



Factors affecting the distribution Of North Sea fish

CONTENTS:

- 1 *Physical environment*
 - 1.1 *The North Sea*
 - 1.2 *Skagerrak and Kattegat*
- 2 *Factors affecting the distribution of fish*
- 3 *Biological environment*
- 4 *References*

1 Physical environment

Although strictly speaking outside the scope of this *Atlas*, brief reference must be made to some basic physical features of the North Sea and adjacent waters, since these are important factors affecting the distribution of fishes. Over broad spatial areas, the main abiotic factors that affect the distribution of fishes and fish communities are water temperature, salinity, depth and substrate type. Obviously other features, including biotic factors (predator-prey interactions, competition, local-scale habitat features) and anthropogenic activities (e.g. the presence of artificial structures, fisheries) can also be important factors operating on a variety of temporal and spatial scales.

1.1 The North Sea

The North Sea is a relatively small basin, with a surface area of about 575 300 km², and a volume of 42 300 km³ [1]. The northern-western boundary lies along the edge of the continental shelf, west of Orkney and Shetland. The northeastern boundary is formed by a deep-water trough, the Norwegian Deep, which attains depths of up to 700 m. The North Sea is connected to Atlantic water masses along these northern boundaries. The North Sea is also connected to the Baltic by the Skagerrak and Kattegat and has a southerly connection with the Atlantic, via the English Channel, at the Dover Strait.

Although the North Sea occupies a rather small area, it is by no means homogeneous as regards, for example, depth (Fig. 1), temperature, water type, and substratum. Waters are relatively shallow over much of the area, with average depths ranging from about 30 m in the southeast to 200 m in the northwest.

The North Sea is influenced by the Atlantic Ocean, mainly by input from the north but also, to a lesser extent, via the Channel. To the northwest of the British Isles, a strong Atlantic current flows north along the edge of the continental shelf. Several currents bring Atlantic water into the northern North Sea, with one current entering the Norwegian Deep [2,3]. The physical oceanography has been reviewed by [4].



Factors affecting the distribution of North Sea fish

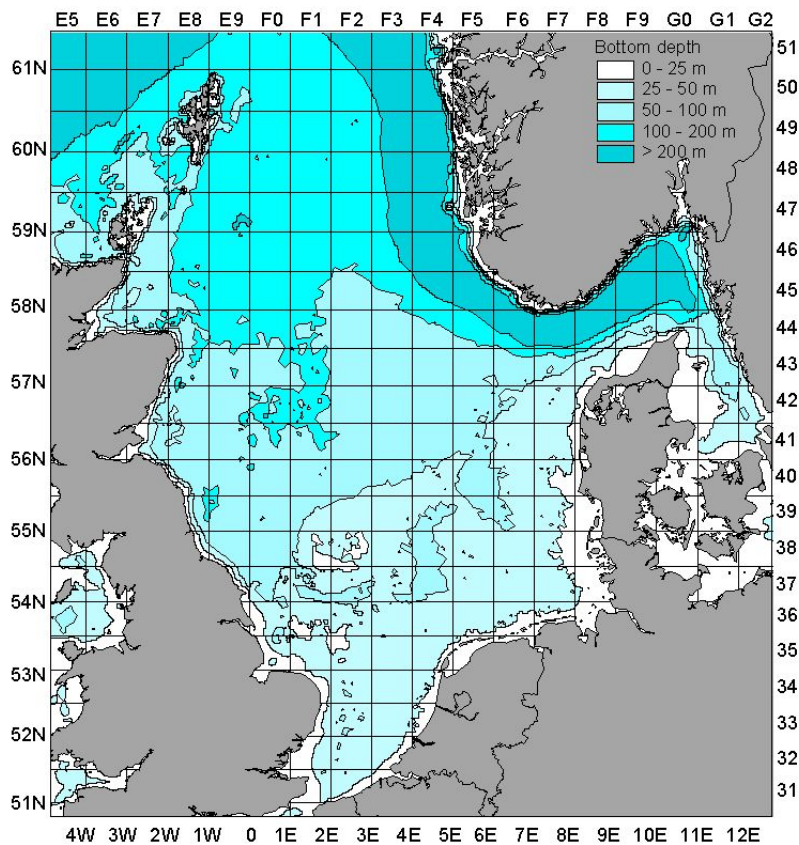


Figure 1. Bathymetry of the North Sea.

There are marked seasonal and regional differences in the vertical structure of the water column. Throughout the winter, the water in most areas is vertically well mixed, or only slightly stratified. From spring to autumn, however, the waters in some areas remain mixed, whereas stratification occurs in other areas. In stratified waters, which occur over large parts of the northern and central North Sea, the water temperature near the surface increases much more rapidly than the temperature near the bottom and a strong seasonal thermocline develops during May and June. The thermocline becomes more pronounced during the summer and autumn and is broken down by wind and wave action in late autumn. The boundaries between mixed and stratified areas are usually characterized by steep horizontal gradients in temperature and/or salinity [5]. Average bottom temperatures and salinities in winter and summer are shown in Figures 2–5.

Temperatures in the deeper parts show less seasonal variation in comparison to the shallow waters of the German Bight, where drift ice may occur during cold winters. Salinity ranges from approximately 29‰ in the southeastern North Sea, where a large volume of fresh water inputs occur, to more than 35‰ in the northwest, where oceanic Atlantic water enters the North Sea. The major source of fluvial input in the southern North Sea and coastal waters of the central North Sea is the Rhine, with further contributions of the Thames Estuary, the Wash, Humber, Tees, Tyne, Scheldt, Weser and Elbe.

On the basis of hydrographic and biological conditions, the North Sea has been divided into seven geographical 'boxes' (Fig. 2).



Factors affecting the distribution of North Sea fish

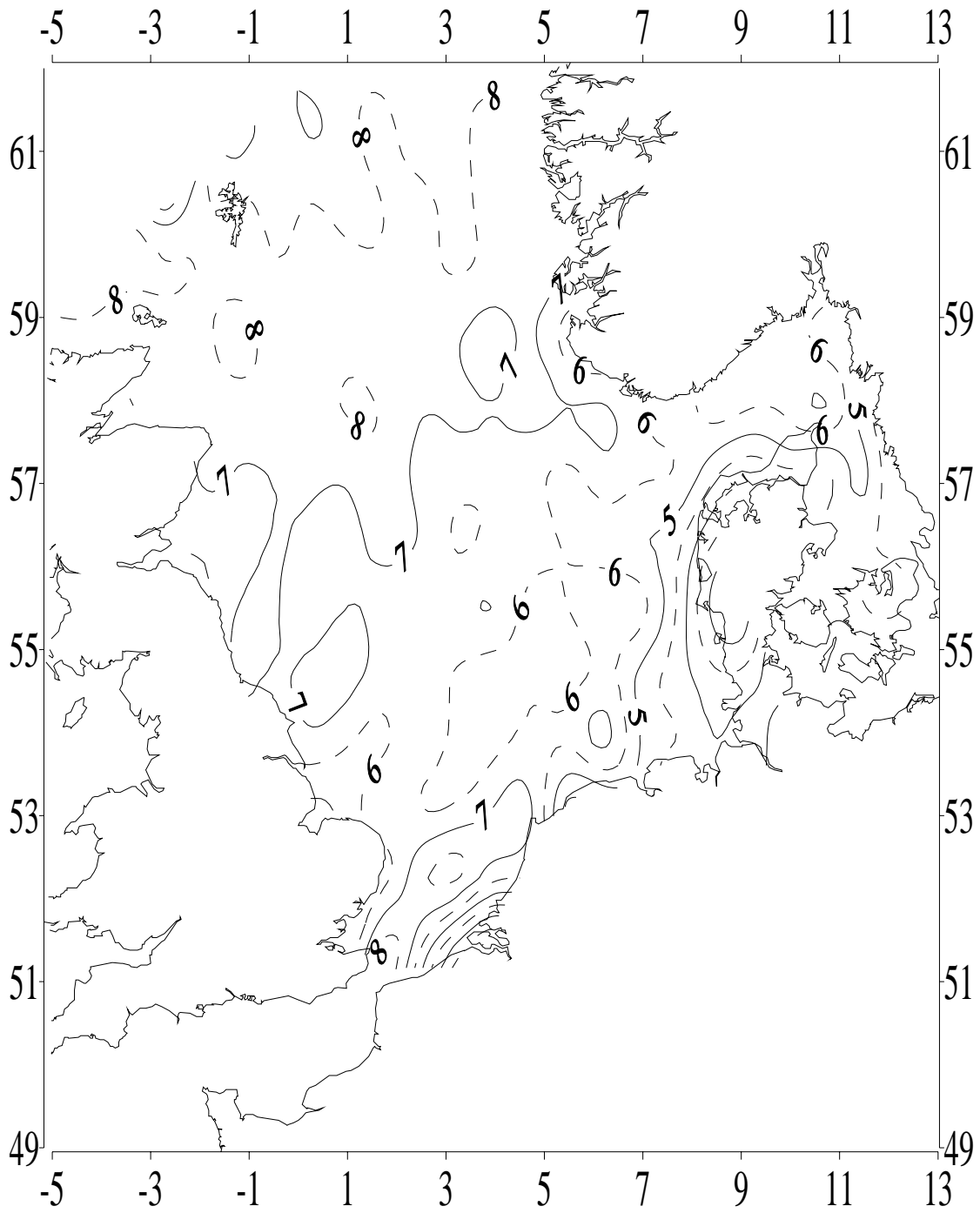


Figure 2. Average bottom temperature in winter, 1997-2002 (ICES).



Factors affecting the distribution of North Sea fish

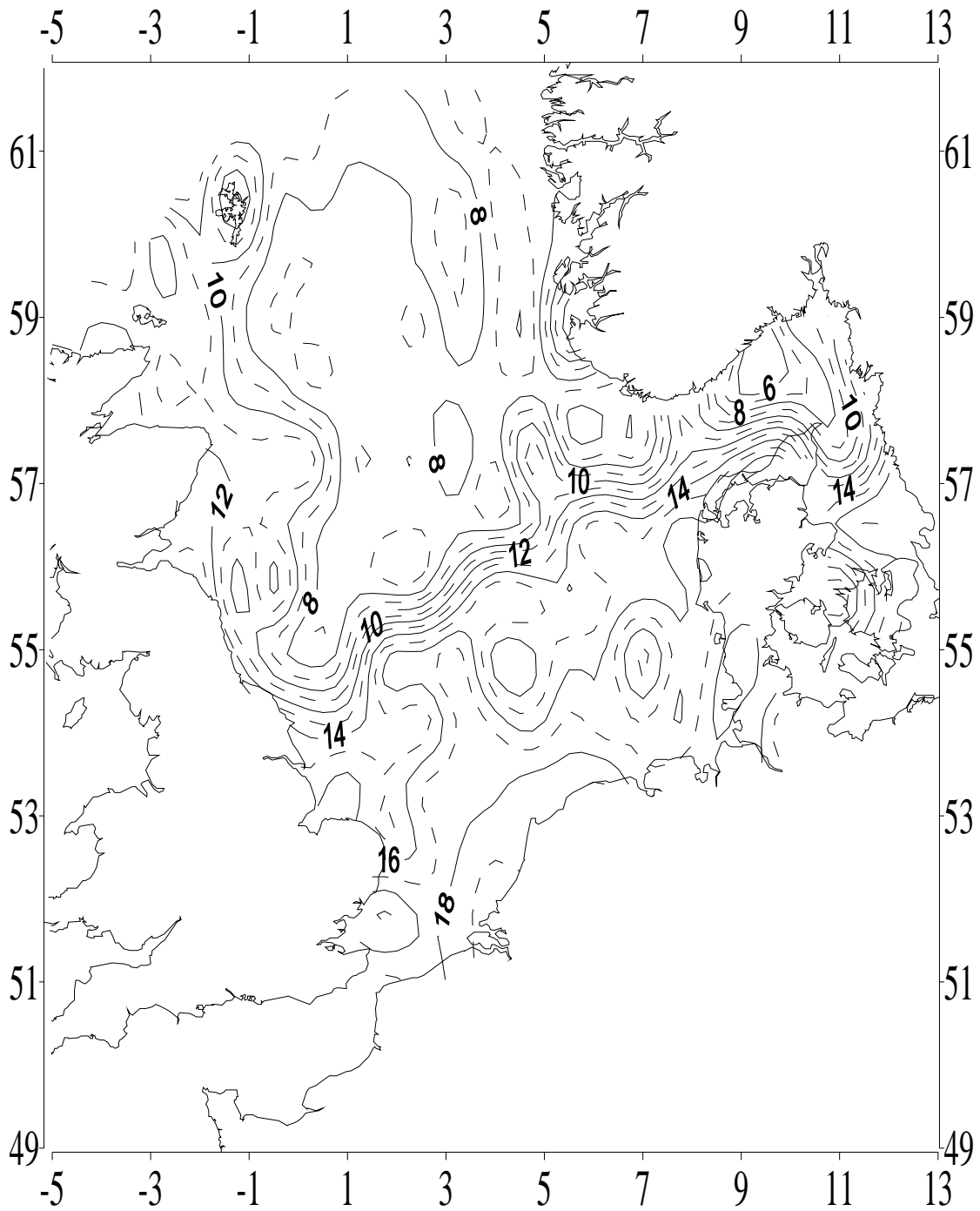


Figure 3. Average bottom temperature in summer, 1997-2002 (ICES).



Factors affecting the distribution of North Sea fish

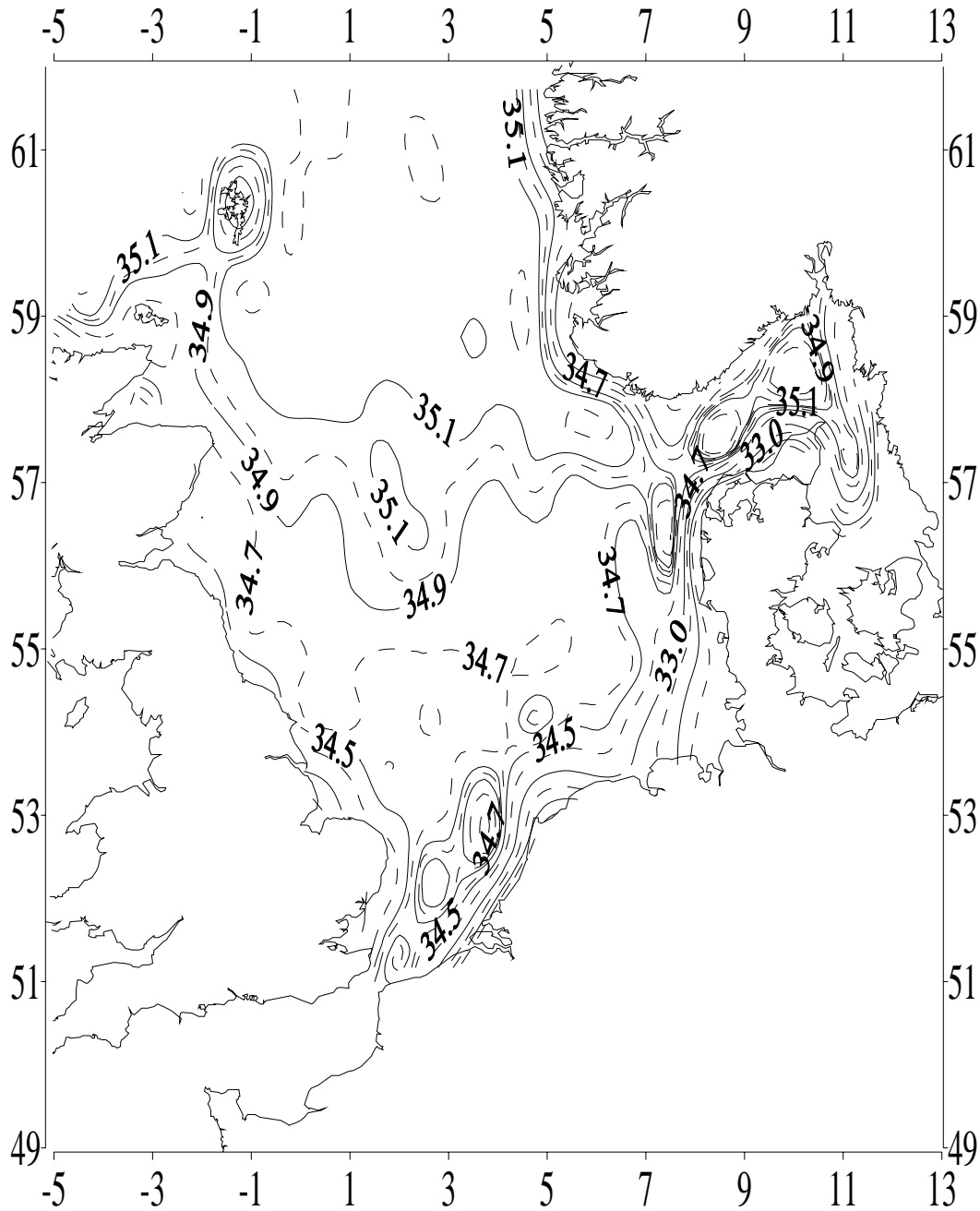


Figure 4. Average salinity in winter, 1997-2002 (ICES).



Factors affecting the distribution of North Sea fish

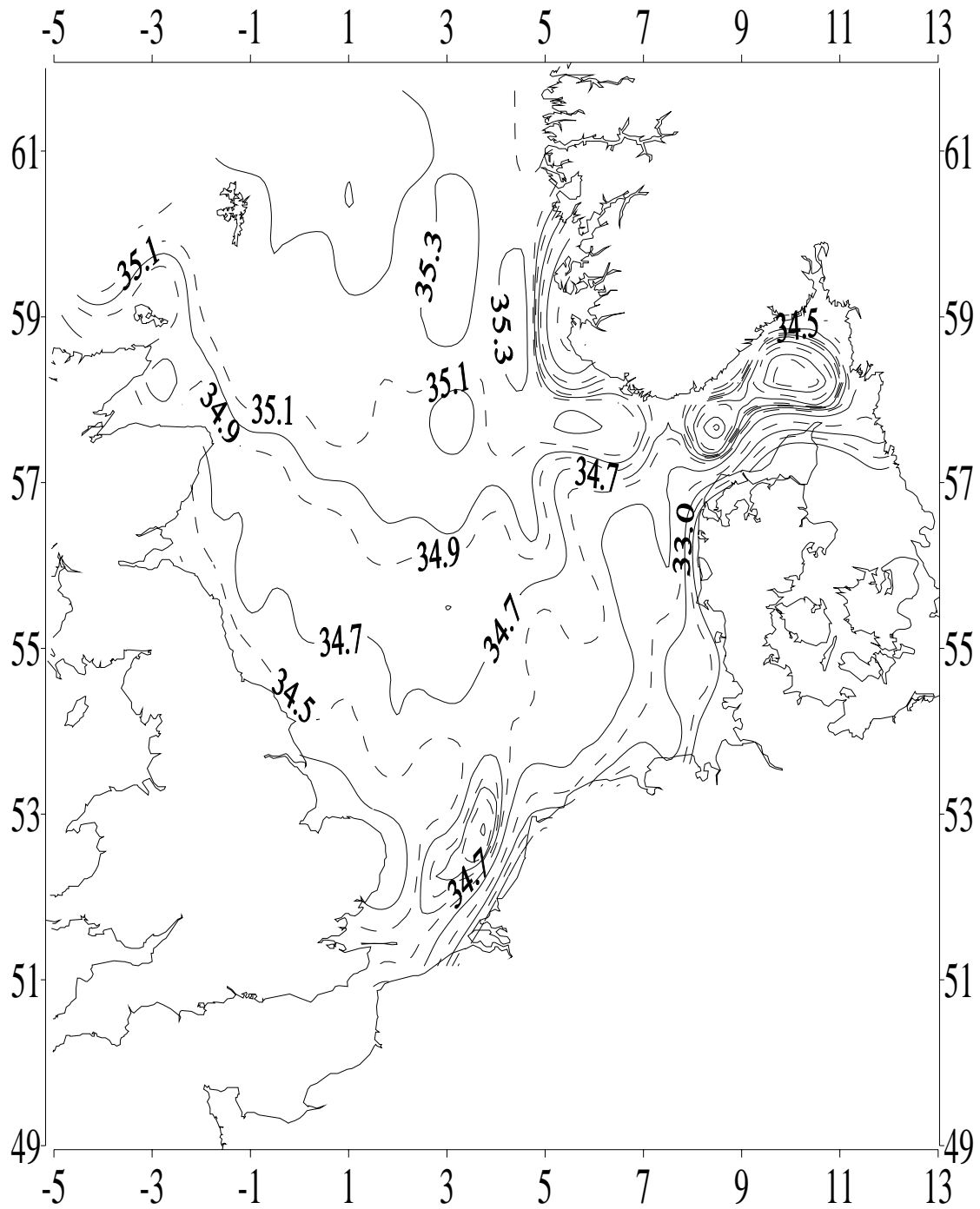


Figure 5. Average salinity in summer, 1997-2002 (ICES).



Factors affecting the distribution of North Sea fish

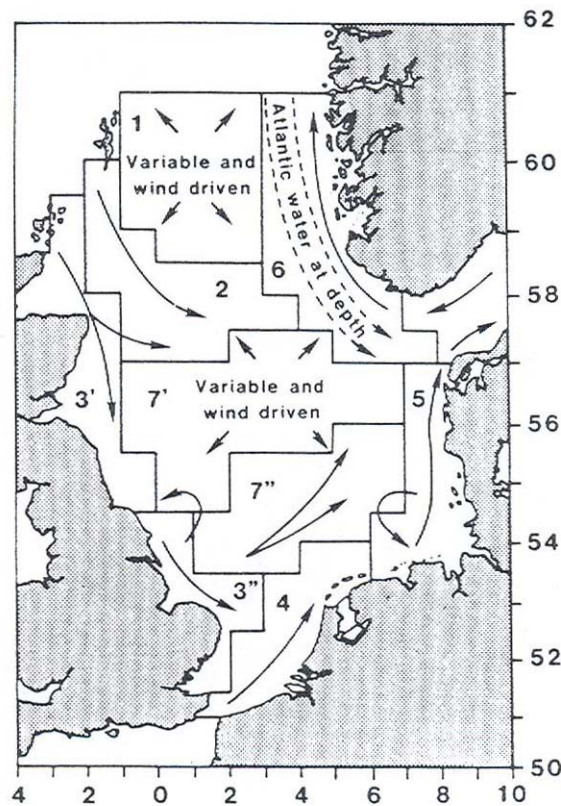


Figure 6. Hydrographical subdivisions of the North Sea. A schematic representation of the surface currents is superimposed [1]. See text for further explanation.

Area 1, in the northern North Sea east and south-east of Shetland is characterized by a slow-moving water mass of recent oceanic origin, and is stratified in the summer. Area 2, which lies south and south-west of area 1, has more rapid water movements of mixed oceanic-coastal waters, and is only partly stratified during the summer. The coastal waters of Scotland and England (Area 3) are comprised of slow-moving waters with a southerly drift, with transient stratification, with several sources of fresh water input. The coastal waters of Scotland and north-east England (Area 3') tend to be deeper (> 50 m) than off south-east England (Area 3''), where waters are usually less than 50 m deep. The waters off Belgium and The Netherlands (Area 4) are also shallow (< 50 m deep) and have an inflow of Atlantic water from the Channel that mixes with the coastal water under a relatively strong influence of tidal currents. There are strong horizontal gradients of salinity in this area, with vertical stratifications only occurring close to the coast. The coastal waters off Germany and Denmark (German Bight, Area 5) have a general northward drift, with coastal waters having some stratification. The waters of the northeastern North Sea (Area 6) comprise surface waters with a northward movement of Norwegian coastal water and Baltic outflow; and deeper layers that are laterally heterogeneous, with a southerly flow in the west (water of recent oceanic origin) and northerly flow in the east (mixed water masses). The central North Sea water masses (Area 7) comprise waters moving in variable directions, with a slow net movement and strongly developed summer thermoclines, and in the summer there are some differences between the areas north and south of the Dogger Bank (Areas 7' and 7'').

In terms of substrate, the seabed of the North Sea is variable, consisting of mud, sand, gravel, and boulders (Fig. 7).

The sedimentary environment of the North sea is dominated by muddy sands, sand and gravelly sand, with several important muddy habitats. Harder grounds (e.g. boulder fields) occur in the German Bight and off the coasts of Scotland, Orkney and Shetland.



Factors affecting the distribution of North Sea fish

Distribution of Bottom Deposits

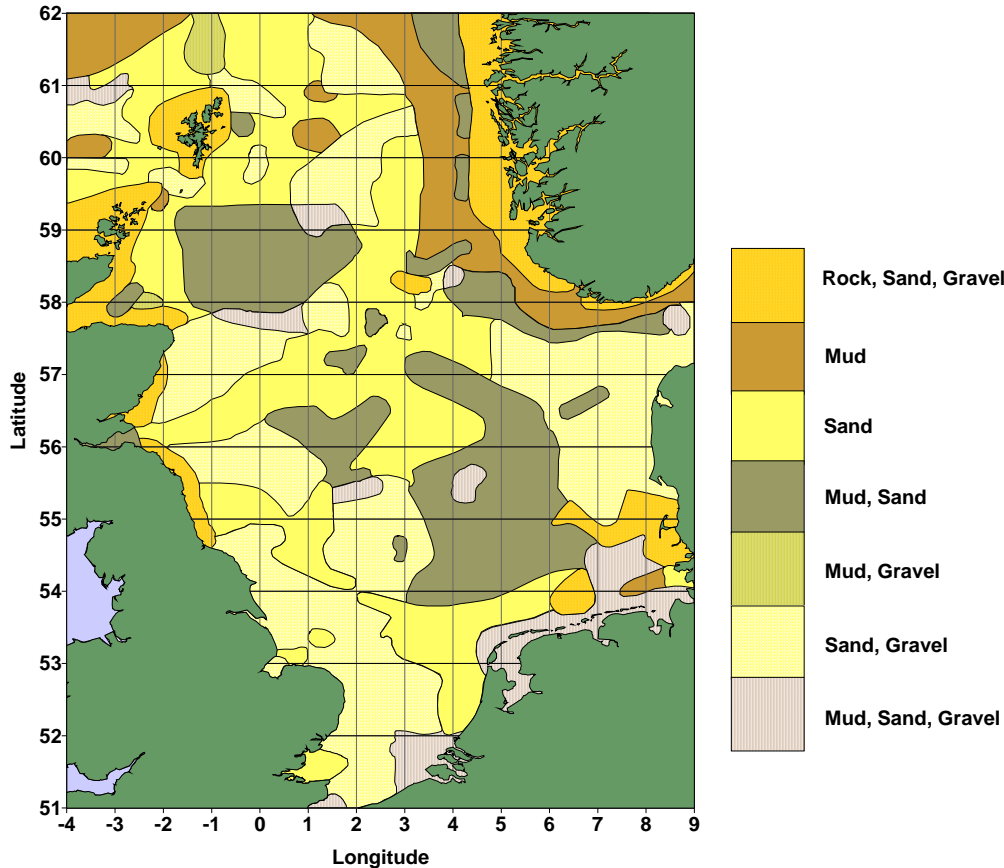


Figure 7. Distribution of bottom deposits in the North Sea [6].

1.2 Skagerrak and Kattegat

The Skagerrak can be regarded as a transitional area between the North Sea and the Baltic [7,8], whereas the Kattegat can be considered as part of the Baltic. The surface area of the Skagerrak is 32 300 km², its volume 6 780 km³ and its average depth is 210 m. The relatively great average depth of the Skagerrak is largely due to the fact that there is an area of deep water (ca. 700 m) in the region where the Norwegian Deep and the Skagerrak meet. The Kattegat, in contrast, is much shallower with an average depth of only 23 m. Water from the Skagerrak enters the Kattegat via a deep current, while a surface current (the Baltic current) transports brackish Baltic water to the Skagerrak and North Sea. In the southern areas of the Kattegat surface salinity may be as low as 15‰. The salinity in the Skagerrak is lowest along the Norwegian and Swedish coasts (ca. 25‰) but increases nearer to the North Sea, where salinities can reach ca. 30‰. In February the mean surface temperature in the Kattegat is 2°C, and extensive areas of drift ice may occur in the Skagerrak and Kattegat in winter. In August, surface temperatures reach 16–17°C.



Factors affecting the distribution of North Sea fish

2 Factors affecting the distribution of fish

The Channel is generally considered to represent a biogeographical boundary between the northerly boreal province, and the more southerly Lusitanian province [9]. Although many boreal species are widespread throughout much of the North Sea (e.g. cod, herring), several of the Lusitanian species that are largely restricted to the Southern Bight such as lesser weever *Echiichthys vipera*, greater weever *Trachinus draco*, striped red mullet *Mullus surmuletus* and bass *Dicentrarchus labrax*. In contrast, many boreal species tend to be more abundant in northern parts of the North Sea such as haddock *Melanogrammus aeglefinus*, and species such as wolf-fish *Anarhichas lupus* and Norway pout *Trisopterus esmarki* reach their southern limits in the central North Sea.

Owing to the oceanic circulation of the North Atlantic, a warm current (North Atlantic Drift) runs northwards along the western coasts of the British Isles, and this enables some southerly species to occur further north along the western seaboard of the British Isles than in the North Sea. Those southerly species of fish that occur along the edge of the continental shelf (ca. 200m depth) will also occur at more northern latitudes in the westerly North Sea, for example blue-mouth redfish *Helicolenus dactylopterus*, while more broadly distributed deepwater species such as rabbitfish *Chimaera monstrosa* may be found all along the northern shelf edge and the Norwegian Deep. During some years, when there is an influx of oceanic Atlantic water into the northern North Sea, there can be increased numbers of particular species [10,11].

Other physical factors (e.g. salinity, hydrodynamics and substrate type) and biological interactions (e.g. predator-prey relationships) will also affect the distribution and relative abundance of fish on more local scales. Some species have specific habitat requirements, for example witch *Glyptocephalus cynoglossus* tend to occur on muddy grounds. In addition to sediment type, the structure and topography of the seabed (e.g. the presence of sand ripples, sessile invertebrates and wrecks) will also affect the local distribution of fish, as such complex habitats can provide cover, and therefore reduce natural mortality. However, the habitats favoured by any given species of fish may vary both with age and time of year.

Though the overall biogeographical distribution of fishes is well documented in ichthyological literature [12-14], there is less information on the distribution and relative abundance of fishes, and their various life-history stages, using contemporary data on spatial scales relevant to fisheries management [15].

3 Biological environment

The variation in the physical environment is, of course, reflected in the flora and fauna. The different substrata support very diverse communities of bottom-living animals and, similarly, each water mass supports a different group of planktonic organisms. A description of this diversity is beyond the scope of *ICES-FishMap*, but general information can be found in a number of review papers [16-23].

It must be realized that for the fish the North Sea is an open system which can not be considered in isolation from the west of Scotland shelf, Norwegian Sea, Channel, and Skagerrak [24]. Although many commercial species are considered to represent self-sustaining stocks within the boundaries of the North Sea, others are only parts of a much larger stock complex (e.g. spurdog *Squalus acanthias*).

Over 230 fish species have been recorded from the North Sea (24-27). These species originate from three zoogeographical regions, with approximately 30% of Boreal (northern) origin, 50% of Lusitanian (southern) origin and 20% of Atlantic origin [26, 29].



Factors affecting the distribution of North Sea fish

The fish fauna of the North Sea can be grouped into distinct assemblages, which differ in species composition, abundance, and habitat. Over the North Sea as a whole, three main groups may be identified on the basis of trawl survey data [23,30], corresponding with the southern, central and northern North Sea (see text on *The North Sea Fish Community*). However, more discrete communities (e.g. those that occur on rocky grounds or in estuaries) are also present in the region.

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