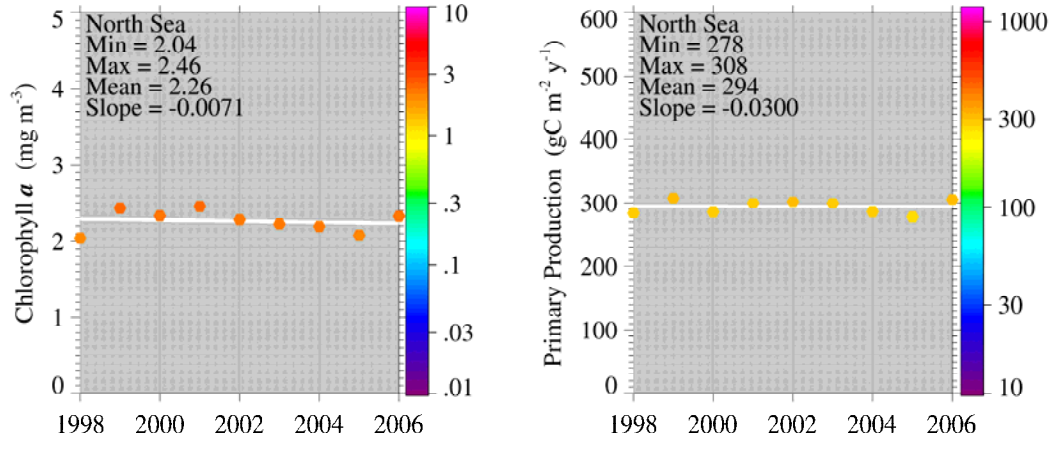

Figure XIII-42.3. North Sea LME trends in chlorophyll *a* (left) and primary productivity (right), 1998-2006, from satellite ocean colour imagery; courtesy of K. Hyde.

II. Fish and Fisheries

Fishing is a long-established activity in the North Sea LME and there is a wealth of fisheries data. The most important species for human consumption represented in the catch are cod-like fishes (cod, saithe, haddock, etc.), herring, sprat and flatfishes. For more information on North Sea fishing fleets, see McGlade (2002). Landings from the industrial fishery consist mainly of sandeels, Norway pout and sprat. There are several commercially important shellfish species of molluscs and crustaceans, including shrimp, crab, lobster, oysters, mussels and scallops. The North Sea, on average, supported total reported landings of over 3 million tonnes per year from the mid 1960s to the early 1990s, with a peak landing of 4.4 million tonnes in 1968 (Figure XIII-42.4). However, reported landings have declined consistently since the early 1990s. The value of the reported landings reached US$3.5 billion (in 2000 US dollars) in 1968, following which it steadily declined (Figure XIII-42.5).

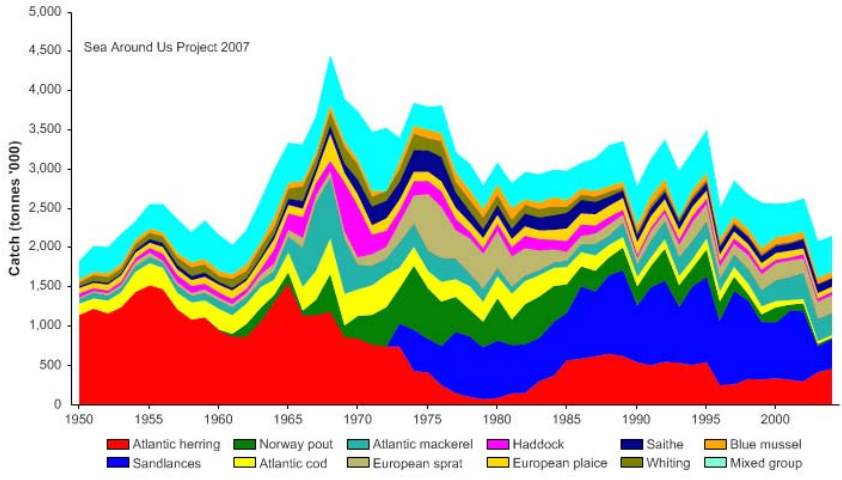

Figure XIII-42.4. Total reported landings in the North Sea LME by species (Sea Around Us 2007)

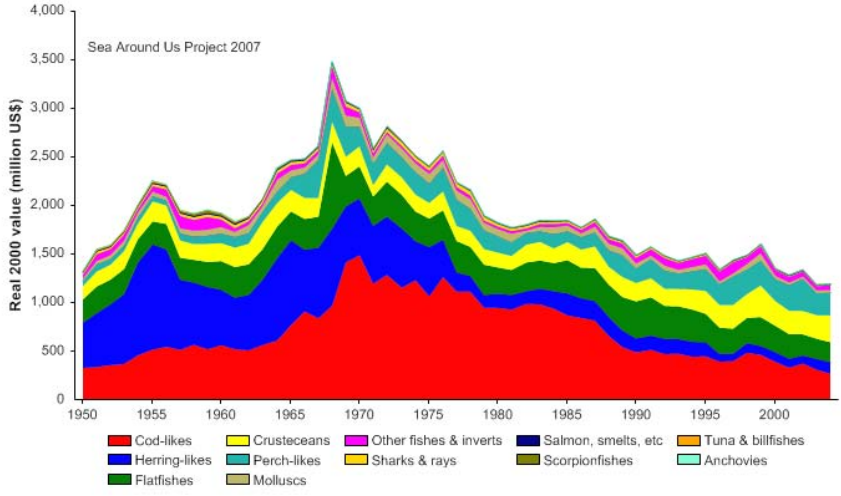

Figure XIII-42.5. Value of reported landings in the North Sea LME by commercial groups (Sea Around Us 2007)

The primary production required (PPR; Pauly & Christensen 1995) to sustain the reported landings in this LME reached an extremely high level, over 70% of the observed primary production in the late 1960s, but has declined to less than 40% in recent years (Figure XIII-42.6). Denmark, Norway and the United Kingdom account for the highest share of the ecological footprint in this LME. The mean trophic level of the reported landings (i.e., the MTI; Pauly & Watson 2005) has shown a steady decline since 1970 (Figure XIII-42.7, top), an indication of a 'fishing down' of the food web in the LME (Pauly et al. 1998). The FiB index has been on a similar decline over the past three decades (Figure XIII-42.7, bottom). Both indices thus correspond with the detailed analysis by Froese & Pauly (2003), which was based on catch data starting in 1903. The Stock-Catch Status Plots, based on the first analysis of an LME using such plots (Froese and Pauly 2003), indicate that the numbers of collapsed and overexploited stocks have been increasing, accounting for close to 80% of all commercially exploited stocks in the LME (Figure XIII-42.8, top). A majority of the reported landings biomass, particularly in recent years, is supplied by overexploited stocks (Figure XIII-36.8, bottom).

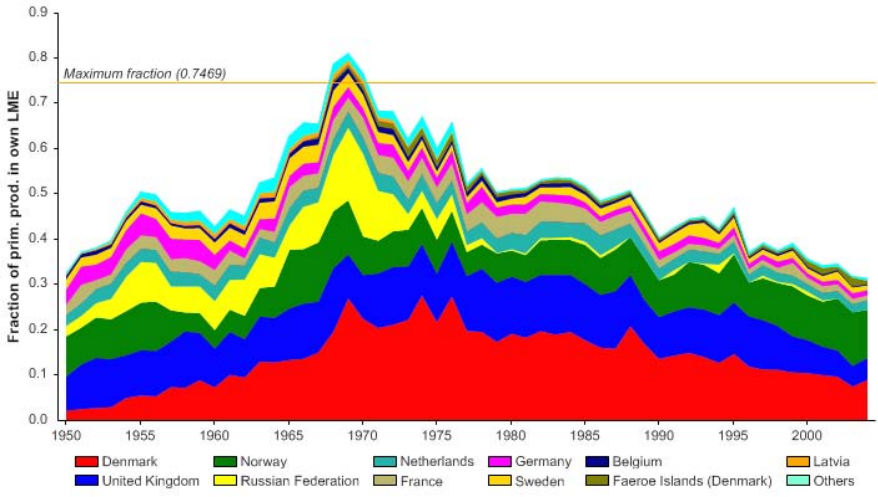

Figure XIII-42.6. Primary production required to support reported landings (i.e., ecological footprint) as fraction of the observed primary production in the North Sea LME (Sea Around Us 2007). The 'Maximum fraction' denotes the mean of the 5 highest values.

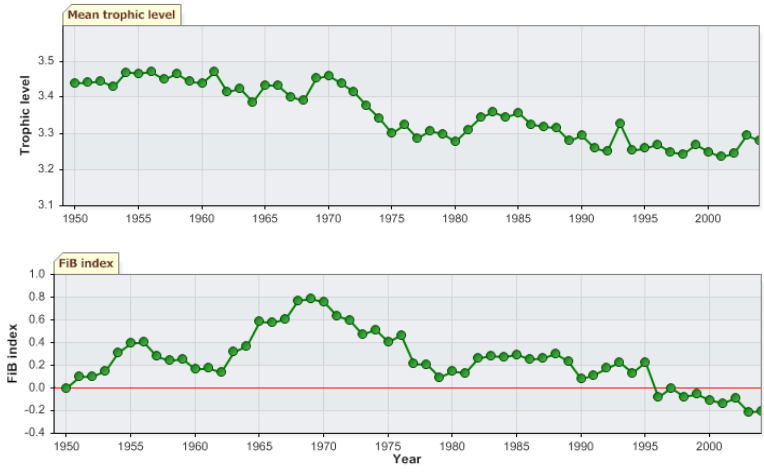

Figure XIII-42.7. Mean trophic level (i.e., Marine Trophic Index) (top) and Fishing-in-Balance Index (bottom) in the North Sea LME (Sea Around Us 2007).

The LME is not stable with regard to individual fish species. Changes in the abundance of commercially important fish stocks have been monitored since the 1950s. All are heavily exploited and the majority of those exploited for human consumption are considered to be seriously depleted. In fact, intensive fishing is the primary force driving the LME. Analytical assessments of all commercially important species are carried out by ICES (www.ices.dk). Improvements in fishing equipment (more powerful engines, hydroacoustic equipment, and the purse-seine net in the mid 1960s) have changed the nature of the fisheries. Various management measures (closures, restrictions on the number of vessels, fishing gear and time) have been enacted to try to control fishing mortality, but these are not systematic throughout the LME. The inclusion in the EU of all riparian countries except Norway led to the development of the Common Fisheries Policy, the results of which are mixed.

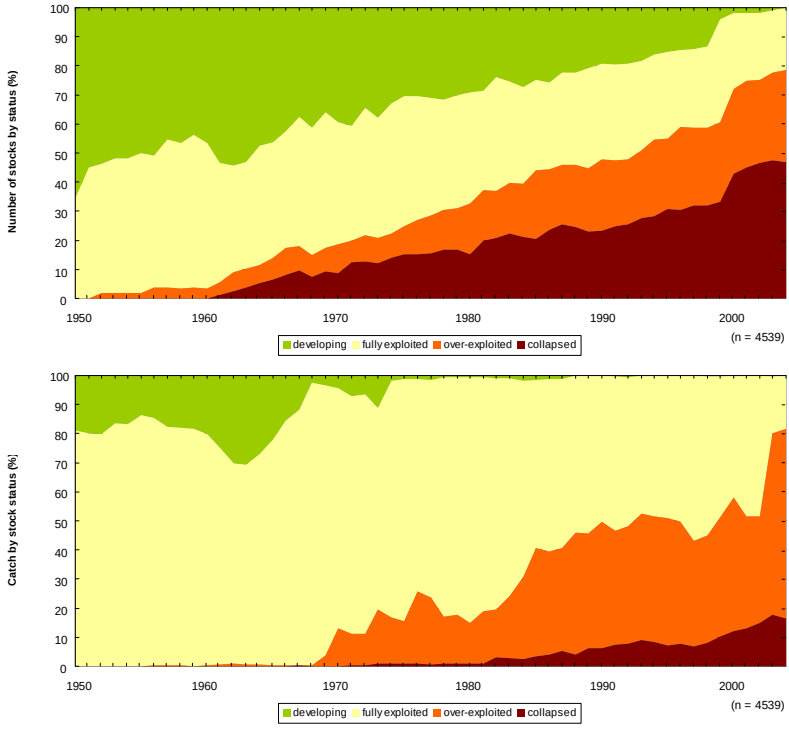

Figure XIII42.8. Stock-Catch Status Plots for the North Sea LME, showing the proportion of developing (green), fully exploited (yellow), overexploited (orange) and collapsed (purple) fisheries by number of stocks (top) and by catch biomass (bottom) from 1950 to 2004. Note that (n), the number of 'stocks', i.e., individual landings time series, only include taxonomic entities at species, genus or family level, i.e., higher and pooled groups have been excluded (see Pauly *et al*, this vol. for definitions).

III. Pollution and Ecosystem Health

Both offshore and land-based activities have a significant effect on the North Sea LME. Eutrophication is now a major environmental issue arising from the general increase in nutrient discharges from rivers, land run-off and the atmosphere, largely resulting from sewage effluents, leaching from agricultural land, contributions from rural populations and atmospheric nitrogen deposition. Hazardous substances, oily wastes and slicks are a problem for birds and marine mammals. Alien species have been introduced into the North Sea ecosystem through ballast water and shipping. For more information on the impacts of non-indigenous species, coastal habitats, the ecological impacts of pollution and the effects of marine industries (hazardous and radioactive substances, oil and oily wastes, litter and dumping), see McGlade (2002). An assessment of the health of the North Sea LME was initiated in 1987 as part of the international ministerial activities to address concerns over the impact of human activities and climate change on the ecosystem. In 2000, ICES reviewed the effects of different types of fisheries on North Sea benthic ecosystems. Effective on 11 August 2007, the EU Directive 2005/33/EC on the North Sea SECA (Sulphur Emission Control Area) came into force to regulate sulphur emissions from all ship fuels not to exceed 1.50% m/m/ (www.imo.org and www1.veristar.com).

IV. Socioeconomic Conditions

The North Sea LME plays a key role in one of the world's major economic regions. Approximately 185 million people live in highly industrialised countries, the United Kingdom, Norway, Sweden, Denmark, Germany, the Netherlands, Belgium, France, the Czech and Slovak Republics, Switzerland, and Austria, which have part or the totality of their territory in the catchment area of the North Sea (Ducrotoy 2003). The fishing sector is important in terms of employment, with about 260,000 fishers directly involved in fishing. Currently, the European Union fishing industry comprises 97,000 vessels. The industry supports additional significant numbers of jobs in processing, packing, transportation, marketing, ship-building, fishing gear manufacture and servicing. The LME is also a source of economic resources other than fisheries. The North Sea supports highly productive extractive industries of hydrocarbons, sand and gravel. It is a transport highway as well as a sink for waste and pollution. The Straits of Dover and the North Sea itself are among the most heavily-used sea routes in the world, and are serviced by large commercial ports. Recreation and tourism are important activities in the LME. Large wind parks are in advanced planning stages.

In 2000, the EEA reported that approximately 164 million people lived in the North Sea catchment area, and use the coastline and the marine environment. Due to increased population growth and industrial activity, many of its resources are close to over-exploitation. The fisheries sector is under increasing pressure to allow fish stocks to recover. The northern seaboard will continue to supply at least 50% of the total energy requirements of the European Union, with increases in natural oil and gas production from the North Sea and off Scotland.

V. Governance

A new Marine Strategy Framework Directive was recently enacted which promotes and integrates environmental considerations into all relevant policies areas and which forms the basis for a future Maritime Policy for the EU. The exploitation of natural marine resources in the North Sea is governed by a number of conventions, declarations and regulations. These include the Geneva Convention on the Continental Shelf (1958), the joint declaration of the EU Commission on the coordinated extension of jurisdiction in the North Sea through the establishment of EEZs (1992), and European Commission directives and regulations within the Common Fisheries Policies. All in all, a large number of instruments from international bodies, such as the UN, IMO and the EU, exist to conserve natural resources, protect the environment and ensure health and safety standards. The European Community laws protect the environment in terms of air and noise, chemicals and industrial risks, nature conservation, waste and water. The European Union "North Sea Programme Progress Report" (2006) offers insight into social and environmental activities calculated to build capacity to enable sustainable management of existing resources in rural and urban areas around the North Sea. The OSPAR Commission has information on the 1992 Convention and ministerial declarations on the ecosystem approach (www.ospar.org/eng/html/ welcome.html). The Oslo and Paris Conventions (OSPARCOM) contain a number of supporting legislative and policy instruments. The Esbjerg Conference in 1995 enlarged the focus of protection to wildlife beyond territorial waters, promoted sustainable fishery management, and pushed for more research on the effects of chemicals on reproductive systems. It is expected that future conferences will be held at 5-year intervals (see Reid 1999). The principle of precautionary management has been successfully introduced in the North Sea fisheries, particularly for herring. For more information on governance of European fisheries, and on political and legal regimes, see McGlade (2002).

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