MINISTRY OF AGRICULTURE, FISHERIES AND FOOD
DIRECTORATE OF FISHERIES RESEARCH

FISHERIES RESEARCH TECHNICAL REPORT
NUMBER 99

Biogeographical identification of English Channel fish and shellfish stocks

M.G. Pawson

LOWESTOFT
1995

The editor: M. G. Pawson, is a Grade 7 (Principal) Scientific Officer in the Fish Stock Management Division, Section 2, at the Fisheries Laboratory at Lowestoft. He is co-chairman of the Channel Fisheries Study Group through which English, French and Channel Isles scientists are investigating the nature and activities of fishing fleets, and the fish and shellfish resource populations they exploit, in the English Channel. The contributions of members of the Study Group to this Laboratory Leaflet are detailed in the Acknowledgements.

Fish. Res. Tech. Rep., MAFF Direct. Fish. Res., Lowestoft, (99): 72pp.

CONTENTS Page

Acknowledgments

This Technical Report is based on a report to the European Commission prepared by staff of the MAFF Directorate of Fisheries Research at Lowestoft and the Institut Francais de Recherche pour l'Exploitation de la Mer (IFREMER) Centres at Boulogne, Port-en-Bessin and Brest. The following people were responsible for the original extraction of information from published research papers and analyses of unpublished data held by MAFF or IFREMER, and the subsequent interpretation of each species' stock identity:

MAFF	(Lowestoft)		
		D Bennett	lobster, edible crab, spider crab
		J Casey	hake
		D Palmer	scallop
		W Dawson	anglerfish, mackerel, scad
		S Flatman	lemon sole
		T Hulme	herring, sprat, pilchard
		S Jennings	cod, whiting
		R Millner	plaice, sole
		G Pickett	bass, black bream
		M Vince	spurdog, rays
IFREMER	(Boulogne)		
		P Lorance	mackerel, herring
		A Souplet	cod, whiting
	(Port-en-Bessin)		
		M Giret	plaice, sole
		J Morin	scallop
		A Tetard	rays
	(Brest)		
		P Berthou	scallops
		D Latrouite	edible crab, spider crab, lobster
		Y Morizur	pollack, black bream, anglerfish, bass

Biological information was also provided on edible crab by S Ozanne (Guernsey Sea Fisheries Committee), black bream by S Bossy (Jersey SFC) and cuttlefish by V Legrand (French Regional Fisheries Committee), and by D Symonds (groundfish surveys), J Riley (nursery area surveys) and R Harrop (plankton distributions), all of MAFF.

INTRODUCTION

At present, the majority of fisheries around the British Isles are monitored and regulated in areas which are delineated by the International Council for the Exploration of the Sea (ICES), as shown in Figure 1. Fish communities are unlikely to be restricted to any of these areas, though the abundance of the more important commercial species, and their response to exploitation, are assessed within each of these areas, and thus **management** stocks are defined principally on a species-area basis. The concept of **biological** stocks, however, relies on the premise that there are groups within a species population which have sufficient spatial and temporal integrity to warrant consideration as self-perpetuating units. It is possible that several biological stocks of the same species may be exploited within each management area, and stocks which migrate through any particular area may have been exploited by fisheries in other areas. It is unlikely that the exploitation rate on individual biological stocks can be optimised when fish are being harvested from a number of such stocks. Furthermore, over-exploitation of any biological stock may result in a loss of genetic diversity and may reduce the resilience of the species as a whole to environmental change.

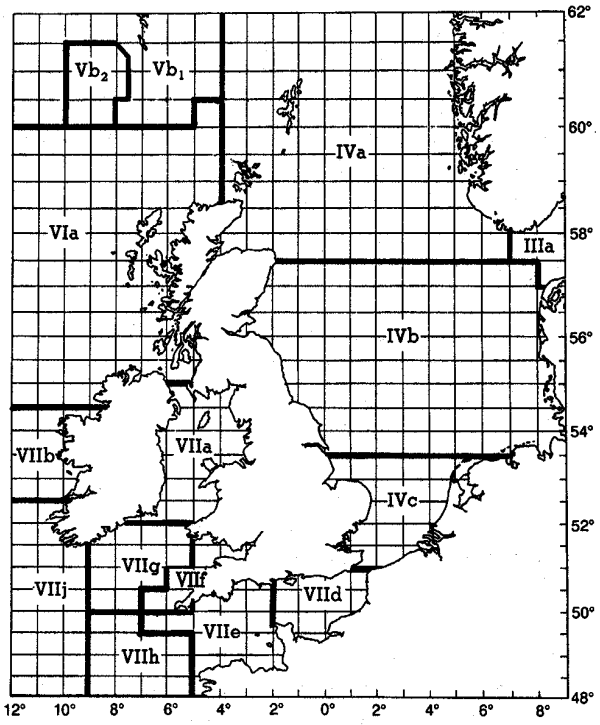

Figure 1. The ICES Divisions of the sea areas around the British Isles

Table 1. Total national landings of 25 species by French, English, Channel Island and Welsh vessels and corresponding landings from the English Channel (ICES divisions, VIId and VIIe) in 1989

Species		Landings (tonnes)		
Common name	Scientific name	Total *[1,2]	Channel *[1,2] (VIId & e)	% from Channel
Scallop	*Pecten maximus*	10370	8998	87
Cuttlefish	*Sepia officinalis*	14343	13737	96
Lobster	*Homarus gammarus*	875	357	41
Edible crab	*Cancer pagurus*	13812	8758	63
Spider crab	*Maja squinado*	6491	5548	85
Spurdog	*Squalus acanthias*	10836	621	0.6
Thornback ray	*Raja clavata*)	11233*[3]	1975*[3]	18
Cuckoo ray	*Raja naevus*)			
Herring	*Clupea harengus*	15387	10732	70
Sprat	*Sprattus sprattus*	1632	1584	97
Pilchard	*Sardina pilchardus*	11701	1899	16
Cod	*Gadus morhua*	62857	5711	0.9
Whiting	*Merlangius merlangus*	30905	6008	19
Pollack	*Pollachius pollachius*	6815	2982	44
Hake	*Merluccius merluccius*	23646	932	4
Ling	*Molva molva*	12469	2310	19
Bass	*Dicentrachus labrax*	3134*[4]	1311*[4]	42
Black bream	*Spondyliosoma cantharus*	1041	640	61
Mackerel	*Scomber scombrus*	59913*[5]	16203*[5]	27
Scad	*Trachurus trachurus*	14165	3354	24
Red gurnard	*Aspitrigla cuculus*	6179*[6]	4193*[6]	68
Plaice	*Pleuronectes platessa*	37923	8687	23
Lemon sole	*Microstomus kitt*	4662	1143	25
Sole	*Solea solea*	10852	3022	28
Angler	*Lophius piscatorius*	24144*[7]	3810*[7]	16

Notes: *[1] *Official landings from MAFF database unless stated otherwise*
*[2] *Official landings from IFREMER database unless stated otherwise*
*[3] *UK landings data are for all skate and ray species combined*
*[4] *Official landings plus logbook-based UK landings estimates*
*[5] *International landings estimate for 1990*
*[6] *No English or Welsh data available*
*[7] *Data for L. piscatorius and L. budegassa combined*

For fisheries management purposes, the stock unit is conventionally delineated by the extent to which the effects of exploitation in a particular fishery are recognisable through a species' population. Nevertheless, this management unit should also have a high degree of biological integrity. The biological identification of stocks is, therefore, an important step towards developing a rational strategy for the management of their fisheries.

The aim of this Report is to present information describing the identification and distribution of the stocks of the most commercially important species which support fisheries in the English Channel, (Table 1). For this purpose, members of the Channel Fisheries Study Group have reviewed the existing literature and analysed some historical data sets and other previously unpublished material, on each of 25 marine species. Their overall distribution is described, in conjunction with a more detailed analysis of seasonal abundance in the Channel and adjacent seas, followed by a synthesis of information on the distribution and movements of the early life history stages obtained from plankton samples and mathematical models of water current movements. Movements of the adult component of stocks in the Channel, and adjacent seas, have been determined from the results of tagging studies and examination of fish sampled from research survey catches and commercial landings from different regions. Each sub-section ends with an evaluation of our knowledge of that species' stock structure in the English Channel. The validity of the various approaches to stock identification is discussed, together with our conclusions about the relationships between probable stock boundaries and the existing management areas in the English Channel.

A DESCRIPTION OF THE PHYSICAL, CHEMICAL AND BIOLOGICAL STRUCTURE OF THE ENGLISH CHANNEL

The separation of stocks and their identity may be maintained by characteristics of their environment. Therefore, before dealing with the 25 species listed in Table 1, a brief description is provided of the physical, chemical and biological characteristics of the English Channel.

The English Channel has a maximum depth of 100 m at its western mouth (5°W), shallowing to 40 m in the central Dover Strait (Figure 2). The bottom is relatively flat, except near the coast and around the Hurd Deep. Waters with depths below 50 m are more extensive in the Golfe Normande-Breton and Baie de Seine than off the English coast. The Channel is a shallow part of the Atlantic Ocean's continental shelf, and has strong tidal currents which are superimposed on long-term water movements called tidal residuals.

Although the currents in the Channel are mainly the result of tide, they are also influenced by wind and pressure gradients and, to a lesser extent, by density gradients and temperature differences induced by freshwater (from rivers) mixing with marine waters. The vertical hydrodynamic structure of this area depends mainly on depth and the effect of bottom topography on tidal currents. It varies from a stratified structure (weak currents, deep water) in the west, where a thermocline develops from March to September, to an eastern zone which remains relatively homogeneous, due mainly to bottom turbulence (strong currents, shallow waters). The transitional areas have characteristics of both regimes: a slightly stratified profile which becomes homogeneous at depth, dependent on the bottom turbulence, and where there are large horizontal surface water temperature discontinuities called thermal fronts. Salinity gradients have their greatest effect on the physical structure in estuaries, where vertical stratifications can develop due to freshwater input (e.g. in the Baie de Seine).

Our knowledge of the general flow of water through the Celtic Sea and the English Channel has been established by direct and indirect measurements with the aid of numerical models. It appears that the circulation pattern is composed of a 'river' between the Atlantic and the North Sea, which carries a water flux of about 17 000 cubic metres per second, for an average tide. Eddies, associated with tidal flow around headlands, within basins or over sand ridges, have been confirmed from direct observations. Examination of residual circulation also reveals confined areas, closed gyres (eddies) and boundaries, which must play a role in containing fish eggs and limiting the dispersion of larvae in the plankton. Tidal flow also has a significant effect on the transport of solids within the Channel and thus the distribution of sediments. Alluvial deposits and the associated organic material have an important influence on the development and structure of biological ecosystems. It has been estimated that the drainage area of freshwater into the Channel is 13000 km², of which the Seine basin represents two-thirds.

Phytoplankton is an important component of the ecosystem in the frontal and mixed regions, where the zooplankton biomass considerably exceeds that of the well-stratified water. In the English Channel, as in other temperate shelf waters, the distribution of plankton is determined directly by water movement and indirectly by the effects of tidal mixing, and seasonal stratification has an important effect on species' succession and survival.

Climate and sedimentary texture determine the distribution of benthic organisms, due to their ecological requirement or tolerance: many species are restricted largely to the western Channel, whereas other species, fewer in number, have a strictly eastern distribution. Thus, there is a net decrease in the diversity of benthic organisms from west to east. The persistent west to east movement of water through the Channel makes north-

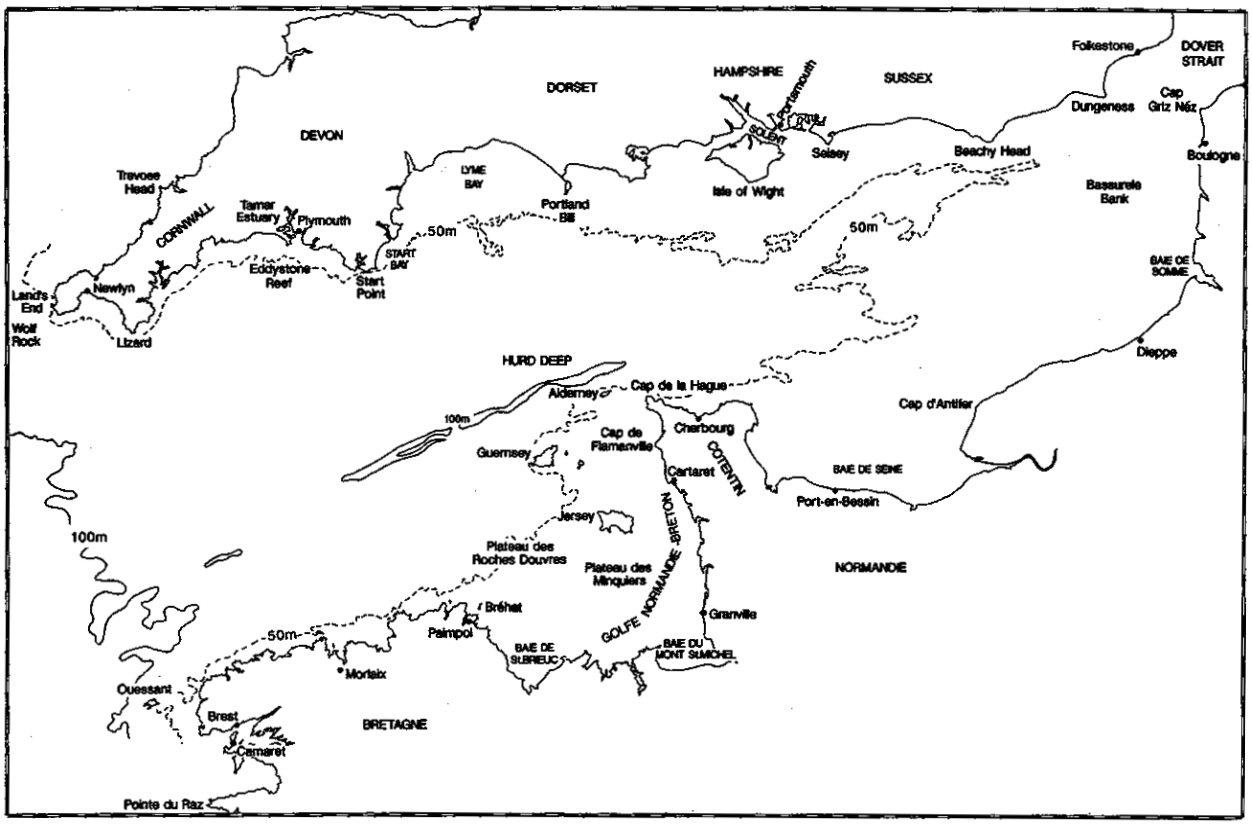

Figure 2. The English Channel and location of places named in the text

south connections difficult, and may cause a separate development of colonies of particular species on both sides of the Channel.

It is likely that these vertical and horizontal gradients in water properties, and the distribution of substrates in the English Channel and its adjacent seas, have a strong influence on the recruitment, survival, migrations and integrity of fish stocks which are found in this area.

THE IDENTITY OF ENGLISH CHANNEL FISH AND SHELL-FISH STOCKS

Most of the information contained in the following synopses of our contemporary knowledge of stock structure for 25 Channel species has been obtained from studies using conventional stock identification methods. Commercial landings or landings per unit of fishing effort (LPUE) data and groundfish survey catch-per-unit-effort (CPUE) data have also been used to help provide an indication of stock distribution and movement of demersal species which are caught by otter and beam trawls, and for which a 'fishing hour' is a realistic measure of effort. For other species, total landings data have been used. In all cases, these data are presented in population density maps by ICES statistical rectangle.

Two sets of French landings data were available: those registered as official statistics (in which the statistical rectangle of capture is usually known), and those estimated on the basis of additional market landings and landings recorded elsewhere (located only by ICES divisions). French fishing effort statistics relate to the number of trawling hours used to catch the fish included in the official statistics. English and Welsh landings are recorded for nationally registered vessels landing at major ports in all countries, and both landings and fishing effort are attributed to specific ICES rectangles. The figures provide only a poor coverage of the many inshore fisheries, from which landings do not always go through the markets. For some species, like shellfish and bass, specialists' estimates of landings have been preferred to official data.

For 1989, LPUE for rectangles in the southern North Sea (division IVc), the English Channel (divisions VIId and e), and the Celtic Sea and Western Approaches (divisions VIIf, g and h), were calculated as kilograms of each species landed per hour of otter or beam trawling, and are represented on charts using a series of graduated tones. The precision of these values as an index of abundance is affected by variations in boat power, net size, net efficiency, skipper ability, the species targeted and the proportion of the catch discarded before landing, etc. No attempts were made to

correct for these sources of error, but it was considered that the basic LPUE calculation was adequate for present purposes.

Groundfish survey data are represented on the figures using superimposed roundals with an area proportional to the CPUE (as kg per hour of fishing with otter or beam trawls). The data originated from surveys in the Bay of Biscay and Celtic Sea during autumn 1990 and spring 1991 (France), in the western Channel and Celtic Sea during March 1988 and October 1988 (England), in the eastern Channel during October 1988-1991 (France), and in the eastern Channel and North Sea during August and September 1989 and 1990 (England). No attempt was made to allow for differences in gears and vessels used in the different surveys. Survey results were plotted onto the distribution map representing the calendar quarter in which they were conducted. Unfortunately, surveys have not been conducted in all areas in every quarter of the year.

1. SCALLOPS

1.1 General distribution

Scallops, *Pecten maximus*, are distributed in northeast Atlantic shelf waters from northern Norway south to the Iberian peninsula, Figure 1.1, and have been reported from coastal waters around the Azores, the Canaries and Madeira. They are most abundant on gravel, sand/shell or stony substrates at depths of 15-75 metres. The distribution and abundance of scallops in the Channel and adjacent seas has been determined by biological survey and by study of the commercial fishery. Landings of scallops by English, Welsh and French vessels by rectangle during 1989-1990 are shown in Figure 1.2, which indicates that there are important scallop grounds are in both the east and west Channel. Scallops are widely distributed in the Channel, but their density is considerably lower outside the commercially exploited grounds.

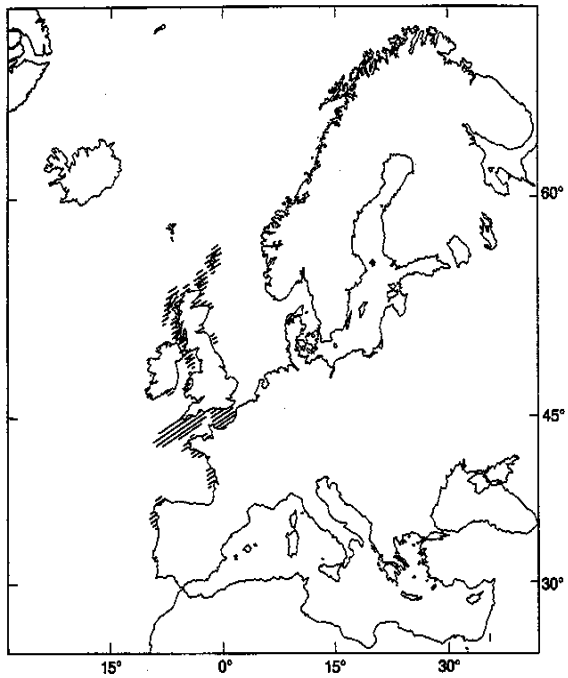

Figure 1.1 The distribution of scallop in the northeast Atlantic

1.2 Spawning areas

Scallops are sedentary for most of their life cycle, and thus their spawning areas correspond with the areas of adult distribution. Examination of the maturity of gonads shows that spawning occurs between spring and autumn, but there is considerable regional variation in the timing of spawning. Scallops in the Baie de St Brieuc are unusual in that they all spawn in a short period during summer. It is possible that a minimum density of spawning adults is necessary to ensure good recruitment of spat (juvenile scallops), and productive spawning areas may therefore be more restricted than the overall distribution of the species would indicate.

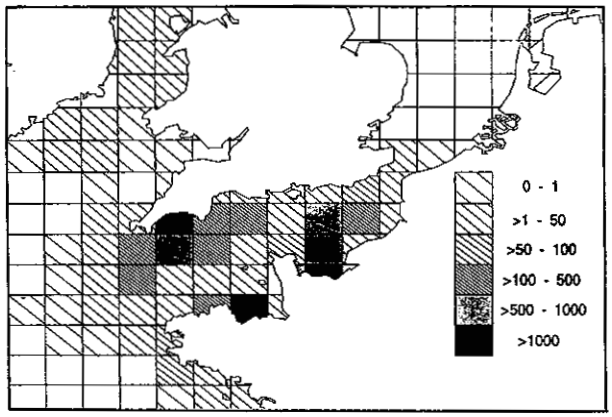

Figure 1.2 The annual distribution (mean 1989-1990) of estimated scallop landings (tonnes) by ICES rectangle in the Channel and adjacent sea areas

1.3 Larvae and spatfall

Following fertilisation, the egg develops rapidly to become a shelled veliger larva which is planktonic for 4-5 weeks, depending on water temperature. The pelagic larvae eventually descend towards the seabed where metamorphosis takes place. Hydrographic models have been used to investigate the likely directions in which these larvae disperse from spawning areas and to show possible relationships between scallops from different areas. These suggest that, in some areas, scallops are self-recruiting, whereas others depend on immigration (Figure 1.3). The results also indicate that several discrete scallop stocks may exist in the Channel. Thus, there would appear to be little or no exchange of larvae between the eastern and western Channel or between inshore beds on the French and

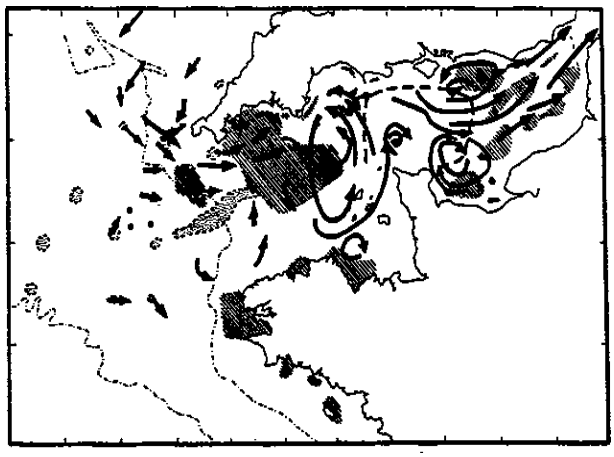

Figure 1.3 NORSWAP simulation of particle dispersal by water circulation in the Channel. The predicted average annual pattern of scallop larvae transport from 'release' points is shown by arrows, for a 30-day pelagic period during the main spawning season (July-September) (after Dare et al., in press). Exploited aggregations of scallop are denoted by diagonal shading

English sides of the western Channel. The scallop bed in the Baie de Seine may provide recruits to most areas in the eastern Channel, whereas scallop larvae originating from beds in the Baie de St Brieuc and the Golfe Normande-Breton may be contained within a gyre.

1.4 Biological parameters and population structure

The young scallops are sedentary (though mobile) and areas of good spatfall on appropriate substrates subsequently develop into adult beds. Consequently, the age structure on a particular bed is dependent on annual recruitment levels and survival, and on the effects of size-selective fishing effort during the previous years. The growth of scallops from different regions varies considerably and, within regions, their growth rates are not consistent from year to year. The extensive variations in the growth, size and age structure of scallop populations are thus related to local environmental conditions after spatfall (i.e. they are phenotypic), and are unlikely to be of value for investigating inherited traits in scallop stocks. Nevertheless, some grounds produce morphologically recognisable shell types which may help in stock identification.

Although there are variations in the age at maturity of scallops from different regions, size at maturity remains relatively constant. This suggests that age at maturity is a function of growth rate and is thus determined by local environmental factors.

Population differences in the reproductive cycles of scallops might be inherited. For example, scallops from Brest have been shown to maintain their original spawning pattern after being transplanted to the Baie de St Brieuc, as have Scottish scallops moved to the same area. Gonadal recovery following spawning does not begin until the spring for scallops from the Baie de St Brieuc and the Golfe Normande-Breton whereas, in the Brest region, scallops recover quickly from spawning and develop full gonads before winter. Scallops from the eastern Channel have an intermediate cycle and their gonads recover during winter.

Because scallops are distributed widely throughout the Channel at lower densities than those on the fished 'beds', the transfer of veligers from low-density areas to the 'beds' may be sufficient to maintain genetic homogeneity. When considered in conjunction with biological and oceanographic information, differences in the reproductive cycles of Channel scallops, which were maintained after transplantation, suggests that there are genetic differences, though none so far have been detected by electrophoretic or DNA studies.

1.5 Conclusions

The only significantly dispersive phase in the scallop's life cycle is during the 4-5 weeks that the larval veliger is planktonic. The water transport regime during this period determines whether larvae disperse to new areas or return to their bed of origin. Models of veliger transport suggest that scallops in the eastern Channel remain in this area or recruit to the southern North Sea - where the species is comparatively rare. Those on the English and French sides of the western Channel are likely to recruit to their respective areas of origin. Differences in the reproductive cycle suggest that scallops in the Baie de St Brieuc are a largely self-recruiting unit and should be considered as a discrete stock for management purposes. Similarly, the relative isolation of beds on the English side of the western Channel and eastern Channel, both from each other and from those in the Baie de St Brieuc region, suggests that scallops in these areas belong to distinct stocks.

2. CUTTLEFISH

2.1 General distribution

Cuttlefish, *Sepia officinalis*, are found in eastern Atlantic shelf waters, usually over sandy ground at depths of less than 150 m, from southern Norway and northern England south to South Africa. They are most abundant in the Bay of Biscay, and are absent from the Baltic and Black Seas (Figure 2.1). The quarterly distributions of cuttlefish LPUE from English, Welsh and French vessels in 1989, and CPUE from groundfish surveys, are shown in Figure 2.2. These distributions suggest that cuttlefish are concentrated in the central western Channel during winter and in coastal areas during spring and summer.

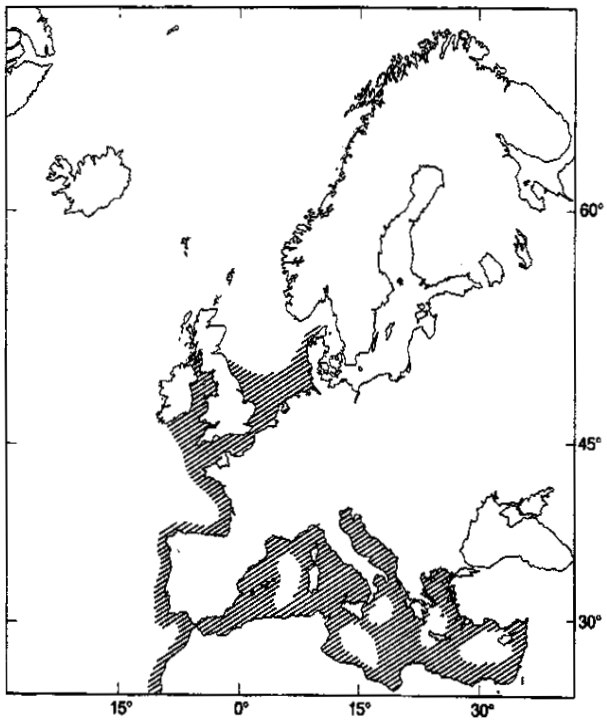

Figure 2.1 The distribution of cuttlefish in the northeast Atlantic

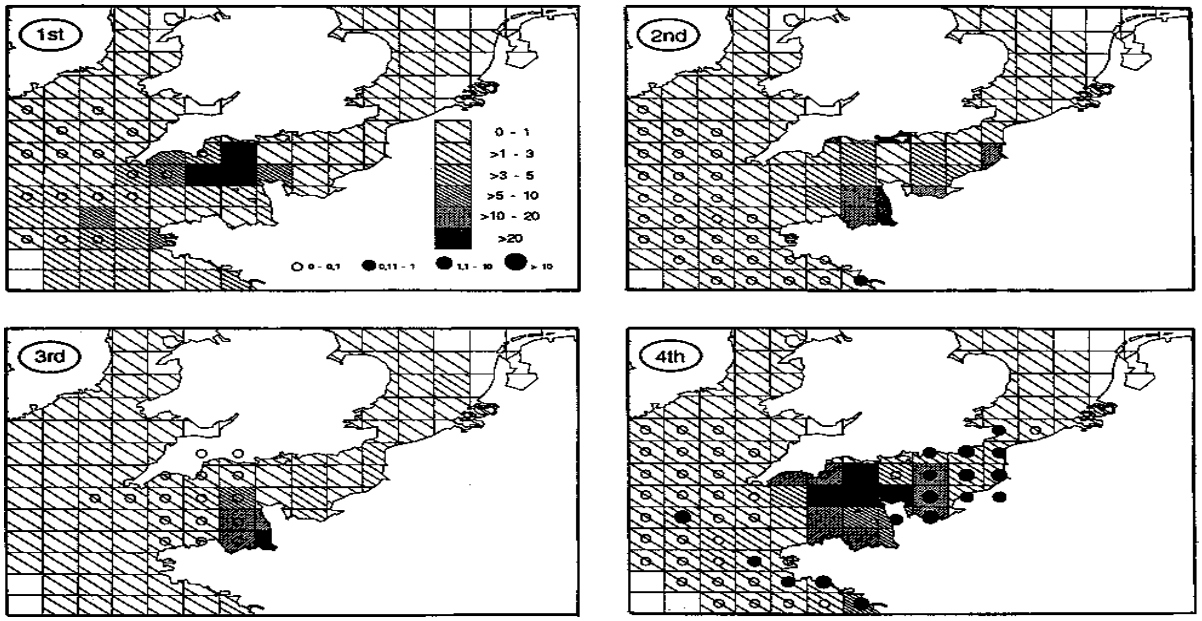

Figure 2.2 The quarterly distribution of cuttlefish LPUE by ICES rectangle in the Channel and adjacent sea areas in 1989. CPUE from English and French groundfish surveys are indicated with superimposed circles

2.2 Egg laying areas

Cuttlefish lay their eggs on marine algae, sessile animals, man-made obstructions and the seabed from early February until the end of May. The peak of spawning occurs from mid-April to mid-May. Major spawning areas on the Channel coast are found in the Baie du Mont St Michel and Lyme Bay. Cuttlefish also spawn in the Baie de Seine, Baie de St Brieuc, Baie de Somme and the Solent. It is probable that eggs are laid in other areas where depths are less than 30-40 m along the English and French coasts, and some spawning areas have been identified in the Bay of Biscay. Cuttlefish eggs hatch after 80-90 days at 15°C and 40-45 days at 20°C. Newly hatched cuttlefish, with a mantle length of 6-9 mm, appear in coastal waters of the Channel during July to September.

2.3 Juveniles

First-year (0-group) cuttlefish remain inshore close to the site of hatching during the summer months. They burrow in the sand during daylight hours and emerge to feed at night. Tagging experiments and observation from the fisheries suggest that juvenile cuttlefish leave shallow coastal nurseries in October, when they have attained a mean length of 6 cm, and migrate to areas of the western Channel where the depth exceeds 70 m and the mean water temperature remains above 9°C. They aggregate around the Hurd Deep from November to February. There is a similarly deep overwintering area in the Bay of Biscay, but juveniles from the Channel do not appear to migrate there.

Juvenile cuttlefish return to shallow inshore areas as 1-groups in the following summer, but do not necessarily return to their original nurseries. During this second summer, cuttlefish grow 1-2 cm in length each month and exhibit the first signs of sexual development. In the Channel, males start to mature at a mean mantle length of 10 cm and, by October, when approximately 13 months old and 13 cm long, they are sexually mature. Females begin to mature in July at a similar size and, by October, their ovary follicle cells are dividing. The final stages of maturation occur during the subsequent overwintering period.

2.4 Adult migrations

The migrations of adult cuttlefish have been elucidated by tagging mature and maturing cuttlefish in the Baie de Seine and west Cotentin during summer and in the central western Channel during winter. The distribution of recaptures indicates that the cuttlefish migrate offshore during October and November and, by mid-November, landings in the fishery demonstrate that all cuttlefish have left inshore waters. From November to January, the mature cuttlefish are concentrated near to the Hurd Deep, and they move progressively west to reach deep water south of the Lizard at the beginning of March. By this time, the mature females all contain free eggs in the ovary. Both the 0-group and the maturing 1-group cuttlefish from all regions of the French Channel coast mix during this migration.

The return migration from overwintering areas is rapid, with some cuttlefish moving from the central western

Channel to Normandy coastal waters in two weeks. Cuttlefish are rarely caught during this phase of the migration, which suggests that they travel high in the water column where they would be less accessible to trawls. Large, mature male cuttlefish arrive inshore first (at the beginning of April) followed a few days later by the females. The cuttlefish mate and the eggs are laid, following which almost all mature cuttlefish die.

Cuttlefish have not been tagged in English coastal waters, but the seasonal distribution of landings from the fishery suggests that these join cuttlefish from the French coast on the overwintering migration. Cuttlefish tagged in the Bay of Biscay have not been recaptured within the Channel. The migrations of cuttlefish in these two areas are summarised in Figure 2.3.

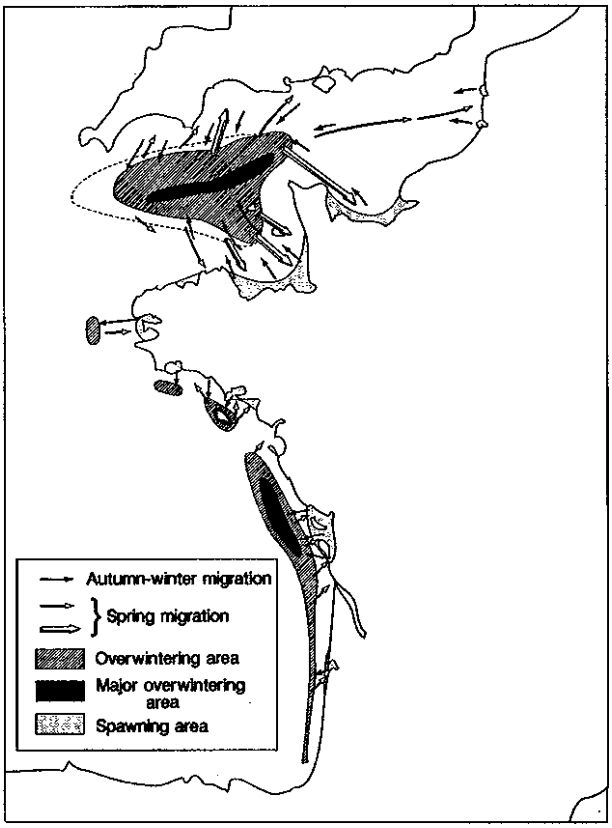

Figure 2.3 The seasonal migration of cuttlefish in the Channel and Bay of Biscay (V. Legrand, unpublished data)

2.5 Biological parameters and population structure

There are spring and summer breeding cohorts of cuttlefish in the Mediterranean and in the Bay of Biscay. In the Channel, however, almost all cuttlefish breed in April and May, and size classes in the overwintering population suggest that there is generally only one maturing cohort present. However, on some occasions (e.g. 1989), two cohorts have been identified.

Growth parameters have been calculated for male and female cuttlefish in the Bay of Biscay and in the Channel, but they are not entirely comparable because they were calculated by different methods. The maximum length of Channel cuttlefish is higher than for those in the Bay of Biscay, but there is considerable variability in growth between individuals and years. Consequently, growth parameters are unlikely to be of value for separating stocks.

2.6 Conclusions

Cuttlefish hatching in the Channel are unlikely to move to other regions during the course of their life cycle. However, it is not known whether the cuttlefish of the Channel are members of one stock unit, or whether there are separate breeding stocks, all of which overwinter in the same region.

3. LOBSTER

3.1 General distribution

Lobsters, *Homarus gammarus*, are distributed in the northeast Atlantic from northern Norway and the Faeroe Islands south to North Africa. They are present in parts of the Mediterranean but absent from the Baltic Sea and Black Sea (Figure 3.1). Lobsters are found from the intertidal zone to depths of 200 m, but they are scarce below 100 m.

The mean annual lobster landings from English, Welsh, French and Channel Islands vessels for 1986 to 1990

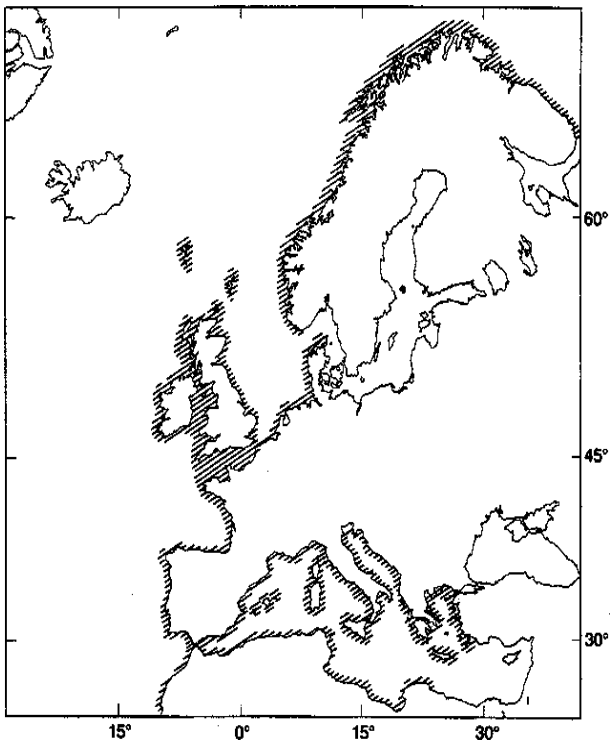

Figure 3.1 The distribution of lobster in the northeast Atlantic

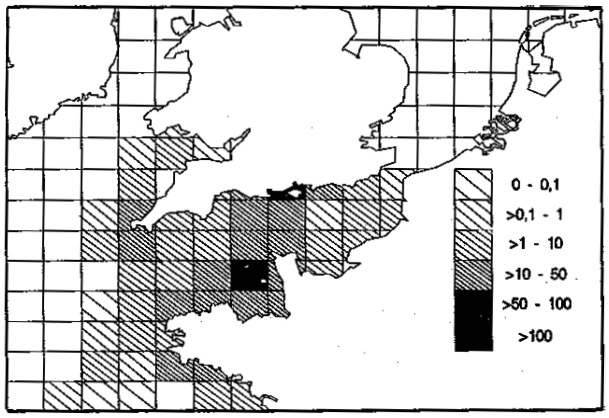

Figure 3.2 The annual distribution (mean 1986-1990) of estimated lobster landings (tonnes) by ICES rectangle in the Channel and adjacent sea areas

are shown in Figure 3.2. This suggests that lobsters are particularly abundant on the English coast around the Isle of Wight, in north and west Cotentin and around the Channel Islands. In the extreme eastern Channel and southern North Sea, lobster densities are low. To the west, there are directed lobster fisheries off west Cornwall and southwest Brittany.

3.2 Spawning and hatching areas

Mating occurs in the summer, and newly berried (egg-carrying) females begin to appear from September to December in all areas where lobsters are present, on both inshore and offshore grounds. Lobsters do not appear to make extensive movements when berried, and hatching takes place in spring and early summer on the same grounds. Lobsters on the offshore grounds are generally less abundant than those inshore, but with their larger mean size and high fecundity (number of eggs being carried) they may make a significant contribution to larval production.

3.3 Larvae

Little is known about the distribution and abundance of lobster larvae in the Channel. They are pelagic for about 3 weeks and undergo 3 moults before metamorphosing and settling on the seabed.

3.4 Juveniles

The main lobster nurseries are found on rocky ground in coastal waters. There has been no systematic survey in the Channel, but important nurseries are recognised in central west Cotentin (Carteret to Granville), Jersey and Minquiers, and in an area around Bréhat and Roches-Douvres. On the English coast, juvenile lobsters are most frequently caught off Sussex, Hampshire, Dorset and Cornwall.

3.5 Adult migrations

Lobsters have been tagged and released at sites in northern Biscay, northern Brittany, west Cotentin, Jersey and at Selsey on the English coast. Tags which were designed to persist through moulting were used, and most lobsters were recaptured within 1 or 2 years after release. Although some lobsters released in shallow waters in west Cotentin moved to deeper water, it is concluded that, unlike the edible or spider crabs, lobsters do not undertake regular migrations, but simply make small random movements which could be prompted by local competition for food or by the need to change habitats as their size increases.

3.6 Biological parameters and population structure

The size composition of lobsters sampled from different regions of the Channel coast may vary considerably. In general, smaller lobsters are found in inshore areas. Growth rates have been derived from the Selsey tagging experiment, but there are no comparable data from other regions on the English coast. Growth has also been estimated following a French tagging experiment in west Cotentin.

A comparison of the proportion of berried females by size class showed no differences between areas ranging from Guernsey, Roches-Douvres, west Brittany and Biscay. Berried lobsters are rarely less than 80 mm in carapace length. The fecundity of lobsters from different areas may vary, but only one set of fecundity data has been collected in the Channel.

Some biometrical analyses of length, width and weight relationships of lobsters from the Bay of Biscay, the Channel and the North Sea have been conducted for stock assessment and management purposes, but the data have not been analysed for comparison.

3.7 Conclusions

Within the overall range of their distribution, lobsters are abundant only in relatively localised areas. Their larvae are likely to have a limited dispersal because the planktonic phase only lasts for around 3 weeks, and there is no evidence of extensive migrations by the adults. There are marked differences in the population structure of lobsters in various parts of the Channel, but these may be the result of different levels of exploitation and available habitat. At present, no separate lobster stocks can be recognised within the Channel.

4. EDIBLE CRAB

4.1 General distribution

Edible crabs, *Cancer pagurus*, are distributed in north-east Atlantic shelf waters from northern Norway south to Morocco. They are most abundant around the British Isles and off the northern and western coasts of France at depths from 0 to 200 m, but they are absent from the Baltic and Mediterranean Seas (Figure 4.1). The distribution of crab catches by English and French vessels by rectangle can be derived from official landings statistics, but these are considered to be unreliable. A better indication of relative crab population density may be based on estimates of mean annual landings for the period 1985-1990 (Figure 4.2). These suggest that the abundance of crabs is highest in the western Channel.

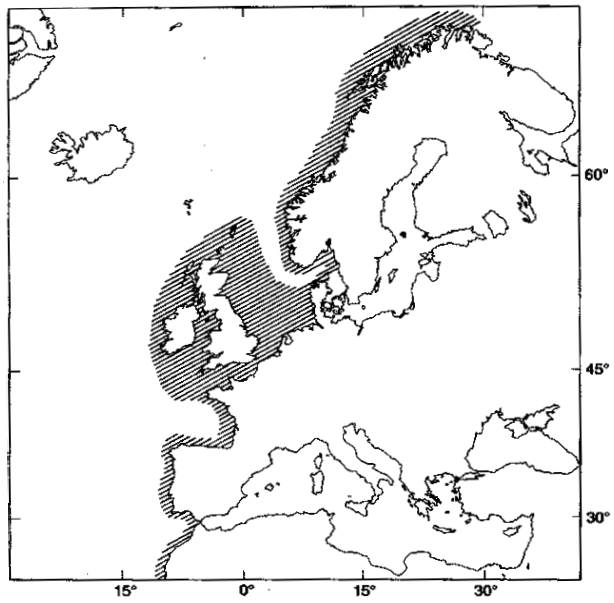

Figure 4.1 The distribution of edible crab in the northeast Atlantic

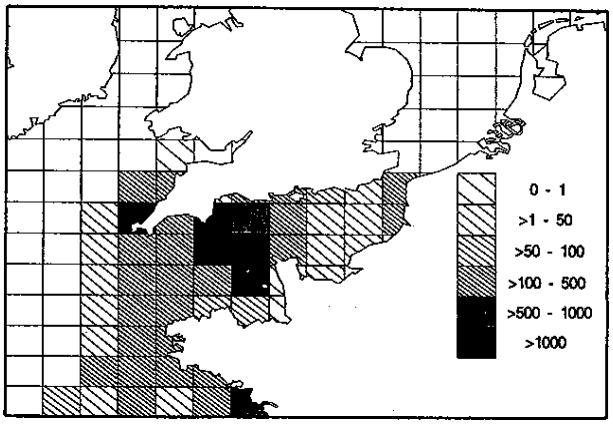

Figure 4.2 The annual distribution (mean 1985-1990) of estimated edible crab landings (tonnes) by ICES rectangle in the Channel and adjacent sea areas

4.2 Spawning areas

Areas where edible crabs spawn in the Channel and Western Approaches have been identified by assessing the abundance of mature females in commercial landings. During the autumn, the majority of female crabs landed from the offshore grounds in the Channel are in the pre-spawning condition with well developed gonads, and they probably remain in the same area during the overwintering egg-carrying phase, when they bury themselves in the seabed or hide in natural shelters. Unlike berried female lobsters, they do not feed and are rarely caught in traps. Consequently, catch rates of female crabs decrease at the end of November and into December and, as there are few direct observations or records of berried crabs, their distribution is not well defined.

4.3 Larvae

Edible crab larvae have been found to be distributed widely in the Channel and the Western Approaches during spring and early summer. Two centres of larval distribution were observed in the Channel - in the extreme east and central west. Hatching areas have also been located in the Bay of Biscay and Celtic Sea.

Crab larvae are planktonic for 60 to 90 days, and the NORSWAP hydrographic model has been used to predict their movements before metamorphosis and settlement. Little movement was expected in the Western Approaches and within bays, whereas it was predicted that larvae hatched offshore in the Channel would drift up to 100 nautical miles to the east (Figure 4.3). However, surveys have not provided direct evidence that larvae move from the eastern Channel into the southern North Sea.

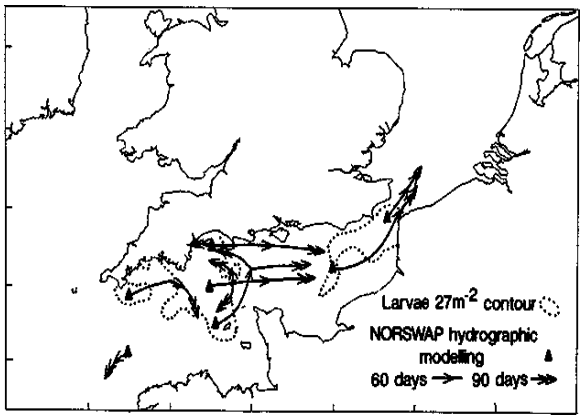

Figure 4.3 The movement of edible crab larvae in the Channel as indicated by NORSWAP models

4.4 Juveniles

Newly settled, juvenile edible crabs are abundant on rocky ground in English and French coastal waters. The most important nurseries on the French coast are in

north Cotentin and in north Brittany from Paimpol to Pointe du Raz. On the English coast, there are major nurseries on the rocky coasts of Devon and Cornwall and in shallow, rocky areas in the eastern Channel (Figure 4.4). Small crabs are rarely caught in offshore areas, and this suggests that crabs only move to deeper water as they grow and approach maturity. There may be some segregation of male and female crabs at maturity: mature males are caught on predominantly rocky substrates whereas females are more abundant on sand and gravel.

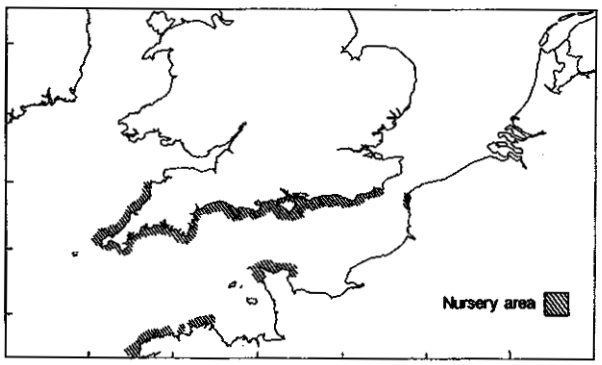

Figure 4.4 The main nursery grounds of edible crab in the Channel and adjacent sea areas

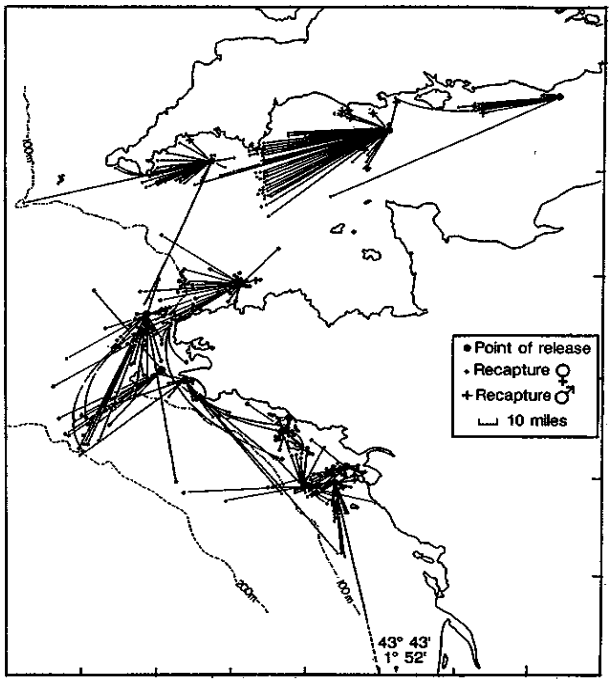

Figure 4.5 The movement of tagged edible crabs in the Channel (after Bennett and Brown, 1983 and Latruite and Le Foll, 1989)

4.5 Adult migrations

Edible crabs tagged with suture tags, which persist through moulting, have been released in the Channel, the North Sea and the Bay of Biscay. In the Channel, many female crabs moved west or southwest, but there was no indication of a return movement. Males made shorter, less directed, movements (Figure 4.5). Some edible crabs tagged off Cornwall moved south to areas around Brittany, and crabs tagged in Brittany or the Bay of Biscay also tended to move west or south. There are no records of crabs moving from the North Sea to the Channel. Some crabs achieved a mean speed of 2-3 km per day during migrations of up to 200 nautical miles. The westerly movements of female crabs may be contranatent (i.e. against the prevailing current), thus ensuring that their progeny drift back towards their own nursery grounds.

4.6 Biological parameters and population structure

It is not possible to age edible crabs directly, and the population structure is usually described using size distributions and sex-ratios. Crabs landed from the North Sea and the Channel come from populations with distinct structural differences. Male crabs with carapace widths over 18 cm are frequently caught in the Channel fishery, whereas males over this size constitute less than 2% of landings off Norfolk and Yorkshire, where those greater than 20 cm in width are rare. Similar size differences are observed for female crabs. In the western Channel, the mean carapace width of females is 16 -17.5 cm. In the Norfolk inshore and Northumberland fisheries, the mean widths of female crabs are approximately 13 cm and 15 cm respectively.

Growth rate estimates for edible crabs have been derived from tagging studies in the North Sea, in the Channel and the Bay of Biscay. Immature crabs of both sexes and mature males have a growth pattern in which the size-gain increases at successive moults, whereas the moult increments of mature females are more regular and smaller. These moult increments are similar in crabs from all of the areas studied, but moult frequency, and hence annual growth, differs significantly. In the Channel, male crabs moult more frequently than females, and thus grow more quickly, but the opposite case exists in the North Sea. Both male and female crabs moult more frequently in the Channel than in the North Sea, and thus their growth rates are higher. It appears that crabs in the southwestern Channel and Bay of Biscay have even higher growth rates than those in the mid-western Channel.

No estimates are currently available of the size at maturity of edible crabs from the Channel, though in southern Brittany the mean carapace width of females at first maturity was 12 cm, based on ovary development, and 11 cm based on evidence of mating. In northern Brittany, the mean width was 14 cm when female crabs first become berried.

4.7 Conclusions

There is no clear discontinuity in the distribution of edible crabs from the Western Approaches and the northern Bay of Biscay to the eastern Channel. However, tagging and landings data indicate that the areas of relatively high crab abundance in the Channel and in the North Sea are effectively separate. Tagging in the Channel has demonstrated that edible crabs move westwards down the Channel, though there was no evidence that adult crabs moved into the eastern Celtic Sea.

Whereas there are significant differences in the size structure and growth of crabs in the Channel and in the North Sea, there are no major differences between Channel crabs and those in the Bay of Biscay and Western Approaches. The available evidence suggests that edible crabs in the Channel, northern Biscay and the Western Approaches should be treated as a single stock for management purposes.

5. SPIDER CRAB

5.1 General distribution

Spider crabs, *Maja squinado*, are distributed in the east Atlantic from northern Scotland south to Guinea. They are present in the southern North Sea, the Irish Sea, the Channel and most parts of the Mediterranean, but are absent from the Baltic and Black Seas (Figure 5.1). Spider crab are most abundant at depths of 0-70 m, although they have been recorded at 120 m.

The mean annual spider crab landings by rectangle for 1986 to 1990 from English, Welsh, Channel Island and French vessels are shown in Figure 5.2. This suggests that spider crabs are most abundant in the western Channel, particularly in the areas from Cap de la Hague to Guernsey and to Morlaix.

5.2 Hatching areas

Berried female spider crabs are caught in the Channel from April onward, and by June all mature females are berried. The eggs begin to hatch in July and the hatching period extends until November. Some females produce two batches of eggs in a season.

Berried spider crabs are predominantly caught from areas less than 20 m deep along the coasts of Brittany, north and west Cotentin and the Channel Islands. Berried females are also caught in English coastal waters and the eastern Channel, but their overall distribution is not known because spider crabs are only targeted by the UK fishery in years when catch rates are high.

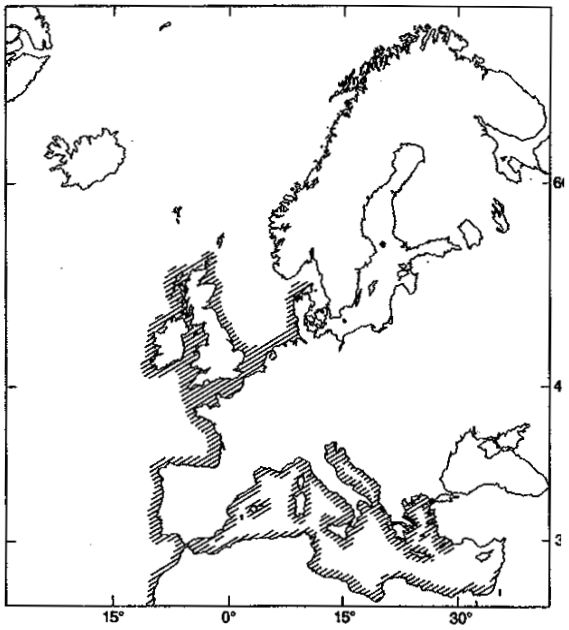

Figure 5.1 The distribution of spider crab in the northeast Atlantic

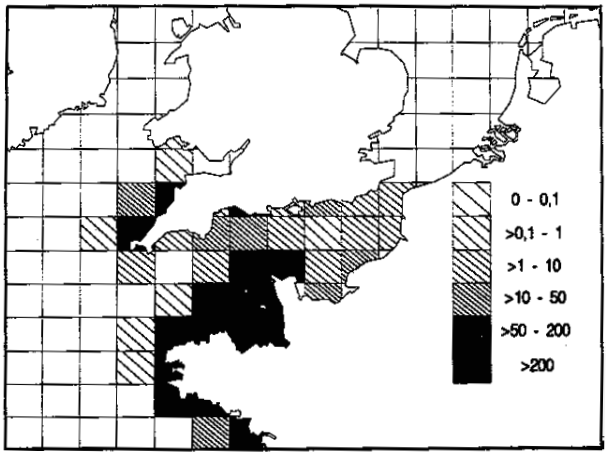

Figure 5.2 The annual distribution (mean 1986-1990) of estimated spider crab landings (tonnes) by ICES rectangle in the Channel and adjacent sea areas

5.3 Larvae

Spider crab larvae have a pelagic life of 2-3 weeks, depending upon water temperature. Given the almost exclusively coastal distribution of berried female spider crabs throughout the period of egg development, the relatively short duration of the pelagic larval phase, and the low rates of residual current flow in coastal waters, it is suggested that interchange of larvae between north and south Channel coasts is unlikely. In addition, knowledge of current systems suggests that few larvae would be transported from the Golfe Normande-Breton to adjacent areas on the French coast.

5.4 Juveniles

Spider crab nurseries are restricted to sites where the depth is less than 20 m and the ground consists of rock or gravel alternating with sand or mud. On the French coast, the most important recognised nurseries are south of a line joining the Cap de Flamanville to Jersey and to Paimpol. Nurseries of minor importance are also located in most bays from Paimpol to Camaret on the French coast of the western Channel (Figure 5.3). There have been no attempts to locate nurseries on the English coast or the French coast of the eastern Channel.

Tagging experiments with immature spider crabs have not been successful. However, circumstantial evidence from the spatial and temporal distribution of catches suggests that they remain in shallow coastal waters until reaching maturity in their second year.

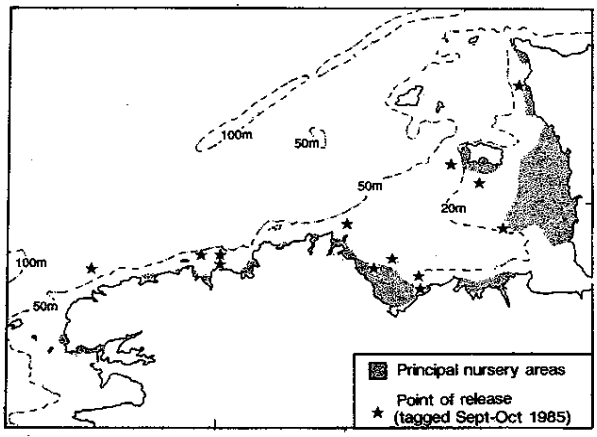

Figure 5.3 The nursery grounds of spider crab on the south coast of the western Channel, and release sites of adult spider crabs tagged in September-October 1985 (after Latruite and Le Foll, 1989)

5.5 Adult migration

Mature spider crabs have been tagged along the coasts of northern Bretagne, Jersey and west Cotentin (Figure 5.3). The recaptures suggest that, once they have attained maturity, spider crabs leave coastal waters from September to January. They migrate to overwintering areas south of Guernsey and off the north-western coast of France (Figure 5.4(a)). The depths in these areas exceed 50 m and the crabs remain there throughout the coldest period of the year. From April to June, the spider crabs return to coastal waters, though not necessarily to their original nursery areas (Figure 5.4(b)).

The seasonal migrations between shallow and deeper areas are combined with longer-term movements parallel to the coast. These are generally from east to west off northern Bretagne, and along the English coast, and spider crabs released in northern Bretagne have been recaptured in southern Bretagne, but none has moved in the opposite direction. There are no records of tagged spider crabs moving between the French and English Channel coasts.

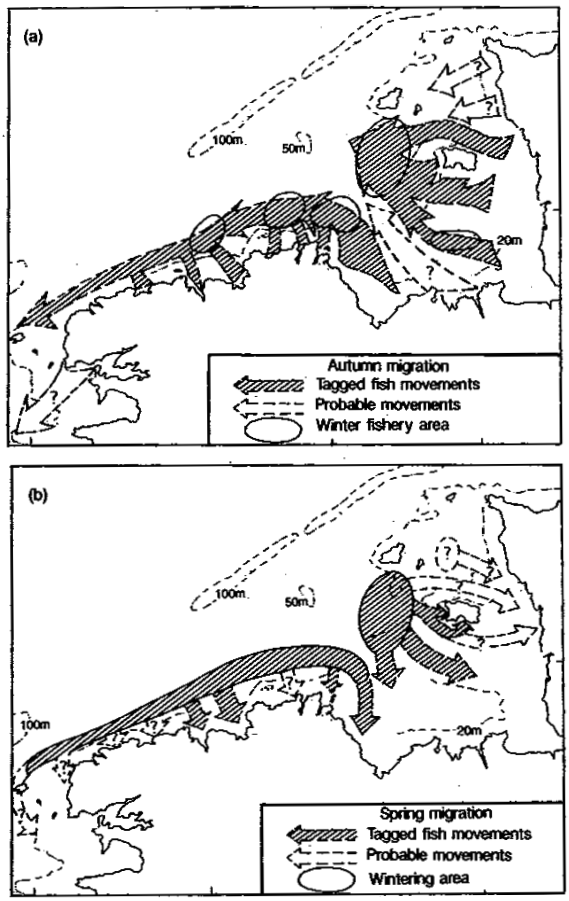

Figure 5.4 The migration patterns of spider crab in the western Channel, (a) in autumn and (b) in spring (after Latruite and Le Foll, 1989)

5.6 Biological parameters and population structure

Throughout the Channel, both male and female spider crabs moult for the last time when they attain maturity at the end of their second year. The carapace width of crabs following the terminal moult vary from 85-200 mm for males and 70-175 mm for females. The size structure of spider crabs in commercial catches is largely determined by the gear in use and the season of capture. In order to conduct realistic comparisons between crabs prior to exploitation, the major nurseries in west Cotentin and Baie de St. Brieuc have been surveyed on a systematic basis since 1986. The mean sizes of newly matured crabs (males and females are considered separately) from these nursery areas have differed significantly in some years. However, the differences in size and sex-ratio are not consistent at specific sites, and it is considered unlikely that there are stock-related differences in the population structure of recently matured crabs.

5.7 Conclusions

This review indicates that there are no highly dispersive phases during the spider crab's life history. Berried females are confined to shallow areas, the larval pelagic phase is relatively short, and juveniles appear to remain in specific nursery areas. Adults undertake short inshore-offshore seasonal migrations and may move parallel to the coast in the longer term.

Spider crab populations in inshore English and French waters appear to be isolated from each other. The fishery in the eastern Channel has been of little importance and the abundance of crabs in this area is usually low. In the western Channel, the crabs found off the northwestern French coast and around the Channel Islands are probably members of a self-perpetuating unit, which could be considered as a single stock for management purposes, even if there is some emigration of crabs into northern Biscay.

6. SPURDOG

6.1 General distribution

Spurdog, *Squalus acanthias*, are distributed in the eastern and western North Atlantic to depths of 600 m. In the northeast Atlantic, they are found from Iceland south to the Mediterranean and are abundant in all of the seas which surround the British Isles, although they are absent from the Baltic Sea (Figure 6.1). The quarterly distribution of spurdog LPUE for French, English and Welsh vessels by rectangle and quarter in 1989 is shown in Figure 6.2. CPUE values from groundfish surveys superimposed on this figure suggest that, although spurdog are distributed throughout the Channel, they occur at relatively low abundance.

6.2 Juveniles

Spurdog give birth to live young of 20-33 cm total length. Each mature female releases 3-15 live young in the period between November and January every second year. Commercial landings from the eastern Celtic Sea in winter and spring often contain large, pregnant female spurdog, and young fish from 25-40 cm total length have been caught during research vessel cruises in this area. In the past, mackerel-drift-net fishermen have occasionally caught large numbers of young spurdog around the Scilly Isles.

Juvenile spurdog were frequently caught during research vessel cruises off the south Devon coast in September and October from 1984 to 1991. However, the catch rates (less than10 fish per hour) suggest that this is not an important nursery area, as they are considerably lower than those recorded in the eastern Celtic

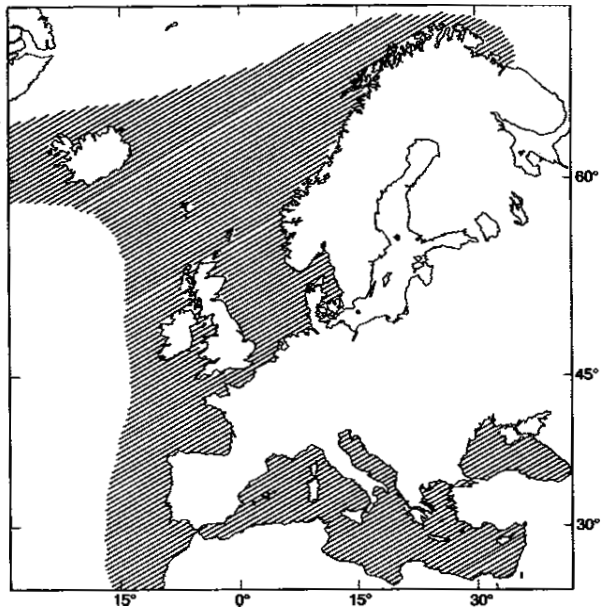

Figure 6.1 The distribution of spurdog in the northeast Atlantic

Sea. Similarly, although young spurdog are caught during the eastern Channel beam-trawl surveys and western Channel groundfish surveys, they are relatively scarce. It is concluded that major spurdog nurseries do not exist in the Channel and that adult spurdog usually recruit to the Channel from other areas. Male spurdog mature at approximately 60 cm total length, when 5 years old, and females at 80 cm, when 10 years old, though, off southwest Ireland, half of the females were mature at 74 cm and 14 years old. Fish of these sizes are widely distributed and not confined to specific areas.

6.3 Adult migration

Several thousand spurdog have been tagged in the northeast Atlantic since the late 1950s. The published results of these tagging experiments are summarised in Figure 6.3. On the basis of returns of 2000 spurdog released in the eastern Channel during April and May in 1961 and 1962, it was thought that these spurdog moved into the North Sea during the summer and returned to the eastern Channel in winter. However, these were short-term results, and an analysis of returns (over 20 years) of tagged spurdog released in 1966 in the Celtic Sea indicates wider movements underlying the seasonal migrations, and that their migratory pattern changes as they reach maturity. Mature male spurdog tended to migrate to the north and east of the British Isles in spring and return to the southwest in autumn. Immature females were evenly distributed in all seas areas at all times of the year, and year by year tended to move away from the tagging area in a clockwise direction around the British Isles. Few of the females

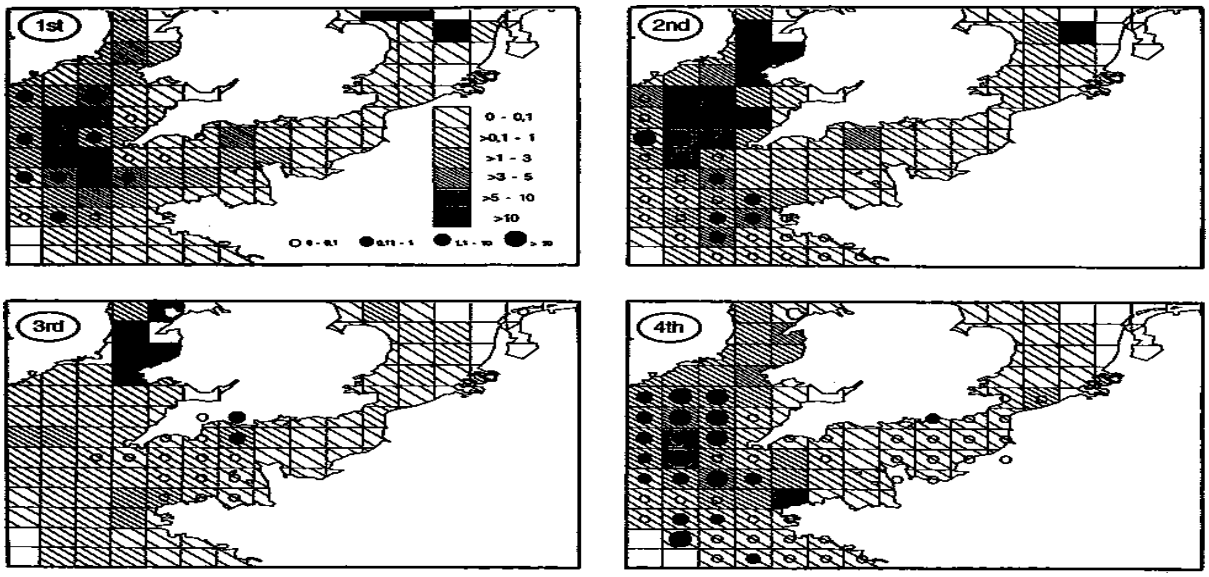

Figure 6.2 The quarterly distribution of spurdog LPUE by ICES rectangle in the Channel and adjacent sea areas in 1989. CPUE from English and French groundfish surveys are indicated with superimposed circles

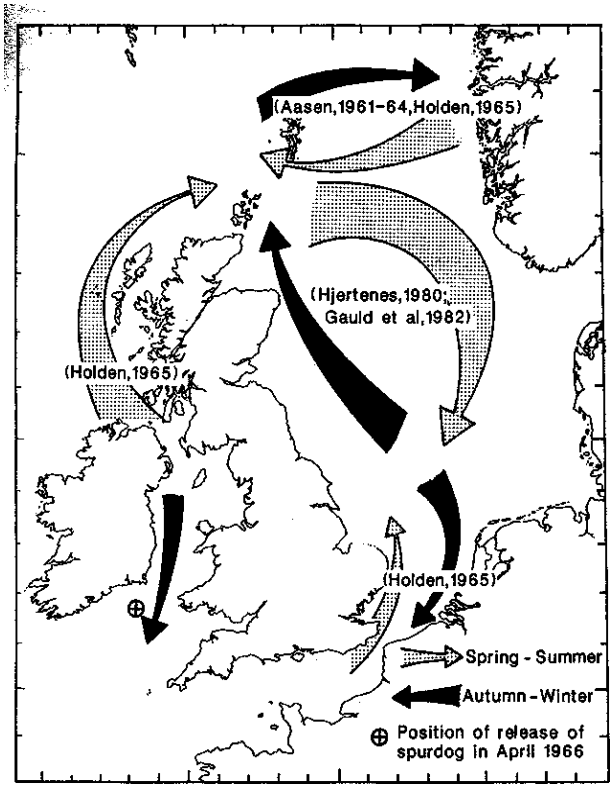

Figure 6.3 Spurdog migration routes between 1961 and1982 according to various authors; also the position of release of spurdog in 1966 (from Vince, 1991)

which were tagged or recaptured after tagging were mature, and no clear, seasonal, migratory pattern was observed. However, data from the fishery indicate that adult females gather in the eastern Celtic Sea in winter and spring to release their young. They leave this area rapidly in late spring, but their subsequent movements are not known.

There is both spatial and temporal separation of spurdog sexes and maturity stages in landings from the Channel and adjacent seas. Large pregnant females, mature females, immature females and immature males and females were found in separate shoals. Larger female fish were most abundant in deep water but, when pregnant, they were found inshore.

6.4 Biological parameters and population structure

The dorsal spine of a spurdog bears dark marks which may be laid down annually. However, ageing errors of up to three years were recorded in two-thirds of recaptured fish, which had been injected with oxytetracycline hydrochloride solution at the time of tagging to provide a permanent time-marker on the dorsal spine. As a consequence, the significance of small differences in the growth rates of spurdog landed from several sea areas around the British Isles cannot be assessed. Information on the length of spurdogs at maturity is available for spurdogs in the Channel and other regions, but the data are too limited to make meaningful comparisons.

6.5 Conclusions

The extensive migrations of both maturing and adult spurdog suggest that there are no separate identifiable spurdog stocks in the seas around the British Isles. Adult spurdog in the Channel are temporary visitors and generally recruit to the Channel from nurseries in other areas. It appears that the dispersion of maturing spurdog around the British Isles is sufficiently extensive that management cannot be based on the concept of 'stocks' identified within limited geographic areas.

7. THORNBACK RAY

7.1 General distribution

Thornback rays, *Raja clavata*, are distributed in north-east Atlantic shelf waters from southern Iceland and central Norway south to North Africa, and are most common in depths of 10-60 m. They are present in the western Baltic, the Mediterranean and the Black Sea (Figure 7.1). The LPUE of thornback rays, by French trawlers by quarter and rectangle in 1989, are shown in Figure 7.2. They appear to be abundant in the Irish Sea and Celtic Sea, but the lower values of LPUE in the western Channel must be treated with caution, because a large proportion of landings there are declared under the general 'skates and rays' category. Thornback ray landings from English and Welsh vessels could not be included because rays are not divided by species in the landings. Ray landings from the Channel are dominated by *R. clavata*.

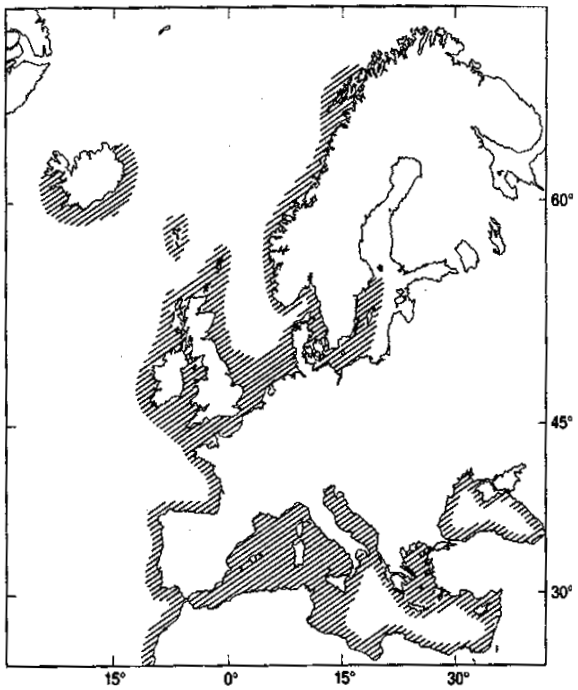

Figure 7.1 The distribution of thornback ray in the northeast Atlantic

7.2 Eggs and young-of-the-year juveniles

Thornback rays lay their eggs in shallow water from February to September, with a peak in June in the southern North Sea. The egg production rate for thornback rays in the Wash was 140 eggs per female per year, and 100 eggs per female per year in the Bristol Channel. The available data are insufficient to indicate whether egg production rates differ significantly between regions.

Thornback rays hatch after 16-20 weeks and their disc width at hatching is approximately 8 cm (equivalent to 12 cm total length). In November-December, the young-of-the-year appear inshore in the Channel and the Bay of Biscay.

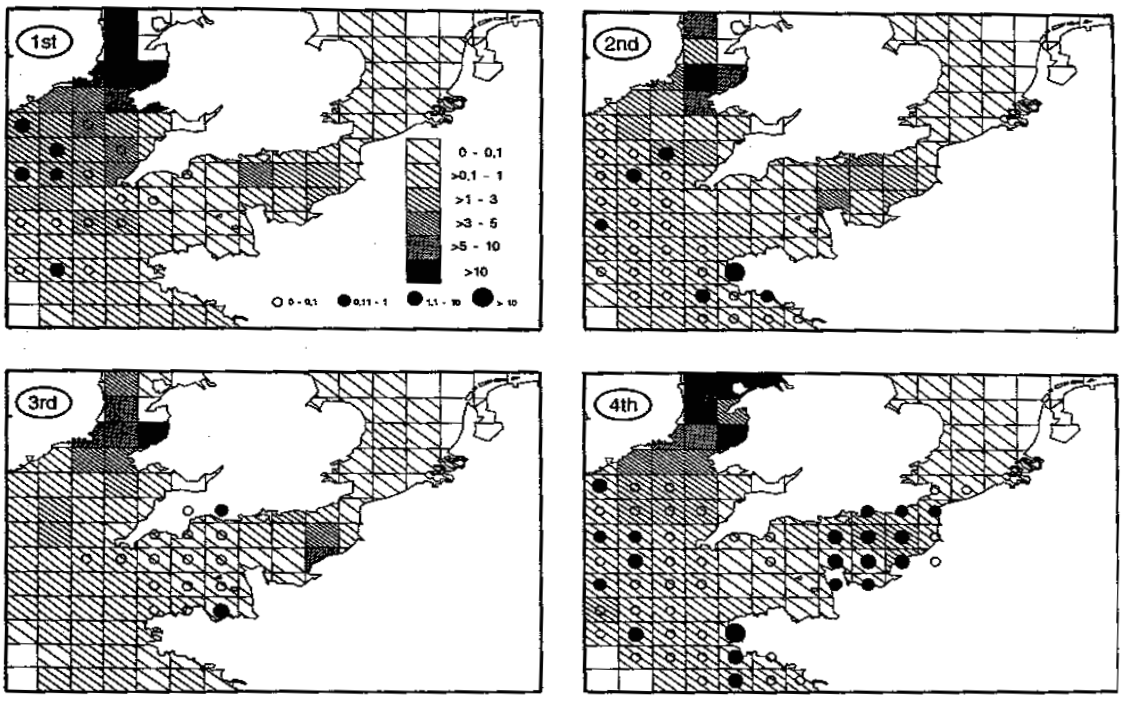

Figure 7.2 The quarterly distribution of thornback ray LPUE by ICES rectangle in the Channel and adjacent sea areas in 1989. CPUE from English and French groundfish surveys are indicated with superimposed circles

7.3 Juvenile and adult migrations

Tagging studies of thornback rays in the Irish Sea and Bristol Channel has been used to obtain information on dispersion and migration. Juvenile females were recaptured over a wider area than were the males, though all were reported from within the Bristol Channel or eastern Celtic Sea. Dispersal of juvenile thornback rays released off the east coast of Ireland was more widespread, though there were insufficient recaptures of adult rays from which to determine the population's movements. A total of 614 thornback rays, mostly juveniles, were tagged and released in 1930-1935 off Plymouth in the western Channel. Two hundred and three recaptures were reported within 4 years of release. Juvenile rays tended to remain on the same grounds throughout the year. One individual was recaptured on the same grounds on six occasions in a period of 14 months. Thornback rays which were becoming mature appeared to range more widely than juveniles, but no rays were recaptured more than 50 nautical miles from the release position. Returns from the releases of 237 juvenile thornback rays in the eastern Channel, during spring and summer 1975, produced few recaptures from areas which were not adjacent to the tagging site.

Seasonal changes have been observed in the ray fisheries of the western Channel, which suggested that thornback rays moved progressively further offshore as they grow. However, once mature, females returned to inshore waters each spring, followed by the males. Once the egg laying season was completed, the fish segregated into single sex shoals in deeper water.

7.4 Biological parameters and population structure

An examination of thornback ray landings from the western Channel showed that females matured at 65-70 cm disc width, when aged 9, and males at 50 cm disc width, when aged 7. Rays matured in the Bristol Channel when aged 4-6. The growth of rays in the Irish Sea and the Channel appears to be similar for male and female fish.

7.5 Conclusions

Tagging studies have shown that immature thornback rays do not make extensive migrations, but insufficient numbers of adult fish have been tagged to determine the extent of their movements. There are few rigorous studies of ray biology and, because rays are not recorded by species in English and Welsh fishery statistics, these basic data cannot be used for studies on stock identification or stock composition. Catch data (mainly from surveys) do, however, suggest that thornback rays in the Channel are most closely linked with stocks in the Celtic Sea and around Ireland. At present, it is impossible to state whether separate thornback ray stocks exist in the Channel.

8. CUCKOO RAY

8.1 General distribution

Cuckoo rays, *Raja naevus*, are distributed in northeast Atlantic shelf waters from the Shetland and Orkney Islands south to the eastern Mediterranean, and are rare in areas deeper than 150 m (Figure 8.1). The LPUE of cuckoo rays by French trawlers by quarter and rectangle in 1989 are shown in Figure 8.2. They appear to be most abundant in the north of the Bay of Biscay and the Celtic Sea and, as with the thornback ray, there is a decrease in LPUE in the western Channel. In the eastern Channel, most catches reported to IFREMER as *R. naevus* are known to be *R. undulata* and this will bias the distribution maps.

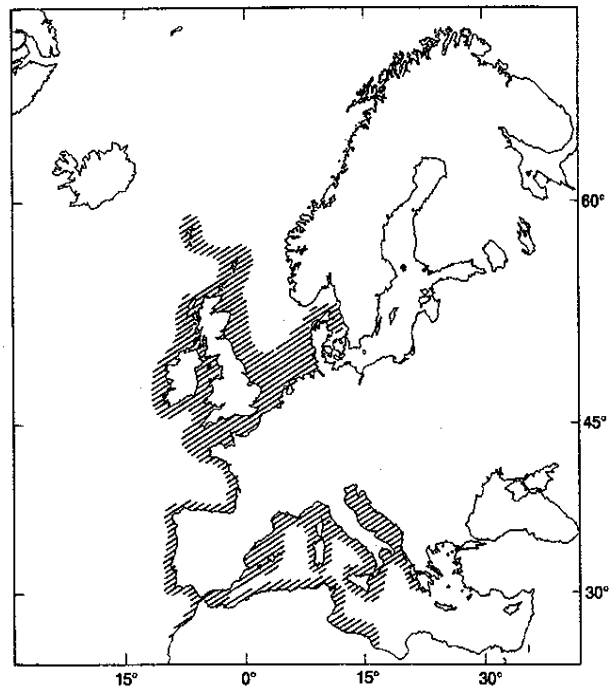

Figure 8.1 The distribution of cuckoo ray in the northeast Atlantic

8.2 Eggs and young-of-the-year juveniles

Cuckoo rays lay eggs all the year round, though mostly in December to May, and females produce 90-100 eggs per year. It has been reported that the eggs took 240 days to hatch in aquaria and that the young were then 12 cm long.

Young cuckoo rays are rarely caught, and it is not possible to locate their favoured nursery habitats using the information currently available. Fine mesh, beam-trawl surveys along the English Channel coast, in the eastern Channel and deeper waters of the western Channel, have rarely caught cuckoo rays, which suggests that they do not use the same nurseries as thornback rays.

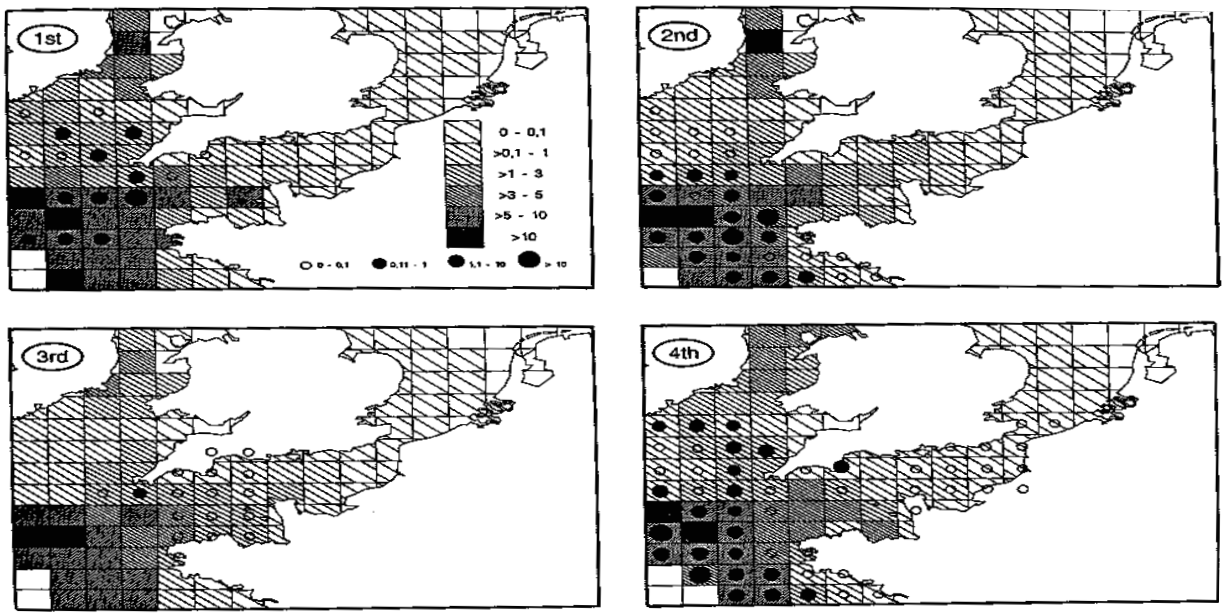

Figure 8.2 The quarterly distribution of cuckoo ray LPUE by ICES rectangle in the Channel and adjacent sea areas in 1989. CPUE from English and French groundfish surveys are indicated with superimposed circles

8.3 Biological parameters and population structure

The growth of cuckoo rays has been described for the Celtic Sea; males and females matured when aged 8 years, at an average disc width of 34 cm.

8.4 Conclusions

Cuckoo rays in the Channel appear to belong to a population which extends from the Celtic Sea and northern Bay of Biscay. At present, it is impossible to state whether separate cuckoo ray stocks exist in the Channel.

9. HERRING

9.1 General distribution

The Atlantic herring, *Clupea harengus*, is distributed throughout north Atlantic shelf waters from the White Sea and Iceland to the Straits of Gibraltar in the east (Figure 9.1) and from Greenland and Canada to South Carolina in the west. Figure 9.2 shows the total landings of herring in the Channel and adjacent areas by international vessels in 1989. Landings are not presented per unit of fishing effort because reliable effort statistics are not available for this fishery. Nevertheless, it is considered that the Channel fleets are sufficiently flexible to respond to most changes in the distribution of these fish, and thus the plots do provide an indication of seasonal distribution and abundance patterns.

Because groundfish surveys use methods which are inefficient for pelagic species, the CPUE data superimposed on Figure 9.2 add relatively little substance to the picture.

9.2 Spawning areas

Herring spawn their eggs onto the seabed, and information on the extent of their spawning areas and times of spawning are usually determined by surveys of the

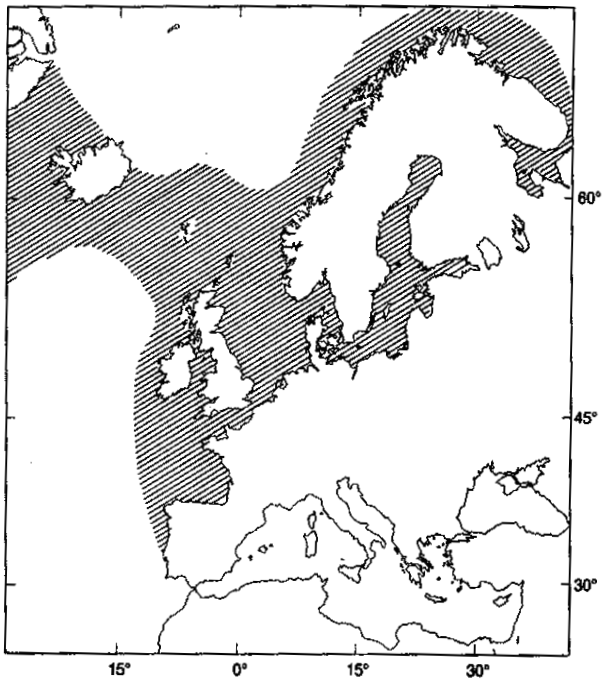

Figure 9.1 The distribution of herring in the northeast Atlantic

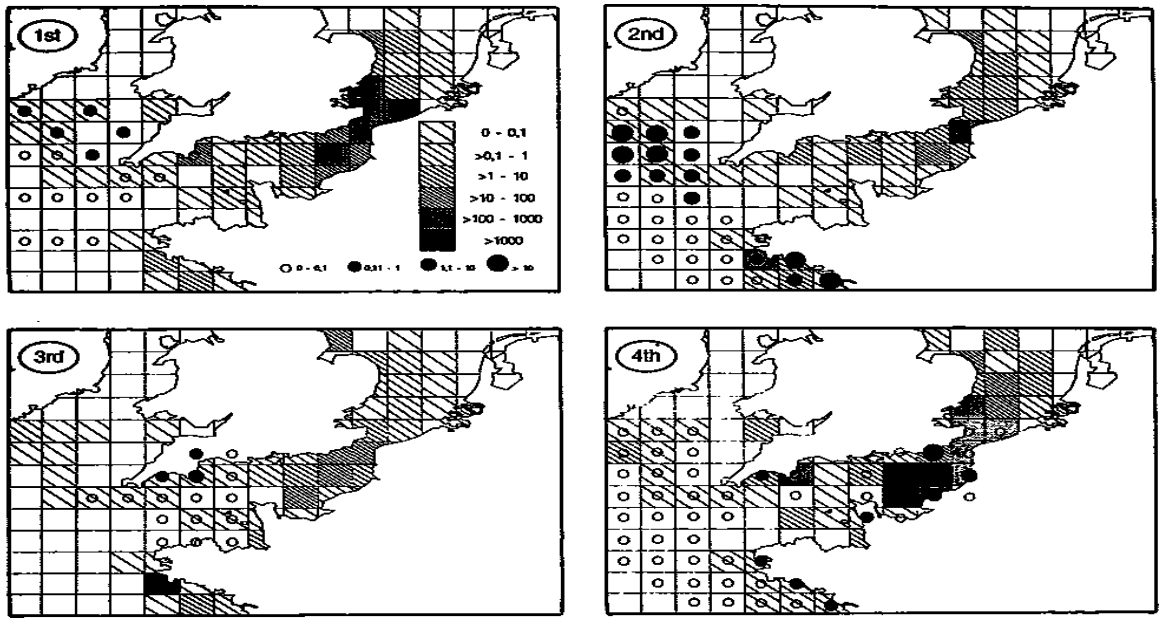

Figure 9.2 The quarterly distribution of herring landings (tonnes) by ICES rectangle in the Channel and adjacent sea areas in 1989. CPUE from English and French groundfish surveys are indicated with super-imposed circles

distribution and abundance of ripe fish and yolk-sac larvae. Prior to the 1950s, spawning areas used by herring in the Channel extended from banks off the Belgian coast west to the Baie de Seine (Figure 9.3). Since the 1970s, most herring have spawned on gravel beds from Cap d'Antifer to Cap Griz Nez, and these are referred to as Downs spawners. Spawning commences in late November, peaks in December and declines through January into February. Captures of ripe herring in seasonal fisheries show that there are groups of herring spawning in autumn, winter and spring at other sites in the Channel. These groups were more easily identified when they were exploited by small local fisheries, but they have seldom been fished in recent years. Larval surveys in 1974 and 1991 included regions where herring larvae from inshore spawnings might be expected to occur, but only small numbers of larvae were found. Therefore, the present status of these small spawning groups of herring is uncertain.

9.3 Larvae and juveniles

The distribution and abundance of herring larvae is revealed by regular plankton surveys in the eastern Channel during winter. The centres of larval abundance appear to shift south and east as the larvae grow and, by April, large post-larval herring are found close to the French coast from Boulogne to Dieppe. In addition, there are extensive nursery grounds for 0-group herring off the German and Danish coasts, and young Downs-spawned herring may share these with young herring from other spawning grounds in the North Sea. It is suggested that, as 1-group, the herring move offshore to feed in the central North Sea. They reach maturity when aged 2 or 3, and the maturing fish begin a seasonal southerly migration each autumn to the eastern Channel for spawning.

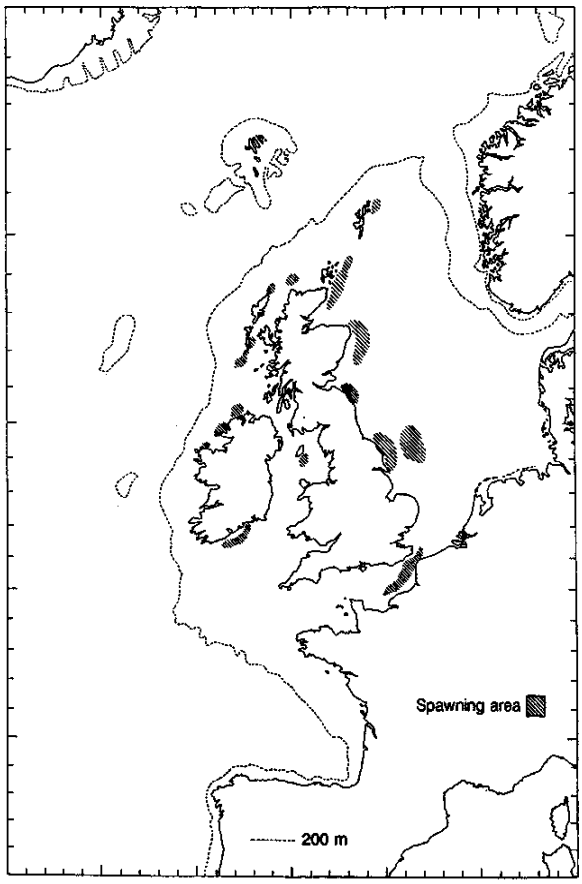

Figure 9.3 The spawning grounds used by herring in the Channel and sea areas adjacent to the British Isles

The movements of larvae hatching from other small spawnings on the Channel coast are poorly understood, although larval herring are reported from plankton surveys in these areas and young herring are frequently recorded from river estuaries in Devon and Cornwall.

9.4 Adult migrations

The migrations of Downs-spawning herring have been elucidated from a series of tagging studies, by acoustic surveys and by following the seasonal distribution of the fishery. Central North Sea spawners (Bank herring) and Downs spawners share the same feeding grounds in the central North Sea, but segregate for spawning. Tagging studies suggest that the interchange between these two spawning groups is negligible. In autumn, the Downs-spawning herring migrate south and appear in the Channel during November. After spawning, spent Downs fish return to the central North Sea, where they feed during the summer.

The migrations of the small spawning groups on the English and French Channel coasts have not been studied by tagging, and little is known of their movements when they disperse after spawning. Fishermen reported that the Plymouth-spawning herring used to migrate inshore from an area south of the Eddystone Reef during the period from October to January. However, it is not known whether this migration still occurs, because the traditional Plymouth fishery is no longer prosecuted and fishing for herring in the western Channel is only carried out irregularly.

9.5 Biological parameters

The Downs-spawning herring may be distinguished from other spawning groups in the North Sea on the basis of spawning time and location, mean egg size and fecundity, and length at age one. The series of catch-at-age compositions of Downs herring also indicates that their population dynamics are distinct from those of other North Sea groups. Growth rate, age at maturity and the age structure of the Downs-spawners has changed considerably with time, and variations in these characters are attributable to environmental influences rather than to genetic differences. However, all studies of these life history parameters of the Downs and other groups of North Sea herring show that, at the same age, the Downs herring are smaller.

Studies of parasites may provide further information on stock identity. For example, herring from coastal nurseries in the eastern North Sea are moderately infected with the tapeworm *Lacistorhynchus* sp. and those from coastal nurseries in Scotland are heavily infected with the trematode *Renicola* sp. Herring which are infected as juveniles carry parasites throughout their life and, when captured from mixed adult stocks, their origins can thus be determined. Although the nematode *Anisakis* sp. is present in herring from several stocks in the northeast Atlantic, the parasite's abundance increases with the age of herring and this may reduce its potential value as a biological marker.

9.6 Conclusions

Genetic evidence generally indicates that Downs-spawning herring are not reproductively isolated from other spawning groups. On the other hand, one tagging study has indicated that the Downs population and that of the central North Sea (the 'Bank' population) are independent. The observed decline of the Downs group (at the end of the 1950s) preceded that of the central and north North Sea spawning groups (which declined in the 1970s), and appears to support this hypothesis. This does not necessarily signify a genetic identity. In fact, genetic homogeneity between the two populations might be expected to be maintained by exchanges of fish which are insignificant with respect to exploitation and regeneration rates within the Downs group.

Although there is little hope, in the short term, of progress in the identification of herring stocks, the Downs herring are treated as a distinct stock for management purposes. The Channel serves only as a breeding ground for the Downs herring stock when it migrates from the North Sea to spawn in autumn, but it also contains a relatively unimportant resident group of spring spawners.

10. SPRAT

10.1 General distribution

Sprat, *Sprattus sprattus*, are distributed in northeast Atlantic shelf waters from northern Norway, the Orkney Islands and the northern Baltic south to the Mediterranean and the Black Sea (Figure 10.1). The total landings of sprat by rectangle and quarter for English, Welsh and French vessels during 1989 are shown in Figure 10.2. Groundfish survey CPUEs are superimposed, but it should be noted that bottom-trawl surveys do not readily illustrate the distribution of pelagic species such as sprat.

10.2 Spawning areas

Sprat eggs are recorded in the Channel throughout the year, but the peak spawning period in the western Channel is from January to July, and in the eastern Channel from February to late June. The distribution of sprat eggs, (Figure 10.3), shows that spawning occurred throughout the Channel, although there is a marked reduction in egg density in the area between the Isle of Wight and the Cherbourg Peninsula. There is, however,

no discontinuity in the distribution of eggs in the eastern Channel and into the southern North Sea, Figure 10.4.

Centres of spawning are found in the coastal waters off southwest England and in the mid-eastern Channel from Dungeness to Portsmouth. In addition, there is a spawning area to the west of the Channel Islands. A study of sprat spawning off Plymouth in the western Channel indicated that the centre of spawning would initially appear inshore in January and shift offshore as the season progressed. At the end of each season, in June and July, further small spawnings would take place inshore.

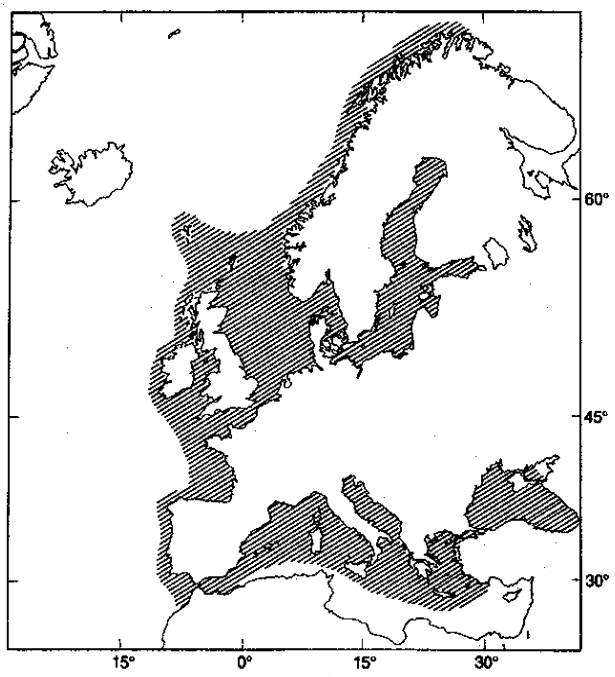

Figure 10.1 The distribution of sprat in the northeast Atlantic

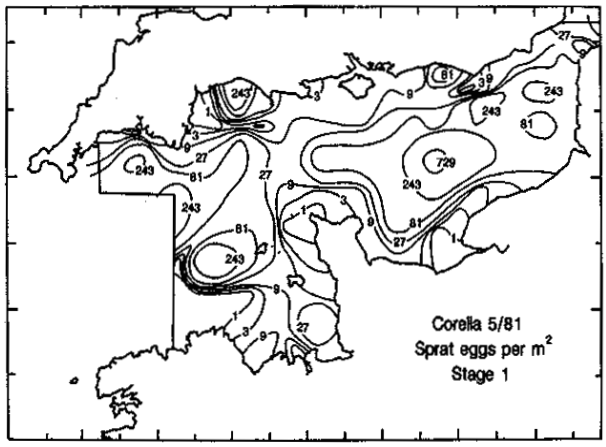

Figure 10.3 The distribution of sprat eggs in the Channel during 4-13 April, 1981 (from Milligan, 1986)

10.3 Larvae and juveniles

Sprat larvae are distributed throughout the northern side of the English Channel, and egg distributions suggest that sprat larvae will have an almost continuous distribution in the Channel.

0-group sprat are reported in August and September from shallow inshore sites and estuaries in the eastern and western Channel. As 1-group fish, sprat are rarely found in shallow water, but begin to appear in commercial catches. Sprat fisheries are targeted on large, overwintering concentrations of adults and, accordingly, it is impossible to assess the overall distribution of the 1-group fish.

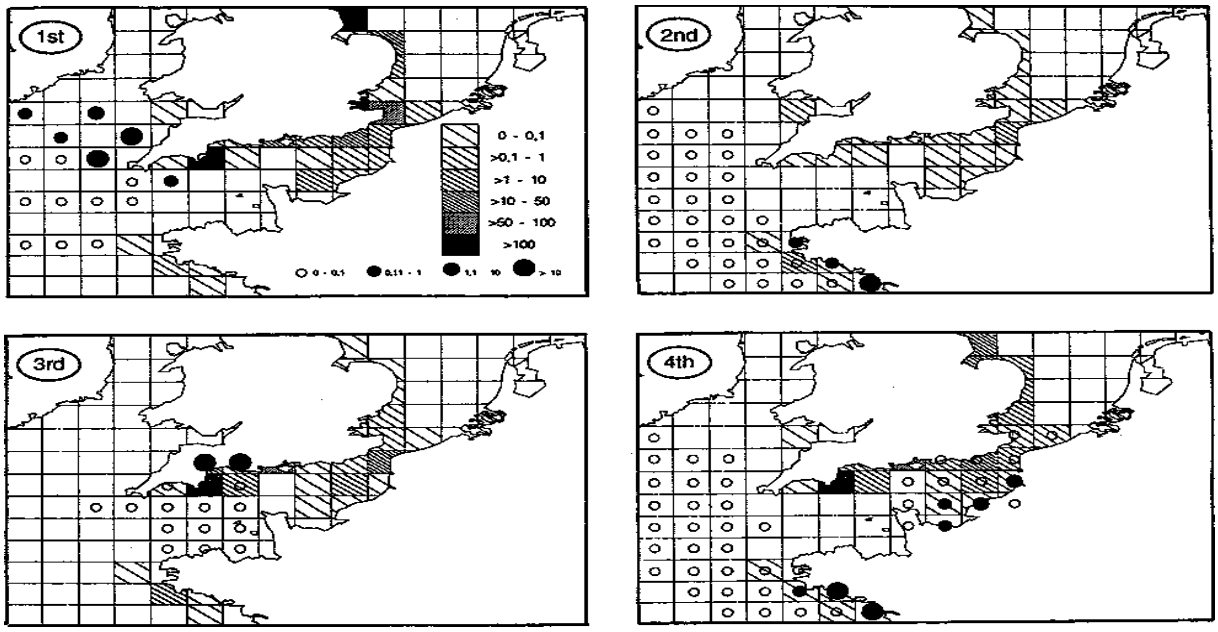

Figure 10.2 The quarterly distribution of sprat landings (tonnes) by ICES rectangle in the Channel and adjacent sea areas in 1989. CPUE from English and French groundfish surveys are indicated with superimposed circles

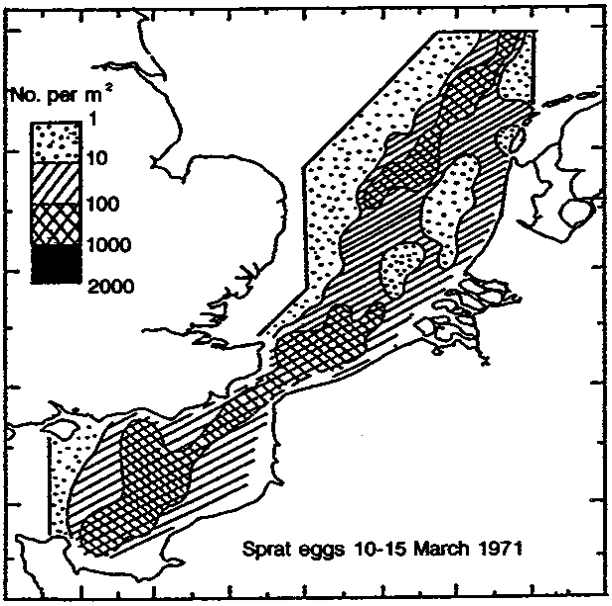

Figure 10.4 The distribution of sprat eggs in the eastern Channel and southern North Sea, 10-15 March, 1971

10.4 Adult migrations

Sprat are too delicate to tag effectively, and the seasonal movement of the sprat fishery (Figure 10.2), coupled with changes in the distribution of eggs (Figures 10.3 and 10.4) indicate their migrations. Shoals of sprat move inshore during September in the western Channel and during November or December in the east. The shoals are concentrated during December and January and this allows the fishery to be prosecuted by pelagic trawlers. In February, the shoals begin to disperse prior to spawning, most of which takes place seaward of the winter concentration areas. It is not clear whether this is a simple, seasonal, onshore/offshore movement, or part of a more complex migratory cycle. There is no evidence that adult sprat move between the eastern Channel and southern North Sea.

10.5 Biological parameters and population structure

Meristic and morphometric data have been published for sprat from the North Sea, Norwegian waters and the Baltic, which may allow any stocks to be identified if similar data were collected for Channel sprat. Vertebral counts of Channel sprat (mean 47.67; range 46-49), however, are identical to those of fish in the North Sea and west of Scotland.

The Lyme Bay (western Channel) sprat fishery has been sampled regularly since 1966, and it has been found that sprat recruit to this fishery a year later than those in the southern North Sea and eastern Channel; the bulk of the landings from Lyme Bay consists of 3 year olds and older fish. In addition, the back-calculated length at age 1 for sprats in the western Channel is consistently different from that in other regions, despite considerable inter-annual variation.

10.6 Conclusions

Sprat eggs, larvae, juveniles and adults are distributed almost continuously through the Channel, with the exception of a zone between the Isle of Wight and the Cherbourg Peninsula. Sprat landings from the southern North Sea and eastern Channel have similar age distributions, and a spawning area extends from the eastern Channel through the Dover Strait into the southern North Sea. The ICES Sprat Working Group concluded that discrete spawning areas and stocks could not be identified in the North Sea.

Sprat landed from the western Channel have a markedly different age distribution from those to the east, and spawning is rare in the region lying between the eastern and western Channel. It is possible, therefore, that there is only a limited interchange of sprat between the eastern and western Channel, and that the two areas contain separate stocks from a management point-of-view. However, there are no reliable data on the actual movements of sprat to confirm this hypothesis.

11. PILCHARD

11.1 General distribution

Pilchard, *Sardina pilchardus*, are found in northeast Atlantic shelf waters from Scotland and southern Norway south to the Mediterranean and the Black Sea (Figure 11.1). They are most abundant in the region extending from the western English Channel to the Canaries.

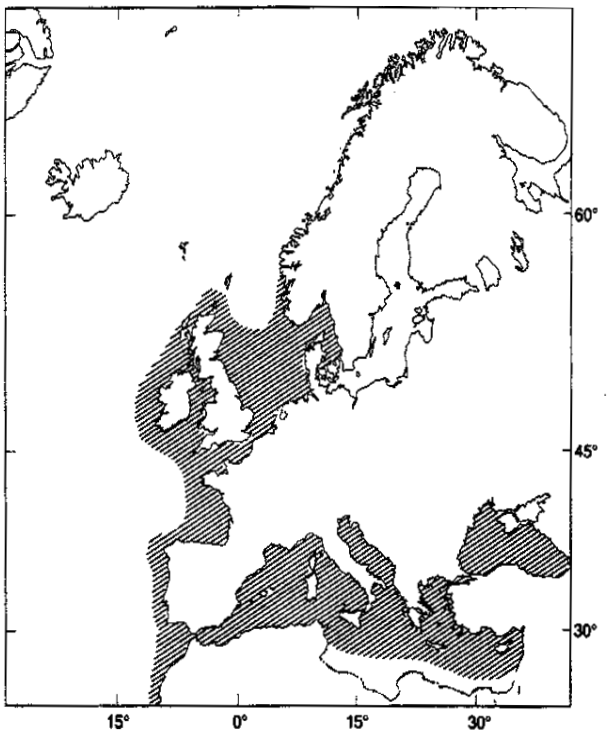

Figure 11.1 The distribution of pilchard in the northeast Atlantic

The quarterly pilchard landings in 1989 by ICES rectangle, from combined English and French statistics, are shown in Figure 11.2. Groundfish survey CPUE are superimposed on this map, but pilchard are not targeted by these surveys, which do not readily illustrate the distribution of pelagic species.

11.2 Spawning areas

The timing of pilchard spawning in the Channel has been recorded during a series of ichthyoplankton surveys in the Plymouth area and has varied considerably since the 1950s. Prior to 1959, pilchard eggs were most abundant in April and May whereas, from 1960 to 1974, they were most abundant in June and October. From 1975-1984, there were virtually no pilchard eggs present in June and most spawning occurred during October. The reasons for these changes are not known. The Plymouth site, however, represents only one part of a far larger pilchard spawning area (Figure 11.3), which includes most of the western Channel, and spawning patterns off Plymouth may not represent those throughout the whole area.

The egg surveys have illustrated the overall distribution of spawning pilchard in the Channel. In 1950, for example, spawning began in the western Channel off Start Point during April and spread to the east of Beachy Head during May, and into the southern North Sea in June and July. Pilchard eggs were most abundant in the western Channel until June but, by July, the centre of abundance had shifted east to the mid-central Channel. Egg surveys along the northern side of the Channel during February, April, June and September 1974 indicated that pilchard eggs were present in the Channel throughout this period, and that the spawning area again moved east as the season progressed. In February, eggs were only found west of the Lizard, but in June and September they were present all along the southern English coast.

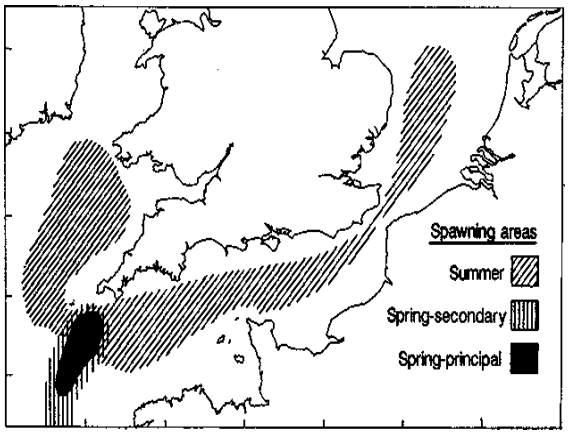

Figure 11.3 Pilchard spawning areas in the northeast Atlantic in spring and summer

11.3 Larvae and juveniles

Early pilchard larvae have been captured during egg surveys, but the distribution and movements of older larvae have not been reported.

Young fish surveys from 1971 to 1975 indicated that 0- and 1-group pilchards were present at inshore sites along the entire southern English coast. However, either their abundance was very low or the small beam trawls used for the survey could not catch them effectively. Juvenile pilchard have also been caught during

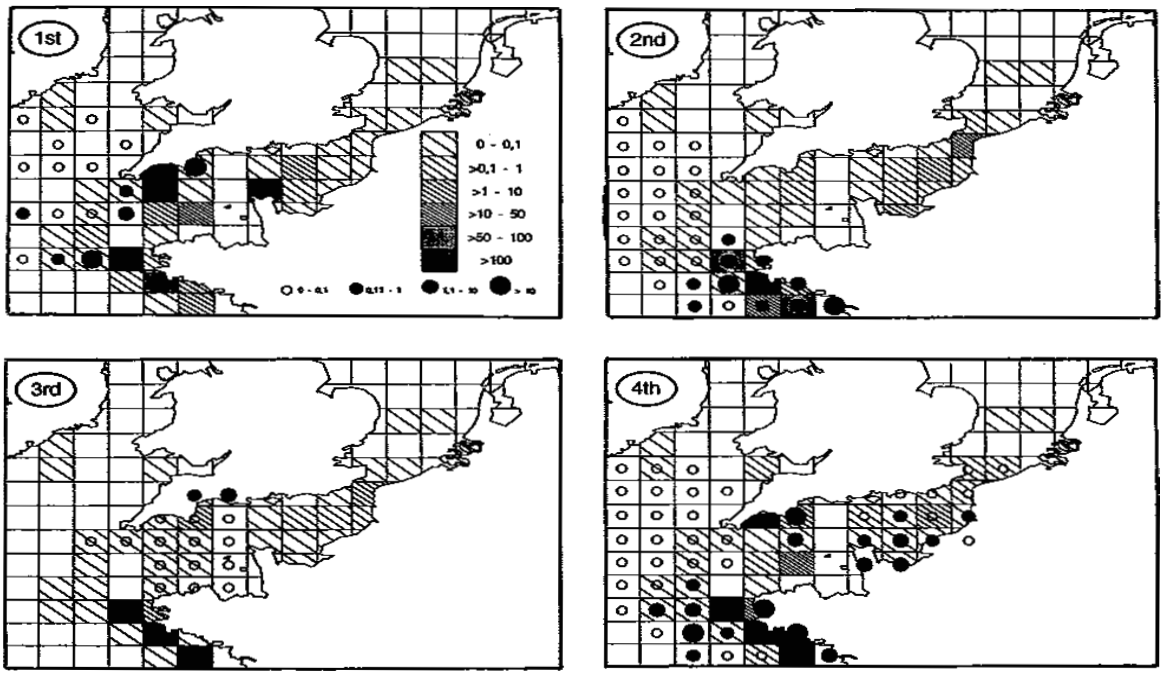

Figure 11.2 The quarterly distribution of pilchard landings (tonnes) by ICES rectangle in the Channel and adjacent sea areas in 1989. CPUE from English and French groundfish surveys are indicated with superimposed circles

fine mesh trawl surveys off Plymouth, and two different modal size classes are recognisable within each year class, possibly derived from early (June) and late (October) spawnings.

11.4 Adult migrations

Pilchard are too delicate to tag effectively, but their movements were traced using acoustic surveys during the 1950 egg study. Pilchard shoals were virtually absent from the eastern Channel during April, but more abundant when eggs appeared there in June and July. A study of pilchard in the western Channel only, using fishing and echo-surveys, located dense wintering concentrations in the vicinity of Wolf rock. Observations from the fishery in the eastern Channel from December to April suggest that pilchards are rarely present in this region, when they are consistently caught in the western Channel. It is reasonable, therefore, to conclude that shoals of pilchard were migrating east through the Channel and spawning as they progressed.

11.5 Biological parameters and population structure

Channel pilchard attain maturity at a total length of around 19 cm - considerably larger than those from the Atlantic coasts of Spain and Portugal. An examination of the maturity stages of pilchard in the western Channel fishery suggested that three groups of spawning fish passed through the fishery at different times each year. It was not clear, however, whether these groups represented fish from different stocks or different components of the same stock. Pilchard in the Bay of Biscay can be divided into two groups, which have lengths at the end of their first year of around 8 cm and 12 cm. These groups also have slightly different mean vertebral counts.

11.6 Conclusions

It is considered that there are two stocks of pilchard in the Bay of Biscay, based on vertebral counts and differences in length at the end of their first year. The northern stock consists of pilchard which spawn in summer and autumn on the southern Brittany coast, and the older fish from this group are thought to migrate into the English Channel. Their progeny recruit to the Channel, from which they return to the Bay of Biscay as juveniles. This theory is open to question, because two size groups of pilchard, similar to those in the Bay of Biscay as a whole, have been observed in the western Channel. In addition, the continued presence of these fish in the lower temperature water of the western Channel may be the reason why they mature at age 4, rather than age 2, as is typical of the Biscay fish.

An hypothesis, that there are several spawning groups of pilchard, is based on egg distribution data, which show considerable separation of spawning areas in space and time. On the basis of available data, however, it is not clear whether these have sufficient integrity to be considered as stocks. The general easterly migration of pilchards into and through the Channel may involve one stock or several stocks responding to the same environmental cue.

12. COD

12.1 General distribution

Cod, *Gadus morhua*, are distributed in north Atlantic waters to a depth of 600 m (Figure 12.1). They are abundant throughout the North Sea, the Irish Sea and the Channel, but their abundance is reduced in the western Channel and they are relatively scarce in the southern Bay of Biscay. The quarterly distribution of cod LPUE in 1989 by English, Welsh and French trawlers by rectangle in the Channel and CPUE values from English and French groundfish surveys are shown in Figure 12.2.

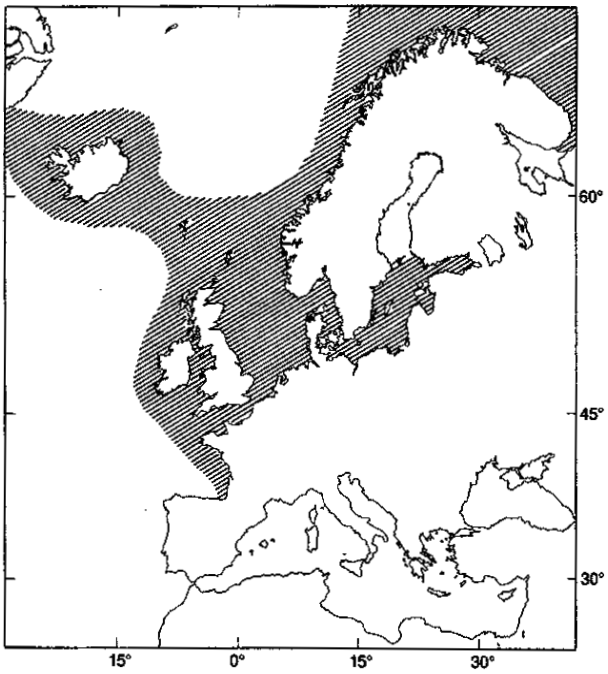

Figure 12.1 The distribution of cod in the north-east Atlantic

12.2 Spawning areas

Cod spawn in the southern North Sea and eastern Channel from January to April, although peak spawning is in late February. Within the Channel, cod spawn inshore along the south east coast of England and off Dieppe and in the Baie de Seine. Eggs are also found near the Bassurelle Bank west of Boulogne and in mid-Channel east of a line from Beachy Head to Dieppe

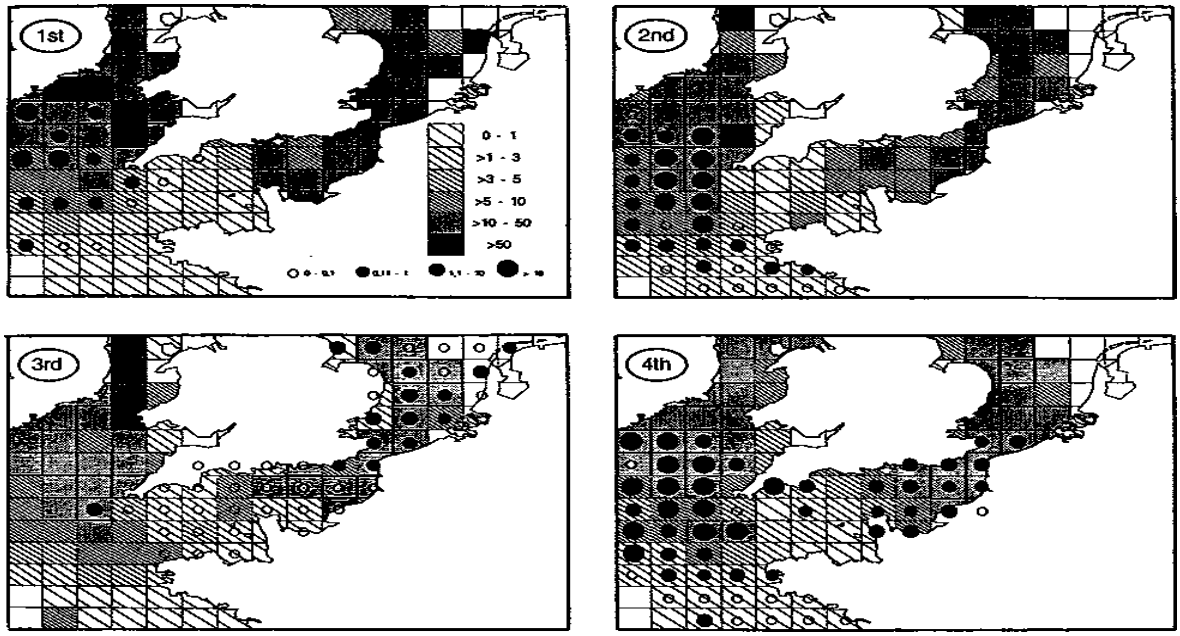

Figure 12.2 The quarterly distribution of cod LPUE by ICES rectangle in the Channel and adjacent sea areas in 1989. CPUE from English and French groundfish surveys are indicated with superimposed circles

(Figure 12.3). Spawning is seldom observed in the western Channel, and no cod eggs were recorded in the central Channel, and relatively few around Start Point, at a time when they were abundant near the Dover Strait. There are also cod spawning areas off northern Cornwall and south-eastern Ireland.

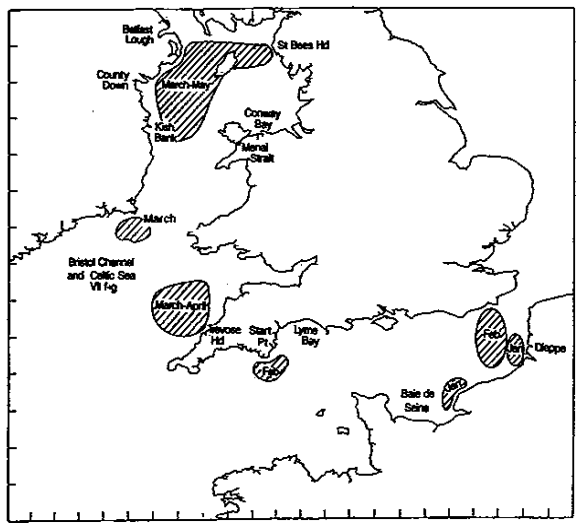

Figure 12.3 The main cod spawning areas to the south and west of England and Wales

12.3 Larvae and juveniles

There is little information on the movements of cod larvae in the southern North Sea, although hydrographic studies suggest that they probably drift to the north or east. Young cod become demersal at lengths above 2 cm and, by late summer, at a length of 2-8 cm, they are concentrated mainly in the eastern North Sea and coastal waters. Later in the year, young cod may move into the deeper estuaries and, by the first winter, have attained a length of 13 -28 cm and are primarily concentrated in shallow areas off Denmark, Germany, Holland and the north-east coast of England. One-group cod are also abundant on the French coast of the eastern Channel, but appear to emigrate during their second year. The distribution of spawning areas and nurseries in the eastern Channel suggest that the larvae generally drift east to nursery areas.

12.4 Migrations

The relationships between spawning areas, nursery areas and the adult stocks to which young cod recruit are not well understood. A tagging experiment with 1-group cod released close to the Dutch coast showed that, from April to June, they tended to move north and west of the release position and, from July to September, 88% of recaptures were made away from the release position. However, by January, the fish were recaptured inshore, in shallow, low salinity areas. The movements agreed with those suggested by data from a trawl survey during the same period. Analysis of 2840 returns of cod tagged in the southern North Sea indicated that 0.2% were recaptured in the western Channel, 2% in the eastern Channel and the remainder in the North Sea.

Many immature cod have been tagged in the eastern Channel. These fish, 30-49 cm in length, generally moved east into the southern North Sea (40% of returns) and only 5% of returns indicated a movement into the western Channel. Occasionally, immature cod have been very abundant throughout the Channel. For

example, in 1964, cod of approximately 35 cm in length were reported to be numerous from Newlyn (west) to Folkestone (east) on the English coast.

Although the analysis of tagging data is complicated by a lack of detailed knowledge of the fishing effort which will influence the pattern of recaptures, the data indicate an overall movement of immature cod from the Channel to the southern North Sea. This movement also includes a seasonal component, with fish moving north in summer and south and west during autumn and winter.

Juvenile cod in the eastern Channel probably originate from eggs spawned by adult cod in the same area. Tagging studies suggest that adult cod in the eastern Channel are semi-resident and move into the Southern Bight less frequently than the juvenile fish. However, as the juvenile cod grow, they filter into the North Sea and, as such, the eastern Channel cod clearly have close links with the North Sea stock.

Immature cod tagged in the eastern Channel showed less tendency to move west than those tagged in the western Channel did to move east. Recaptures from taggings in the eastern Channel during the winter indicate that some juvenile and adult fish moved into the western Channel from the east during the summer and autumn. Cod tagged in the Celtic Sea and Bristol Channel are seldom recaptured in the English Channel, and it appears that cod in the western Channel may have more affinity with those in the eastern Channel than with those in the Celtic Sea.

Mature cod tagged off north Cornwall were recaptured along the south west coasts of England and Wales, though others subsequently returned to the release area. In conjunction with size composition data, these movements suggest that these cod are part of a group which regularly returns to the spawning area off north Cornwall. There is no evidence to indicate that these adult cod or their progeny ever move into the western Channel. The results of the cod tagging studies described above are summarised in Figure 12.4.

12.5 Biological parameters

The North Sea cod population is genetically homogeneous, but there is some evidence of genetic separation of the cod which spawn in the Irish Sea to the west and east of the Isle of Man. Channel cod have not been investigated, but the age compositions of cod landings from east and west Channel differ, with the dominant age being 2 and 3 respectively. This may indicate that two different stocks are fished in these regions and that at least one stock boundary exists in the Channel. Further evidence for this comes from recruitment studies, which show that the 1985 year class was of well-above average abundance in the North Sea and eastern Channel, whereas the1986 year class of cod was very strong on the west coast.

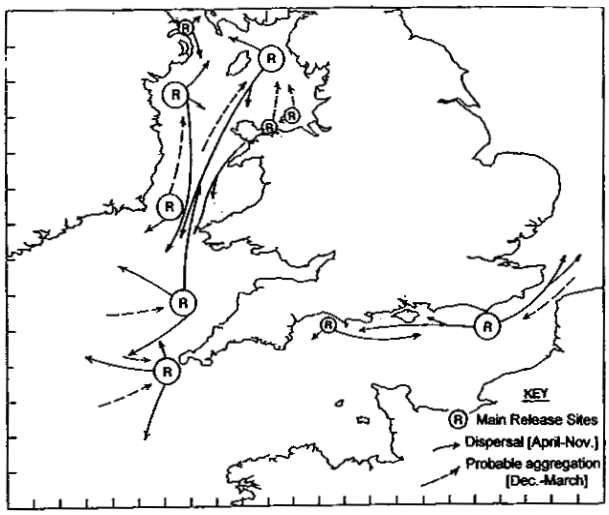

Figure 12.4 The movements of tagged cod in the Channel and adjacent sea areas

12.6 Conclusions

It appears that cod which spawn in the eastern Channel recruit from within this area, but that the eastern Channel also acts as a nursery ground for many cod which subsequently migrate to the southern North Sea and do not return. There is no evidence to suggest that adult spawning stocks in the eastern Channel are supplemented by seasonal immigration of fish from the southern North Sea. Within the eastern Channel, adult cod can be caught offshore throughout the year.

Juvenile cod tagged in the western Channel rarely move into the North Sea and do not migrate into the Celtic Sea. Furthermore, adult cod in the Celtic Sea do not show any association with western Channel fish. Thus, there is some evidence that the western Channel cod are isolated from stocks to the east and west. This hypothesis is supported by circumstantial evidence from the fishing communities of the south Cornish coast. They suggest that cod in this area make a simple inshore-offshore migration between deep-water wrecks and reefs in the summer and inshore areas in winter.

13. WHITING

13.1 General distribution

Whiting, *Merlangius merlangus*, are distributed in northeast Atlantic shelf waters from Iceland and northern Norway south to the coast of Portugal (Figure 13.1). They are abundant in the North Sea, the Irish Sea and the Channel, almost absent from the Baltic Sea, and their presence in the western Mediterranean is doubtful. A separate population of the sub-species *M. merlangus euxinus* occurs in the Black Sea and Adriatic. LPUE of whiting in 1989 for French, English and Welsh vessels by rectangle and quarter, and CPUE from groundfish surveys, are shown in Figure 13.2.

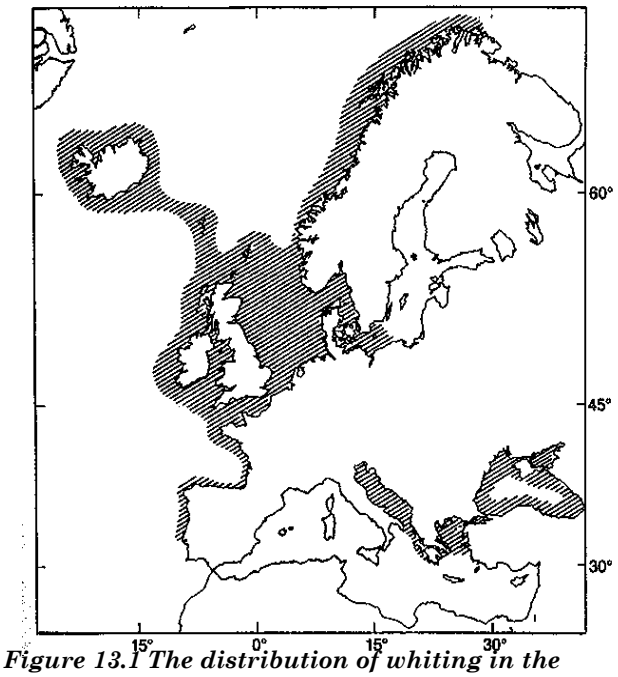

Figure 13.1 The distribution of whiting in the northeast Atlantic

13.2 Spawning areas

Whiting egg data from a series of MAFF cruises during 1971, 1976 and 1984 were used to plot a series of monthly egg distribution maps for the Channel and the North Sea (Figure 13.3). Whiting in the eastern Channel began to spawn in January, and spawning intensified in this area during February, when it was first observed in the western Channel. Spawning continued until May, but the abundance of eggs progressively decreased and, by June, few whiting eggs were found. These surveys did not include the western Channel during March, April or May. However, ichthyoplankton surveys off the northern coast of the western Channel in April 1974 indicated that whiting eggs were present throughout this region and were particularly abundant off Start Point.

13.3 Larvae and juveniles

English ichthyoplankton surveys in June 1974 indicated that whiting larvae were present at inshore sites throughout the Channel. They were most abundant around Beachy Head in the east and Start Point in the west, the areas where eggs were most concentrated in February, March and April. In September and October 1974, whiting larvae were not captured at coastal sites during ichthyoplankton surveys, but small beam-trawl surveys caught 0-group whiting at shallow inshore sites throughout the Channel. This indicates that whiting post-larvae adopt a coastal demersal existence by September.

0-group whiting appear to show an affinity for estuaries, both on the English Channel coast and in other estuarine regions, such as the Bristol Channel, and 0- and 1-group fish were abundant in catches of French beam-trawl surveys along the French coast of the eastern Channel. 1-group and older whiting are regularly caught throughout the Channel at sites frequented by adult fish.

13.4 Adult migrations

Whiting have been tagged in the Channel on a number of occasions. Nearly 4000 trawl-caught fish were released off Start Point during August 1958 and 1960, and a large proportion of the 12-13% returned were recorded within 3 months of being tagged: there was

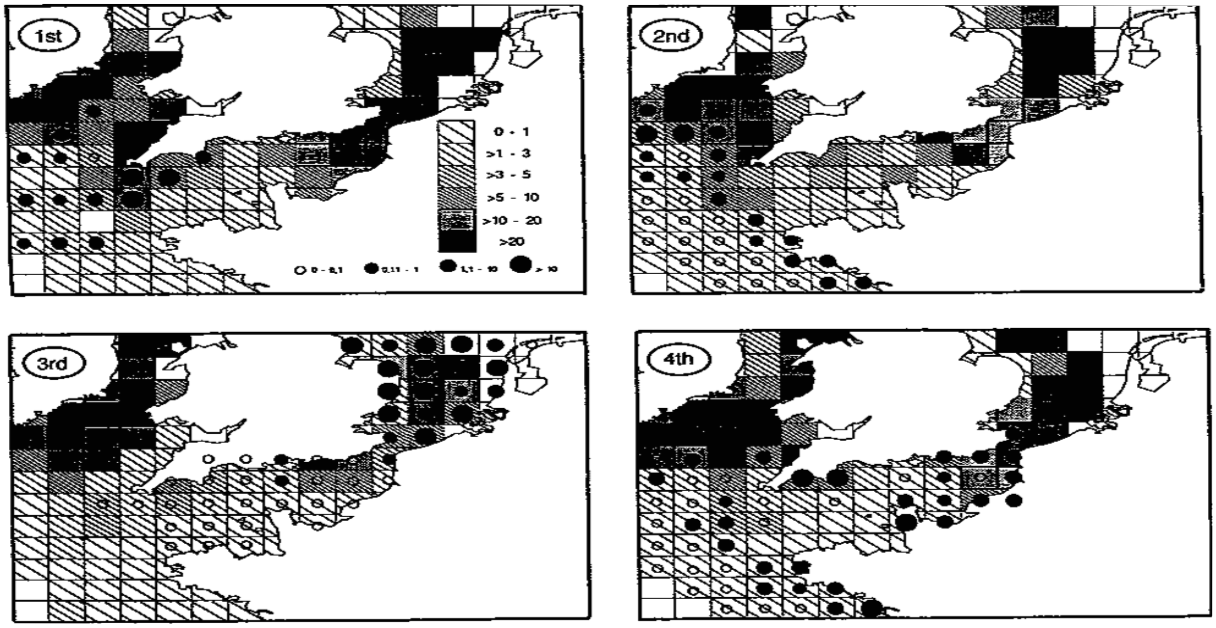

Figure 13.2 The quarterly distribution of whiting LPUE by ICES rectangle in the Channel and adjacent sea areas in 1989. CPUE from English and French groundfish surveys are indicated with superimposed circles

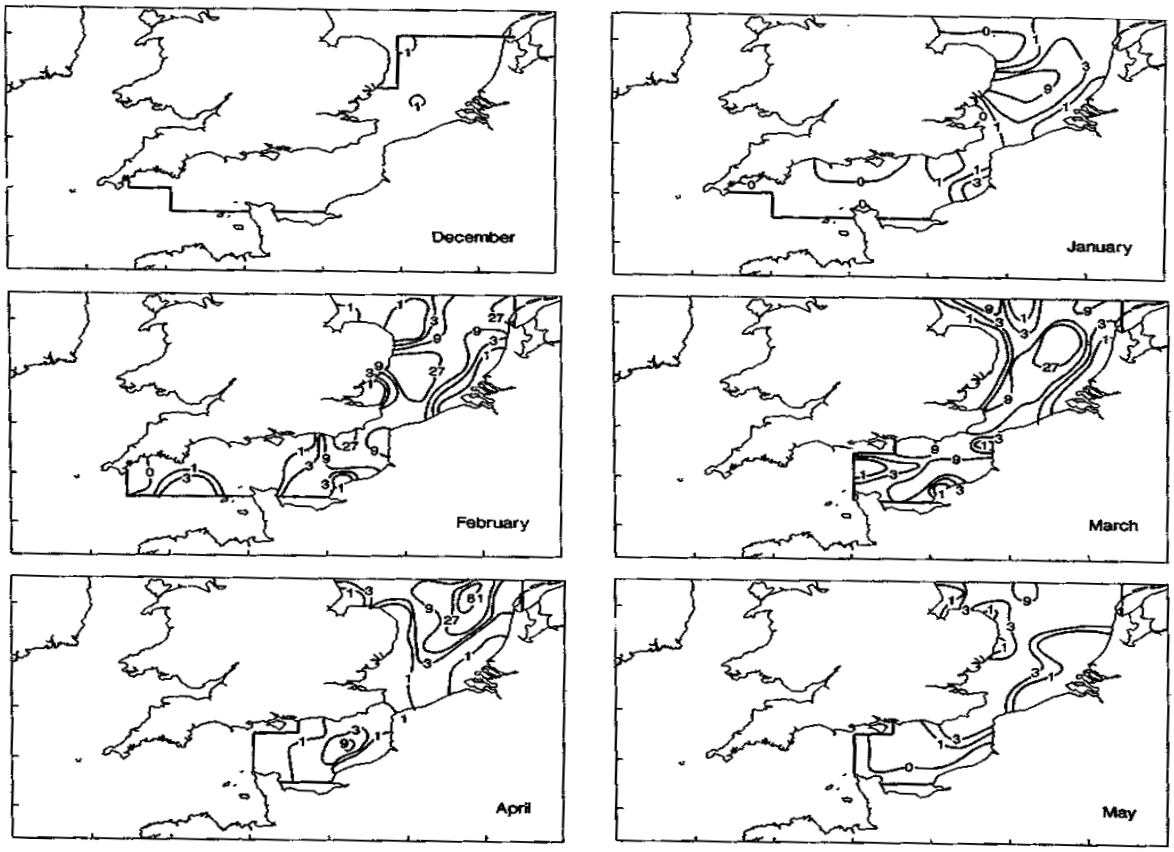

Figure 13.3 The distribution of whiting eggs in the Channel and southern North Sea, December- May (Katerinas, unpublished data)

little indication of any migratory movement in these results. Of 400 whiting tagged in 1958 at Lowestoft in the eastern North Sea, using line-caught fish from shallow water, 28.5% had been recaptured by 1960. These returns indicate that whiting moved into the eastern Channel and southern North Sea during winter, and returned to the southern central North Sea from June to October. Only 2 fish were recorded from the northern North Sea. Out of 332 returns of whiting tagged during October, November and December in the southern North Sea in the period 1950-1988, only 6 were recorded in the northern North Sea, but many fish moved into the eastern Channel. However, only 3 returns were recorded from the western Channel.

13.5 Biological parameters and population structure

Studies of the parasites of whiting in the Channel and North Sea indicated that fish from the western Channel and southern North Sea were predominantly infected by *Myxidium* sp and by *Lernaeocera branchialis*, whereas those from the northern North Sea were predominantly infected by *Ceratomyxa* sp and *Diclidophora merlangi*. Other data suggest that *Diclidophora* infection rates may be higher in the Plymouth area than in the southern North Sea. An analysis of *Myxidium* parasites in saithe, *Pollachius virens*, indicated that 65% of fish from the northern North Sea were infected. This suggests that differences in the *Myxidium* infection of whiting from the northern and southern North Sea were not due to variations in the abundance of these parasites, but to differences in the whiting's life histories, and that adult whiting from these two areas did not mix significantly.

Because *Lernaeocera* do not infect whiting until after they have recruited to nursery areas, they cannot be used to track whiting throughout a complete life cycle, but their presence may indicate the separation of juvenile and adult whiting.

Vertebral and gill raker counts for whiting are higher in the northern than southern North Sea, and though meristic data are available for whiting in the Bristol Channel, there are no similar data for whiting from the western Channel.

An analysis of allele frequencies at two loci in samples of 1-group whiting from different regions of the North Sea, suggests that there is no genetically-based division between whiting from the southern and northern North Sea.

13.6 Conclusions

Tagging data and the prevalence of parasites suggest that whiting from the southern North Sea have a closer

affinity with those in the Channel than with whiting in the northern North Sea. Unfortunately, there are very few data which allow relationships between whiting in the Channel and on the west coast to be examined. The tagging experiments in the Channel produced few returns which indicated any whiting movements between the eastern and western Channel, and it is likely that there is a stronger relationship between whiting in the southern North Sea and the eastern Channel than between whiting in the east and west Channel.

14. POLLACK

14.1 General distribution

Pollack, *Pollachius pollachius*, are distributed in the northeast Atlantic from northern Norway and the Faeroe Islands south to North Africa. They are not present in the Baltic Sea and are only found occasionally in the Mediterranean (Figure 14.1). Adult pollack are most abundant at depths of 40-100 m and juveniles are predominantly found in shallower water. The landings of pollack by English, Welsh and French vessels by rectangle and quarter in 1989 and CPUE values from groundfish surveys (Figure 14.2), suggest that the highest densities are found in the western Channel and Western Approaches. Pollack appear to be relatively scarce in the southern North Sea.

14.2 Spawning areas

The spawning areas of pollack have not been fully identified, but in the period from February to April, offshore trawlers have recently taken large catches of large pollack at depths around 100 m in the western regions of the Channel. These fish appear to be more accessible to the inshore fishery in the preceding and subsequent months. It is concluded that adult pollack leave shallower waters in November or December and migrate to offshore spawning areas where they form dense aggregations. Shortly after spawning, adults return to coastal waters.

Pollack eggs have been reported from Plymouth waters in February and March and along the northern coast of the western Channel in April, though not during February or June. No pollack eggs were found in the eastern Channel during ichthyoplankton surveys.

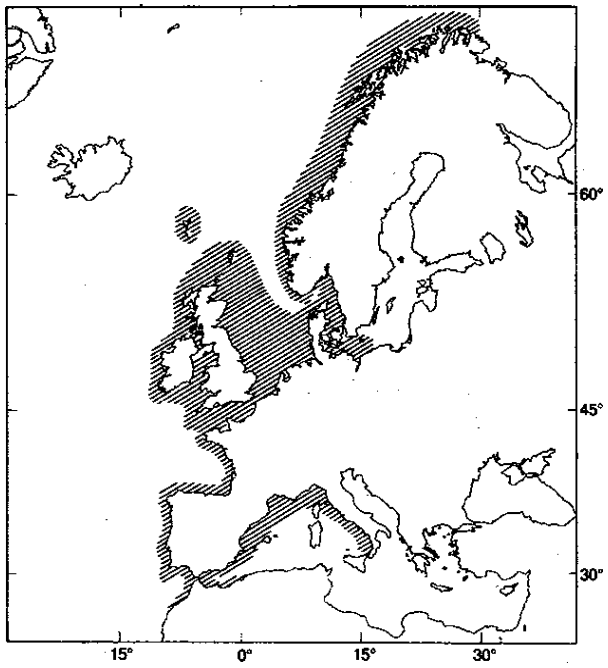

Figure 14.1 The distribution of pollack in the northeast Atlantic

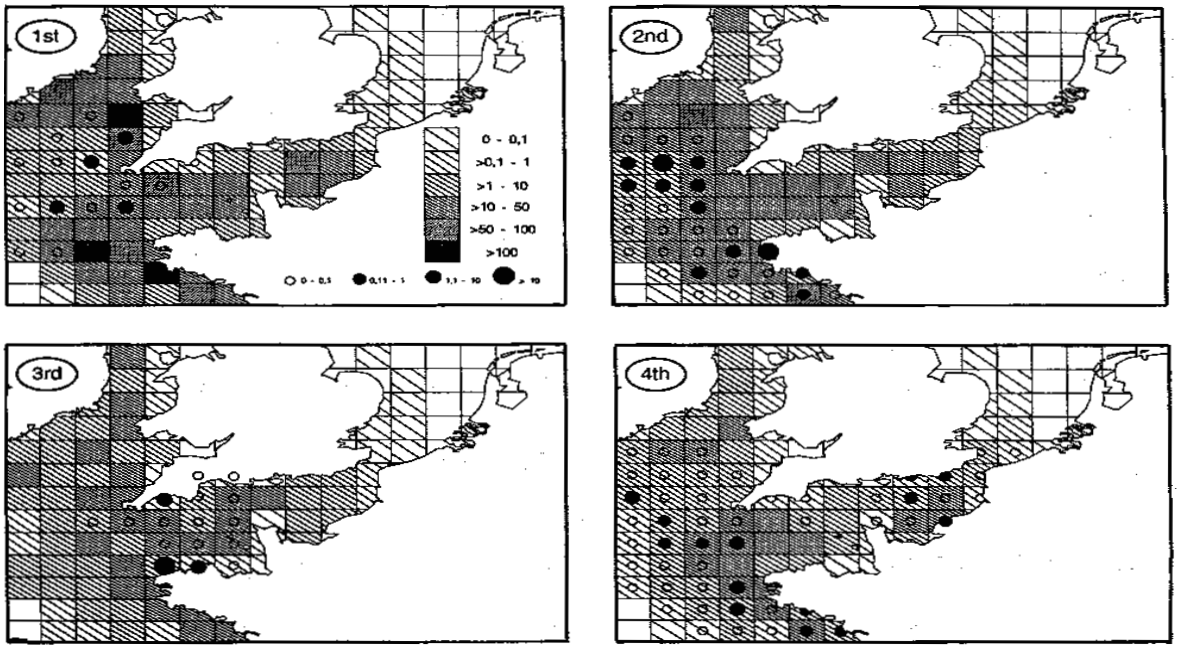

Figure 14.2 The quarterly distribution of pollack LPUE by ICES rectangle in the Channel and adjacent sea areas in 1989. CPUE from English and French groundfish surveys are indicated with superimposed circles

14.3 Larvae and juveniles

Pollack larvae were caught from inshore areas in the vicinity of Land's End during April and June 1974. No pollack larvae were present east of Start Point at this time, which suggests that most spawning and larval development occurs in the extreme western Channel. However, in August and September, 0-group pollack were caught at inshore sites from Beachy Head to Plymouth and around the Scilly Isles. Observations along the rocky coasts of England and France suggest that young pollack frequent the coastal zone for the first year of their life, before moving to slightly deeper inshore waters when 15-20 cm in length. They are relatively scarce in areas where the depth exceeds 30 m, but move to deeper water at maturity. Juvenile pollack are abundant in the western Channel and around the Channel Islands.

14.4 Adult migrations

No tagging studies of pollack have been conducted by MAFF or IFREMER, but some information on adult migration is provided by seasonal changes in the distribution of the fishery. In the western Channel, landings data (Figure 14.2) suggest that pollack are widely dispersed during summer, autumn and winter, but aggregate during spring. Landings in the eastern Channel are too low to provide indications of a migration. Outside the spawning season, pollack generally congregate around wrecks and reefs where they are targeted by set nets.

14.5 Biological parameters and population structure

There is little available data on the growth or maturity of pollack. The mean length of Celtic Sea pollack at age 5 has been reported to be 65 cm, and pollack from the western Channel in 1989 and 1990 had a mean length at age 5 of 69 cm. French catches from spawning areas in the western Channel indicate that they first become mature at age 3.

14.6 Conclusion

There is insufficient information available to determine whether pollack in the western Channel and Western Approaches may be treated as a single stock.

15. HAKE

15.1 General distribution

Hake, *Merluccius merluccius*, are distributed in the eastern Atlantic from northern Norway and Iceland south to Mauritania, and are most abundant on the continental shelf from Ireland south to Gibraltar. They are present in the Mediterranean, but absent from the Baltic and Black Seas (Figure 15.1). Hake densities are highest at depths of 100-300 m. LPUE of hake in 1989 by English, Welsh and French vessels and survey CPUE data are shown in Figure 15.2, which indicates that, in relation to the Channel as a whole, hake are only abundant near its western mouth.

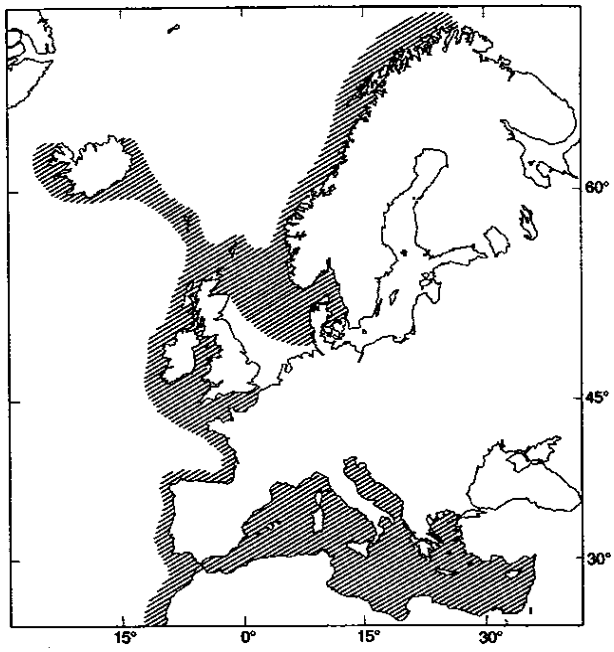

Figure 15.1 The distribution of hake in the north-east Atlantic

15.2 Spawning areas

Hake have a protracted spawning season and, in the southern Bay of Biscay and off the Spanish coast, spawning probably takes place throughout the year. Spawning in waters adjacent to the Channel is thought to be more seasonal, from March to July in areas south and west of Ireland. IFREMER ichthyoplankton surveys in 1978 indicated that the main spawning period was in March, in depths of 120-160 m and associated with water temperatures of 11-12°C. Hake eggs have been found in the western Channel, but it is unlikely to be an important spawning area. (Figure 15.3)

15.3 Larvae and juveniles

Hake larvae appear to be most abundant during March to June along the shelf edge from southern Ireland to the southern Bay of Biscay. Occasional larvae have been caught in the western Channel, but the centres of larval distribution are offshore. Young hake descend to the seabed from May onwards and measure approximately 4 cm when they begin a demersal existence. They concentrate initially at depths in excess of 200 m, but they move to shallower water (75-120 m) by

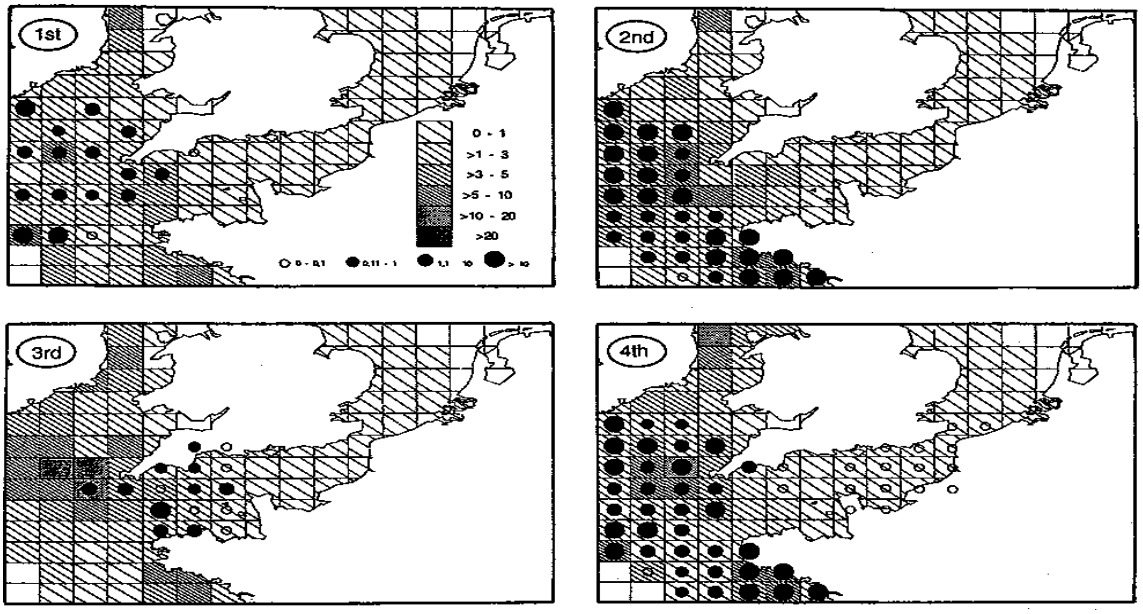

Figure 15.2 The quarterly distribution of hake LPUE by ICES rectangle in the Channel and adjacent sea areas in 1989. CPUE from English and French groundfish surveys are indicated with superimposed circles

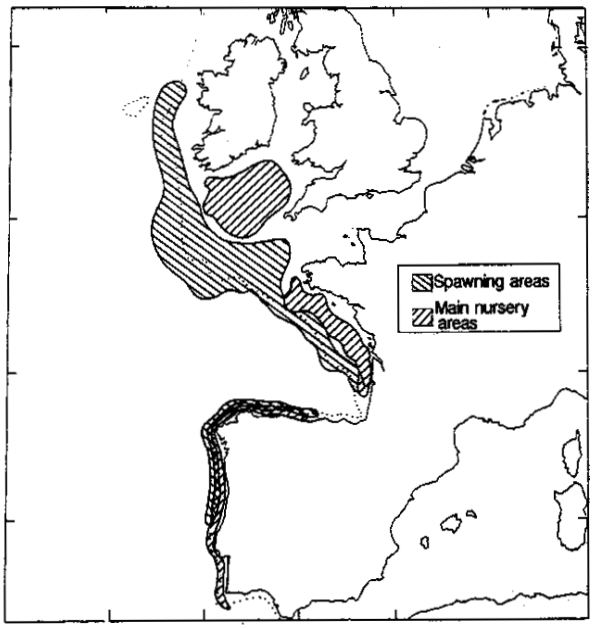

Figure 15.3 The distribution of hake spawning grounds and nursery areas in the northeast Atlantic

September when the modal length is approximately 11 cm. Two major nurseries are recognised in regions adjacent to the western Channel: one in the Bay of Biscay and one off southern Ireland. As 0- and 1-group fish, the hake appear to favour habitats with muddy substrates.

When three years old, the hake begin to move into shallower regions of the Celtic Sea and the Bay of Biscay, but as they approach maturity they disperse to offshore regions. Male hake mature when 3-4 years old (at 20-27 cm) and female hake when 6-7 years old (57-70 cm).

15.4 Adult migrations

Hake movements are indicated by the seasonal distributions of catches in the fishery. From December to March, hake support a fishery which commences in the southern Bay of Biscay and moves north as these fish migrate, reaching the northern Bay of Biscay in March and April. Subsequently, they appear on the Celtic Sea shelf-edge in June and July. Between August and December the hake fishery is centred to the west and southwest of Ireland, and catch rates decline in shallower waters. A small proportion of the hake involved in these migrations will enter the deeper regions of the western Channel.

15.5 Biological parameters and population structure

The ageing of hake has proved to be very difficult because there is no firm criterion for distinguishing 'true' and 'false' annual rings on the otoliths. Although growth data for hake in waters adjacent to the Channel have been published, there are no comparable data for hake in the Channel. Hake in the Bay of Biscay and Celtic Sea appear to grow to a greater maximum length (~ 140 cm) than those around the Iberian peninsula (~ 100 cm).

Sex-ratios may provide some information to assist with stock identification. In northern regions of Biscay and the Celtic Sea, the sex ratio is approximately 1:1 for hake less than 30-40 cm. Males are more abundant than females between 40 and 55 cm, and then females become more abundant. Males greater than 60 cm are very rare. This phenomenon has also been observed in other areas. Differences in the growth of the sexes may explain the changes in sex ratio.

15.6 Conclusions

Two stocks of hake are recognised for management purposes. The 'northern stock' includes hake in the Celtic Sea, north and west of Ireland, the western English Channel and the northern Bay of Biscay. At present, it is uncertain whether this stock should be considered as a single biological management unit. However, it is clear that the hake which enter the western Channel are members of a much larger stock and seasonally migrate into this area from the Celtic Sea.

16. LING

16.1 General distribution

Ling, *Molva molva*, are distributed in the northeast Atlantic from Greenland and northern Norway south to the Bay of Biscay. They are not, however, present in the Baltic Sea (Figure 16.1). Adult ling are most abundant at depths of 100-400 m, whereas juveniles are predominantly found in shallower water. LPUE data for English, Welsh and French vessels by rectangle and quarter in 1989, and CPUE data from groundfish surveys (Figure 16.2), suggest that high densities of ling are found in the extreme western Channel and Western Approaches. Ling are scarce in the eastern Channel and the southern North Sea.

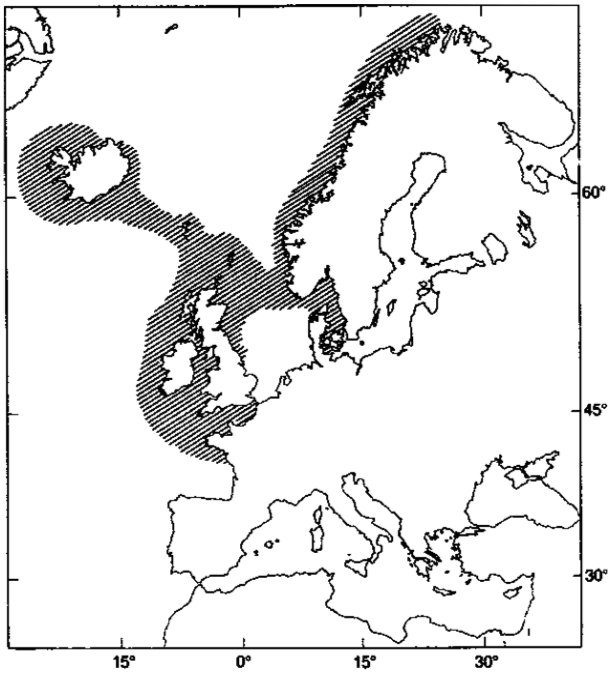

Figure 16.1 The distribution of ling in the north-east Atlantic

16.2 Spawning areas

The spawning areas of ling are not well known, but it appears that most spawning takes place in the west of the Celtic Sea and that relatively little spawning takes place within the western Channel (Figure 16.3).

In the period from February to May, large ling are relatively abundant in French catches in the Celtic Sea and Western Approaches at depths of around 100 m, and many of these fish have ripe gonads. Ling of this size do not appear in catches there at other times of the year. It is thought that these ripe ling are migrating to spawn at depths of 100-200 m.

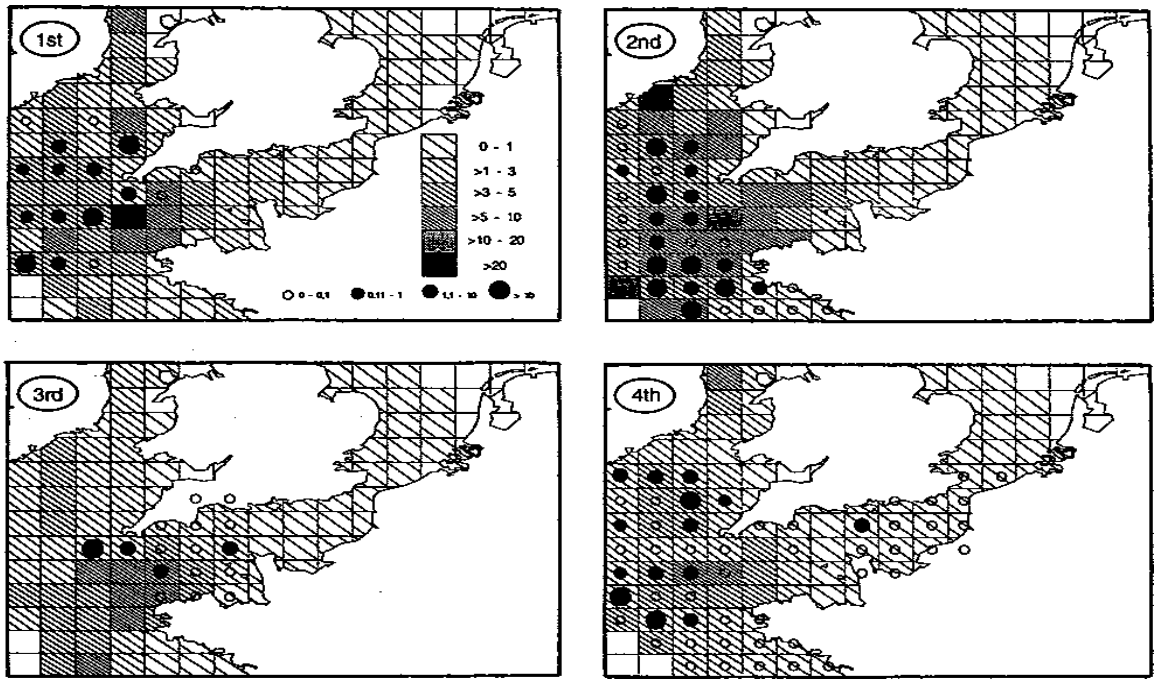

Figure 16.2 The quarterly distribution of ling LPUE by ICES rectangle in the Channel and adjacent sea areas in 1989. CPUE from English and French groundfish surveys are indicated with superimposed circles

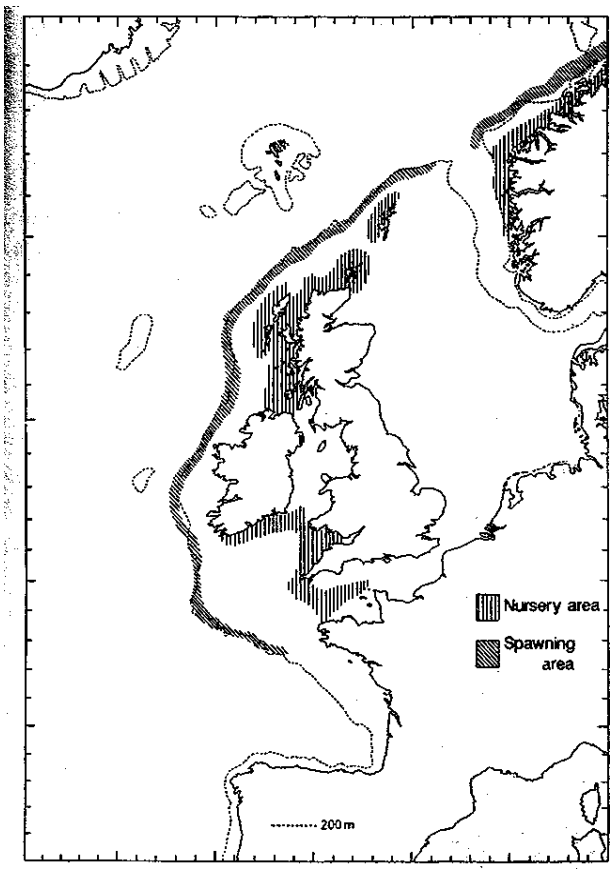

Figure 16.3 The distribution of ling spawning grounds and nursery areas in the northeast Atlantic

Ling eggs were recorded from inshore waters less than 100 m deep in the extreme western Channel and around the Scilly Isles during ichthyoplankton surveys in June 1974, though none were found in samples taken in the Channel during February, April or September 1974. Adult ling are rarely caught in inshore waters during the spawning season, and these eggs are unlikely to have resulted from the main spawning (unless they had drifted a considerable distance).

16.3 Larvae and juveniles

Ling larvae were caught close to the southern English coast of the western Channel during surveys in April and June 1974. No larvae were caught during similar surveys in February and September. The distribution of ling larvae elsewhere in the western Channel and in the eastern Celtic Sea has not been studied.

The duration of the larval stage is not known, but young-of-the-year ling with a length of 4-8 cm are caught at depths of 25-50 m in December. The juvenile ling remain in inshore waters, typically 20-100 m deep, for approximately four years, and then move to depths of 100-300 m as they approach maturity. Juvenile ling favour rocky substrates and are difficult to locate by conventional young-fish survey techniques. It is thought that they are present in most shallow rocky regions around the western Channel coast (Figure 16.3).

16.4 Adult migrations

The quarterly distributions of LPUE (Figure 16.2), and the prevalence of different sized ling in the trawl fishery landings, suggest that adult ling migrate to deep water near the shelf edge for spawning in March to June.

16.5 Biological parameters and population structure

The ling appears to show considerable variability in the age and size at which it matures. Some data indicate that males mature at age 3 when 50 cm in length and females at age 4 when 55 cm, whereas there are other reports that males mature at 80 cm and females at 90-100 cm, aged 6-8. It is difficult to judge which of these values is most appropriate, or whether they merely reflect variability within the ling population.

16.6 Conclusion

There is insufficient information available to determine whether ling in the western Channel and eastern Celtic Sea may be treated as a single stock.

17. BASS

17.1 General distribution

Bass, *Dicentrarchus labrax*, are distributed in northeast Atlantic shelf waters from southern Norway, through the North Sea, the Irish Sea, the Bay of Biscay, the Mediterranean and the Black Sea to North-west Africa (Figure 17.1). The quarterly distribution of bass landings by rectangle in the Channel in 1989, and CPUE values from English and French groundfish

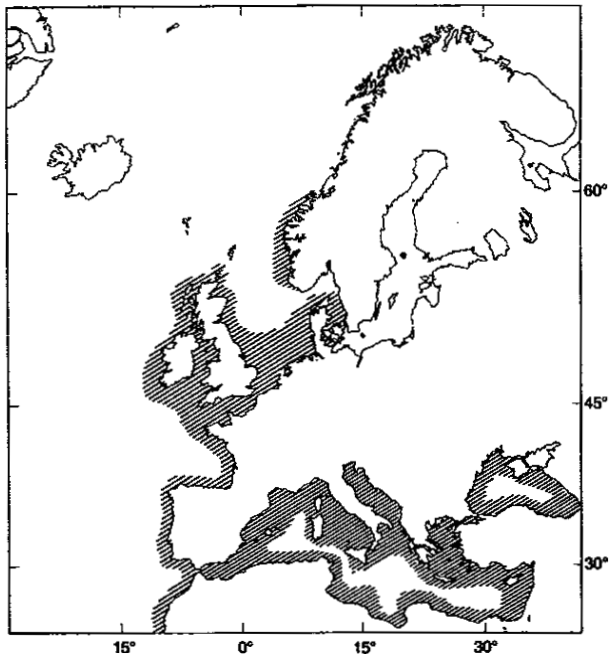

Figure 17.1 The distribution of bass in the north-east Atlantic

surveys, are shown in Figure 17.2. Only a small proportion of the UK bass catch is landed through major ports, and the landings data shown are based on a combination of the official UK statistics and figures derived from a voluntary logbook scheme. In France, a higher proportion of the bass catch is sold through markets which supply statistics to IFREMER.

17.2 Spawning areas

Bass spawn in the Channel and adjacent regions from February to June, and plankton surveys have revealed that their eggs were most abundant in the mid-western Channel during April, when the temperature range at spawning was 8.5-11°C. The area of spawning appeared to spread east as the surface water temperature exceeded 9°C and, by May, there were additional centres of spawning in coastal waters of the eastern Channel from the Isle of Wight to Beachy Head (Figure 17.3). In addition to the extensive spawning areas in the Channel, bass spawn off Trevose Head in southwest England during March and April and occasionally off the Isle of Man in the Irish Sea and in the southern North Sea during May and June.

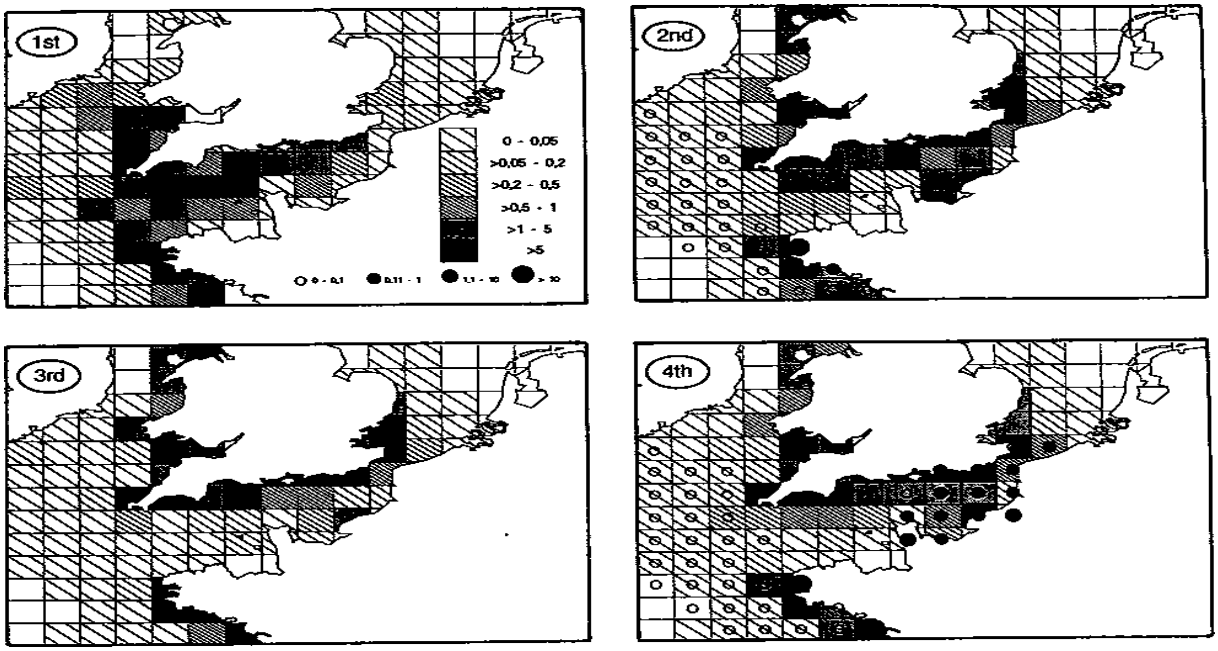

Figure 17.2 The quarterly distribution of bass landings (tonnes) by ICES rectangle in the Channel and adjacent sea areas in 1989. CPUE from English and French groundfish surveys are indicated with superimposed circles

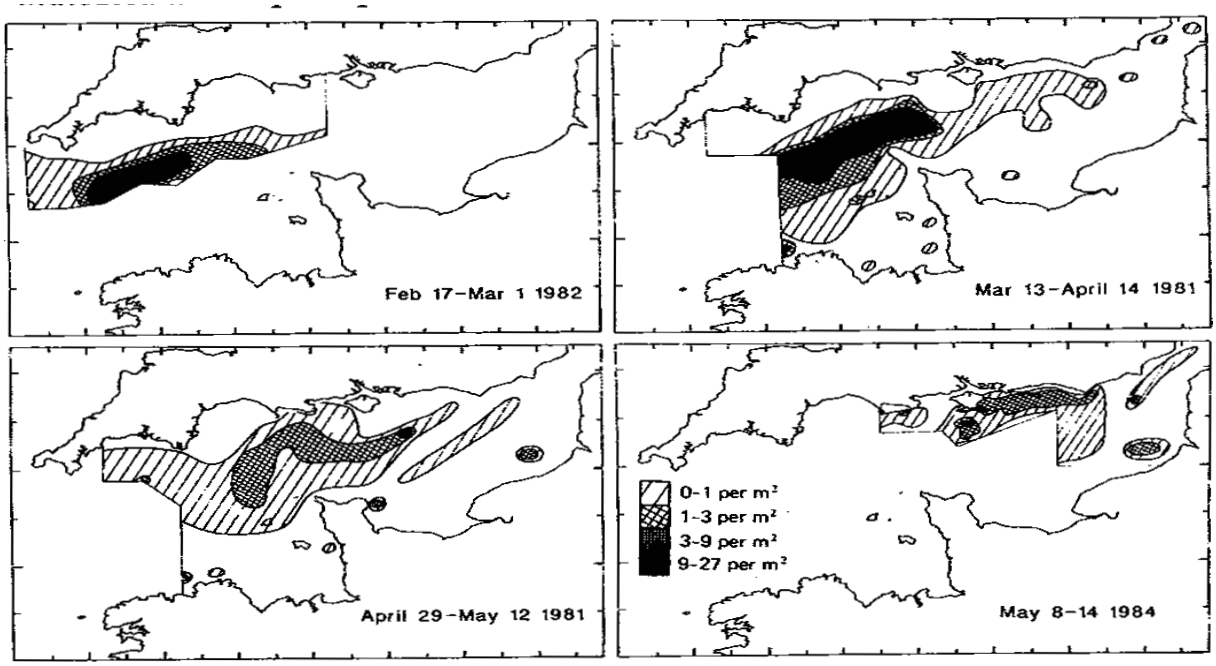

Figure 17.3 The distribution of bass eggs in the Channel during: (a) February and March 1982; (b) March and April 1981; (c) April and May 1981; and (d) May 1984 (from Thompson and Harrop, 1987)

17.3 Larvae

Only a small number of early larval bass have been caught during plankton surveys in the English Channel. Studies of older larvae in the Channel, and in the Bristol Channel, suggest that bass larvae move steadily inshore as they grow. The larger larvae aggregate in inshore waters and it is thought that, when they reach a specific developmental stage at around 15 mm in length, they respond to an environmental cue and actively swim into estuarine nursery habitats.

17.4 Juveniles

From June onwards, young-of-the-year bass in excess of 15 mm long are found extensively in creeks, estuaries, backwaters and shallow bays which border the Channel. Studies on the south and west coasts of the UK have shown that bass remain in these nursery areas through their first and second years, after which they migrate to overwintering areas in deeper water. Juvenile bass may return in summer to the larger estuaries (typically greater than 4 km² at low water) until their fifth year. Figure 17.4 shows the distribution of known bass nursery areas in the Channel. After 4-7 years, or at approximate lengths of 35 cm for males and 42 cm for females, bass attain maturity and adopt the migratory movements of the adult fish.

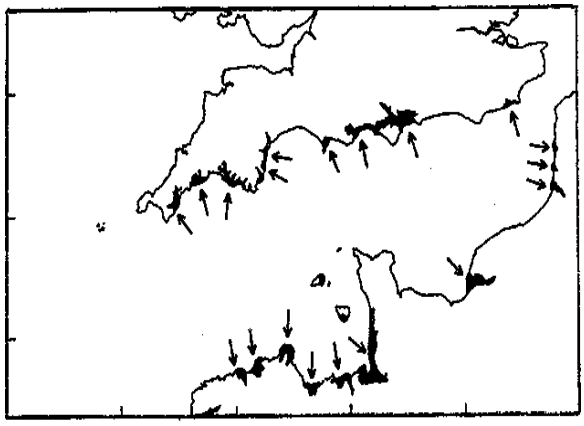

Figure 17.4 Bass nursery areas in the Channel

17.5 Adult migrations

The movements of adult bass in the Channel and adjacent seas have been indicated by a series of tagging studies. Bass which appeared on the south coast of England and around the Thames estuary during the summer spent the winter offshore in the western Channel. However, bass approaching first maturity and which originated in the Thames estuary, did not migrate so extensively, and some appeared on the south coast of England in the winter. Bass of a similar age, tagged on the south coast of England in summer, had very limited seasonal movements, and were usually recaptured within 50 miles of the tagging site.

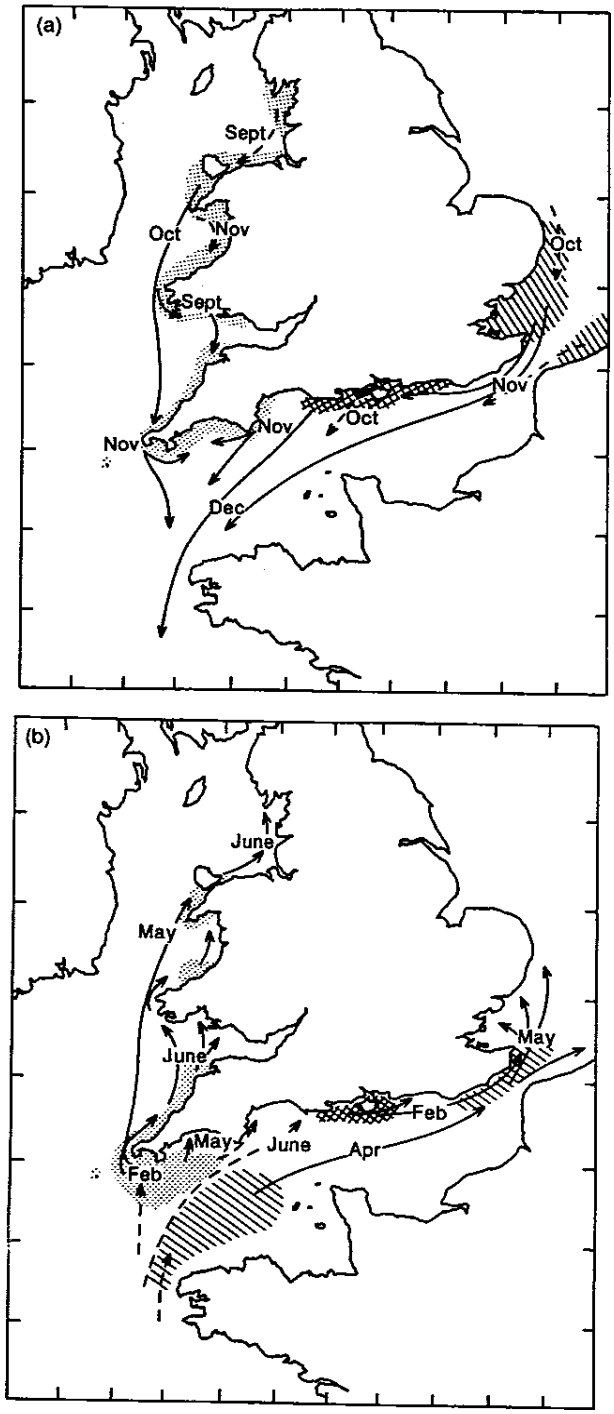

Figure 17.5 Seasonal movement and distribution of adult bass in the 3 main populations tagged around England and Wales, indicated by shaded areas: (a) autumn movements from summer areas; and (b) late winter and spring movements from winter areas (after Pawson et al., 1987)

Figure 17.5 indicates the probable migrations of Channel bass. It is thought that most adult bass from the eastern area aggregate in the western Channel during winter. The final maturation and spawning of these fish takes place in spring as the water temperature

increases above 9°C. As the return migration of spawning fish continues, so the centre of the spawning areas shifts progressively further east until, by June, spawning is complete. In late spring, the spent fish move into feeding grounds in the eastern Channel and southern North Sea, where they remain until the water temperature decreases in late autumn; they then migrate south and west to the winter pre-spawning areas.

Many adult bass from the western area spend the winter off Cornwall and, as they become ripe in February and March, they begin to migrate north along the west coast of the UK. A major spawning area is located off Trevose Head, and the fish proceed northwards to summer feeding areas from north Devon to north Wales and northwest England. In the autumn, the fish return towards their pre-spawning areas off Cornwall.

Bass on the west coast of the UK do not appear to mix across the Celtic Sea with those from the east coast of Ireland. Some fish on the west coast of the UK, however, have been observed to cross the English Channel and mix with those on the west coast of the European mainland. Moreover, the recovery at a site in northern Spain, of a bass tagged off Portland Bill, suggests that some large bass which appear on the south coast of England during summer may be migrants from much further south.

It is not clear whether Channel nursery areas provide recruitment to specific adult stocks, although tagging studies with 3-4 year old bass in the Solent indicate that very few subsequently appear in the western Channel.

17.6 Biological parameters

The life history traits of bass vary across their environmental range, with those fish at the cooler, northern extremes usually exhibiting slower growth, later maturity and longer maximum lifespans than those from warmer environments. Males mature at a length of 31-35 cm aged 4-7 years and females at 40-45 cm aged 5-8 years in British and Irish seas, whereas, off the Tunisian coast, males mature at around 24 cm, aged 2-3 years, and females at around 32 cm, aged 4-5 years. Bass from the Mediterranean Sea grow considerably faster than most of those in the Channel, although recent MAFF data indicate that growth on the UK south coast is similar to that in the Bay of Biscay.

Studies have indicated that there are genetic differences between immature bass from the Irish Sea and elsewhere around Britain, which supports the hypothesis that the western Channel might be the boundary region for two bass stocks.

17.7 Conclusions

The data from tagging studies and the seasonal distribution of the fishery suggest that 2 major bass stocks may be identified in the Channel - an eastern stock which moves between the English Channel and the southern North Sea, and a western stock which migrates along the west coast and into Cornish waters. In general, a boundary running southwest from Start Point roughly indicates the separation between these stocks, though adults from the eastern stock may spend winter to the west of this line.

18. BLACK BREAM

18.1 General distribution

Black bream, *Spondyliosoma cantharus*, are distributed in northeast Atlantic shelf waters from Norway and the Orkney Islands south to the Mediterranean Sea and the Canary Islands. They are not present in the Baltic and are most abundant in the Channel and south to the Mediterranean Sea (Figure 18.1). The quarterly distribution of commercial landings, by English and French vessels by rectangle in 1989, and CPUE values from English and French groundfish surveys, are shown in Figure 18.2

18.2 Spawning areas

Black bream are demersal spawners. The male makes a depression in a gravel substrate and subsequently guards the fertilised eggs. Accordingly, spawning areas cannot be identified by planktonic egg surveys. The

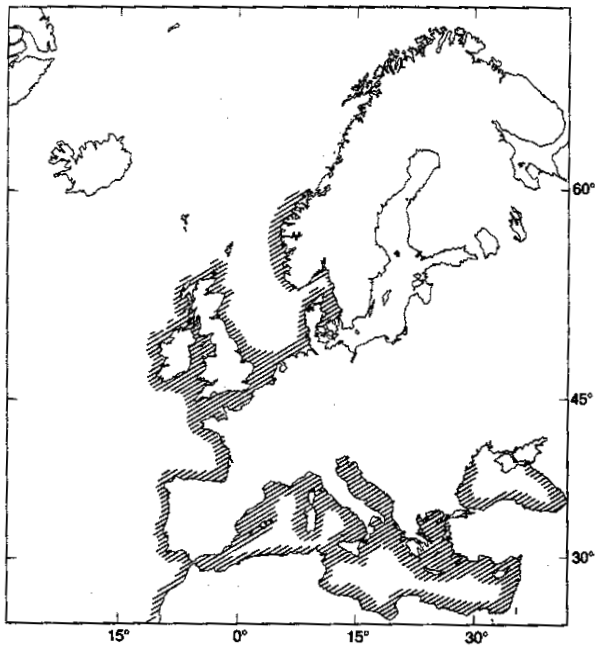

Figure 18.1 The distribution of black bream in the northeast Atlantic

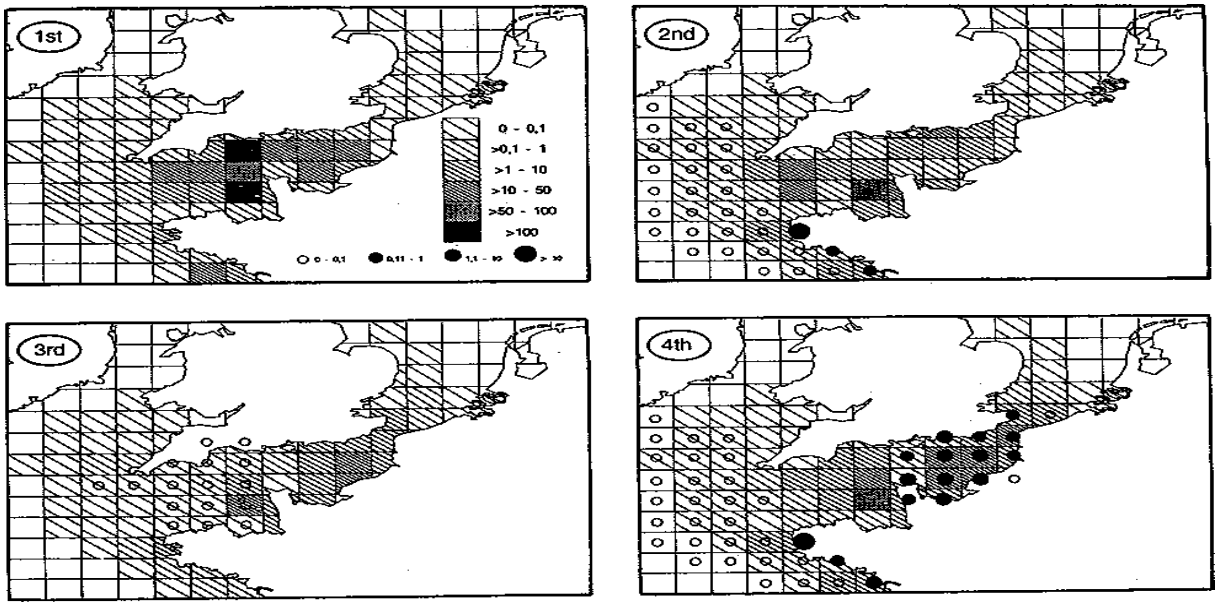

Figure 18.2 The quarterly distribution of black bream landings (tonnes) by ICES rectangle in the Channel and adjacent sea areas in 1989. CPUE from English and French groundfish surveys are indicated with superimposed circles

presence of ripe and running bream in commercial catches suggests that spawning begins in the southwestern Channel in April and takes place around the Channel Islands and off the Isle of Wight in May. The latest spawning recorded was in the Baie de Seine during September and October. Most spawning areas are less than 50 m deep.

18.3 Larvae and juveniles

Juvenile black bream are found inshore around the Channel Islands, Port en Bessin, the Isle of Wight and in the Solent, which suggests that they do not move far from the spawning grounds. Juveniles remain in these inshore areas for 2-3 years before recruiting to the adult stock at a length of approximately 20 cm.

18.4 Adult migrations

Although black bream were tagged in the extreme southwestern Channel during February 1981 and off Jersey in July 1986, only a few returns from areas close to the tagging sites were recorded. Consequently, bream migrations have been elucidated by inferring seasonal movements from fishery data and analysing the distribution of maturing, ripe and spent fish (Figure 18.3). During the winter months, pre-spawning adult concentrations are found in waters from 50-100 m depth west of a line from Alderney to Start Point. Evidence for this is provided by the French pair- and otter-trawl fisheries and incidental catches by English purse seiners fishing off Land's End.

During April and May, adult fish are caught in shallow (under 50 m) water around the Channel Islands, where they are no longer accessible to the deeper water pair-

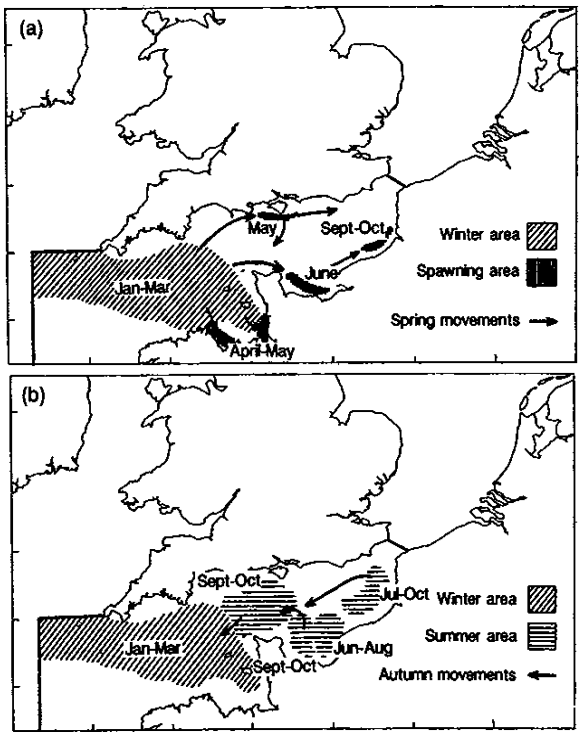

Figure 18.3 The migration of black bream in the Channel: (a) spring movements, (b) autumn movements

trawl fishery. In the subsequent months, bream migrate east along the English and French coasts, and they probably enter the southern North Sea during July. It has been suggested that the migrations of bream (like bass) follow the eastward movement of the 9°C isotherm as the Channel warms in spring.

Once bream have entered the eastern Channel, groups are regularly encountered in particular localities during

the summer. These support commercial fisheries off Boulogne (July to December), Dieppe (July to November), Port en Bessin (July to October) and the Isle of Wight and Sussex coast (May to November). Recreational fisheries also target bream off Sussex and south Devon, west Wales and around the Channel Islands. Bream feed in these inshore sites after spawning and begin to leave the eastern Channel in November and December. The winter concentrations in the western Channel appear in January as the fish move offshore into deeper water.

18.5 Biological parameters and population structure

Black bream all mature as males at a length of around 20 cm and remain male to a length of approximately 30 cm. However, once bream exceed 30 cm, they may change into females and all bream over 40cm in length are females. This may have important consequences for the sustained reproductive capacity of a bream stock; the modal size of bream decreased from 37-38 cm in 1977 to 28-30 cm in 1979 as the bream fishery expanded. If the sex ratio of bream in samples from different areas has been greatly affected by fishing, this may provide a means of tracking groups of black bream in the Channel and of indicating their integrity.

There are differences between the length-weight relationships for fish in the western Channel and the Bay of Biscay, but the variation is considerable and this difference has not been tested statistically. Despite these interannual variations, growth in the northern Bay of Biscay is consistently faster than that in the Channel.

18.6 Conclusion

Black bream over-winter in the western Channel and migrate into the eastern Channel during May and June. There is no evidence to indicate that these fish are a single stock, rather than several stocks of fish which use different spawning areas but spend the winter in the same region.

19. MACKEREL

19.1 General distribution

Mackerel, *Scomber scombrus*, are distributed in north Atlantic shelf waters, usually at depths of less than 200 m, from Iceland south to the Mediterranean Sea and off the eastern coasts of Canada and North America (Figure 19.1). Restrictions on the fishery may influence the officially reported distribution of catches. These are not, therefore, always a reliable guide to positions where the mackerel were actually caught. The quarterly distribution of mackerel landings in 1989 by rectangle in the Channel shown in Figure 19.2. include some information from unofficial sources which has been incorporated in rectangles where these landings exceed the officially reported values.

19.2 Spawning

Mackerel spawn in two main regions of the northeast Atlantic: the central North Sea, Skagerrak and Kattegat, and along the continental shelf from western Ireland to the Bay of Biscay. In the North Sea, spawning begins in May, reaches a peak at the end of June and ends in August. In the west, the spawning season usually begins in March, peaks in May/June and ends in July, Figure 19.3.

Triennial egg surveys, conducted in the western area since 1977 to obtain annual estimates of egg production, and hence spawning stock biomass, indicate that the timing and distribution of spawning have remained relatively constant. The western spawning area may extend into the Channel, but an egg survey in June 1989 indicated that no more than 3% of Western mackerel spawning takes place in the western Channel.

19.3 Larvae and juveniles

Data on the distribution and abundance of mackerel larvae around the British Isles, from 1947 to 1978, showed that larvae were most abundant in the Celtic Sea and central and northern North Sea, although a few larvae were found in the western Channel during July and August.

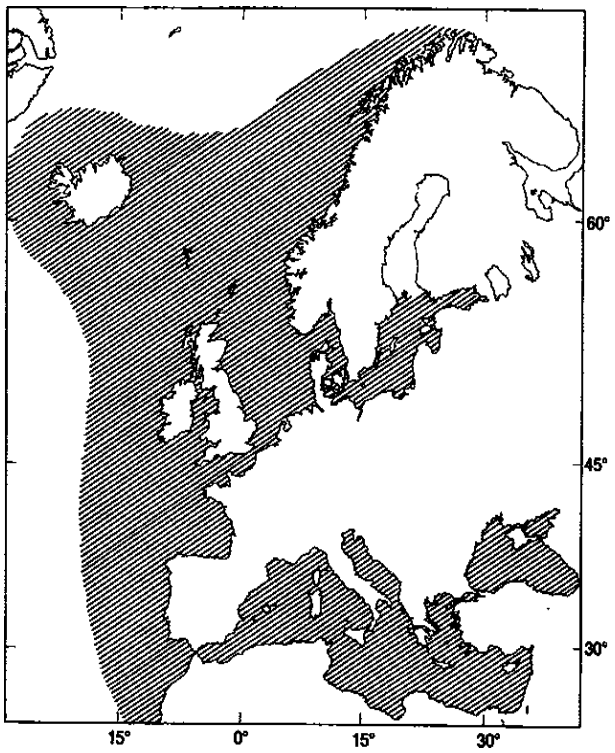

Figure 19.1 The distribution of mackerel in the northeast Atlantic

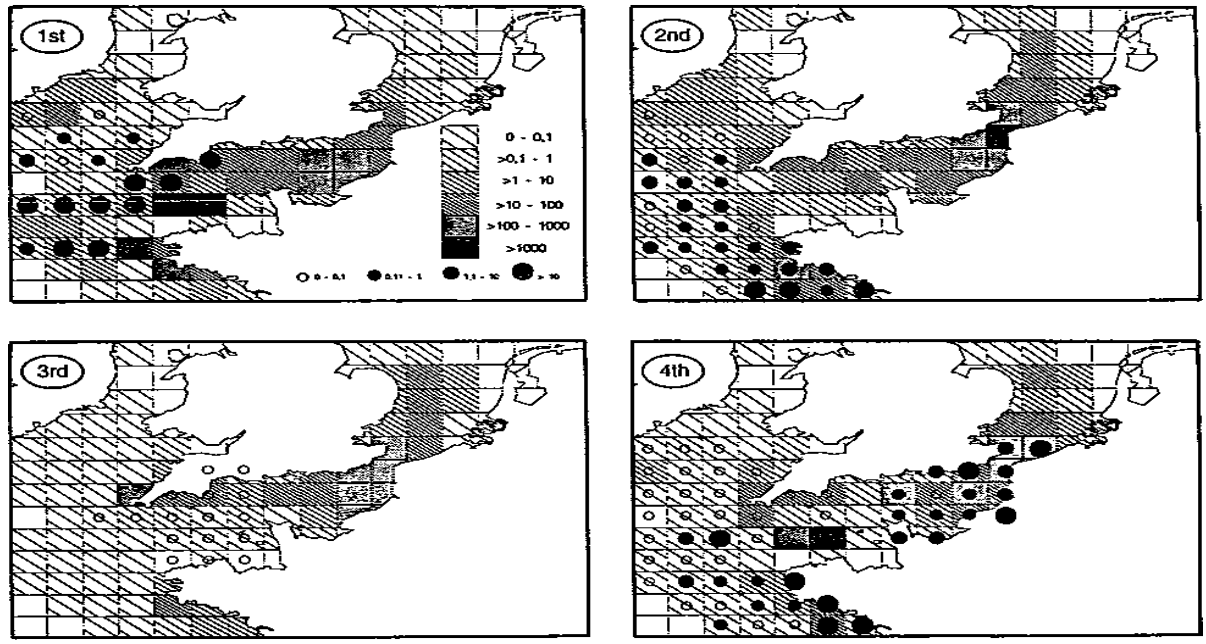

Figure 19.2 The quarterly distribution of mackerel landings (tonnes) by ICES rectangle in the Channel and adjacent sea areas in 1989. CPUE from English and French groundfish surveys are indicated with superimposed circles

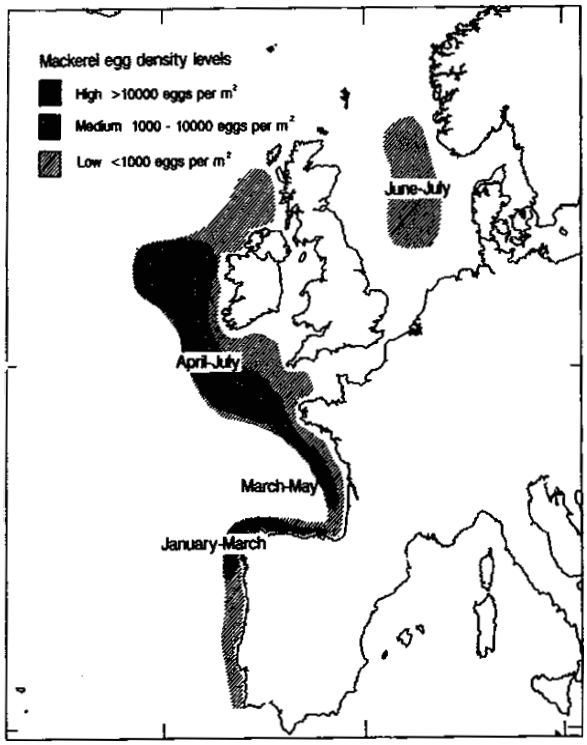

Figure 19.3 The spawning grounds and peak spawning periods of mackerel in the northeast Atlantic

Very little is known about the distribution of post-larval mackerel, as they are seldom caught below a length of 15 cm. Some 0-group mackerel, 3-8 cm in length, have been caught in the surface waters of the Celtic and North Seas, and mackerel of 6-8 cm have been caught in mid-water off Norway's North Cape during young fish surveys in the Barents Sea. However, only one 0-group fish, of 3.5 cm, has been taken in the western Channel, with a surface net in July 1983.

The distribution of older juveniles, the first- and second-winter fish, is better known; these are generally concentrated along the shelf edge from Biscay to the west of Scotland. In addition, large shoals of juveniles have been found in the western Channel off Cornwall since 1981 and, in years of high abundance, they are also found in the central and southern North Sea. There are presently very few North Sea-spawned juveniles because of the low stock size, and these are found mainly in the northern North Sea.

19.4 Adult migrations

The migration patterns of mackerel have been determined from seasonal changes in the distribution of fisheries and by tagging studies conducted during the past 30 years. Mackerel which spawn in the North Sea migrate north in June and July and disperse to feed in the central and northern North Sea and Skagerrak in late summer. In October, some of these fish migrate to western Shetland and some to the Norwegian Trench, where they overwinter. The following spring, they return south to the spawning grounds.

During the past three decades, there have been some dramatic changes in the distribution and migration of Western mackerel, which are particularly relevant to the identification of the Channel stocks. After spawning, Western mackerel migrate north along the continental slope during June and July, into the Norwegian Sea and northern North Sea. They feed during summer and overwinter off northern Scotland and around the Shetland Isles before returning south to the spawning grounds in February/March. In the late 1960s and throughout the 1970s, however, the bulk of the Western stock overwintered in the western Channel, a change, it

is thought, which took place in response to changes in environmental conditions. The migration pattern of the Western stock, which was characteristic of the situation in the 1980s, is shown in Figure 19.4.

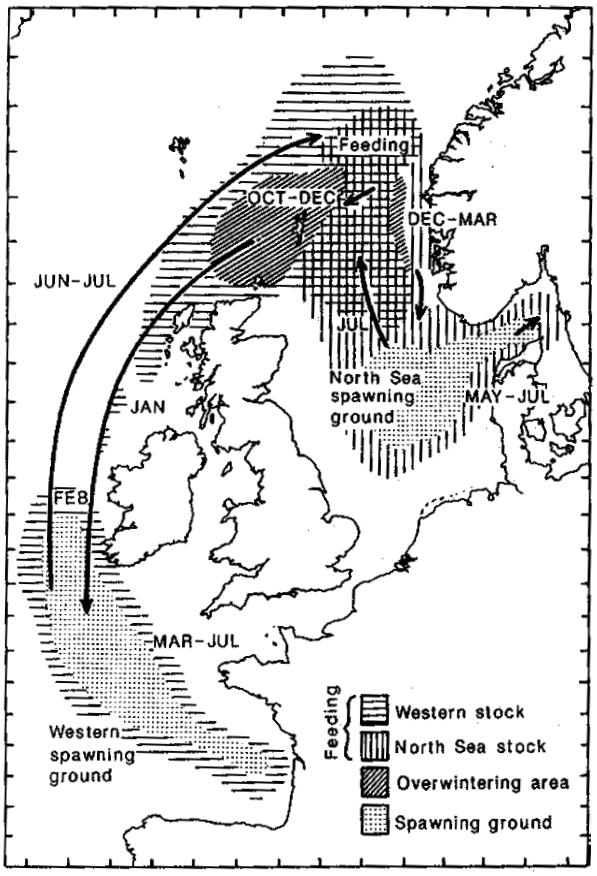

Figure 19.4 The migration of mackerel in the 1980s (from Dawson, 1991)

19.5 Biological parameters

The growth of the western mackerel population has been described using samples from the Cornish winter fishery from 1975 to 1980. The age composition shows that these fish usually mature at 2-3 years, but there are no comparable and reliable data for North Sea spawners, as these are still recovering from a stock collapse in the early 1970s.

Mackerel which spawn in the North Sea and the Celtic Sea are part of a genetically homogeneous population. Prior to the collapse of the North Sea spawning group, tagging experiments indicated that there was very little mixing of North Sea and Western spawning mackerel. Since 1980, however, the level of mixing has increased, particularly on the summer feeding grounds in the northern North Sea. This mixing may have resulted from an influx of Western spawners which could have led to considerable interchange of fish from different spawning areas. Tagging data, however, indicate that the majority of mackerel return to the same spawning area each year, and this suggests that the spawning groups are largely isolated.

Further evidence for reproductive isolation of the spawning groups is the fact that the North Sea spawners have not recovered from their collapse, even though the biomass of the Western spawning group remains high. In the fourth quarter of 1986 and 1987, 0-group mackerel were abundant in the central southern North Sea and were subsequently caught there in considerable quantities. However, they did not contribute significantly to the biomass of the North Sea spawning group, and it is suggested that the North Sea has become an important nursery area for juvenile Western mackerel, which subsequently recruit to the western spawning area.

Attempts to identify the origins of mackerel sampled from mixed stocks have not been successful. The parasitic cestode *Grillotia angeli* infected Western spawning mackerel prior to 1977, but, since then, changes in the distribution and migration of Western spawners has occurred, and a far smaller proportion of mackerel has been infected with *Grillotia*.

Measurement of otoliths, to determine the amount of first year growth, allowed the identification of mackerel from different origins prior to 1974, when growth of fish from the Western stock was significantly faster than that of the North sea stock. However, following the collapse of the latter, the growth rate of these fish has increased, and this has obscured any differences.

19.6 Conclusions

The Western and North Sea spawning mackerel are currently recognised as being independent stocks for assessment purposes. The majority of fish from each stock appear to return to their respective spawning grounds, and the limited interchange of fish which enables genetic homogeneity to be maintained is too small to influence management decisions. Mackerel in the Channel are predominately members of the Western stock.

More recently, mackerel off the Atlantic coasts of Spain and Portugal have also been treated as a third, independent group, and are now referred to and assessed as the Southern stock.

20. SCAD (horse mackerel)

20.1 General distribution

Scad, *Trachurus trachurus*, are found at depths of less than 200 m in northeast Atlantic shelf waters from Iceland to Cape Verde Island and in the Mediterranean and Marmara Seas, but are rare in the Black Sea, (Figure 20.1). The quarterly distribution of scad landings in 1989 by rectangle and CPUE from groundfish surveys are shown in Figure 20.2.

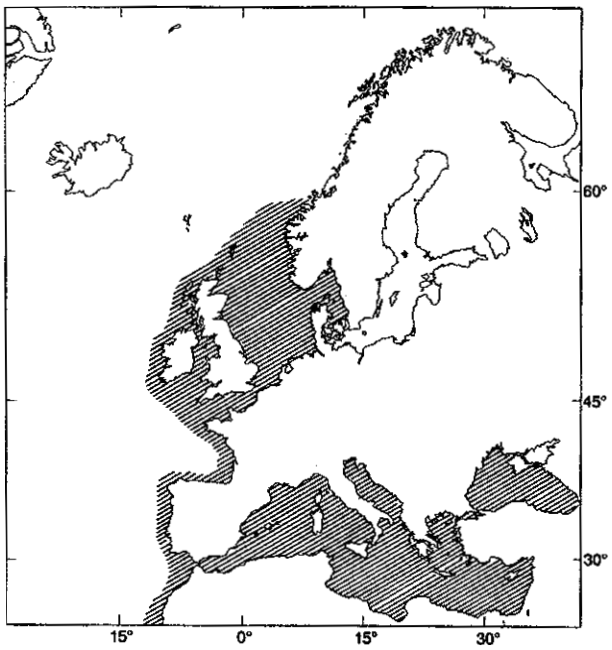

Figure 20.1 The distribution of scad in the north-east Atlantic

20.2 Spawning areas

Scad spawn along the continental shelf off the west coast of Ireland, in the Celtic Sea and south into Biscay and around the Iberian Peninsula. This westerly spawning area extends eastwards throughout the Western Approaches and into the western Channel. Scad also spawn in the southern North Sea and in the eastern Channel, Figure 20.3. The spawning periods are slightly different for each main area. In the North Sea, spawning commences in late May and continues until July with a peak in June. In the western area, from northern Biscay northwards, spawning takes place from March to July with a peak in June, and in the south spawning extends from January to August.

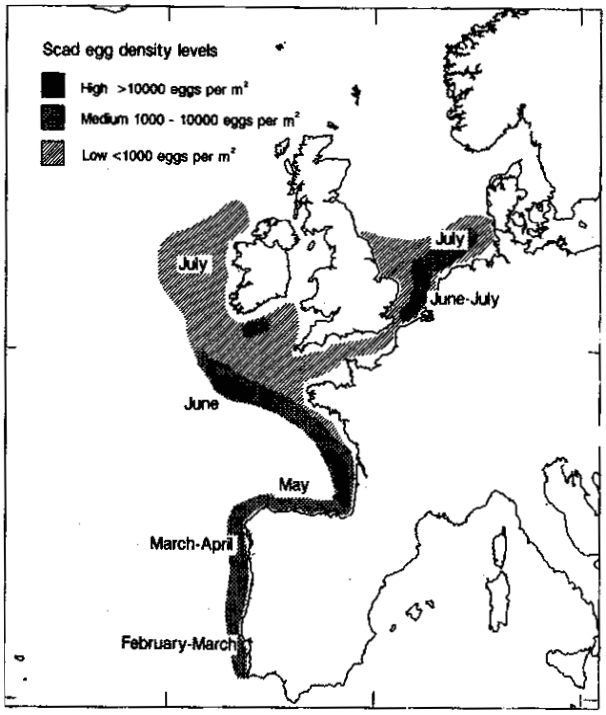

Figure 20.3 The spawning grounds and peak spawning periods of scad in the northeast Atlantic

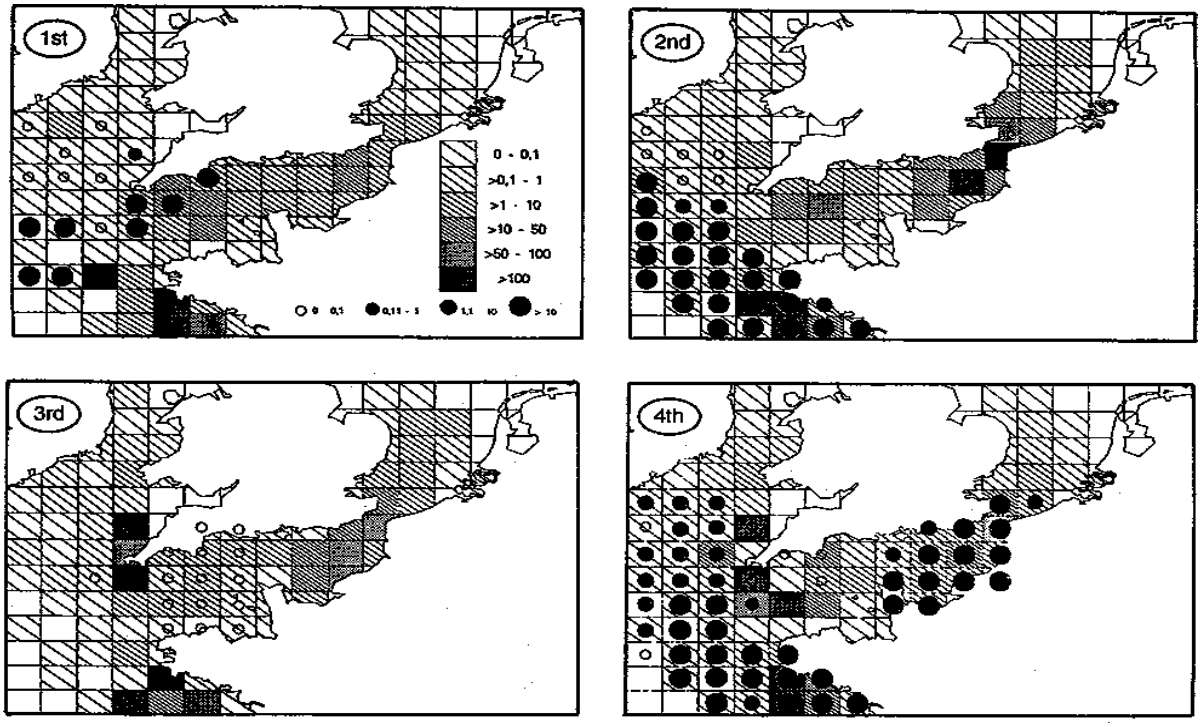

Figure 20.2 The quarterly distribution of scad landings (tonnes) by ICES rectangle in the Channel and adjacent sea areas in 1989. CPUE from English and French groundfish surveys are indicated with superimposed circles

An egg survey conducted in the western area during June 1989 indicated that no more than 8% of the Western spawning takes place in the western Channel. The biomass of the Western and North sea spawning stocks was estimated by egg survey in 1989 to be approximately 2 million tonnes and 0.2 million tonnes respectively.

20.3 Larvae and juveniles

Scad larvae hatch at about 2.5 mm long. In the Channel, post larvae occur in the plankton from July to October, with a maximum abundance in August. By the end of the first year, they are about 10 cm long and largely pelagic in life style, staying high in the water column in shoals separate from larger fish, though many fish smaller than 10 cm have been taken in small-mesh bottom trawls during research vessel surveys. Such surveys during the fourth quarter of 1990 showed that high densities of 0- and 1-group scad occur throughout the Channel.

20.4 Adult migration

Scad are highly migratory fish. The distribution of the fisheries and survey data provide indications of the migratory routes for the different spawning groups. A schematic diagram of the assumed migratory patterns of scad is given in Figure 20.4.

The Western scad appears to have a similar migratory pattern to that of the Western mackerel. After spawning, scad migrate north along the continental slope during June and July. They remain off the Norwegian coast from July to September and migrate into the northern North Sea during October and November. They then begin their return migration to the western area via Scotland and Shetland.

North Sea scad migrate east from the Channel during June, along the Dutch coast, where they spawn in July, and along the west Danish coast in August. In the summer and autumn, scad are abundant in the southern and southeastern part of the North Sea, and have been observed to move west and southwards through the Channel in October.

It is thought that the Western and North Sea spawning groups mix in the central North Sea in the summer and autumn, and in the western Channel mainly in autumn. Scad are present along the Atlantic coasts of Spain and Portugal throughout the year, but little information is available on the migratory behaviour of this Southern group.

20.5 Biological parameters and population structure

Scad are a long-lived species and it is quite common to find fish older than 30 years of age. The age composi-

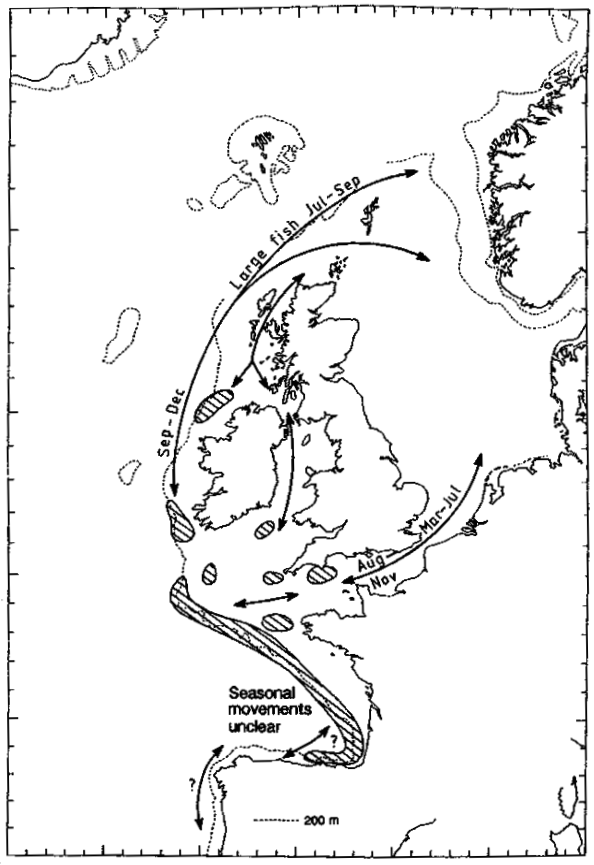

Figure 20.4 The migration routes and main wintering grounds of scad in the northeast Atlantic (after Eaton, 1983)

tions of scad in the North Sea and the west indicate that both groups have been dominated by the strong 1982 yearclass, which comprised almost 70% of the landings by number in 1990. Only seven strong yearclasses have been recorded in the past 50 years. Maturity data indicate that 50% of scad are mature at 23 cm.

Stock separation techniques which have been applied to scad include gonadosomatic indices, age composition data and electrophoretic analysis of samples from the North Sea, the Celtic Sea, the Bay of Biscay and Portuguese waters, none of which have provided evidence for discrete stocks of scad in the northeast Atlantic.

20.6 Conclusions

The present assumption is that, in addition to the North Sea spawning group, there are two separate groups of scad in the Western and Southern areas and that there is no substantial interchange of fish between the areas. There is, however, a continuous scad egg distribution between the western and southern areas, and into the Channel. Furthermore, the Channel is an important area for juvenile scad, and provides a migratory route for both Western and North Sea spawning groups. It seems, therefore, that it us not possible to discriminate stocks of this species in the Channel.

21. RED GURNARD

21.1 General distribution

Red gurnard, *Aspitrigla cuculus*, are distributed in northeast Atlantic shelf waters from around Scotland and southern Norway south to North Africa. They are present in the Mediterranean but absent from the Baltic Sea (Figure 21.1). Gurnards are not identified by species in English and Welsh landings data. French commercial LPUE for 1989 and groundfish survey CPUE data were therefore used to provide an index of the seasonal distribution and abundance of red gurnard (Figure 21.2). Red gurnard appear to be abundant in the Channel throughout the year.

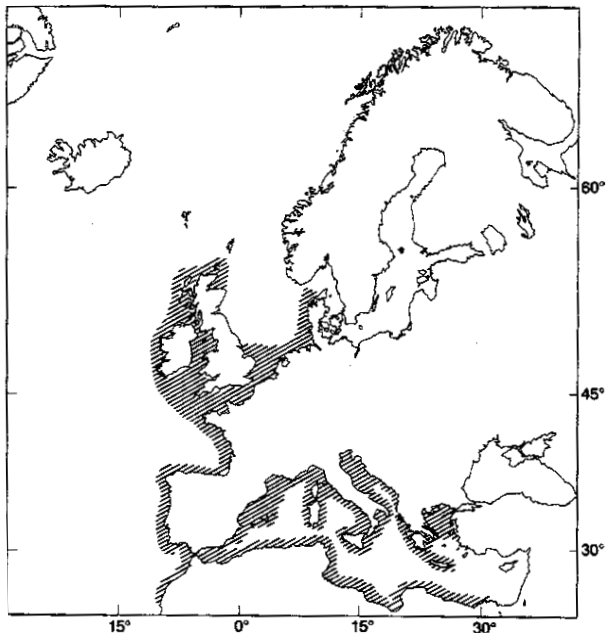

Figure 21.1 The distribution of red gurnard in the northeast Atlantic

21.2 Spawning areas

The eggs and larvae of gurnards have been sorted from ichthyoplankton samples on several occasions, but they have not been identified to species because there is little available information on the identification of gurnard eggs and larvae. Ripe and running red gurnard, however, have been caught in the area between north Cotentin and the Isle of Wight from the end of February until June.

21.3 Juveniles

Nursery areas for this species have not been identified. No red gurnard were caught during inshore young fish surveys on the English Channel coast in August and September 1971 and 1974. The smallest benthic red gurnard caught during French surveys were 3 cm long, but it is not known which areas the juveniles favour.

21.4 Adult migrations

Red gurnard do not appear to have been been tagged, and migration patterns are therefore inferred by seasonal changes in the abundance of red gurnard in the fishery. The fish appear in the central and western

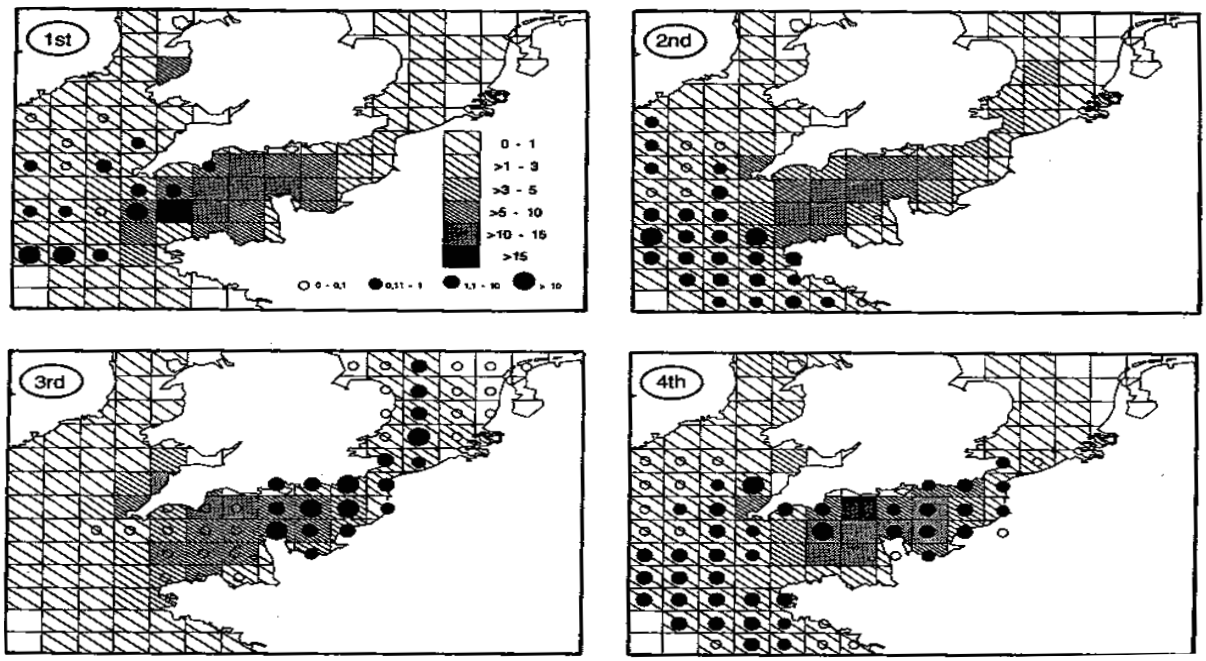

Figure 21.2 The quarterly distribution of red gurnard LPUE by ICES rectangle in the Channel and adjacent sea areas in 1989. CPUE from English and French groundfish surveys are indicated with superimposed circles

Channel during September and remain in an area between Ouessant and the Isle of Wight, and particularly around the Hurd Deep, from November to January. Spawning commences in February, and spent fish appear to move west. Spawning continues through the summer and, by July and August, the majority of fish are caught in the western Channel. The changes in sex ratio of red gurnard in the fishery suggest that females migrate back to the central Channel before the males, which arrive there in December, and that males leave more rapidly after spawning. It has also been suggested that males favour rocky grounds which cannot be trawled effectively .

21.5 Biological parameters and population structure

Female red gurnard caught in the Channel appear to grow faster than males. Their mean lengths at ages 5 and 10 respectively are 35.5 cm and 40.5 cm compared with 32 cm and 34.5 cm for males. Growth data are not available for red gurnard from regions outside the Channel. Red gurnard first attain maturity in the Channel at approximately 25 cm and 50% are mature when 26-29 cm in total length at age 3.

21.6 Conclusion

There is insufficient information available to determine whether or not red gurnard in the Channel are members of a single stock which also occupies the North Sea and waters to the west of the Channel.

22. PLAICE

22.1 General distribution

Plaice, *Pleuronectes platessa*, are distributed in north Atlantic shelf waters from Greenland and the White Sea south to North Africa. They are present in the southern areas of the Baltic and Black Seas but absent from the extreme eastern Mediterranean (Figure 22.1). LPUE of plaice by French, English and Welsh vessels by rectangle and quarter in 1989, and CPUE from groundfish and beam-trawl surveys, are shown in Figure 22.2.

22.2 Spawning areas

Plaice spawn from December to March in the Channel, with the peak of spawning being in January and February. Five main areas have been recognised (Figure 22.3): two in the central western Channel south of Start Point and Portland Bill respectively; and three in the central eastern Channel from Dungeness to the Isle of Wight. Around three-quarters of the total egg production in the Channel occurs in the eastern Channel, where the distribution of eggs is often continuous with that in the North Sea.

22.3 Larvae and juveniles

The centres of plaice spawning in January and February are within an easterly-moving current system. Hydrographic studies have indicated that a large proportion of the eggs produced in the Channel will enter the North Sea before larval metamorphosis occurs. The timing of egg production in the eastern Channel and of the immigration of larval plaice into the Easterscheldt and western Waddensea, together with information on developmental rates of eggs and larvae and the hydrography of that area, suggest that young-of-the-year plaice in the Easterscheldt were spawned in the eastern Channel. However, those spawned in the western Channel, where currents are rather weaker, are unlikely to be transported out of the Channel and probably maintain recruitment to nurseries which are located in sandy bays on the Channel coast.

Development of plaice eggs and larvae to metamorphosis takes between 60-120 days, depending on temperature, and plaice generally commence the benthic phase when 2-4 cm in length. Recruitment of newly metamorphosed plaice into nurseries in the North Sea has been shown to involve changes in the vertical distribution of larvae, such that they move into mid-water during flood tides and return to the seabed at high water slack, where they remain during the ebb tide. Similar transport processes are ultimately used by the adult fish during spawning and feeding migrations.

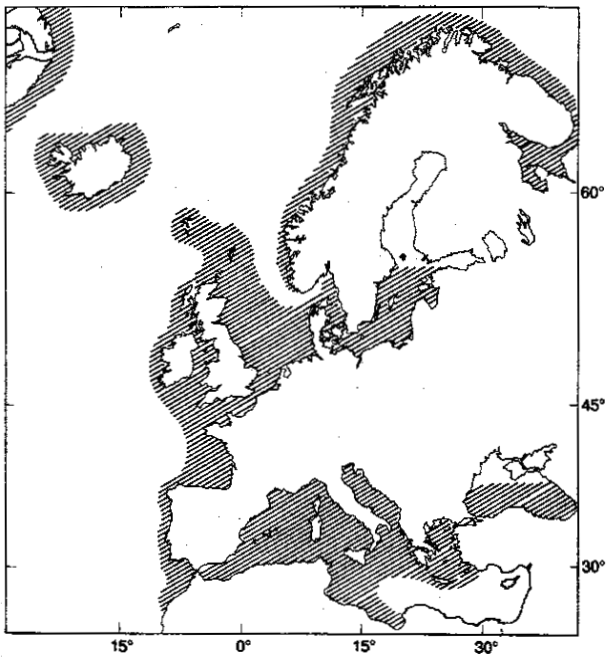

Figure 22.1 The distribution of plaice in the northeast Atlantic

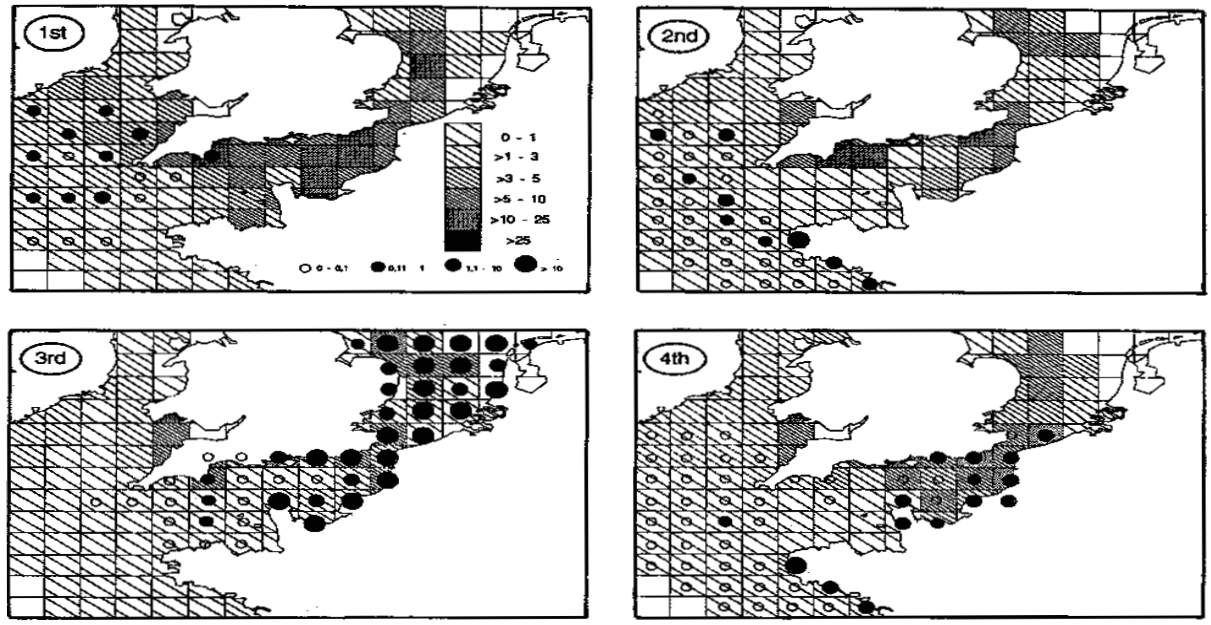

Figure 22.2 The quarterly distribution of plaice LPUE by ICES rectangle in the Channel and adjacent sea areas in 1989. CPUE from English and French groundfish surveys are indicated with superimposed circles

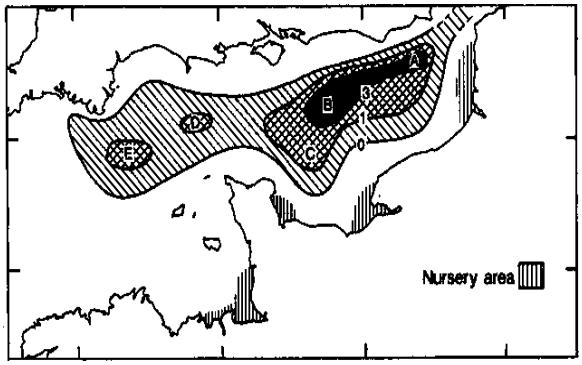

Figure 22.3 The distribution of plaice eggs in the Channel at the peak of spawning, contoured at intervals of 0, 1 and 3 eggs per square metre per day. The letters A to E denote the 5 centres of egg production referred to in the text (from Houghton and Harding, 1976). The main nursery areas for plaice along the French coast are also shown

The movements of juvenile plaice have not been studied in Channel nurseries, but tagging in the Irish Sea and North Sea suggests that the plaice remain for up to two years in the nurseries to which they recruited. Some 1- and 2-group plaice tagged in the Easterscheldt (the nursery ground for plaice spawned in the eastern Channel) were subsequently recaptured as mature fish in the eastern Channel.

An analysis of juvenile plaice taggings in the North Sea and eastern Channel indicates that 38% of plaice in the eastern Channel came from nursery grounds in the North Sea. Eastern Channel nursery grounds supplied only 0.3% of recruits to the North Sea, but 34% of the recruits in the western Channel. The North Sea is also an important source of plaice migrating into the western Channel, supplying 53% of the recruits. The main nursery areas for Channel plaice are shown in Figure 22.3.

22.4 Adult migration

Adult plaice have been tagged on many occasions in the Channel and adjacent seas. Many ripe, running and spent plaice, tagged in the eastern and western Channel during 1971 and 1972, migrated rapidly to the North Sea after spawning. An analysis combining spawning stock biomass estimates with fishing intensity estimates at the recapture sites suggested that, of the plaice spawning in the Channel during January and February, 20% spent the summer in the western Channel, 24% in the eastern Channel, and approximately 56% migrated to the North Sea.

A review of plaice taggings in the Channel at different times of the year showed that 20-30% of the plaice catch from the eastern Channel in winter contained migratory North Sea fish. Plaice tagged in the Channel during the summer were not recaptured outside the Channel, which suggests that they were resident there. The resident plaice appeared to be members of two groups which returned to specific (east or west Channel) spawning areas each winter. Migratory North Sea plaice only entered the Channel in autumn, and left rapidly after spawning.

Tagging experiments in the North Sea confirm the hypothesis that few North Sea plaice remain in the

Channel during summer. For example, only 5 fish out of 702 mature plaice tagged in the southern North Sea during January and February 1975 were recaptured in the Channel, one in the west and four in the east. All other recaptures were made in the southern or central North Sea.

Plaice tagged in the North Sea and Channel, in all seasons of the year, were rarely recaptured from the Irish Sea. Similarly, only a small proportion of the fish recaptured from 16 771 plaice tagged in the Irish Sea had been returned from the western Channel.

22.5 Biological parameters and population structure

Because the growth of plaice within a single region has changed considerably through the years, and in the absence of studies which examine regional and yearly effects concurrently, it is unlikely that an examination of growth parameters will assist with plaice stock identification. The mean age of plaice at maturity in the southern North Sea is around 4 years for females and 2 years for males, with mean lengths of 30-33 cm and 20-22 cm respectively, but there is considerable inter-annual variation within a given area and the range of age at maturity for individuals is 2-7 years. In the Channel, females are mature on average at 31-33 cm and males at 25 cm, both at 3 years old. It is unlikely, therefore, that differences in age or length at maturity could be used to distinguish plaice in the Channel and southern North Sea.

Although there are significant inter-annual differences in plaice fecundity within one area, even when the effects of length and age are considered, fecundity of Channel plaice (at a standard size and age) tends to be higher than that in the central North Sea.

Several genetic studies have indicated differences between plaice from different regions, but none of the studies provided information which would assist with differentiation between plaice in the Channel and those in adjacent regions.

In the southern North Sea, there are some differences in the pigmentation of plaice 'stocks' as recognised on the basis of otoliths, meristic features and tagging studies. Channel fish, however, have not been studied in this way.

22.6 Conclusions

There have been numerous studies describing the general structure, fecundity and biochemical characteristics of plaice populations which have provided information on stock separation, but extensive tagging programmes and ichthyoplankton surveys have provided most of the information upon which management of the plaice fishery has been based.

Plaice which spawn in the eastern Channel may use the southern North Sea at many stages in their life history. Most newly metamorphosed fish recruit to southern North Sea nurseries where they remain until mature. Subsequently, these might migrate to the eastern Channel for spawning, but often return to the North Sea when spent.

Other plaice, which spawn in the same areas of the eastern Channel at the same time, are clearly a resident Channel stock, as are most plaice which spawn in the western Channel. The movements of plaice between the Channel and the Irish Sea are unlikely to be of significance to fishery managers.

It is possible that three plaice stocks, which probably have sufficient integrity to be considered as largely self-perpetuating units, could be recognised in the Channel: the resident Channel stock; the western Channel stock; and a migratory Channel/southern North Sea stock. However, their distributions frequently overlap for considerable periods and thus it would be difficult to manage them independently.

23. LEMON SOLE

23.1 General distribution

Lemon sole, *Microstomus kitt*, are found in shelf waters of the northeast Atlantic from the White Sea and Iceland south to the Bay of Biscay. They are common in the North Sea and the Channel, but absent in the Baltic Sea (Figure 23.1). Combined French, Welsh and English LPUE data for 1989 and groundfish survey CPUE data (Figure 23.2) indicate that lemon sole are abundant in the extreme western Channel throughout the year.

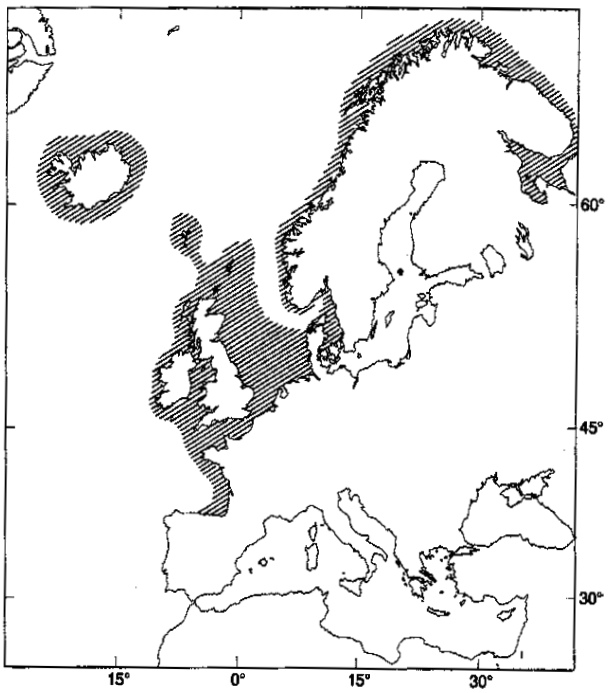

Figure 23.1 The distribution of lemon sole in the northeast Atlantic

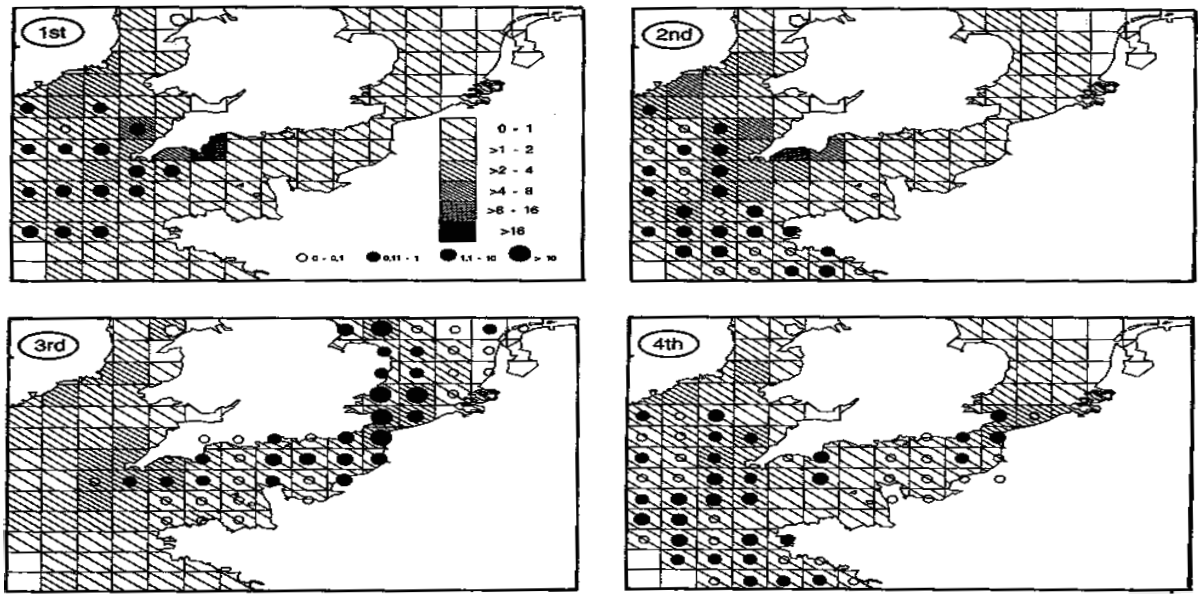

Figure 23.2 The quarterly distribution of lemon sole LPUE by ICES rectangle in the Channel and adjacent sea areas in 1989. CPUE from English and French groundfish surveys are indicated with superimposed circles

23.2 Spawning

Ripe and running lemon sole were caught off the south English coast in the western Channel during a monthly sampling programme conducted each year from 1969 to 1974. Male fish were ripe and running from February to September and females from March to August, although spawning peaked in April, May and June. Maturity has not been assessed for samples of lemon sole from other regions of the Channel.

Icthyoplankton samples taken within 30 nautical miles of the English southern coast, from North Foreland (east) to Lands End (west), during February, April and June 1974; indicate that lemon sole eggs were most abundant in the western Channel during April, but eggs were also present in this area in June (Figure 23.3). No lemon sole eggs were found in samples collected in February. The inshore location of this survey may not cover the overall spawning area of lemon sole, but it appears that most spawning is confined to the western Channel.

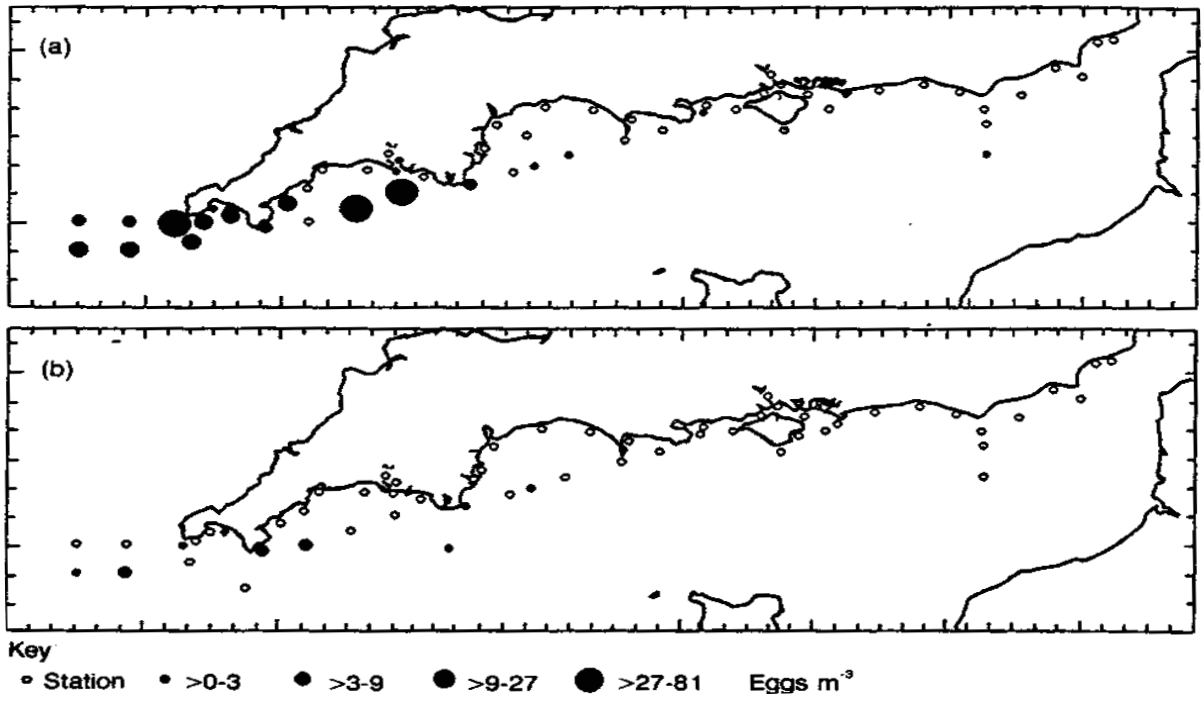

Figure 23.3 The distribution of lemon sole eggs in the Channel: (a) from 17 to 22 April 1974; and (b) from 13 to 20 June 1974

23.3 Larvae and juveniles

The distributions of lemon sole larvae in the western Channel are similar to the egg distributions already described.

No juvenile lemon sole have been captured in extensive young fish push-net and beam-trawl surveys along the entire southern English coast at depths to 20 m during August and September 1971 and September and October 1974. Juvenile sole and plaice were abundant at many sites, which suggests that lemon sole do not use the shallow, sandy inshore nurseries typically used by other flatfish.

A series of surveys, conducted in September and October each year from 1984 to 1991, using a commercial fishing vessel to tow a 4 m beam trawl off south Devon and designed to estimate the abundance of juvenile plaice and sole, produced no lemon sole less than 18 cm in length. Because the 40 mm mesh used is expected to retain most lemon sole in excess of 15 cm, it is assumed that juvenile lemon sole were absent on these grounds. Such fish are considered to be a rarity in catches during MAFF groundfish surveys in the western Channel and Celtic sea, whereas, in Scottish waters, juvenile lemon sole have been found mixed with the adults.

Thus, lemon sole which have metamorphosed, but are less than 18 cm, appear not to be accessible to the beam trawls used for sampling in the western Channel and eastern Celtic Sea. The western Channel contains many areas of rocky and boulder-strewn ground, which are geographically close to the adult grounds, and may provide a refuge for juveniles.

23.4 Adult migration

Over a thousand ripe, running and spent lemon sole were tagged off south Devon during April and May 1970. By the end of 1972, only 4 fish had been recaptured away from the tagging area; 3 in the Celtic Sea and caught within one year of release; and one from the eastern Channel in the second quarter of 1972. All recaptures of lemon sole in 1973 and 1974 were from or adjacent to the release area.

The returns from these tagging experiments suggest that most adult lemon sole remain in the western Channel throughout the year and undertake no extensive migration.

23.5 Biological parameters and population structure

Although MAFF has collected lemon sole maturity data for the western Channel from 1969 to 1974, no similar data exist for lemon sole from other regions of the Channel or adjacent sea areas. No genetic or meristic studies of lemon sole have been conducted in the Channel.

23.6 Conclusions

LPUE data suggest that lemon sole are relatively abundant in the western Channel throughout the year. They are scarce in other regions of the Channel, and the closest concentrations of similarly high density may be found off south-western Ireland and in the northern Bay of Biscay.

The seasonal movements of adult lemon sole in the western Channel appear to be very restricted and for assessment purposes, it is suggested that the lemon sole of the western Channel may be considered as a single stock.

24. SOLE

24.1 General distribution

Sole, *Solea solea*, are distributed in northeast Atlantic shelf waters from southern Norway and the Shetlands south to Mauritania. They are absent from the Baltic and parts of the Mediterranean and Black Seas (Figure 24.1). LPUE of sole by French, English and Welsh vessels by rectangle and quarter in 1989, and CPUE values from groundfish and beam-trawl surveys, are shown in Figure 24.2.

24.2 Spawning

Sole spawning starts when the water temperature rises above 7°C, and occurs from late February until late June

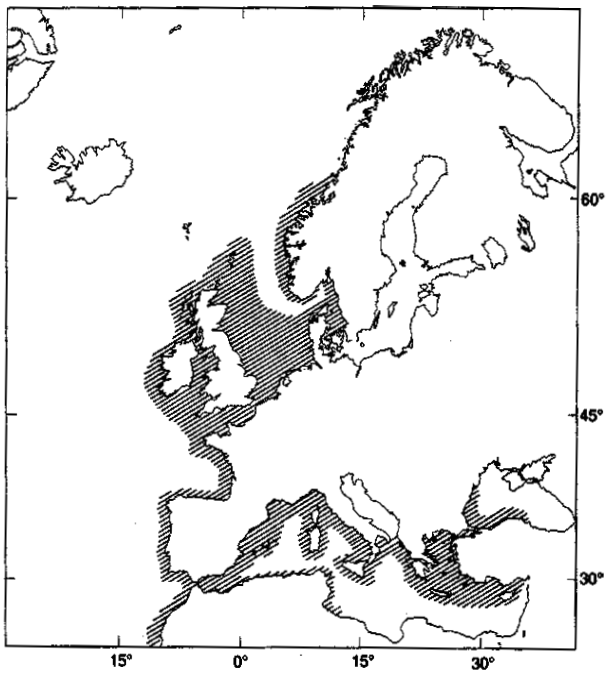

Figure 24.1 The distribution of sole in the north-east Atlantic

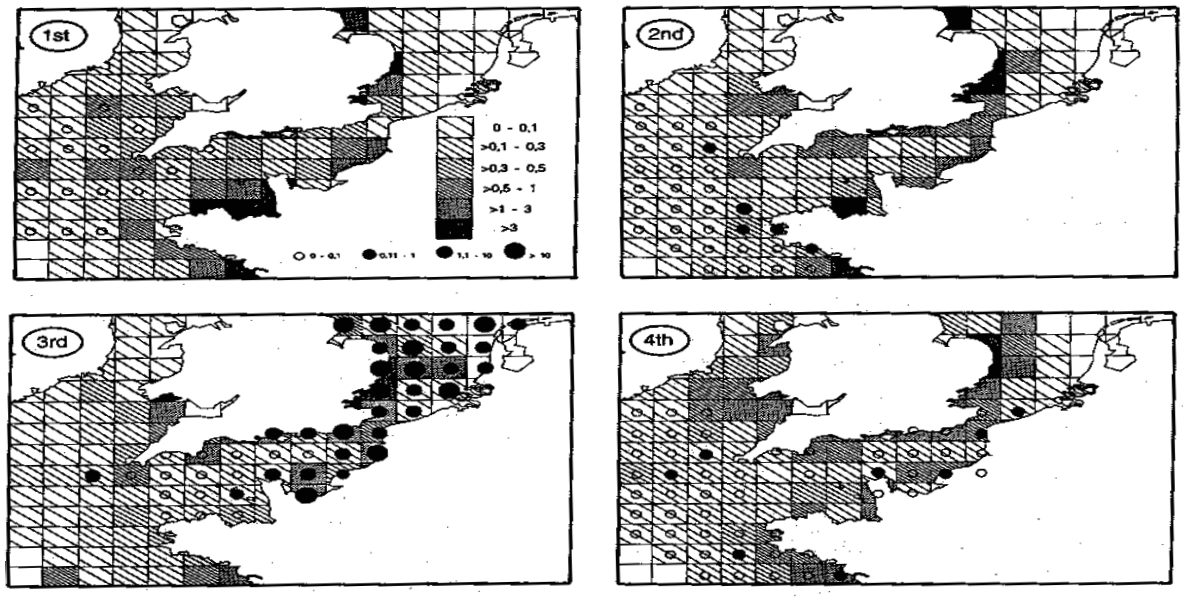

Figure 24.2 The quarterly distribution of sole LPUE by ICES rectangle in the Channel and adjacent sea areas in 1989. CPUE from English and French groundfish surveys are indicated with superimposed circles

in the Channel and adjacent seas, although the peak spawning period is in April and May. The main spawning areas of sole are shown in Figure 24.3. An important spawning area in the Baie de Somme has been identified by several ichthyoplankton surveys. However, sole eggs are widely distributed at lower densities throughout the eastern Channel.

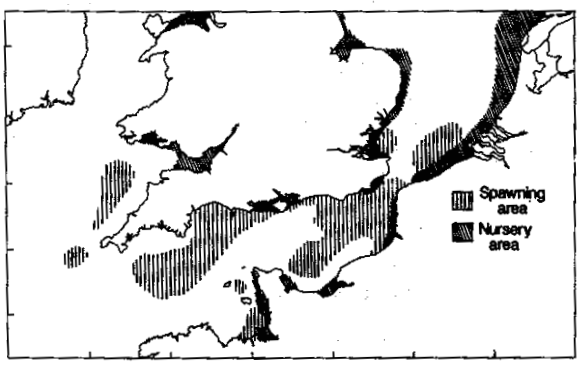

Figure 24.3 The distribution of sole spawning and nursery grounds in the Channel and adjacent sea areas

Spawning areas have been reported close to the English coast during April, centred between Beachy Head and the Isle of Wight, to the west of the Isle of Wight and in the vicinity of the Hurd Deep. In 1991, a series of extensive egg surveys started in the Channel, which mapped sole egg concentrations over the entire spawning period. In the eastern Channel, the highest egg concentrations were found in the Dover Strait, the Baie de Seine and around the Isle of Wight. In the western Channel, sole eggs were generally less abundant and the highest densities of eggs were found in the Baie de St Michel, Start Bay and in mid-Channel.

There are several important sole spawning areas adjacent to the Channel. High egg densities have been recorded in the Thames Estuary, Belgian coastal waters, Texel and Vlieland Grounds and part of the Heligoland Bight. To the west of the Channel, sole spawn in deep water off Trevose Head in the Celtic Sea and offshore in northern Biscay.

24.3 Larvae and juveniles

Sole eggs hatch approximately 8 days after fertilisation (depending on seawater temperatures) and the larvae are pelagic for up to 6 weeks. Larval transport in the northern Bay of Biscay appears to be governed by the larvae's behaviour, since they did not move in the same direction as residual currents. There have been no studies of larval movement in the Channel but, on the basis of current movements, a proportion of larvae hatching in the eastern Channel may move east and recruit to nurseries in the southern North Sea.

Larvae recruit to shallow inshore nurseries at metamorphosis and it has been suggested that, in estuaries, this recruitment is an active process which is determined by the salinity and temperature regime at the estuarine front.

There are sole nurseries in estuaries, tidal inlets and shallow, sandy bays on the English and French Channel coasts (Figure 24.3). The overall density of juvenile sole is highest in the eastern Channel, although sole may be abundant in small western Channel nurseries such as the Tamar. Marking studies suggest that sole are resident in these latter nurseries for at least 2 years after metamorphosis. A study on the migrations of

freeze-branded juvenile sole in the Tamar Estuary nursery showed that 0-group sole inhabited deeper areas, whereas 1-group fish made a tidally-related movement onto mud flats. Individual sole tended to stay within specific regions of the estuary, although there was a general movement up the estuary during May and June with a return migration towards the sea in October and November. In the Baie de Vilaine, 0-, 1- and 2-group sole moved offshore in the winter and migrated inshore again in the spring. Recruitment to the spawning population occurred as 2- or 3-year olds.

Juvenile sole tagged in the eastern Channel were recaptured as 2-year old fish in the release area. However, as 3-year olds, some sole began to emigrate from the release areas. A proportion of sole released in the Baie de St Michel and the Baie de Seine moved to the English side of the western Channel, and the seasonal distribution of returns suggested that this movement was permanent. Similarly, some juvenile sole released in the Baie de Somme were recaptured on the English coast. In general, recaptures from eastern Channel releases suggested that there was a permanent emigration of around 10% of 3- and 4-year old sole to the southern North Sea and up to 30% to the western Channel. There was, however, no evidence of a significant immigration to the eastern Channel by sole tagged in the southern North Sea.

24.5 Adult migration

Sole undertake their most extensive migrations as maturing juveniles, and once fully mature, their movements appear to be relatively restricted. The seasonal distribution of tag returns and, to some extent, shifts in LPUE in the sole fishery (Figure 24.2), suggests that adult sole make short seasonal migrations between deeper offshore areas and the shallower spawning grounds, with a return movement in the autumn. It is unlikely that a significant proportion of adult sole migrate from the Channel to adjacent seas, because sole appear to continue to use the spawning ground to which they first recruit. For example, sole tagged on the spawning grounds in the eastern central North Sea migrated offshore from June to October, to areas south west of the Dogger Bank. They remained there until March, when they returned to the spawning ground. Very few fish departed from this cyclical migration to spawn in other areas. Similarly, sole appear to move predominantly south through the Dover Strait in December, and it has been suggested that a proportion (~5%) of the population, which feeds and spawns in the southern North Sea, moves into the eastern Channel for the winter.

24.5 Biological parameters and population structure

Although there is considerable inter-annual variation in the age at which sole attain maturity in the southern North Sea and the Channel, the majority of females are mature at a length of 26-28 cm, and this precludes the use of age at maturity data for the identification of Channel stocks. Similarly, the growth rate of North Sea sole varies markedly between years, but suitable comparative data have not been analysed for the Channel.

The fecundity of sole has been reported for fish from the Channel and adjacent sea areas. The results suggest that female sole in the eastern Channel and North Sea produce more eggs for a given body weight than do those in the western Channel, the northern Bay of Biscay or the eastern Celtic Sea.

24.6 Conclusions

Adult sole in the eastern Channel are largely isolated from those in other regions, except during the winter, when sole from the southern North Sea may enter the Channel temporarily. However, a proportion of their progeny may emigrate to the southern North Sea and the western Channel. There is no evidence for a compensatory immigration, and thus the eastern Channel nurseries maintain recruitment to stocks of sole in both the eastern Channel and adjacent regions.

Adult sole in the western Channel may recruit from local nurseries and from those in the eastern Channel. Juvenile sole may recruit from the French coast to the English coast of the western Channel as they mature, but there is no evidence for significant emigration from the western Channel. The movements of adult sole in the western Channel are not well known, but the limited migration of adult sole in other regions, coupled with the localised spawning areas in the western Channel, suggest that these fish are largely isolated from those in northern Biscay, the eastern Celtic Sea and the eastern Channel.

25. ANGLERFISH

25.1 General distribution

The anglerfish, *Lophius piscatorious*, is found in north-eastern Atlantic waters from Iceland and Norway south to central West Africa. They are absent in the Baltic, but present in the Mediterranean, and are usually caught at depths of 20-150 m, although they have been recorded from 550 m (Figure 25.1). The closely related black-bellied anglerfish, *Lophius budegassa*, is distributed from western Scotland south to North Africa, and tends to occur at depths greater than 100 m, being recorded at a maximum depth of 800 m. *L. budegassa* is rarely caught in the Channel, and is not considered in this report.

LPUE data for *L. piscatorious* 1989, and CPUE data from groundfish surveys, indicate that their abundance is greatest in the deeper water of the western Channel and Celtic Sea throughout the year (Figure 25.2).

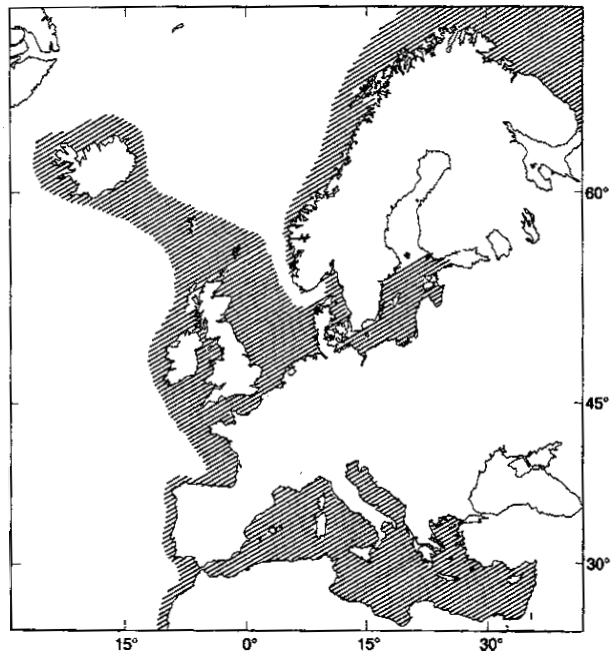

Figure 25.1 The distribution of anglerfish in the north east Atlantic

25.2 Spawning areas

Records of anglerfish eggs and maturity stage information is scarce, but incidental observations suggest that anglerfish spawn from February to August, and that spawning peaks from March to July. The majority of anglerfish are thought to spawn in deep water to the west of Ireland, in the Celtic Sea, the Bay of Biscay and in the Western Approaches. Although there is no evidence for spawning within the Channel, sheets of spawn have been observed floating off the south coast of England.

25.3 Larvae and juveniles

Anglerfish larvae have frequently been observed in ichthyoplankton samples from the continental shelf edge to the west of Ireland and in the Celtic Sea. There are a few records of larvae in the Channel, mainly off Cornwall, and a single larva was caught in the Bristol Channel in April 1990.

The duration of the planktonic larval stage is not known. However, one 11 day-old larva was 7 mm in total length and anglerfish are reported to begin a benthic existence at 40-70 mm total length, which suggests that they have a pelagic phase which lasts for several months.

Juvenile anglerfish have been caught during research vessel groundfish surveys in deep water to the west of the British Isles and in the Bay of Biscay, and frequently during MAFF beam-trawl surveys off south Devon in September and October from 1984 to 1991 at depths to 70 m. One-group anglerfish have also been caught during beach-seine surveys in the Bristol Channel.

25.4 Adult migrations

Little is known about the migrations of anglerfish. Only 2 of 106 anglerfish tagged between the Scilly Isles and Start Point in 1983 were returned, from near Start Point in 1984 and 1985. The quarterly distribution of LPUE data suggests that the centres of the species' distribution do not change appreciably during the course of the year.

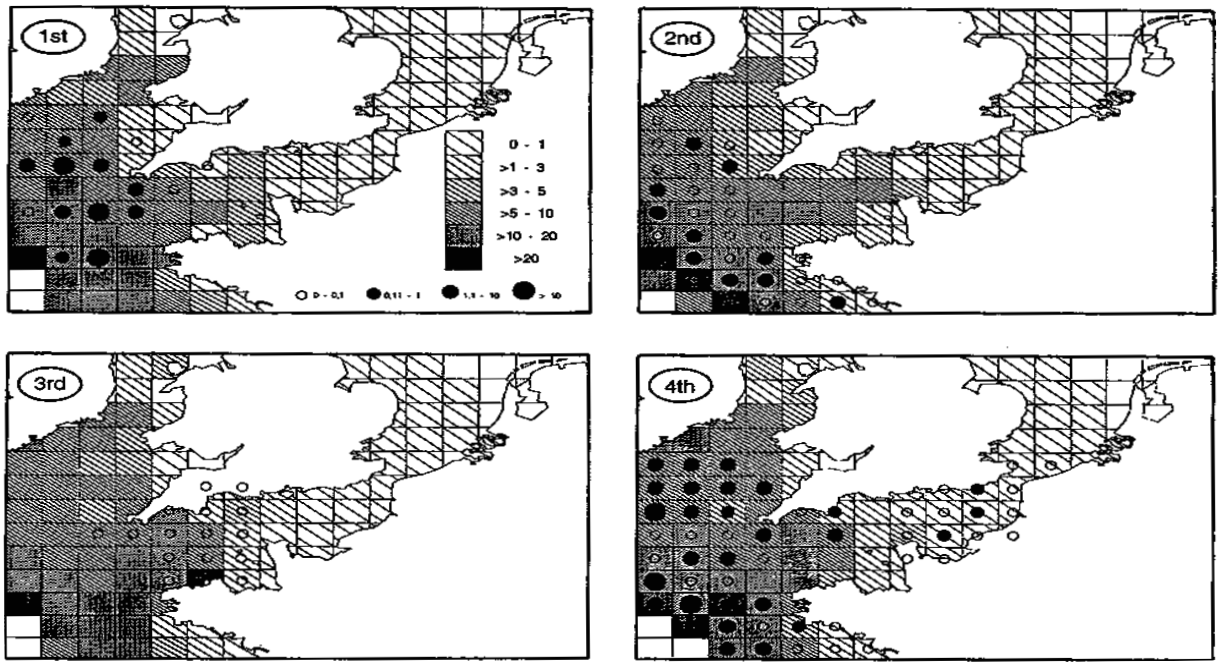

Figure 25.2 The quarterly distribution of anglerfish LPUE by ICES rectangle in the Channel and adjacent sea areas in 1989. CPUE from English and French groundfish surveys are indicated with superimposed circles

25.5 Biological parameters and population structure

A study of the age and growth of anglerfish in the Channel, to the west of the UK and in Biscay, revealed no differences in growth rate between sexes and areas, although females ultimately attained a larger size than males. Age and size data for anglerfish from the northern Irish Sea showed that these fish grew faster than those in the Celtic Sea.

Length at 50% maturity for male and female anglerfish has been reported in the Bay of Biscay as 45 cm and 39 cm respectively, but no comparable data have been collected for anglerfish from the eastern Celtic Sea or western Channel.

25.6 Conclusions

The available data do not elucidate the stock structure of anglerfish which are present in the Channel. Anglerfish are relatively scarce in the eastern Channel, but they are more abundant in western areas, and the centres of maximum adult abundance are west of the Channel, in deeper parts of the Celtic Sea. Juveniles may be abundant in the western Channel and are frequently caught by trawlers targeting sole and plaice.

The duration of the pelagic larval phase suggests that there may be considerable interchange of larvae from different spawning areas in the Celtic Sea and northern Bay of Biscay. If subsequent juvenile and adult migrations are relatively restricted, as their morphology and distribution suggests, then most differences in population structure may result from differences in localised exploitation patterns and fishing intensity.

CONCLUSION

Commercial landings per unit of fishing effort or total landings, and catch per unit of fishing effort in **groundfish surveys**, have been used to provide an indication of seasonal changes in the distribution and abundance of 25 resource species in the English Channel. Because groundfish surveys are conducted infrequently, these indices were derived from surveys by different vessels at various times, and interpretation of the results is complicated by several sources of variability. Nevertheless, the results support those obtained by other methods and provide a good preliminary picture of each species' general distribution. Landings data are seldom wholly reliable, but they do provide a valuable indication of population distribution and movements, which could not be obtained on such an extensive basis by any other means.

Egg and larval surveys frequently provide stock identification information, because stock integrity generally depends upon spawning fish from different stocks being separated in space or time, even if they do mix at other phases of their life history. The prediction of larval movements using hydrographic models can indicate the ways in which progeny from different spawning stocks are dispersed and mixed or separated, and thus enable the spawning areas which provide recruitment to specific nursery areas to be identified.

The **nursery areas** used by many species have been identified because they are often located in accessible inshore areas and the juveniles are present at high densities. However, there are few studies which reliably indicate the relationships between nursery areas and the adult stocks to which the juveniles will subsequently recruit. In recent years, this information has become even more relevant to fisheries management. Stocks are being fished more intensively and juvenile fish frequently form a major proportion of the catch.

On the few occasions when **parasitological** approaches to stock identification have been attempted, they have often provided excellent indications of stock separation. Unfortunately, little is known of the dynamics, distribution and life history of many of the parasites of marine fish. Similarly, **tagging and marking** programmes have provided some of the best evidence for migrations and stock separation. Studies which do not include a tagging exercise have rarely produced working hypotheses on stock identity which could be adopted and used by fishery managers. Unfortunately, the numerous tagging studies which have been conducted have targeted only a minority of the important commercial fish species in the Channel.

Knowledge of **population structure** and **growth parameters** provides an important basis for the initial recognition of stocks, but such parameters cannot be used to indicate whether stocks are genetically discrete, or whether fish are exhibiting characteristic responses to their local environment. Accordingly, they are not a reliable means by which to define stocks for management purposes. Similarly, **meristic** (e.g. fin ray, scale and vertebrae counts) and **morphometric** (body dimension comparison) techniques may indicate differences between fish sampled from a variety of regions, but are unlikely to enable small samples of fish to be identified to specific stocks.

The results of **genetic** studies have conventionally been assumed to provide a more reliable basis for stock identification, because they consider fixed genotypic, rather than environmentally-induced phenotypic, differences between individuals and stocks. When genetic analyses indicate that a population consists of more than one stock, the result is of value. However, difficulties arise when the study fails to provide evidence of stock separation, because this does not necessarily indicate that there are no components within the fishery which have sufficient reproductive integrity to be treated as stocks for management purposes. For example, genetic studies suggest that mackerel and herring populations in the waters around the British Isles are both genetically homogeneous. Studies conducted using other techniques have indicated that these species form a number of stock units which are sufficiently discrete to be managed independently: the transfer of a few individuals between stocks (and thus the maintenance of genetic homogeneity within the population as a whole) is clearly of little or no direct consequence to fishery management.

Ultimately, an appropriate method for stock identification would allow individuals sampled from landings to be assigned to specific stocks. For the marine species found in the Channel, there is not, at present, a reliable method by which to achieve this, and the stock manager has to be content with producing an overall view of the stock composition in a particular fishery at a particular time.

The quality of information on stock identification which was available for each species when compiling this report varies considerably. Nine of the 25 species reviewed have been the subjects of extensive biological study, and there is a comprehensive understanding of their life history, which is an almost essential prerequisite to studies of stock identity. It is possible that sufficient information is available to permit management to be carried out on a stock-by-stock basis for these species: bass, cod, edible crab, herring, mackerel, plaice, scallop, sole and spurdog. For the remainder of the 25 species considered in this report, little is known about stock identity and knowledge of the species' life-history is also poor. Our current understanding of the stock identity of 25 of the most important species exploited in the Channel is summarised in Figure 26 starting with the species for which stocks in the Channel have a southerly/westerly distribution.

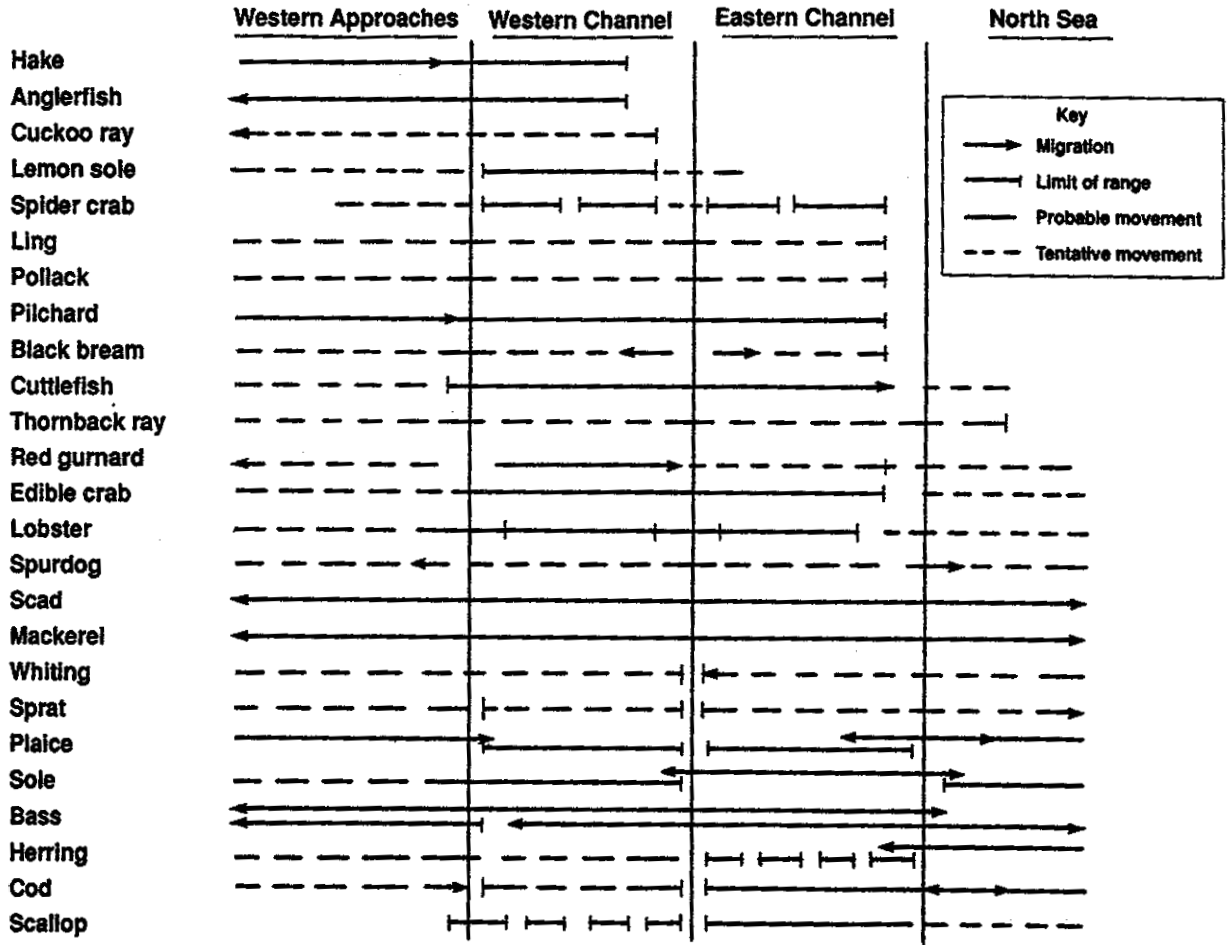

Figure 26. The association between fish in the Channel and those in adjacent regions

REFERENCES

General distribution of species

QUERO, I. C., 1984. Les poissons de mer des pêches françaises. J Grancher (Ed.), 394pp.

RILEY, J.D., SYMONDS, D.J. ANDWOOLNER, L.E., 1986. Determination of the distribution of the planktonic and small demersal stages of fish in the coastal waters of England, Wales and adjacent areas between 1970 and 1984. Fish. Res. Tech. Rep., MAFF Direct. Fish. Res., Lowestoft, ***84***: 23pp.

RUSSELL, F.S., 1976. The Eggs and Planktonic Stages of British Marine Fishes. Academic Press, London, 524pp.

WHEELER, A., 1969. The Fishes of the British Isles and North-West Europe. MacMillan, London, 613pp.

WHEELER, A., 1978. Key to the Fishes of Northern Europe. Frederick Warne, London, 380pp.

WHITEHEAD, P.J.P., BAUCHOT, M-L., HUREAU, J-L., NIELSEN, J. AND TORTENESE, E., 1984. Fishes of the North-Eastern Atlantic and the Mediterranean. UNESCO, Paris, 1473pp.

Physical, chemical and biological structure of the English Channel

AGOUMI, A., 1985. Modélisation de l'écosystème pélagique en Manche. Etude de l'influence des phénomènes physiques sur l'écosystème planctonique. Thèse de Doctorat d'Etat. Univ. Pierre et Marie Curie, Paris.

AGOUMI, A., GOSSE, P. ET KHALANSKI, M., 1983. Modélisation d'un ècosystéme phytoplanctonique marin cotier. Site de Flaamanville. Rapport EDF HE/31-83.35.

BANNER, F.T., COLLINS, M.B. AND MASSIE, K.S. (Eds.), 1980. The North-West European Shelf Seas : the Sea Bed and the Sea in Motion. II : Physical and Chemical Oceanography, and Physical Resources. Elsevier, Amsterdam, Oxford and NewYork, pp415-465.

CABIOCH, L., GENTIL, F., GLAÇON, R. AND RETIERE, C., 1976. Le macrobenthos des fonds meubles de la Manche : Distribution générale et écologie. pp 115-128, *In*: Keegan, B.F., Ceidigh, P. O. and Boaden, P. J. S. (Eds.) Biology of Benthic Organisms. 11th European Symposium on Marine Biology. Galway, October 1976. Pergamon Press, Oxford, 630pp.

HOLLIGAN, P.M., HARRIS, R.P., NEWELL, R.C., HARBOUR, D.S., HEAD, R.N., LINLEY, E.A.S., LUCAS, M.I., TRANTER, P.R.G. AND WEEKLEY, C.M., 1984. Vertical distribution and partitioning of organic carbon in mixed, frontal and stratified waters of the English Channel. Mar. Ecol. Prog. Ser., ***14***: 111-127.

JEGOU, A.-M. AND SALOMON, J.C., 1991. Hydrodynamique côtière: couplage imagine thermique satellitaire - modèles numériques. Application à la Manche. pp. 55-62, *In*: Actes du Colloque International sur l'environnement des mers épicontinentales, Lille, 20-22 Mars 1990, Oceanologica Acta, vol. sp. No. ***11***.

LARSONNEUR, C., 1977. La Cartographie des dépôts meubles sur le plateau continental français: méthode mise au point de utilisée en Manche. J. Rech. océanogr., ***2***: 34-39.

PINGREE, R. D., 1975. A time varying temperature model of mixing in the English channel. J. mar. biol. Ass. U.K., ***55***: 975-992.

RETIERE, C., 1979. Contribution à la connaissance des peuplements benthiques du Golfe Normano-breton. Thèse de Doctorat, Univ. Rennes, 83pp.

ROBINSON, G.A., AIKEN, J. AND HUNT, H.G., 1986. Synoptic surveys of the western English Channel. The relationships between plankton and hydrography. J. mar. biol. Ass. U.K., ***66***: 219-228.

ROBINSON., I. S., 1983. Tidally induced residual flows. pp. 321-356, *In*: B. Johns (Ed). Physical Oceanography of Coastal and Shelf Seas. Elsevier Oceanography Series,

SALOMON, J.C., 1991. Hydrodynamic action on benthic macrofauna in tidal coastal zones. Int. Coun. Explor. Sea mar. Sci. Symp., ***192***: 15-23.

SALOMON, J.C. ET BRETON, M., 1991. Courants de marée et courants résiduels dans la Manche. pp. 47-53, *In*: Actes de Colloque International sur L'environnement des Mers Épicontinentales, Lille, 20-22 mars 1990,. Oceanologica Acta, vol. sp. no ***11***.

TAYLOR, A. H., REID, P. C., MARSH, T. J., JONAS, T. D. AND STEPHENS, J. A., 1981. Year to year changes in the salinity of the eastern English Channel 1948-1973. A budget. J. mar. bio. Ass. UK, ***61***: 489-507.

ZIMMERMAN, J.T.F., 1981. Dynamics, diffusion and geomorphological significance of Tidal residual eddies, Nature, ***290***: 549-555.

1. Scallops

ANSELL, A. D., DAO, J. C., LUCAS, A., MACKIE, L. A. AND MORVAN, C., 1988. Reproductive and genetic adaptation in natural and transplant populations of the scallop, *Pecten maximus*, in European waters. European Commission, Luxembourg, 50 pp.

ANSELL, A. D., DAO, J. C. AND MASON, J., 1991. Three European scallops: *Pecten maximus, Chlamys (Aequipecten) opercularis* and *C. (Chlamys) varia*. pp. 715-752, *In*: Shumway, S. E. (Ed.), Scallops: Biology, Ecology and Aquaculture. Elsevier, New York, 1095 pp.

ANTOINE, L., 1979. La croissance de la coquille St-Jacques, *Pecten maximus* (L), et ses variations en Mer Celtique et en Manche. Thèse de Doctorat de 3ème cycle, COB-UBO, Brest, 148pp.

BEAUMONT, A.R., 1989. Identification of scallop stocks: the uses and value of allozyme data. ICES CM 1989/K:8, 7pp (mimeo).

BEAUMONT, A.R., 1991. Allozyme data and scallop stock identification. J.Cons. int. Explor. Mer, ***47***: 333-338.

BUESTEL, D., GERARD, A. AND GUENOLE, A., 1987. Croissance des differents lots de Coquille Saint-Jaques, *Pecten maximus*, en culture sur le fond dans la rade de Brest. Haliotis, ***16***: 463-477.

CRAGG, S. M. AND CRISP, D. J., 1991. The biology of scallop larvae. pp. 75-132, *In*: Shumway, S. E., (Ed.) Scallops: Biology, Ecology and Aquaculture. Elsevier, New York, 1095 pp.

DARE, P., (in press). Use of external shell microgrowth patterns for determining growth and age in the Scallop, *Pecten maximus* (L). Proc. Eighth International Pectinid Workshop, Cherbourg, May 1991. IFREMER, Brest.

DARE, P. J. AND DEITH, M. R., 1991. Age determination of scallops, *Pecten maximus* (L), using stable oxygen isotope analysis, with some implications for fisheries management in British waters. pp. 118-133, *In*: Shumway, S. E. and Sandifer, P. A. (Eds.) An International Compendium of Scallop Biology and Culture. World Aquaculture Workshop No 1. The World Aquaculture Society, Baton Rouge.

DARE, P.J, DARBY, C.D., DURANCE, J.A. AND PALMER, D.W., (in press). The distribution of scallops (*Pecten maximus*) in the England Channel and Celtic Sea in relation to Hydrographic and substrate features affecting larval dispersal and settlement. Proc. Ninth International Pectinid Workshop, Nanaimo, B.C., Canada, April 1993.

FIFAS, S., 1991. Analyse et modélisation des paramètres d'exploitation du stock de coquilles St-Jacques en Baie de St-Brieuc. Thèse de Doctorat, UBO, Brest, 422pp.

HUELVAN, S., 1985. Variabilité génétique des populations de *Pecten maximus* L. en Bretagne. Thèse de Doctorat de 3ème cycle, UBO Brest, 495pp.

LUBET, P., 1990. Etude des mécanismes physiologiques contrôlant la croissance et la reproduction chez les bivalves d'intérêt commercial. Rapport FRD-Région Basse Normandie-IBBA Univ. de Caen, 24pp.

MASON, J., 1983. Scallop and Queen Fisheries in the British Isles. Fishing News Books Farnham, Surrey, England, 144pp.

MATHIEU, M. ET LUBET, P., 1991. Etude des mécanismes physiologiques contrôlant la croissance et la reproduction chez les bivalves d'intérêt commercial. Rapp. FRD-Région Basse-Normandie-IBBA, Univ. Caen, 53pp.

PAULET, Y.M. ET FIFAS, S., 1989. Etude de la fécondité potentielle de la coquille St Jacques en Baie de St Brieuc. Haliotis, ***19***: 275-285.

TEBBLE, N., 1966. British Bivalve Seashells. London, British Museum (Natural History), 212pp.

2. Cuttlefish

BOUCAUD-CAMOU, E., 1985. Marquage de la Seiche, *Sepia officinalis* L. en Baie de Seine. Rapport CRPCM de Basse-Normandie, 30pp.

BOUCAUD-CAMOU, E., 1987. Migrations de la Seiche *Sepia officinalis* L. des côtes Normandes. Rapport CRPCM de Basse-Normandie, 22pp.

BOUCAUD-CAMOU, E., 1988. Migrations et hivernage de la Seiche (*Sepia officinalis* L.) des côtes Normandes. Rapport CRPCM de Basse-Normandie, 24pp.

BOUCAUD-CAMOU, E. AND BOISMERY, J., 1991. The migrations of the cuttlefish (*Sepia officinalis* L.) in the English Channel. *In*: Boucaud-Camou, E. (Ed.) Actes du 1er Symposium International sur la Seiche, Caen 1-3 juin 1989, Centre de Publications de l'Université de Caen, 12pp.

BOUCAUD-CAMOU, E., KOUETA, N., BOISMERY, J. AND MEDHIUUB, A., 1991. The sexual cycle of *Sepia officinalis* L. from the Bay of Seine. *In*: Boucaud-Camou, E. (Ed.) Actes du 1er Symposium International sur la Seiche. Caen, 1-3 juin 1989. Centre de Publications de l'Université de Caen, 1pp.

JEON, I.G., 1982. Étude des populations de seiches (*Sepia officinalis* L.) du Golfe de Gascogne. Thèse de 3ème cycle, Océanographie. Univ. de Nantes, 271pp.

LE GOFF, R. ET DAGUZAN, J., 1991. Etude des déplacements de la Seiche commune *Sepia officinalis* L. dans le Golfe du Morbihan au cours de la période de la reproduction. Premiers résultats. *In*: Boucaud-Camou, E. (Ed.) Actes du 1er Symposium international sur la Seiche. Caen, 1-3 juin 1989. Centre de Publications de l'Université de Caen, 11pp.

MANGOLD, K., 1966. Sepia officinalis de la mer Catalane. Vie et Milieu, ***17***: 961-1012.

MEDHIOUB, A., 1986. Etude de la croissance et du cycle sexuel de la Seiche (*Sepia officinalis* L.) des côtes Normandes. Thèse de Doctorat 3ème cycle. Univ. Caen, 417pp.

VON BOLETZKY, S., 1983. *Sepia officinalis*. pp. 31-52, *In*: Boyle, P.R. (Ed.) Cephalopod Life Cycles 1, X, Academic Press, London.

3. Lobster

BENNETT, D. B. AND HOWARD, A. E., 1987. Estimates of lobster (*Homarus gammarus*) fecundity from east and west Britain. ICES CM 1987/K:47, 7pp (mimeo).

LATROITE, D., MORIZOR, Y. ET RAGUENES, G., 1984. Fécondités individuelles et par recrue du homard européen *Homarus gammarus* des côtes françaises. ICES CM 1984/K:34, 9pp (mimeo).

LEGRAND, V., VERON, G. ET NOËL, P., 1985. Proposition d'un schéma de croissance pour le homard à partir de marquages réalisés sur la côte ouest-Cotentin. ICES CM 1985/K:21, 9pp (mimeo).

4. Edible crab

BENNETT, D.B., 1974. Growth of the edible crab (*Cancer pagurus* L.) off southwest England. J. mar biol. Ass. U.K., ***54***: 803-823.

BENNETT, D. B. AND BROWN, C. G., 1980. Population and catch structure of the edible crab (*Cancer pagurus*) in the English Channel. J. Cons. int. Explor. Mer, ***39***: 88-100.

BENNETT, D.B. AND BROWN, C.G., 1983. Crab (*Cancer pagurus*) migrations in the English Channel. J. Mar. biol. Ass. U.K., ***63***: 371-398.

BROWN, C.G., 1975. Norfolk crab investigations 1969-1973. Lab. Leafl., MAFF Direct. Fish. Res., Lowestoft, ***30***: 12pp.

EDWARDS, E., 1965. Observations on growth of the edible crab (*Cancer pagurus*). Rapp. P.-v. Réun. Cons. int. Explor. Mer , ***156***: 62-70.

EDWARDS, E., 1979. The Edible Crab and its Fishery in British Waters. Fishing News Books, Farnham, Surrey, England, 140pp.

HANCOCK, D.A. AND EDWARDS, E., 1967. Estimation of annual growth in the edible crab (*Cancer pagurus* L.). J. Cons. int. Explor. Mer, ***31***: 246-264.

LATROITE, D. AND LE FOLL, D., 1989. Données sur les migrations des crabes tourteau *Cancer pagurus* et araignée de mer *Maia squinado*. Oceanis, ***15***: 133-142. (also relevant to spider crab)

LATROITE, D. AND MORIZUR, Y. 1988. Analyse quantitative et qualitative des captures de tourteaux *Cancer pagurus* par la flottille de Manche-ouest. ICES CM 1988/K:33, 7pp (mimeo).

LATROITE, D., MORIZUR,Y., NOËL, P., CHAGOT, D. AND WILHELM, G., 1988. Mortalité du tourteau *Cancer pagurus* provoquée par le dinoflagellé parasite Hematodinium sp. ICES CM 1988/K:32, 11pp (mimeo).

LE FOLL, D., 1982. Les pêcheries de tourteau *Cancer pagurus* sur les côtes de Bretagne sud: déplacements, croissance, reproduction. Thèse Université de Bretagne Occidentale.

MARTIN, J., 1985. Distribution des larves de tourteau (*Cancer pagurus*) en Manche Ouest en 1983. ICES CM 1985/K:25, 8pp (mimeo).

NICHOLS, J.H., THOMPSON, B.T. AND CRYER, M., 1982. Production, drift and mortality of the planktonic larvae of the edible crab (*Cancer pagurus*) off the north-east coast of England. Neth. J. Sea. Res., ***16***: 173-184.

SALOMON, J.C., 1991. see physical, chemical and biological structure of the English Channel.

THOMPSON, B.M., LAWLER, A.R. AND BENNETT, D.B. (in press). Estimation of the spatial distribution of spawning crabs (C*ancer pagurus* L.). Int. Coun. Explor. Sea, Mar. Sci. Symp. Ser.

5. Spider crab

DE KERGARIOU, G., 1975. L'araignée de Mer, *Maia squinado*, sur le littoral de Bretagne. Sci. Pêche, Bull. Inst. Pêch. marit., ***205***: 11-19.

EDWARDS, E., 1980. Preliminary results of a tagging experiment on the spider crab (*Maia squinado*) in the English Channel. ICES CM 1980/K:12, 3pp (mimeo).

6. Spurdog

AASEN, O., 1961. Studies of the spurdog, Translation Series, MAFF Direct. Fish. Res., Lowestoft, (from Fiskets Gang, ***47***: 36-44).

AASEN, O., 1964. The exploitation of the spiny dogfish (*Squalus acanthias* L.) in European waters. FiskDir. Skr., Ser. Havunders., ***13***: 5-6.

BEAMISH, R.J. AND MCFARLANE, G.A., 1985. Annulus development on the second dorsal spine of the spiny dogfish *Squalus acanthias* and its validity for age determination. Can. J. Fish. Aquat. Sci., ***42***: 1799-1805.

FAHY, E., 1989. The spurdog *Squalus acanthias* (L) fishery in South West Ireland. Irish Fish. Invest.. ***32***: 22pp.

FORD, E., 1921. A contribution to our knowledge of the life histories of the dogfishes landed at Plymouth. J. mar. biol. Ass. U.K., ***12***: 468-505.

GAULD, J. AND MACDONALD, W.S., 1982. The results of tagging experiments on spurdog (*Squalus acanthias* L.) around Scotland. ICES CM 1982/H:51, 7pp (mimeo).

HIICKLING, C.F., 1930. A contribution towards the life history of the spurdog. J. mar. biol. Ass. U.K., ***16***: 529-576.

HJERTENES, P.O., (1980). The spurdogs in the North Sea area: the Norwegian fisheries and observations on changes in migration patterns. ICES CM 1980/ H:60, 18pp (mimeo).

HOLDEN, M.J., 1965. The stocks of spurdog (*Squalus acanthias* L.) in British waters and their migration. Fish. Invest. London Ser. 2, ***24(4)***: 20pp.

HOLDEN, M.J., 1967. Spurdogs. Lab. Leafl., MAFF. Direct. Fish. Res., Lowestoft, ***16***: 23pp.

HOLDEN, M. J., 1977. Elasmobranchs. pp. 187-215, *In*: Gulland, J. A. (Ed.). Fish Population Dynamics. Wiley, London and New York.

HOLDEN, M.J. AND MEADOWS, P.S., 1962. The structure of the spine of the spurdog *Squalus acanthias* (L.) and its use for age determination. J. mar. biol. Ass. U.K., ***42***: 179-197.

HOLDEN, M.J. AND MEADOWS, P.S., 1964. The fecundity of spurdog (*Squalus acanthias* L.) J. Cons. int. Explor. Mer, ***28***: 418-424.

NAMMACK, M.F., MUSICK, J.A. AND COLVOCORESSES, J.A., 1985. Life history of the spiny dogfish off the northeastern United States. Trans. Am. Fish. Soc., ***114***: 367-376.

ORLOWSKA, K., 1979. Parasites of North Sea spiny dogfish, *Squalus acanthias* L. (Selachiiformes, Squalidae). Acta. Ichthyol. Piscat., ***9***: 33-44.

SHAFER, T.C., 1970. Migration and distribution of the spiny dogfish (*Squalus acanthias* L.) in the western North Atlantic. Master's Thesis, University of Rhode Island, Kingston, RI, USA.

TUCKER, R., 1985. Age validation studies on the spines of the spurdog (*Squalus acanthias*) using tetracycline. J. mar. biol. Ass. U.K., ***65***: 641-651.

VINCE, M.R., 1991. Stock identity in spurdog (*Squalus acanthias* L.) around the British Isles. Fish. Res., ***12***: 341-354.

WALENKAMP, J.H.C., 1988. Life history and fishery of the spurdog, *Squalus acanthias*, in the Irish Sea. Unpublished M.Sc. Thesis, University of Wales, Bangor.

7. Thornback ray

BRANDER, K.M. AND PALMER, D., 1985. Growth rate of *Raja clavata* in the northeast Irish Sea. J. Cons. int. Explor. Mer, ***42***: 125-128.

FAHY, E., 1989. Growth parameters of rays (Batoidei) in Irish waters from material examined in commercial catches. ICES CM 1989/G:59, 11pp (mimeo).

HOLDEN, M.J., 1972. The growth rates of *Raja brachyura, R. clavata and R. montagui* as determined from tagging data. J. Cons. int. Explor. Mer, ***34***: 161-168.

HOLDEN, M.J., 1974. Problems in the rational exploitation of elasmobranch populations and some suggested solutions. pp. 117-137, *In*: Harden-Jones, F.R. (Ed.) Sea Fisheries Research, Elek Science, London, 510pp.

HOLDEN, M.J., 1975. The fecundity of *Raja clavata* in British waters. J. Cons. int. Explor. Mer, ***36***: 101-118.

RYLAND, J.S. AND AJAYI, T.O., 1985. Growth and population dynamics of three Raja species (Batoidei) in Carmarthen Bay, British Isles. J. Cons. int. Explor. Mer, ***41***: 111-120.

STEVEN, G.A., 1932. Rays and skates of Devon and Cornwall. III. A study of the fishery; with notes on the occurrence migrations and habits of the species. J. mar. biol. Ass. U.K., ***18***: 1-33.

STEVEN, G.A., 1936. Migrations and growth of the thornback ray (*Raja clavata* L.). J. mar. biol. Ass. U.K., ***20***: 605-614.

8. Cuckoo ray

DU BUIT, M., 1977. Age et croissance de *Raja batis* et de *Raja naevus* en Mer Celtique. J. Cons. int. Explor. Mer, ***37***: 261-265.

FAHY, E., 1989 (see thornback ray).

9. Herring

ANON., 1930. Fisheries of the North-east Atlantic: Herring Atlas (Fishing Grounds, Landing Ports and Quality). Int. Coun. Explor. Sea, Copenhagen.

ANON., 1991. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 1991/Assess:15, 192pp (mimeo).

BLAXTER, J.H.S. AND HUNTER, J.R., 1982. The biology of Clupeoid fishes. Adv. Mar. Biol., ***20***: 223pp.

BRIDGER, J.P., 1961. On fecundity and larval abundance of Downs herring. Fishery Invest. Lond., Ser. 2, ***23(3)***: 30pp.

BURD, A.C., 1978. Long-term changes in North Sea herring stocks. Rapp. P.-v. Réun. Cons. int. Explor. Mer, ***172***: 137-153.

BURD, A.C., 1985. Recent changes in the central and southern North Sea herring stocks. Can. J. Fish. Aquat. Sci., ***42 (1)***: 192-206.

CUSHING, D.H., 1958. Some changes in vertebral counts in herring. Rapp. P.-v. Réun. Cons. int. Explor. Mer, ***143***: 126-129.

CUSHING, D.H., 1967. The grouping of herring populations. J. mar. biol. Ass. U.K., ***47***: 193-208.

CUSHING, D.H. AND BURD, A.C., 1957. On the herring of the southern North Sea. Fishery Invest., Lond., Ser. 2, ***20 (11)***: 3pp.

DAHLE, G. AND ERIKSEN, A.G., 1990. Spring and autumn spawners of herring (*Clupea harengus*) in the North Sea, Skagerrak and Kattegat: population genetic analysis. Fish. Res., ***9***: 131-141.

DAVEY, J.T., 1972. The incidence of Anisakis sp. larvae (Nematoda: Ascaridata) in the commercially exploited stocks of herring (*Clupea harengus* L., 1758) (Pisces: Clupeidae) in British and adjacent waters. J. Fish Biol., ***4***: 535-554.

FORD, E., 1933. An account of the herring investigations conducted at Plymouth during the years from 1924 to 1933. J. mar. biol. Ass. U.K., ***19***: 305-384.

GRANT, W.S., 1984. Biochemical population genetics of Atlantic herring *Clupea harengus*. Copeia, ***2***: 357-364.

HEMPEL, G. AND BLAXTER, J.H.S., 1967. Egg weight in Atlantic herring (*Clupea harengus* L.). J. Cons. int. Explor. Mer, ***31***: 170-195.

HOURSTON, A.S., 1982. Homing by Canada's west-coast herring to management units and divisions as indicated by tag recoveries. Can. J. Fish. Aquat. Sci., ***39***: 1414-1422.

JENNINGS, S. AND BEVERTON, R.J.H., 1991. Intraspecific variation in the life history tactics of Atlantic herring (*Clupea harengus* L.) stocks. ICES J. Mar. Sci., ***48***: 117-125.

JØRSTAD, K.E., KING, D.P.F. AND NAEVDAL, G., 1991. Population structure of Atlantic herring *Clupea harengus* L. J. Fish Biol., ***39(A)***: 43-52.

KING, D.P.F., FERGUSON, A. AND MOFFETT, I.J.J., 1987. Aspects of the population genetics of herring *Clupea harengus* around the British Isles and the Baltic Sea. Fish. Res., ***6***: 35-52.

MACKENZIE, K., 1982. Fish parasites as biological tags. Scott. Fish. Bull., ***47***: 27-32.

PARRISH, B.B. AND SAVILLE, A., 1965. The biology of the north-east Atlantic herring populations. Oceanogr. Mar. Biol. Ann. Rev., ***3***: 323-373.

POMMERANZ, T., 1977. Report on the international surveys of herring larvae in the North Sea and adjacent waters in 1974/75. Coop. Res. Rep., Int. Coun. Explor. Sea, ***61***: 16-27.

POSTHUMA, K.H., SAVILLE, A. AND WOOD, R.J., 1977. Herring spawning grounds in the North Sea. Coop. Res. Rep., Int. Coun. Explor. Sea, ***61***: 1-15.

RANKINE, P.W., 1989. A report on the ICES herring larval surveys in the North Sea and adjacent waters in 1988/89. ICES CM 1989/H:5, 6pp (mimeo).

SAVILLE, A. AND MCKAY, D.W., 1974. Report on the international surveys of herring larvae in the North Sea and adjacent waters in 1972/73. Coop. Res. Rep., Int. Coun. Explor. Sea, ***41***:1-39.

SAVILLE, A. AND MCKAY, D.W., 1979. Report on the international surveys of herring larvae in the North Sea and adjacent waters 1975/76 and 1976/77. Coop. Res. Rep., Int. Coun. Explor. Sea 88: 1-52.

SCHNACK, D. (1973). Report on the international surveys of herring larvae in the North Sea and adjacent waters in 1971/72. Coop. Res. Rep., Int. Coun. Explor. Sea, ***34***: 1-31.

SMITH, P.J. AND JAMIESON, A., 1986. Stock discreteness in herrings: a conceptual revolution. Fish. Res., ***4***: 223-234.

STEPHENSON, R.L. AND KORNFIELD, I., 1990. Reappearance of spawning Atlantic herring (*Clupea harengus harengus*) on Georges Bank: population resurgence not recolonization. Can. J. Fish. Aquat. Sci., ***47***: 1060-1064.

WHEELER, J.P. AND WINTERS, G.H., 1984. Homing of Atlantic herring (*Clupea harengus harengus*) in Newfoundland waters as indicated by tagging data. Can. J. Fish. Aquat. Sci., ***41***: 108-117.

WOOD, R.J., 1971. Report on the international surveys of herring larvae in the North Sea and adjacent waters in 1969/70. Coop. Res. Rep., Int. Coun. Explor. Sea, ***22***: 3-36.

WOOD, R.J., 1975. Report on the international surveys of herring larvae in the North Sea and adjacent waters in 1973/74. Coop. Res. Rep., Int. Coun. Explor. Sea, ***48***: 3-36.

WOOD, R.J. (1980). Report on the international surveys of herring larvae in the North Sea and adjacent waters, 1977/78. Coop. Res. Rep., Int. Coun. Explor. Sea, ***90***: 1-37.

ZIJLSTRA, J.J., 1972. Report on the international surveys of herring larvae in the North Sea and adjacent waters in 1970/71. Coop. Res. Rep., Int. Coun. Explor. Sea, ***28***: 1-24.

ZIJLSTRA, J.J., 1973. Egg weight and fecundity in the North Sea herring *Clupea harengus*. Neth. J. Sea. Res., *6*: 173-204.

10. Sprat

ANON., 1969. Sprat Symposium, Lysekil 1968. Papers (First Part). Medd. Havsfiskelab., Lysekil, ***66***: 1-55.

DANNEVIG, A., 1947. The number of vertebrae and rays of the second dorsal fin of fishes from the Norwegian Skagerrak coast. Ann. Biol., ***2***: 131-146.

DANNEVIG, G., 1951. Sprat from Norwegian waters. FiskDir. Skr. Ser. Havunders., ***9***: 1-22.

DEMIR, N. AND SOUTHWARD, A.J., 1974. The abundance and distribution of eggs and larvae of teleost fishes off Plymouth in 1969 and 1970. Part 3. Eggs of pilchard (*Sardina pilchardus* Walbaum) and sprat (*Sprattus sprattus* (L.)). J. mar. biol. Ass. U.K., ***54***: 333-353.

FELDMAN, V.N., 1981. Caractéristiques morphométriques du sprat *Sprattus sprattus* (L.) de la Mer du Nord. Vop. Ikhtiol., ***21***: 427-433.

FELDMAN, V.N., 1986. Quelques traits particuliers de la répartition et de la biologie du sprat de la Mer du Nord en fonction de sa différenciation à l'intérieur de la population. ICES CM 1986/H:32, 15pp (mimeo).

GILIS, C., 1951. Les concentrations de sprats sur la côte Belge. Rapp. P.-v. Réun. Cons. int. Explor. Mer, ***126***: 114-121.

HOWLETT, G. AND JAMIESON, A., 1971. A system of muscle esterase variants in the sprat (*Sprattus sprattus*). Rapp. P.-v. Réun. Cons. int. Explor. Mer, ***161***: 45-47.

JØRSTAD, K. AND NAEVDAL, G., 1981. Enzyme polymorphism of sprat from Norwegian waters - preliminary results. ICES CM 1980/H:15, 10pp (mimeo).

KOVAL, L.I. AND FELDMAN, V.N., 1978. Genetic, biochemical and morphometrical characteristics of the North Sea sprat, *Sprattus sprattus* L. ICES CM 1978/H:19, 26pp (mimeo).

LINDQUIST, A., 1968. Meristic and morphometric characters, year-classes and 'races' of the sprat (*Sprattus sprattus*). Rep. Inst. Mar. Res. (Lysekil) Ser. Biol., ***17***: 26pp

MILLIGAN, S.P., 1986. Recent studies on the spawning of sprat (*Sprattus sprattus* L.) in the English Channel. Fish. Res. Tech. Rep., MAFF Direct. Fish. Res., Lowestoft, ***83***: 16pp.

11. Pilchard

BRIDGER, J.P., 1965. The Cornish pilchard and its fishery. Lab. Leafl., MAFF Direct. Fish. Res., Lowestoft, ***9***: 17pp.

CUSHING, D.H., 1957. The number of pilchards in the Channel. Fishery Invest. Lond., Ser. 2, ***21 (5)***: 27pp.

DEMIR, N. AND SOUTHWARD, A.J., 1974. see sprat

FURNESTIN, J., 1944. Contribution a l'étude biologique de la Sardine Atlantique *Sardina pilchardus* (Walbaum). Rev. Trav. Off. Pêch. Marit., ***13***: 221-386.

L' HERROU, R., 1971. Étude biologique de la sardine du Golfe de Gascogne et du plateau Celtique. Rev. Trav. Pêch. marit., ***35***: 455-473.

MACER, C.T., 1974. Some observations on the fecundity of the pilchard (*Sardina pilchardus* Walbaum) off the south-west coast of England. ICES CM 1974/ J:9, 11 pp (mimeo).

PARNELL, W.G., 1974. On the maturation cycle of the pilchard (*Sardina pilchardus* Walbaum) off the south-west coast of England. ICES CM 1974/J:11, 9p. (mimeo).

SOUTHWARD, A. J. AND BOALCH, G. T., 1988. Aspects of long term changes in the ecosystem of the western English Channel in relation to fish populations. *In*: Int. Symp. Long Term Changes Mar. Fish Pop., Vigo, 1986.

WALLACE, P.D. AND PLEASANTS, C.A., 1972. The distribution of eggs and larvae of some pelagic fish species in the English Channel and adjacent waters in 1967 and 1968. ICES CM 1972/J:8, 4pp (mimeo).

12. Cod

ANON., 1971. Report by the North Sea Roundfish Working Group on North Sea Cod. ICES CM 1971/F:5, 19pp (mimeo).

BEDFORD, B.C., 1966. English cod tagging experiments in the North Sea. ICES CM 1966/G:9, 9pp (mimeo).

BRANDER, K. M., 1994. The location and timing of cod spawning around the British Isles. ICES J. mar. Sci., ***51***: 71-89.

CHILD, A.R., 1988. Population genetics of cod (*Gadus morhua* (L.)), haddock (*Melano-grammus aeglefinus* (L.)), whiting (*Merlangius merlangus* (L.)) and saithe (*Pollachius virens* (L.)). Fish. Res. Tech. Rep., MAFF Direct. Fish. Res., Lowestoft, ***87***: 27pp.

DAAN, N., 1969. Cod tagging experiments in Dutch coastal waters. ICES CM 1969/F:5, 4pp (mimeo).

HEESSEN, J.H.L., 1983. Distribution and abundance of young cod and whiting in the south-eastern North Sea in the period 1980-1982. ICES CM 1983/G:30, 4pp (mimeo).

HEESSEN, J.H.L. AND RIJNSDORP, A.D., 1989. Investigations on the egg production and mortality of cod (*Gadus morhua* L.) and plaice (*Pleuronectes platessa* L.) in the southern and eastern North Sea in 1987 and 1989. Rapp. P.-v. Réun. Cons. int. Explor. Mer, ***191***: 15-20.

JAMIESON, A,. 1970. Cod transferrins and genetic isolates. *In*: Proc. XI. Eur. Conf. on Animal Blood Groups and Biochemical Polymorphism, Warsaw, 1968. Dr W Junk, The Hague PWN, Warsaw, 607pp.

JAMIESON, A. AND THOMPSON, D., 1972. Blood proteins in North Sea cod. pp. 585-591, *In*: Kovacs, G. and Papp, M. (Eds.) Proc. XII Eur. Conf. on Animal Blood Groups and Biochemical Polymorphism, Budapest, 1970. Dr W Junk, The Hague, 686pp.

JAMIESON, A. AND THOMPSON, D., 1972. Butyric esterase differences in Atlantic cod (*Gadus morhua* L.). ICES CM 1972/F:32, 5pp (mimeo).

LEFRANC, G., 1970. Biologie de la Morue du sud de la Mer du Nord et de la Manche orientale. Rev. Trav. Inst. Pêches marit., ***34***: 277-296.

MACER, C.T. AND EASEY, M.W., 1988. The North Sea cod and the English fishery. Lab. Leafl., MAFF Direct. Fish. Res., Lowestoft, ***61***: 22pp.

PARNELL, W.G., 1979. Cod tagging in Rye Bay, 1977. Fish. Not., MAFF Direct. Fish. Res., Lowestoft, ***61***: 7pp.

RILEY, J.D. AND PARNELL, W.G., 1984. The distribution of young cod. Flødevigen Rapportser, ***1, 1984***: 563-580.

SICK, K., 1961. Haemoglobin polymorphism in whiting and cod. ICES CM 1961/128, 8pp (mimeo).

SICK, K., 1965. Haemoglobin polymorphism of cod in the North Sea and the North Atlantic Ocean. Hereditas, ***54***: 59-73.

VAN DER LAND, M.A., HEESSEN, H.J.L. AND RIJNSDORP, A.D., 1990. The result of the 1989 egg surveys for cod and plaice. ICES CM 1990/G:27. 14pp (mimeo). (also relevant to plaice)

13. Whiting

ANON., 1990. Report of the Roundfish Working Group. ICES CM 1990/Assess:7, 93pp (mimeo).

CHILD, A.R., 1988 see cod

GAMBLE, R., 1959. Investigations of the subdivisions of North Sea whiting population. I: Further observations on the vertebral counts of whiting in the North Sea area. Int. Coun. Explor. Sea, Near Northern Seas Committee, Paper ***36***, 3pp (mimeo).

KABATA, Z., 1963. Parasites as biological tags. Spec. Publs int. Commn. NW Atlant. Fish., ***4***: 31-37.

KATERINAS, A., 1986. Flounder and whiting distribution as shown by planktonic eggs in relation to Lernaeocera branchialis cross infection. Sandwich Student's Report, University of Bath.

LLEWELLYN, J., 1956. The host specificity, micro-ecology, adhesive attitudes and comparative morphology of some trematode gill parasites. J. mar. biol. Ass. U.K., ***35***: 113-127.

NOBLE, E.R., 1957. Seasonal variations in host-parasite relations between fish and their protozoa. J. mar. biol. Ass. U.K., ***36***: 143-155.

PILCHER, M.W., WHITFIELD, P.J. AND RILEY, J.D., 1989. Seasonal and regional infestation characteristics of three ectoparasites of whiting *Merlangius merlangus* L. in the North Sea. J. Fish Biol., ***35***: 97-110.

POTTER, I.C., GARDNER, D.C. AND CLARIDGE, P.N., 1988. Age composition, movements, meristics and parasites of the whiting (*Merlangius merlangus*) in the Severn Estuary and Bristol Channel. J. mar. biol. Ass. U.K., ***68***: 295-313.

ROESSINGH, M., 1957. Observations on the whiting made by the Netherlands Institute for Fishery Investigations. ICES CM 1957/ Doc. 82, 6 pp. (mimeo).

ROUT, D.W.R., 1962. Some observations on the whiting (*Gadus merlangus* L.) in the inshore winter fishery off Lowestoft. J. Cons. int. Explor. Mer, ***27***: 316-324.

SPROSTON, N.G. AND HARTLEY, P.H.T., 1939. The ecology of some parasitic copepods of gadoids and other fishes. J. mar. biol. Ass. U.K., ***25***: 361-392.

VAN DEN BROEK, W.L.F., 1979. Copepod parasites of *Merlangius merlangus* and *Platichthys flesus*. J. Fish Biol., ***14***: 371-380.

14. Pollack

DUPOUY, H., CHRISTIEN, D. ET KERGOAT, B., 1989. Estimation des paramètres de croissance du lieu jaune (*Pollachius pollachius*) de la sous-aire VII du CIEM, par l'utilisation des techniques de rééchantillonnage (Bootstrap) pour l'ajustement au modèle de Von Bertalanffy. ICES CM 1989/D:26, 11pp (mimeo).

MOREAU, J., 1964. Contribution à l'étude du lieu jaune (*Gadus pollachius* L.). Rev. Trav. Inst. Pêches marit., ***28(3)***: 236-255.

PRIOL, E., 1959. Fiche technologique du lieu jaune. *In:* France-Pêche, No. ***26***.

SCHMIDT, J., 1909. The distribution of the pelagic fry and the spawning regions of gadoids in the North Atlantic from Iceland to Spain based chiefly on Danish Investigations. Rapp. P.-v. Réun. Cons. int. Explor. Mer, ***10***: 1-229.

15. Hake

ALCAZAR, J., CARRASCO, J., LLERA, E., DE LA HOZ, M., ORTEA, J. AND VIZCAINO, A., 1983. Biologio dinamica y pesca de la merluza en Asturias. Recarsos pesq. de Austurias, ***3***: 135pp.

ANON., 1980. Report of the Working Group on Assessment of Hake Stocks. ICES CM 1981/G:11, 59pp (mimeo).

ANON., 1982. Report of the Working Group on Assessment of Hake Stocks. ICES CM 1983/Assess:14, 63 pp. (mimeo).

ANON., 1987. Report of the Working Group on Assessment of Hake Stocks. ICES CM 1987/Assess:1, 57pp (mimeo).

ARBAULT, S. AND LACROIX-BOUTIN, N., 1968. Ichtyoplankton. Oeufs et larves de poissons téléosteens dans le golfe de Gascogne en 1964. Rev. Trav. Inst. Pêch. marit., ***32(4)***: 413-476.

ARBAULT, S. AND LACROIX-BOUTIN, N., 1969. Epoques et aires de ponte des poissons téléosteens du golfe de Gascogne en 1965 et 1966 (oeufs et larves). Rev. Trav. Inst. Pêch. marit., ***33(2)***: 181-202.

BELLOC, G., 1922. Notes sur la Croissance du merlu. Rapport Atlantique, 1922. Cons. Perm. Explor. Mer. Rapp. p.-v., ***XXXI***, 34-43.

BELLOC,G., (1929). Etude monographique du merlu. Rev. Trav. off. Pech. Marit. Revue Trimestrielle. Tome II, Fasc. II and III.

BIRTWHISTLE, W. AND LEWIS, H.M., 1925. Hake investigations. Rep. Lanc. Sea Fish. Lab., ***36***.

COOMBS, S.H. AND MITCHELL, C.E., 1982. The development rate of eggs and larvae of the hake *Merluccius merluccius* (L.) and their distribution to the west of the British Isles. J. Cons. int. Explor. Mer, ***40***: 119-126.

DECAMPS, P. AND LABASTIE, J., 1978. Note sur le lecture et l'interprétation des otolithes du merlu. ICES CM 1978/G:41, 6pp (mimeo).

FARIÑA, A. C. AND FERNANDEZ, A., 1986. Datos biológicos de la merliza del Oeste de Erlanda. Inf. Téc. Inst. Esp. Oceanogr., ***47/86***

GUICHET, R., (In press). Le Merlu européen (*Merluccius merluccius* L.). Bilan des connaissances biologiques. Exploitation actuelle des stocks et évolution. Rapport provisoire IFREMER, 1-32.

HICKLING, C. F., 1927. The natural history of the hake. Parts I and III. Fishery. Invest., London., Ser. 2, ***10(2)***.

HICKLING, C. F., 1930. The natural history of the hake. Part III: seasonal changes in the condition of hake. Fishery. Invest., Lond., Ser. 2, ***12***: 1-78.

HICKLING, C. F., 1933. The natural history of the hake. Part IV: Age-determination and the growth rate. Fishery. Invest., Lond., Ser. 2, ***13***: 1-120.

HICKLING, C. F. and RUTENBERGE, E., 1936) The ovary as an indicator of the spawning period in fishes. J. mar. biol. Ass. U.K., ***21***: 311-317.

JEGOU, B., 1991. Merlu: un malade bien portant. France-Eco-Pêche Septembre 1991: 73-77.

MERIEL-BUSSY, N., 1966. La maturité sexuelle du merlu dans le golfe de Gascogne. ICES CM 1966/G:16, 4pp (mimeo).

MOGUEDET, P., 1988. Approche de la dynamique de stocks accessoires: le cas des lingues (Molva spp.) exploitées par la flottille industrielle lorientaise. Thèse Docteur de l'Université des Sciences et Techniques de Lille Flandre Artois.

MOGUEDET, P., 1989. Estimate of ling (*Molva molva* L.) length composition in landings of the Spanish trawlers. ICES CM 1989/G:36, 13pp (mimeo).

MONTIERO, R. AND LIMA DIAS, N., 1966. On some aspects of the fecundity of the hake (*Merluccius merluccius* L.) off the Portuguese coast. ICES CM 1966/G:5, 8p. (mimeo).

MORIZUR, Y., BERTHOU, P., LATROITE, D. ET VERON, G., 1990. Les flottilles artisanales françaises de Manche-Ouest. Int. Rep. IFREMER, Brest, 189 pp.

PERIERO, F.J., SANCHES, F. AND FONTENLA, J., 1991. Hake recruitment in the southern stock (ICES divisions VIIc and IXa). ICES CM 1991/G:52, 17pp (mimeo).

PINEIRO, C. AND HUNT, J.J., 1989. Comparative study on growth of European hake (*Merluccius merluccius* L.) from southern stock using whole and sectioned otoliths, and length frequency distributions. ICES CM1989/G:37, 9pp (mimeo).

SARANO, F., 1983. La reproduction du Merlu (*Merluccius merluccius* L.). Thèse, Univ. Poitiers, 147 pp. + annexe.

16. Ling

CHARUAU, A. ET BISEAU, A., 1985. Etude d'une gestion optimale des pêcheries de langoustine et de poissons démerseaux en Mer Celtique. Tome II. Rapport CEE (DG XIV) et IFREMER, Lorient, 137pp.

MORIZUR,Y., BERTHOU,P., LATROITE,D. AND VERNON,G., 1990. Les flottilles artisanales Françaises de Manche-Ouest. Int.Rep. IFREMER, Brest. 189pp.

MOGUEDET,P., 1989. Estimate of ling (*Molva molva* L.) length compositions in landings of the Spanish trawlers. ICES CM 1989/G:36, 13pp (mimeo).

17. Bass

ABBES, R., 1991. Atlas des pêches francaises dans les mers européennes. IFREMER Éditions Ouest-France, 98pp.

BARNABÉ, G., 1973. Contribution to the knowledge of growth and sexuality of the bass (*D. labrax*) in Sete waters. Ann. Inst. Oceanogr. Paris, ***49***: 49-75.

BOU-AIN, A., 1977. Contribution à l'étude morphologique, anatomique et biologique de Dicentrarchus punctatus (Bloch, 1792) des côtes tunisiennes. Thèse de Doctorat de Specialité, Faculté des Sciences, Tunis, 115pp.

CHILD, A. R., 1992. Biochemical polymorphism in bass, *Dicentrarchus labrax*, in the waters around the British Isles. J. mar. biol. Ass. U.K., ***72***: 357-364.

DANDO, P.R. AND DEMIR, N., 1985. On the spawning and nursery grounds of bass, ***Dicentrarchus labrax***, in the Plymouth area. J. mar. biol. Ass. U.K., ***63***: 159-168.

HOLDEN, M. J. AND WILLIAMS, T., 1974. The biology, movements and population dynamics of bass, Dicentrarchus labrax, in English waters, J. mar. biol. Ass. U.K., ***54***: 91-107.

JENNINGS, S. AND PAWSON, M.G., 1992. The origin and recruitment of bass, *Dicentrarchus labrax* larvae to nursery areas. J. mar. biol. Ass. U.K., ***72***: 199-212.

JENNINGS, S., LANCASTER, J.E., RYLAND, J.S. AND SHACKLEY, S.E. ,1991. The age structure and growth dynamics of young-of-the-year bass, *Dicentrarchus labrax*, populations. J. mar. biol. Ass. U.K. , ***71***: 799-810.

KELLEY, D.F., 1979. Bass populations and movements on the west coast of the U.K. J. mar. biol. Ass. U.K., ***59***: 889-936.

KELLEY, D.F., 1986. Bass nurseries on the west coast of the U.K. J. mar. biol. Ass. U.K., ***66***: 439-464.

KELLEY, D.F., 1988. The importance of estuaries for sea-bass **Dicentrarchus labrax** (L.) J. Fish Biol., ***33(A)***: 25-33.

KELLEY, D.F. AND REAY, P.J., 1988. The shallow creek fish communities of south-west England and west Wales estuaries. J. Fish Biol., ***33(A)***: 221-222.

KENNEDY, M. AND FITZMAURICE, P., 1968. Occurrence of eggs of bass, *Dicentrarchus labrax*, on the southern coasts of Ireland. J. mar. biol. Ass. U.K., ***48***: 585-592.

KENNEDY, M. AND FITZMAURICE, P., 1972. The biology of the bass, *Dicentrarchus labrax*, in Irish waters. J. mar. biol. Ass. U.K., ***52***: 557-597.

PAWSON, M.G. AND PICKETT, G.D., 1987. The bass and management of it's fishery in England and Wales. Lab. Leafl., MAFF Direct. Fish. Res., Lowestoft, ***59***: 37pp.

PAWSON, M.G., KELLEY, D.F. AND PICKETT, G.D., 1987. The distribution and migrations of bass *Dicentrarchus labrax* L., in waters around England and Wales as shown by tagging. J. mar. biol. Ass. U.K, ***67***: 183-217.

PICKETT, G.D., 1990. Assessment of the UK bass fishery using a log-book-based catch recording system. Fish. Res. Tech. Rep., MAFF Direct. Fish. Res., Lowestoft, ***90***: 33pp.

SABRIYE, A.S., REAY, P.J. AND COOMBS, S.H., 1988. Sea-bass larvae in coastal and estuarine plankton. J. Fish Biol., ***33(A)***: 231-233.

THOMPSON, B.M. AND HARROP, R.T., 1987. The distribution and abundance of bass (*Dicentrarchus labrax*) eggs and larvae in the English Channel and Southern North Sea. J. mar. biol. Ass. U.K., ***67***: 263-274.

THONG, L.H., 1970. Contribution à l'étude des Bars de la région des Sables d'Olonne. Trav. Fac. Sci., Rennes, ***3***: 39-68.

18. Black bream

PERODOU, J.B. AND NEDELEC, D., 1980. Bilan d'exploitation du stock de dorade grise. Sci. Pêche, Bull. Inst. Pêch. marit., ***308***: 1-7.

PERODOU, J.B. AND NEDELEC, D., 1982. Croissance des dorades grises. ICES CM 1982/G:27, 21pp (mimeo).

SOLETCHNIK, P., 1981. Gestion Rationnelle du storck de daurades grises en Manche: contribution au programme national. Int. Rep. Copepont-Marée-Organisation de Producteurs, Section de Cherbourg, ***1***: 12pp; ***2***: 53pp; ***3***: 6pp; *4*: 64pp.

19. Mackerel

ANON., 1984. Report of the Ad Hoc Working Group on Mackerel Egg Surveys. ICES CM 1984/H:1, 3pp (mimeo).

ANON., 1987. Report of the Mackerel Egg Production Workshop, Lowestoft, 3-7 November 1986. ICES CM 1987/H:2, 58pp (mimeo).

ANON., 1988. Report of the Mackerel Working Group. ICES CM 1988/Assess: 12, 82pp (mimeo).

ANON., 1988. Report of the Norwegian-EEC Joint Scientific Group on Migration and Area Distribution of Mackerel (Western Stock). ICES CM 1988/H:17, 44pp (mimeo).

ANON., 1989. Report of the Mackerel Working Group. ICES CM 1989/Assess:11, 85pp (mimeo).

ANON., 1990(a). Second Report of the EEC-Norwegian Joint Scientific Group on Migration and Area Distribution of Mackerel (Western Stock). ICES CM 1990/H:5, 43pp (mimeo).

ANON., 1990(b). Report of the Mackerel Working Group. ICES CM 1990/Assess:19, 109pp (mimeo).

ANON., 1990(c). Report of the Mackerel/Horse Mackerel Egg Production Workshop, Lowestoft, 29 January-2 February 1990. ICES CM 1990/H:2, 89pp (mimeo).

ANON., 1991. Report of the Mackerel Working Group. ICES CM 1991/Assess: 19, 90pp.(mimeo).

ANON., 1991. Report of the Study Group on Stock Identity of Mackerel and Horse Mackerel. Vigo, 22-29 January 1992. ICES CM 1992/H:4, 12pp (mimeo).

BAKKEN, E. AND WESTGÅRD, T., 1986. Intermixture of the North Sea and Western mackerel stocks determined by analyses of Norwegian tagging data. ICES CM 1986/H:65, 18pp (mimeo).

COOMBES, S.H. AND MITCHELL, C.E., 1981. Long term trends in the distribution, abundance and seasonal occurrence of larvae of mackerel (*Scomber scombrus* L.) around the British Isles, 1948-1978. J. mar. biol. Ass. U.K., ***61***: 343-358.

DAWSON, W.A., 1986. Changes in Western mackerel (*Scomber scombrus*) spawning stock composition during the spawning season. J. mar. biol. Ass. U.K., ***66***: 367-383.

DAWSON, W.A., 1991. Otolith measurement as a method of identifying factors affecting first-year growth and stock separation of mackerel (*Scomber scombrus* L.). J. Cons. int. Explor. Mer 47: 303-317.

DAWSON, W.A. AND MILLIGAN, S.P., 1990. The contribution of spawning in the Western Channel to the Western mackerel (*Scomber scombrus*) and horse mackerel (*Trachurus trachurus*) stocks. Working document; *In*: ICES CM 1990/H:2, 89pp (mimeo).

DAWSON, W.A., WALSH, M., HOPKINS, P., ELTINK, A. AND MOLLOY, J., 1988. The distribution and abundance of juvenile mackerel (*Scomber scombrus* L.) west and south of the British Isles. ICES CM 1988/H:16, 6pp (mimeo).

HAMRE, J., 1980. Biology, exploitation, and management of the Northeast Atlantic mackerel. Rapp. P.-v. Réun. Cons. int. Explor. Mer ,***177***: 212-242.

IVERSEN, S.A., 1981. Spawning and trends in spawning stock size of the North Sea mackerel during the period 1973-1980. ICES CM 1981/H:16, 9pp (mimeo).

IVERSEN, S.A. AND SKAGEN, D.W., 1989. Migration of Western mackerel to the North Sea 1973-1988. ICES CM 1989/H:20, 5pp (mimeo).

IVERSEN, S.A. ANDWESTGÅRD, T., 1981. The size and distribution of the 1984 yearclass of mackerel in the Skagerrak and the North Sea in the autumn of 1986. ICES Mackerel Working Group Document, CM 1987/Assess:11, 72pp (mimeo).

IVERSEN, S.A., ELTINK, A., KIRKEGAARD, E. AND SKAGEN, D.W., 1989. The egg production and spawning stock size of the North Sea mackerel and horse mackerel stocks in 1988. ICES CM 1989/H:16, 22pp (mimeo). (also relevant to scad)

JAMIESON, A. AND SMITH, P.J., 1987. Atlantic mackerel (*Scomber scombrus* L.) stocks and genes: a review. J. Cons. int. Explor. Mer, ***44***: 66-72.

KIRKEGAARD, E., 1989. Some results from a Danish acoustic survey in the North Sea July-August 1988. ICES Mackerel Working Group Document CM 1989/Assess:11, 85pp (mimeo).

LOCKWOOD, S.J., 1988. The Mackerel. Fishing News Books, Farnham, Surrey, England, 188pp.

LOCKWOOD, S.J., NICHOLS, J.H. AND DAWSON, W.A., 1981. The estimation of a mackerel (*Scomber scombrus*) spawning stock size by plankton survey. J. Plank. Res., ***3***: 217-233.

MACKENZIE, K., 1990. Cestode parasites as biological tags for mackerel (*Scomber scombrus* L.) in the North-east Atlantic. J. Cons. int. Explor. Mer, ***46***: 155-166.

MACKENZIE, K. AND MEHL, S., 1984. The cestode parasite, *Grillotia angeli*, as a biological tag for mackerel in the eastern North Atlantic. ICES CM 1984/H:52, 13 pp (mimeo).

WALSH, M. AND MARTIN, J.H.A., 1986. Recent changes in the distribution and migrations of the Western mackerel stock in relation to hydrographic changes. ICES CM 1986/H:17, 24pp (mimeo).

20. Scad

ANON., 1990(d). Report of the working group on the assessment of the stocks of sardine, horse mackerel and anchovy. ICES CM1990/Assess:24, 169pp.

ANON., 1990(c). see mackerel

ANON., 1991. Report of the Horse Mackerel Otolith Reading Workshop, Lisbon, 21-27 November 1990. ICES CM 1991/H:59, 59pp (mimeo).

ANON., 1991. Report of the Working Group on the Assessment of the Stocks of Sardine, Horse Mackerel and Anchovy. ICES CM 1991/Assess:22, 138pp (mimeo).

ANON., 1992. see mackerel

BORGES, M.F. AND GORDO, L.S., 1991. Spatial distribution by season and some biological parameters of house mackerel (*Trachurus trachurus* L.) in the Portuguese continental waters (division IXa) ICES CM 1991/H:54, 16pp (mimeo).

BORGES, M.F. AND NICHOLSON, M.D., 1992. Multivariate analysis of morphometrics to detect differences in populations of horse mackerel in the northeast Atlantic. Working document presented to the Study Group on Stock Identity of Mackerel and Horse Mackerel, Vigo, 22-24 January 1992, ICES CM 1992/H:4, 12pp (mimeo).

BORGES, M.F., TURNER, R.J. AND CASEY, J., 1993. Plasma transferrin polymorphisms in scad (*Trachurus trachurus* L.) populations from the north-east Atlantic. ICES J. mar. Sci., ***50***: 299-301.

CLARK, R.S., 1920. The pelagic young and early bottom stages of teleosteans. J. mar. biol. Ass. U.K., ***12***: 159-240.

EATON, D.R., 1983. Scad in the north-east Atlantic. Lab. Leafl., MAFF Direct. Fish. Res., Lowestoft, ***56***: 20pp.

EATON, D.R., 1989. Spawning-stock biomass of scad (*Trachurus trachurus* L.) to the west of the British Isles, as indicated by egg surveys. J. Con. int. Explor. Mer, ***45***: 231-247.

ELTINK, A. AND KUITER, C.J., 1989. Validation of ageing techniques on otoliths of horse mackerel (*Trachurus trachurus* L.). ICES CM 1989/H:43, 15pp (mimeo).

LUCIO, P. (1990). Some biological data on horse mackerel in the Bay of Biscay in 1982-83 and 1989. Working document presented to the ICES 1990 Sardine, Horse Mackerel and Anchovy Working Group. ICES CM 1989/Assess:24, 169pp (mimeo).

LUCIO, P. AND MARTIN, I., 1989. Biological aspects of horse mackerel in the Bay of Biscay in 1987 and 1988. ICES CM 1989/H:28, 22pp (mimeo).

RUSSELL, F.S., 1930. The seasonal abundance and distribution of the pelagic young of teleostean fishes caught in the ring trawl in offshore waters ian the Plymouth area. J. mar. biol. Ass. UK, ***16***: 639-676.

RUSSELL, F.S., 1935. The seasonal abundance and distribution of the pelagic young of teleostean fishes caught in the ring trawl in offshore waters in the Plymouth area, Part II. J. mar. biol. Ass. UK, ***20***: 147-179.

SMITH-VANIZ, W.F., 1986. Carangidae. pp. 815-833, *In*: P.J.P. Whitehead, M.L. Bauchot, J.C.Hureau, J.Nielsen, E.Tortonese, (Eds.) Fishes in the North-eastern Atlantic and the Mediterranean. ***Vol. 2***. UNESCO.

21. Red gurnard

CLARK, R.S., 1914. General report on the larval and post-larval teleosteans in Plymouth waters. J. mar. biol. Ass. U.K., ***10***: 327-394.

THERET, F., 1983. Biologie et pêche du grondin rouge en Manche. DEA Biologie et Physiologie animales. Univ. Sci. Technol., Lille, 42pp.

22. Plaice

ANON., 1992. Report of the ICES Study Group on Tagging Experiments for Juvenile Plaice. ICES CM 1992/G:10, 73pp (mimeo).

BAGENAL, T. B., 1966. The ecological and geographical aspects of the fecundity of the plaice. J. mar. biol. Ass. U.K., ***46***: 161-186.

BANNISTER, R. C. A., 1978. Changes in plaice stocks and plaice fisheries in the North Sea. Rapp. P.-v. Réun. Cons. int. Explor. Mer, ***172***: 86-101.

BANNISTER, R. C. A., HARDING, D. AND LOCKWOOD, S. J., 1974. Larval mortality and subsequent year-class strength in the plaice (*Pleuronectes platessa* L.). pp. 21-37, *In*: J. H. S. Blaxter (Ed.) The Early Life History of Fish. Springer-Verlag, Heidelberg and New York.

CREUTZBERG, F., ETINK, A. TH. G.W. AND VAN NOORT, G.J., 1978. The migration of plaice larvae *Pleuronectes platess*a into the western Waddensea. pp. 243-251 *In*: D.S.McLusky and A.J. Berry (Eds.) Proc. 12th Europ. Mar. Biol. Symp. Stirling, Scotland. Pergamon Press.

DE CLERCK, R., 1977. The migration of plaice on the spawning grounds. Noord-Hinder. ICES CM1977/ F:40, 9pp (mimeo).

DE VEEN, J. F., 1961. The 1960 tagging experiments on mature plaice in different spawning areas in the southern North Sea. ICES CM 1961/44, 7pp (mimeo).

DE VEEN, J.F., 1962. On the subpopulations of plaice in the southern North Sea. ICES CM 1962/F:94, 89pp (mimeo).

DE VEEN, J.F., 1969. Abnormal pigmentation as a possible tool in the study of populations of the plaice (*Pleuronectes platessa* L.). J. Cons. Int. Explor. Mer, ***32***: 344-383.

DOREL, D., 1986. Poissons de l'Atlantique nord-est, relations taille-poids. IFREMER Report, Nantes, 185pp.

HARDEN JONES, F.R., ARNOLD, G.P, GREER WALKER, M. AND SCHOLES, P., 1979. Selective tidal stream transport and the migration of plaice (*Pleuronectes platessa* L.) in the southern North Sea. J. Cons. int. Explor. Mer, ***38***: 331-337.

HARDING, D. AND TALBOT, J. W., 1973. Recent studies on the eggs and larvae of the plaice (*Pleuronectes platessa* L.) in the Southern Bight. Rapp. P.-v. Réun. Cons. int. Explor. Mer, ***164***: 261-269.

HARDING, D., NICHOLS, J.H. AND TUNGATE, D.S., 1978. The spawning of plaice (*Pleuronectes platessa* L.) in the southern North Sea and English Channel. Rapp. P.-v. Réun. Cons. int. Explor. Mer, ***172***: 102-113.

HILL, H.W., 1971. Seasonal movements of young plaice in the north-east Irish Sea. Fishery Invest., Lond., Ser. 2, ***26(7)***: 24pp.

HORWOOD, J.W., 1990. Fecundity and maturity of plaice (*Pleuronectes platessa*) from Cardigan Bay. J. mar. biol. Ass. UK, ***70***: 515-529.

HORWOOD, J. W., BANNISTER, R. C. A. AND HOWLETT, G. J., 1986. Comparative fecundity of North Sea plaice. Proc. R. Soc. Lond., ***228 (B)***: 401-431.

HOUGHTON, R.G., 1976. The movements of plaice tagged in the English Channel. ICES CM 1976/ F:21, 5pp (mimeo).

HOUGHTON, R.G. AND HARDING, D., 1976. The plaice of the English Channel: spawning and migration. J. Cons. int. Explor. Mer, ***36***: 229-239.

LOCKWOOD, S. J., 1974. The settlement, distribution and movements of 0-group plaice *Pleuronectes platessa* (L) in Filey Bay, Yorkshire. J. Fish Biol., ***6***: 465-477.

MACER, C.T., 1972. The movements of tagged adult plaice in the Irish Sea. Fishery Invest., Lond., Ser. 2, ***27(6)***: 41pp.

MACANDREW, B. J., WARD, R. D. AND BEARDMORE, J. A., 1982. Lack of relationship between morphological variance and enzyme heterozygosity in the plaice, *Pleuronectes platessa*. Heredity, ***48***: 117-125.

MESNIL, B., 1983. Indices d'abondance des juvéniles de poissons plats devant les côtes françaises de Manche-est et Mer du Nord. Résultats des campagnes D.Y.F.S. 1977 à 1982. ICES CM 1983/ G:55, 8pp (mimeo).

PURDOM, C. E. AND WYATT, T., 1969. Racial differences in Irish Sea and North Sea plaice (*Pleuronectes platessa*). Nature, Lond., ***222***: 780-781.

PURDOM, C.E., THOMPSON, D. AND DANDO, P.R., 1976. Genetic analysis of enzyme polymorphisms in plaice (*Pleuronectes platessa*). Heredity, ***37***: 193-206.

RAMSTER, J.W., WYATT, T. AND HOUGHTON, R.J., 1973. Towards a measure of the rate of drift of planktonic organisms in the vicinity of the Strait of Dover. ICES CM 1973/L:8, 7pp (mimeo).

RIJNSDORP, A. D., 1989. Maturation of male and female North Sea plaice (***Pleuronectes platessa*** L.). J. Cons. int. Explor. Mer, ***46***: 35-51.

RIJNSDORP, A. D. AND VAN STRALEN, M., 1985. Selective tidal transport of North Sea plaice larvae *Pleuronectes platessa* in coastal nursery areas. Trans. Am. Fish. Soc., ***114***: 461-470.

RIJNSDORP, A. D., DAAN, N., BEEK, F. A. VAN AND HEESSEN, H. J. L., 1991. Reproductive variability in plaice, sole and cod. J. Cons. int. Explor. Mer, ***47***: 352-375.

RILEY, J.D., 1984. Movements of 0-group plaice *Pleuronectes platessa* L. as shown by latex tagging. J. Fish Biol., ***5***: 323-343.

RYLAND, J. S., 1966. Observations on the development of larvae of the plaice, *Pleuronectes platessa* L., in aquaria. J. Cons. int. Explor. Mer, ***30***: 177-195.

SIMONSEN, V., 1984. Genetic investigations on enzymes and haemoglobin in fish species for identification. Report to EEC.

SIMONSEN, V., NIELSEN, E. AND BAGGE, O., 1988. Discrimination of stocks of plaice in the Kattegat by electrophoresis and meristic characters. ICES CM 1988/G:29, 34pp (mimeo).

SIMPSON, A. C., 1959. The spawning of plaice (*Pleuronectes platessa*) in the North Sea. Fishery Invest., Lond., Ser 2, ***22***: 111 pp.

TALBOT, J.W., 1977. The dispersal of plaice eggs and larvae in the Southern Bight of the North Sea. J. Cons. int. Explor. Mer, ***37***: 221-248.

TALBOT, J. W., 1978. Changes in plaice larval dispersal in the last fifteen years. Rapp. P.-v. Réun. Cons. int. Explor. Mer, ***172***: 114-123.

VAN DER LAND, M.A., HEESSEN, H.J.L. AND RIJNSDORP, A.D., 1990. see cod

WARD, R. D. AND BEARDMORE, J. A., 1977. Protein variation in the plaice *Pleuronectes platessa* L. Genet. Res., ***30***: 45-62.

23. Lemon sole

JENNINGS, S., HOWLETT, G. J., AND FLATMAN, S. , 1994. The distribution, migrations and stock integrity of lemon sole *Microstomus kitt* in the western English Channel. Fish. Res., ***18***: 377-388.

RAE, B.B., 1965. The Lemon Sole. Fishing News Books, London, 106pp.

RILEY, J.D., 1971. The Riley push-net. Appendix 1, pp. 286-290, *In*: N.A. Holme and A.D. McIntyre (Eds). Methods for the study of Marine Benthos, Oxford and Edinb.: Blackwell, 331pp. IBP Handbook No ***16***.

24. Sole

ANON., 1965. Report of the Working Group on Sole. Coop. Res. Rep., Int. Coun. Explor. Sea, ***5***: 126 pp.

ANON., 1986. Report of the Ad Hoc Working Group on the 1984/85 Sole Egg Surveys. ICES CM 1986/ G:95, 93pp (mimeo).

ANON., 1989 Report of ad hoc study group on juvenile sole tagging. ICES CM 1989/G:21, 34pp.

ANON., 1991. Report of the Study Group on the Fecundity of Plaice and Sole in Subareas IV and VIII and Divisions VIId,e. ICES CM 1991/G:2, 25pp (mimeo).

BEILLOU, P., DURAND, J.L., GIRET, M. AND LIORZOU, B. 1981. Marquages des soles sur les côtes françaises de la Manche et de la Mer du Nord. ICES CM 1981/ G:79, 5pp (mimeo).

COGGAN, R. A. AND DANDO, P. R., 1988. Movements of juvenile Dover sole, *Solea solea* (L.), in the Tamar Estuary, south-western England. J. Fish Biol., ***33(A)***: 177-184.

DE VEEN, J. F., 1961. see plaice

DE VEEN, J. F., 1962. see plaice

DE VEEN, J. F., 1970. On some aspects of maturation in the common sole (*Solea solea* L.). Ber. Dt. Wiss. kommn. Meeresforsch., ***21***: 78-91.

DE VEEN, J. F., 1976. On changes in some biological parameters in the North Sea sole (*Solea solea* L.). J. Cons. int. Explor. Mer, ***37***: 60-90.

DOREL, D., KOUTSIKOPOULOS, Y., DESAUNAY, Y. AND MARCHAND, J., 1991. Seasonal distribution of young sole (*Solea solea* (L.)) in the nursery grounds of the Bay of Vilaine (northern Bay of Biscay). Neth. J. Sea Res., ***27***: 297-306.

FONDS, M., 1979. Laboratory observations on the influence of temperature and salinity on development of the eggs and growth of larvae of *Solea solea* (Pisces). Mar. Ecol. Prog. Ser., ***1***: 91-99.

GREER WALKER, M. AND EMERSON, L., 1990. The seasonal migration of soles (*Solea solea*) through the Dover Strait. Neth. J. Sea Res., ***25***: 417-422.

GREER WALKER, M. AND WITTHAMES, P., 1990. The fecundity of sole (*Solea solea*) in ICES areas IVc and VIId during 1988. ICES CM 1990/G:37: 6pp (mimeo).

HORWOOD, J. W. AND GREER WALKER, M., 1990. Determinacy of fecundity in sole (*Solea solea*) from the Bristol Channel. J. mar. biol. Ass. U.K., ***70***: 803-813.

KOTTHAUS, A., 1963. Tagging experiments with the North Sea sole (*Solea solea*) in 1959 and 1960. Spec. Publ. Int. Commn. NW. Atlant. Fish., ***4***: 123-129.

KOUTSIHOPOULOS, C. AND HERBLAND, A., 1987. The stability of the spatial distribution of the pelagic stages of sole as explained by the trajectories of 'Argos' satellite tracked buoys. ICES CM 1987/ Mini 4: 6pp (mimeo).

LE BEC, C., 1983. Fécondité de la sole Solea vulgaris (Quensel, 1806) du Golfe de Gascogne. ICES CM 1983/G:53 8pp (mimeo).

LEE, A.J. AND RAMSTER, J.W., 1981. Atlas of the Seas Around the British Isles. MAFF, London., pag. var.

MARCHAND, J., 1988. Seasonal distribution, growth and ecological role of the juvenile sole, *Solea solea* L., population in the Loire estuary, France. J. Fish Biol., ***33(A)***: 229.

MARCHAND, J., 1991. The influence of environmental conditions on the settlement, distribution and growth of 0-group sole (*Solea solea* (L.)) in a macrotidal estuary. Neth. J. Sea Res., ***27***: 287-296.

MARCHAND, J. AND MASSON, G., 1988. Inshore migrations, distribution, behaviour and feeding activity of sole, *Solea solea* (L.) post-larvae in the Vilaine Estuary, France. J. Fish Biol., ***33(A)***: 227-228.

MARCHAND, J. AND MASSON, G., 1989. Process of estuarine colonisation by 0-group sole (*Solea solea*): hydrological conditions, behaviour and feeding activity in the Vilaine estuary. Rapp. P.-v. Réun. Cons. int. Explor. Mer, ***191***: 287-295.

MESNIL, B., 1983. see plaice

MILLNER, R. S. AND WHITING, C. L., 1990. Distribution and abundance of juvenile sole and plaice in the eastern English Channel from young fish surveys. ICES CM 1990/G:38, 7pp (mimeo).

PERONNET, I. AND TETARD, A., 1984. Evolution pluriannuelle des nourriceries de poissons plats dans le secteur de la Baie de Somme. ICES CM 1984/ G:22, 16pp (mimeo).

RAMSAY, K., 1993. Factors influencing first time maturity in female sole (*Solea solea* (L.)). ICES CM 1993/G:25, 5pp (mimeo).

RIJNSDORP, A. D. AND VAN BEEK, F. A., 1991. Changes in growth of plaice *Pleuronectes platessa* L. and sole *Solea solea* L. in the North Sea. Neth. J. Sea. Res., ***27***: 441-457.

RIJNSDORP, A. D., DAAN, N., BEEK, F. A. VAN AND HEESSEN, H. J. L., 1991. see plaice

RILEY, J. D., 1974. The distribution and mortality of sole eggs (*Solea solea* L.) in inshore areas. pp. 39-52, *In*: Blaxter, J. H. S. (Ed.) The Early Life History of Fish. Springer-Verlag, Berlin.

ROSENBOOM, S., 1985. Fecundity of the North Sea sole (*Solea solea*). ICES CM 1985/G:70, 19pp (mimeo).

URBAN, H., 1991. Reproductive strategies of North Sea plaice, *Pleuronectes platessa*, and North Sea sole, *Solea solea*, batch spawning cycle and batch fecundity. Meersforsch, ***33***: 330-339.

VAN BEEK, F. A., 1988. Egg production of North Sea sole in 1988. Int. Coun. Explor. Sea CM 1989/G:45, 18 pp. (mimeo).

VAN BEEK, F. A., 1988. On the growth of sole in the North Sea. ICES CM 1988/G:24, 23pp (mimeo).

WALLACE, P.D. AND WATSON, A.M. (1980). The migration of sole tagged in the Thames Estuary in the summer of 1976 and 1977. ICES CM 1980/G:14, 8pp (mimeo).

25. Anglerfish

ARBAULT, S. ANDLACROIX-BOUTIN, N., 1968. see hake

BOWMAN, A., 1919. The eggs and larvae of the angler (*Lophius piscatorious* L.) in Scottish waters. A review of our present knowledge of the life history of the angler. Scient. Invest., Fishery. Bd Scotl., ***1919 (1)***: 1-42.

CROZIER, W.W., 1987. Biochemical genetic variation and population structure in angler-fish *Lophius piscatorius* L. from the Irish Sea and west of Scotland. J. Exp. mar. biol. Ecol., ***106***: 125-136.

CROZIER, W.W., 1988. Age and growth of angler-fish (*Lophius piscatorius* L.) in the north Irish Sea. Fish. Res., *7*: 267-278.

DUPOUY, H., PAJOT, R. AND KERGOAT, B., 1984. Etude de la croissance des baudroies, L. piscatorius et L. budegassa de l'Atlantique N.E. obtenue à partir de l'illicium. Rev. Trav. Inst. Pech. Marit., ***(3 et 4)***: 109-131.

FULTON, T. W., 1902. The distribution growth and food of the angler (***Lophius piscatorius***). Ann. Rep. Fishery. Bd Scotl., ***21***: 186-217.

GAERTNER, D., 1985. Contribution à l'étude du stock de lottes (*Lophius piscatorius* L. 1758 et *L. budegassa*, Spinola 1807) du plateau celtique. Oceanol. Acta, *7*: 241-249.

KARLOVAC, J. AND KARLOVAC, O., 1968. *Lophius piscatorius* L. dans les eaux de la haute Adriatique dans toutes les phases de sa vie. Rapp. P.-v. Réun. Cons. int. Explor. Mer 19: 537-540.

LEBOUR, M. V., 1925. Young anglers in captivity and some of their enemies. A study in a plunger jar. J. mar. biol. Ass. U.K., ***13***: 721-734.

TÅNING, Å. V., 1923. Lophius. Rep. Dan. Oceanogr. Exped. Mediterr. 1908-10, Medit. adjac. Seas. 2. Biology A, ***10***: 1-30.