INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA

DEMERSAL FISH COMMITTEE
CM1992/G:59.Ref K

PRELIMINARY ANALYSIS OF FISH AND SHELLFISH DISTRIBUTIONS IN THE EASTERN ENGLISH CHANNEL FROM BEAM TRAWL SURVEYS, 1988-1991

K Ramsay
Ministry of Agriculture, Fisheries and Food
Directorate of Fisheries Research
Fisheries Laboratory
Lowestoft
Suffolk NR33 0HT, England

ABSTRACT

A beam trawl survey of the eastern English Channel (ICES area VIID) has been carried out in the years 1988-1991 inclusive. The results have been used to provide information about the catch rates and geographical distributions of English Channel fish species. Distributions are presented as average catch numbers over four years for the commoner species. Relationships between catch rates, depth and sediment type have also been examined and species association investigated using cluster analysis. The results demonstrate the importance of depth and sediment in the distribution of fish in the eastern English Channel.

INTRODUCTION

A series of annual beam trawl surveys, commencing in 1988 has been carried out in the eastern Channel (ICES area VIID). These surveys were originally set up to provide information on sole and plaice abundance and biology (Millner and Whiting 1989). Data relating to the abundance and geographical distribution of other species in area VIID has also been collected . Complementary data relating to roundfish species in area VIID sampled using a GOV trawl are given by Carpentier, Lemoine & Souplet (1989) and Souplet, Lanoy & Carpentier (1991). This study examines the distribution of both commercial and non-commercial species in area VIID, as well as investigating the effect of depth and sediment on the abundance of species.

METHODS

Beam trawl surveys were carried out in August from 1988-91. The 1988 survey was completed on a commercial beam trawler, the 'Suzanna D'. The later surveys were carried out on the research vessel CORYSTES. The survey area is shown in Figure 1.

An effort was made to sample the same stations each year, although some stations were omitted due to unsuitability and extra stations were added through the years. Choice of stations was made partly with the aim of sampling every depth band in every ICES rectangle, although greater emphasis was put on the shallower depths where higher catch rates can be expected.

The gear used was a 4 m beam trawl with a chain mat, flip-up ropes and a cod-end mesh of 75 mm with a 40 mm liner. On the 'Suzanna D', two such beam trawls were used, whilst on the CORYSTES fishing was with a single trawl. The fishing speed was 4 knots and the haul duration was 30 minutes unless unsuitable ground or high catch rates necessitated hauling early. Further details of the gear and survey methods used are given in Millner and Whiting (1989).

All fish were identified, weighed, counted and measured (with subsampling in the event of large catch numbers) and otoliths were collected from sole and plaice for age determination. For all analyses catch numbers were standardised to numbers per single 4 m beam per 30 minutes. Sediments were sampled by the use of an underwater camera attached to the beam of the trawl on the CORYSTES and with a grab sampler on the 'Suzanna D'. Geographical distributions of species were investigated by splitting each ICES rectangle into four and then calculating the average catch number for each sub-rectangle. Fig 2 shows the number of hauls in each sub-rectangle sampled in the survey. In order to avoid the effect of year class variation the distributions of plaice and sole by age were expressed as percentages and averaged across the 3 year period 1989-91 by calculating:

$$\left(\sum_{y=1}^{n} \left(Cyr/\sum_{r=1}^{n} Cyr\right) \times 100\right)/ny$$

where y = year, ny = number of years (in this case 3), r = subrectangle and C is the average catch number in a subrectangle given by

$$\frac{\Sigma c_r}{n_r}$$

where c_r = catch number in subrectangle r and n_r = number of hauls in subrectangle r.

Relationships between depth and catch numbers were examined by calculating average catch numbers in each of three depth bands (0-19.9m, 20-39.9m and 40+m). The depths used were the chart depths for each station.

Sediments were classified into three groups:- 1) muddy sand, 2) sand, 3) hard sediments including gravel and stones. On the CORYSTES where the underwater camera was used, approximately 15 photographs were taken during each tow. Each photograph was given a sediment value and these were averaged to give a value for each station. For the 'Suzanna D' grab sample a description of the sample was noted and a value assigned to this.

Species groupings were investigated by principal components analysis and cluster analysis. The analyses were performed on data which had been transformed using ln (1+ catch number) to reduce the weight being given to species with high catch numbers. Principal components analysis was carried out (using the correlation matrix to compute the principal components) and the proportion of variance explained by each component was examined. In cluster analysis the average linkage method was used (Sokal & Michener, 1958).

RESULTS

Over the four years a total of 73 fish species was caught (see Table 1). A comparison between catch numbers and weights over the four years is given in Figures 3 and 4 (numbers and weights are standardised to the average number or weight caught in a 30 minute tow by a 4m beam trawl). The most abundant species in terms of catch numbers were bib, dragonets, poor cod, solenettes, dab and plaice, although there was a large amount of variation between years. Fluctuations in bib numbers were especially large, with the average number of bib in each tow varying from 8 in 1991 to 63 in 1990. In contrast, sole numbers were one of the most consistent of all species varying between an average of 6 and 11. When catches by weight are considered the variation between years is reduced in all species with plaice making up the highest proportion of the catch, followed by sole, dab, dragonets and bib. The plaice weights vary from an average of 10 kg per tow in 1988 to 15 kg in 1991. The mean species biomass by years shows a fairly steady decline between 1988 and 1990 with a small increase in 1991. This contrasts with the average total catch numbers which were at a peak in 1989 whilst the lowest numbers were found in 1988.

DISTRIBUTION OF SPECIES

The catch rates of 15 of the commoner species (standardised to numbers caught in a 30 minute tow by a 4m beam trawl, averaged over the four beam trawl surveys) are shown in Figures 5 to 8. Dab, plaice, sole, solenettes, sand gobies and weavers show a predominately coastal distribution, whilst lemon sole, red gurnards and dogfish are more abundant offshore. There is an increase in catch numbers towards the Dover

Strait in the north eastern end of area VIID of some species, including dab, lemon sole, plaice and weavers. There is also a further area of increased catch rates for dragonets, bib, pogge and sand gobies in the Baie de Seine.

The distribution of plaice and sole by age are shown on Figures 9 and 10. The distribution of 1 year old sole and plaice was similar with the main area of high catch rates in the north east and further regions of higher abundance in the Baie de Seine and around the Isle of Wight. In both species there are increases in catch rates offshore as the fish age.

DEPTH

Table 2 shows the average catch numbers and weights of the more abundant species over 3 depth bands (0-19.9m, 20-39.9m and 40m+). Most species appear to show a preference for shallow water, with a steady decrease in catch rates by numbers and weight with increasing depth. Plaice and thornback rays have their highest catch rates in shallow water but do not otherwise show a trend with depth. Only edible crabs, red gurnard, lemon sole, dogfish and poor cod show the reverse with an increase in catch rates in deeper water. The high catch numbers of poor cod in the 40m+ depth band are especially noticeable with poor cod making up 41% of the total catch numbers in this depth band. The total catch numbers of all species decreases with increasing depth, whilst total catch weights are highest in depth band 1 (0-19.9m), lowest in depth band 2 (20-39.9m) and intermediate in depth band 3 (40m+).

When the catch rates of sole and plaice are compared over the three depth bands by age (Table 3) it can be seen that catch rates in each depth band vary according to age. For sole all age groups show decreasing catch numbers with increasing depth but this trend becomes less pronounced as the fish become older. Plaice show decreasing catch numbers in deeper water for 1, 2 and 3 year olds. However, at age 4+ the highest catch rates are in depth band 3 (40m+), although the variation between depth bands is not very large.

The ratios of catch weights to catch numbers are given in Table 4. For edible crabs, dab, bib, sole, thornback rays and plaice the average weight of the individual increases as depth increases. This also occurs to a lesser extent in dragonets, poor cod and scaldfish. The reverse occurs in dogfish with the average weight decreasing with increasing depth.

SEDIMENTS

Average catch numbers of 19 species in each of three sediment bands recognised as muddy sand, sand or gravel and stones are shown in Table 5. The majority of species have their highest catch numbers in muddy sand, with the exception of red gurnards, dogfish and poor cod which are most abundant in areas of hard sediments (gravel and stones) and edible crabs, lemon sole and thornback rays which have their highest

catch numbers in sand. Plaice and whiting show a more or less equal preference for softer sediments but decrease in catch numbers when the sediment is gravel/stones. Cuttlefish show no obvious preference for sediment type.

The average catch numbers of plaice and sole by age for the three different sediment types is shown in Table 6. Sole of ages 1 to 3 have their highest numbers in muddy sand but the 4+ age group shows increased catch rates in sand. Plaice of ages 1 and 2 appear to have a preference for muddy sand but also have high numbers in sand. Age 3 and 4+ plaice show an increase in catch numbers in gravel/stones.

SPECIES GROUPINGS

Cluster analysis was carried out on catch numbers of 19 species for each individual years data and on the data of all four years combined. The five resulting dendrograms were extremely similar to one another and the dendrogram for the combined years data is shown in Fig 11. Sole, plaice, dab and solenettes were always found in the same cluster. Poor cod, bib and dragonets were usually either clustered together or found as individuals. In 1990 and 1991 lemon sole and edible crabs were clustered as a pair, as were red gurnards and dogfish.

A principal components analysis was also carried out on catch numbers of 19 species in each of the 4 years to obtain an indication of the reliability of the cluster analysis. This showed that on average 58% of the variation was explained by the first two components and 81% by the first five (see Table 7). Species groupings obtained by plotting the 1st and 2nd principal components against each other were similar to those described by the cluster analysis.

DISCUSSION

Figures 3 and 4 show that there are large fluctuations in catch numbers of most species from one year to the next, whilst catch weights appear more stable. This could be due to year class effects, with a strong year class contributing significantly to the catch numbers but less to the catch weights in the first few years. The high proportion of plaice in weight compared to the relatively low proportion in numbers is noticeable. The high plaice weights in 1988 and 1989 reflect the strength of the 1985 year class and the reduction in 1990 and 1991 provides an indication of the heavy fishing mortality. The trend in mean species biomass over the four years corresponds with the trend in plaice weights, demonstrating the importance of plaice in the biomass of fish in the Channel (Figure 4).

In discussing the distribution of species it has been assumed that catch rates provide a reasonable indication of the abundance and distribution of the species and age group in question. Previous studies have

shown that geographical area, depth and sediment all appear to effect the distribution of species (Henderson 1989, Kruuk 1988, Riley *et al* 1979). The results of this analysis suggest that two important factors influencing species abundance in the eastern Channel are sediment type and depth. A third component could be geographical location since species abundance tended to be high in the Dover Strait area of the Channel and decrease westwards. However, as there is an increase in depth and sediment hardness towards the west (Lee and Ramster 1981) it is not possible to distinguish which factors are most important from these results.

From the analysis of depth and sediment it appears that most species can be assigned to one of four groups:

1. species preferring mainly shallow water and muddy sediments (the majority of species)
2. species preferring mainly shallow water and mud or sand (whiting, thornback rays, flounder and plaice)
3. species preferring mainly deep water and sand (lemon sole, edible crab)
4. species preferring mainly deep water and hard sediments (gravel/stones) (dogfish, poor cod and red gurnard)

The dendrogram produced from the cluster analysis (Figure 11) shows some consistency with these groupings. Species generally preferring shallow water and soft sediments were associated together such as the flatfish group (sole, plaice, dab and solenettes). The basis for other clusters were less clear although the grouping of red gurnard with dogfish (deep water and hard sediments) and lemon sole with crab (deep water and sand) suggests that the two variables probably act together in determining distribution.

In the eastern Channel possible nursery areas were identified from the high catch rates of 1 year old sole and plaice in the Dover Straits, Baie de Seine and west of the Isle of Wight. As sole and plaice age they move into deeper water and this may result in a shift in sediment preference. For example one year old plaice were found in shallow muddy or sandy areas but fish of three years or older occurred in abundance in water deeper than 40m and associated with harder deposits. The change in mean weight of individuals with increasing depth indicates that a wide range of species also show the same pattern of movement offshore. As a result the offshore grouping may include species that have moved into deeper water as they have grown as well as species that show a constant preference for harder ground such as lemon sole and red gurnard. This suggests that in order to group species by depth or sediment, changes in preference by age should also be considered.

These results indicate that depth and sediment are important factors in determining the distribution of species and that species can, to a certain extent, be grouped together by these two factors. However, it is also apparent that factors such as movement offshore with age are involved in determining species abundance and more work is needed in order to be able to describe these factors and provide an increased understanding of the biology of these species.

BIBLIOGRAPHY

CARPENTIER, A., LEMOINE, M. and SOUPLET, A. 1989. Description and first results of a new ground fish survey in the English Channel. ICES CM 1989/G:43.

EDWARDS, R. and STEELE, J.H., 1968. The ecology of 0 group plaice and common data at Loch Ewe. I. Population and food. J exp mar biol ecol 2 215-238

HENDERSON, P.A., 1989. On the structure of the inshore fish community of England and Wales. J mar biol Ass UK, 69 145-163

KRUUK, H., NOLET, B. and FRENCH, D., 1988. Fluctuations in numbers and activity of inshore demersal fishes in Shetland. J mar biol Ass UK 68 601-617.

LEE, A.J. and RAMSTER, J.W. (Eds) 1981. Atlas of the seas around the British Isles. MAFF, London. 4 pp., 75 maps.

MILLNER, R.S. and WHITING, C.L., 1989. Preliminary results of a beam trawl survey for sole and plaice in the eastern English Channel. ICES CM 1989/G:50.

RILEY, J.D., SYMONDS, D.J. and WOOLNER, L.E., 1979. On the factors influencing the distribution of 0-group demersal fish in coastal waters. ICES/ELH Symp./DA:1.

SOKAL, R.R. and MICHENER, C.D., 1958. A statistical method for evaluating systematic relationships. University of Kansas Science Bulletin, 38. 1409-1438.

SOUPLET, A., LANOY, J. and CARPENTIER, A., 1991. Bottom trawl survey in the Eastern Channel results of the first three years. ICES CM 1991/G:72.

Table 1. Total catch numbers and weights for beam trawl surveys 1988-1991 (299 stations, 8970 minutes fishing)

		total catch number	total catch weight (kg)	occurrences (number of stations)
Labrus bergylta	Ballan wrasse	19	10.4	10
Dicentrarchus labrax	Bass	1	0.7	1
Trisopterus luscus	Bib	12206	297.0	165
Gobius niger	Black goby	253	2.7	40
Spondyliosoma cantharus	Black sea bream	129	3.4	38
Raja brachyura	Blonde ray	8	2.8	6
Scophthalmus rhombus	Brill	102	62.5	64
Myoxocephalus scorpius	Bullrout	1		1
Pholis gunnellus	Butterfish	73	0.7	32
Blennius ocellaris	Butterfly blenny	72	0.8	21
Gadus morhua	Cod	9	4.7	4
Molva molva	Common ling	2	0.7	2
Crenilabrus melops	Corkwing	17	0.3	9
Labrus mixtus	Cuckoo wrasse	3	0.2	3
Limanda limanda	Dab	6098	385.4	172
Scyliorhinus canicula	Dogfish (lesser spotted)	305	142.0	73
Callionymus lyra	Dragonet	15814	404.0	289
Phrynorhombus regius	Ekstoms topknot	12	0.3	9
Ciliata mustela	Five bearded rockling	8	0.0	6
Platichthys flesus	Flounder	399	156.4	38
Ctenolabrus rupestris	Goldsinny	12	0.7	10
Syngnathus acus	Greater pipefish	40	1.0	24
Eutrigla gurnardus	Grey gurnard	83	6.7	45
Clupea harengus	Herring	3	0.2	3
Trachurus trachurus	Horse mackerel	18	1.8	8
Zeus faber	John dory	24	5.5	19
Microstomus kitt	Lemon sole	479	121.3	80
Thorogobius ephippiatus	Leopard spotted goby	1		1
Torpedo marmorata	Marbled electric ray	5	7.0	4
Squatina squatina	Monkfish	2	43.0	2
Syngnathus rostellatus	Nilsson's pipefish	1		1
Phrynorhombus norvegicus	Norweigan topknot	16	0.1	11
Scyliorhinus stellaris	Nursehound	24	7.0	12
Pomatoschistus pictus	Painted goby	184	0.1	11
Raja microocellata	Painted ray	7	6.0	4
Pleuronectes platessa	Plaice	5243	1717.4	212
Agonus cataphractus	Pogge	2344	22.2	201
Trisopterus minutus	Poor cod	9269	189.4	163
Aspitrigla cuculus	Red gurnard	496	77.4	116
Mullus surmuletus	Red mullet	53	3.8	25
Callionymus reticulatus	Reticulate dragonet	9	0.1	4
Centrolabrus exoletus	Rockcook	1	0.0	1
Pomatoschistus minutus	Sand goby	1599	2.5	85
Pegusa lascaris	Sand sole	35	4.6	20
Ammodytes spp	Sandeel spp	60	1.7	36
Arnoglossus laterna	Scaldfish	622	8.9	78
Hippocampus ramulosus	Sea horse	1	0.0	1

Table 1. (cont...)Total catch numbers and weights for beam trawl surveys 1988-1991 (299 stations, 8970 minutes fishing)

		total catch number	total catch weight (kg)	occurences (number of stations)
Taurulus bubalis	Sea scorpion	211	13.3	14
Liparis liparis	Sea snails	1		1
Hippocampus hippocampus	Short snouted seahorse	41	0.1	7
Apletodon microcephalus	Small headed clingfish	9	0	5
Mustelus mustelus	Smoothhound	2	0.1	3
Solea solea	Sole	3535	467.7	237
Buglossidium luteum	Solenette	8634	110.3	126
Raja montagui	Spotted ray	177	49.4	52
Sprattus sprattus	Sprat	7	0.1	6
Squalus acanthias	Spurdog	6	3.1	2
Mustelus asterias	Starry smooth hound	33	12.1	20
Dasyatis pastinaca	Sting ray	3	6.3	2
Trigloporus lastoviza	Streaked gurnard	127	20.3	49
Microchirus variagatus	Thick back sole	178	5.2	61
Raja clavata	Thornback ray	340	154	115
Gaidropsarus vulgaris	Three bearded rockling	3	0	3
Parablennius gattorugine	Tompot blenny	2	0	2
Galeorhinus galeus	Tope	3	0.5	1
Zeugopterus punctatus	Topknot	12	0.2	11
Trigla lucerna	Tub gurnard	218	43.5	111
Scopthalmus maximus	Turbot	53	32.9	25
Diplecogaster bimaculata	Two spotted clingfish	84	0.1	7
Raja undulata	Undulate ray	23	10.5	18
Echilichthys vipera	Weaver (lesser)	481	9.1	82
Trachinus draco	Weaver (greater)	7	0.2	4
Merlangius merlangus	Whiting	662	57.9	40
Cancer pagurus	Edible crab	301	106.4	77
Majidae spp	Spider crabs	86	222.9	35
Homarus gammarus	Lobster	31	13.8	18
Chlamys opercularis	Queen scallop		39.5	4
Sepia spp	Cuttlefish	1581	523.5	165
Loliginidae	Squid	90	5.3	42

Table 2. Average catch numbers & weights (per standard tow) by depth band

	average numbers			average weights (kg)		
depth band	1 (0-19.9m)	2 (20-39.9m)	3 (40m+)	1 (0-19.9m)	2 (20-39.9m)	3 (40m+)
Bib	64.3	31.4	7.0	0.94	0.90	0.90
Dab	31.8	14.7	2.8	1.64	1.23	0.46
Dogfish (lesser spotted)	0.0	0.9	3.4	0.02	0.55	1.74
Dragonet	88.2	45.8	12.0	2.01	1.37	0.50
Flounder	1.8	0.4	0.1	0.75	0.14	0.03
Lemon sole	0.4	2.0	2.4	0.13	0.55	0.74
Plaice	23.5	14.7	15.5	7.44	5.18	6.71
Pogge	7.5	6.6	5.7	0.07	0.07	0.05
Poor cod	12.1	28.5	92.5	0.20	0.53	1.93
Red gurnard	0.1	2.3	5.5	0.02	0.35	0.86
Sand gobies	9.1	5.2	0.1	0.01	0.01	0.00
Scaldfish	3.2	1.7	0.4	0.05	0.02	0.01
Sole	14.4	5.9	1.7	1.92	0.98	0.48
Solenettes	67.4	13.1	0.7	0.87	0.17	0.01
Thornback ray	2.0	0.5	0.5	0.51	0.34	0.67
Weaver (lesser)	2.1	1.4	0.8	0.04	0.03	0.01
Whiting	0.4	0.0	0.0	0.04	0.00	0.01
Cuttlefish	6.1	5.6	2.4	1.74	1.92	0.92
Edible crab	0.2	0.7	1.5	0.09	0.34	0.79
Total all species	345.8	187.1	161.4	21.91	15.77	19.52

Table 3. Average catch numbers (per standard tow) for sole and plaice by age and depth band

		average numbers		
	depth band	1 (0-19.9m)	2 (20-39.9m)	3 (40m+)
	age			
Sole	1	3.8	1.8	0.1
	2	7.1	3.0	0.7
	3	1.4	0.7	0.5
	4+	1.2	0.9	0.6
Plaice	1	3.8	1.4	0.2
	2	3.6	2.8	1.4
	3	3.6	3.3	2.8
	4+	7.1	5.6	12.2

Table 4. Ratio of catch weight: catch number by depth band

depth band	1 (0-19.9m)	2 (20-39.9m)	3 (40m+)
Bib	0.015	0.029	0.129
Cuttlefish	0.286	0.344	0.387
Dab	0.052	0.084	0.164
Dogfish (lesser spotted)	0.800	0.627	0.506
Dragonet	0.023	0.030	0.041
Edible crab	0.398	0.494	0.521
Flounder	0.412	0.401	0.439
Lemon sole	0.313	0.282	0.303
Plaice	0.316	0.353	0.434
Pogge	0.009	0.010	0.009
Poor cod	0.017	0.019	0.021
Red gurnard	0.154	0.154	0.155
Sand gobies	0.002	0.002	0.003
Scaldfish	0.014	0.015	0.018
Sole	0.134	0.165	0.279
Solenettes	0.013	0.013	0.013
Thornback ray	0.251	0.743	1.280
Weaver (lesser)	0.020	0.020	0.017
Whiting	0.085	0.072	0.195

Table 5. Average catch numbers (per standard tow) by sediment type

sediment type	average numbers (muddy sand)	2 (sand)	3 (stones etc)
Bib	38.8	31.5	21.4
Dab	46.4	33.2	2.2
Dogfish (lesser spotted)	0.0	0.2	2.1
Dragonet	91.3	41.4	38.3
Flounder	2.5	2.2	0.1
Lemon sole	0.6	1.7	0.9
Plaice	29.9	31.7	6.5
Pogge	11.8	8.0	4.6
Poor cod	11.5	14.8	48.2
Red gurnard	0.4	0.7	3.6
Sand gobies	10.3	6.2	0.3
Scaldfish	4.1	3.2	0.7
Sole	17.8	12.5	3.6
Solenettes	72.8	48.3	5.1
Thornback ray	1.3	1.9	0.5
Weaver (lesser)	3.9	2.2	0.2
Whiting	0.9	0.9	0.0
Cuttlefish	6.7	5.7	5.8
Edible crabs	0.5	0.8	0.3

Table 6. Average catch numbers (per standard tow) for sole and plaice by age and sediment type

		average numbers		
	sediment type	(muddy sand)	2 (sand)	3 (stones etc)
	age			
Sole	1	8.0	3.2	0.3
	2	10.3	5.3	1.8
	3	1.4	1.0	0.8
	4+	0.9	1.1	0.8
Plaice	1	3.9	2.4	0.0
	2	3.8	4.1	0.7
	3	4.1	4.0	2.2
	4+	9.1	8.2	9.3

Table 7. Cumulative proportions of variance explained by each eigenvalue from principal component analyses carried out for each year on catch numbers by station for 19 species

	years			
principal component	1988	1989	1990	1991
number				
1	0.39	0.35	0.32	0.34
2	0.63	0.59	0.52	0.56
3	0.72	0.69	0.64	0.68
4	0.81	0.77	0.72	0.74
5	0.85	0.82	0.78	0.79
10	0.96	0.95	0.93	0.93
12	0.98	0.97	0.96	0.96
16	1.00	0.99	0.99	0.99
18	1.00	1.00	1.00	1.00

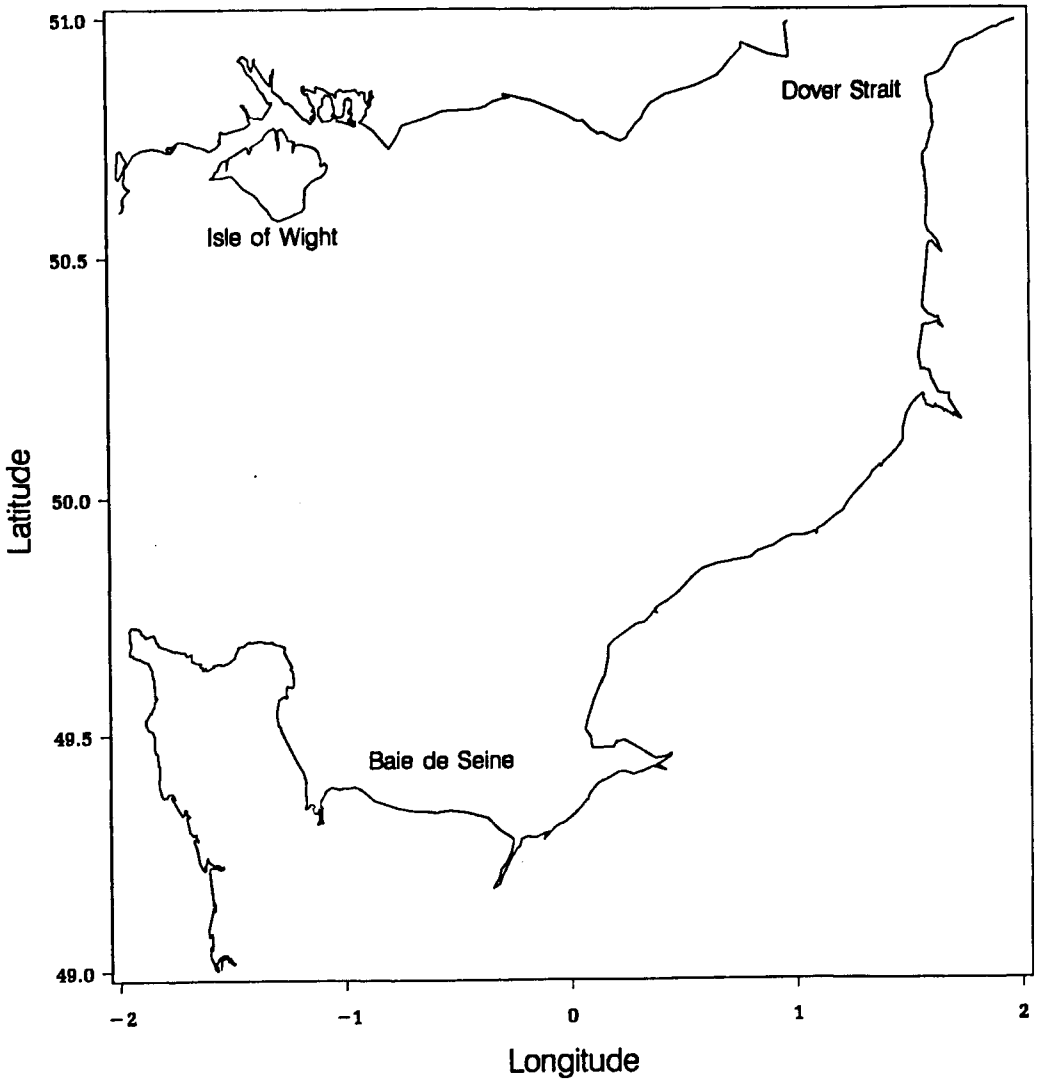

Figure 1. Survey area in the eastern Channel

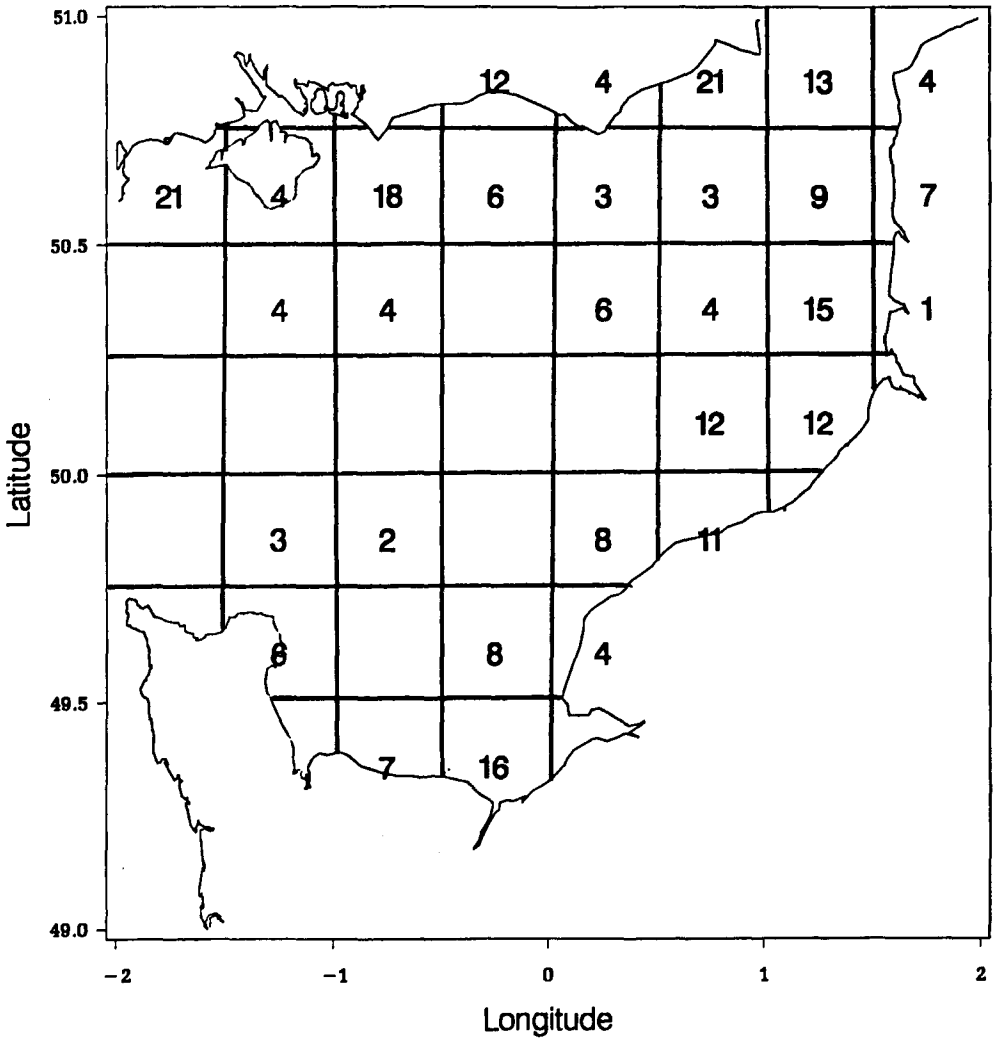

Figure 2. Total number of hauls in 1988-1991 in each subrectangle

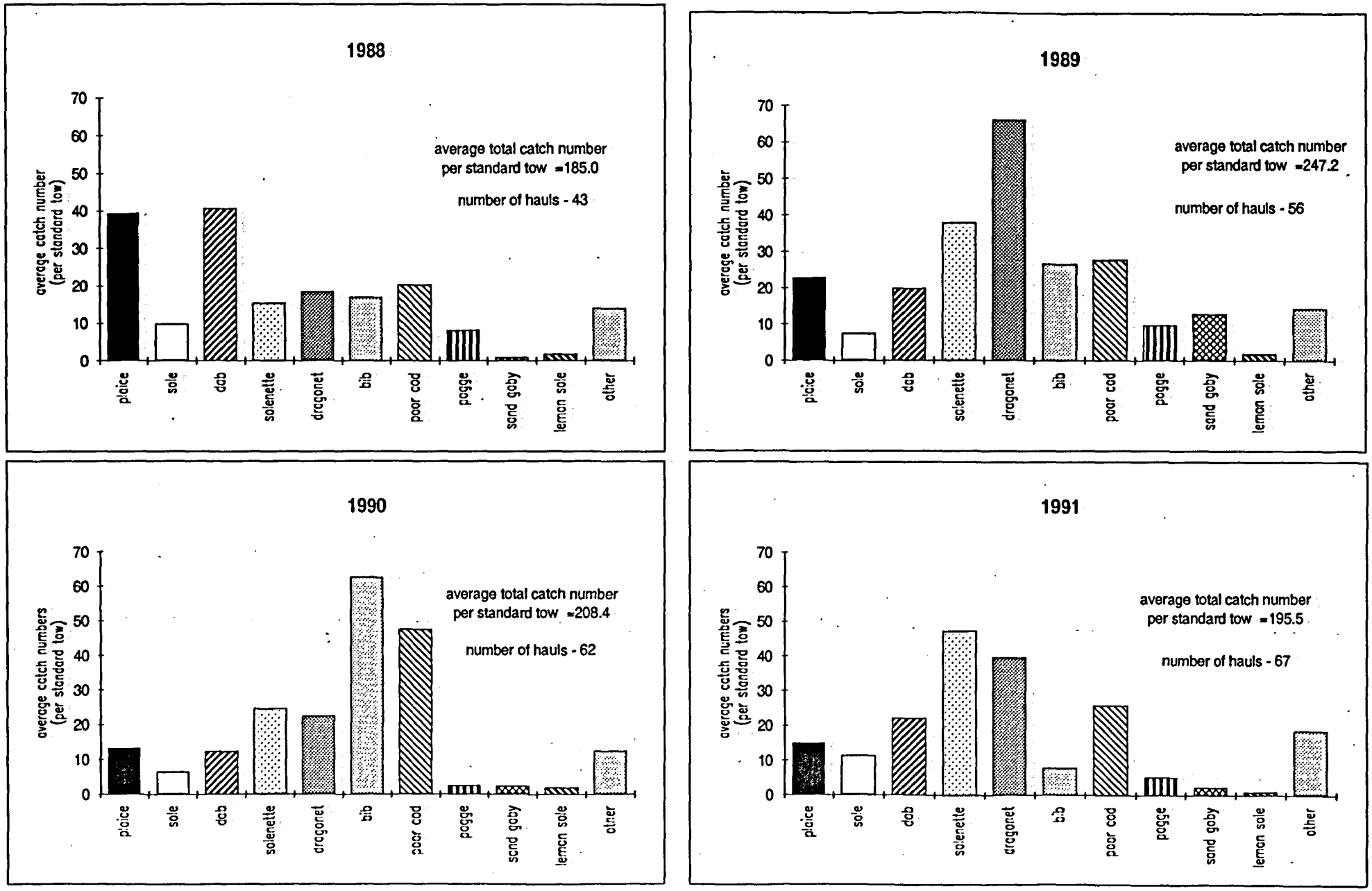

Figure 3. Average catch by numbers of main species for 1988-1991

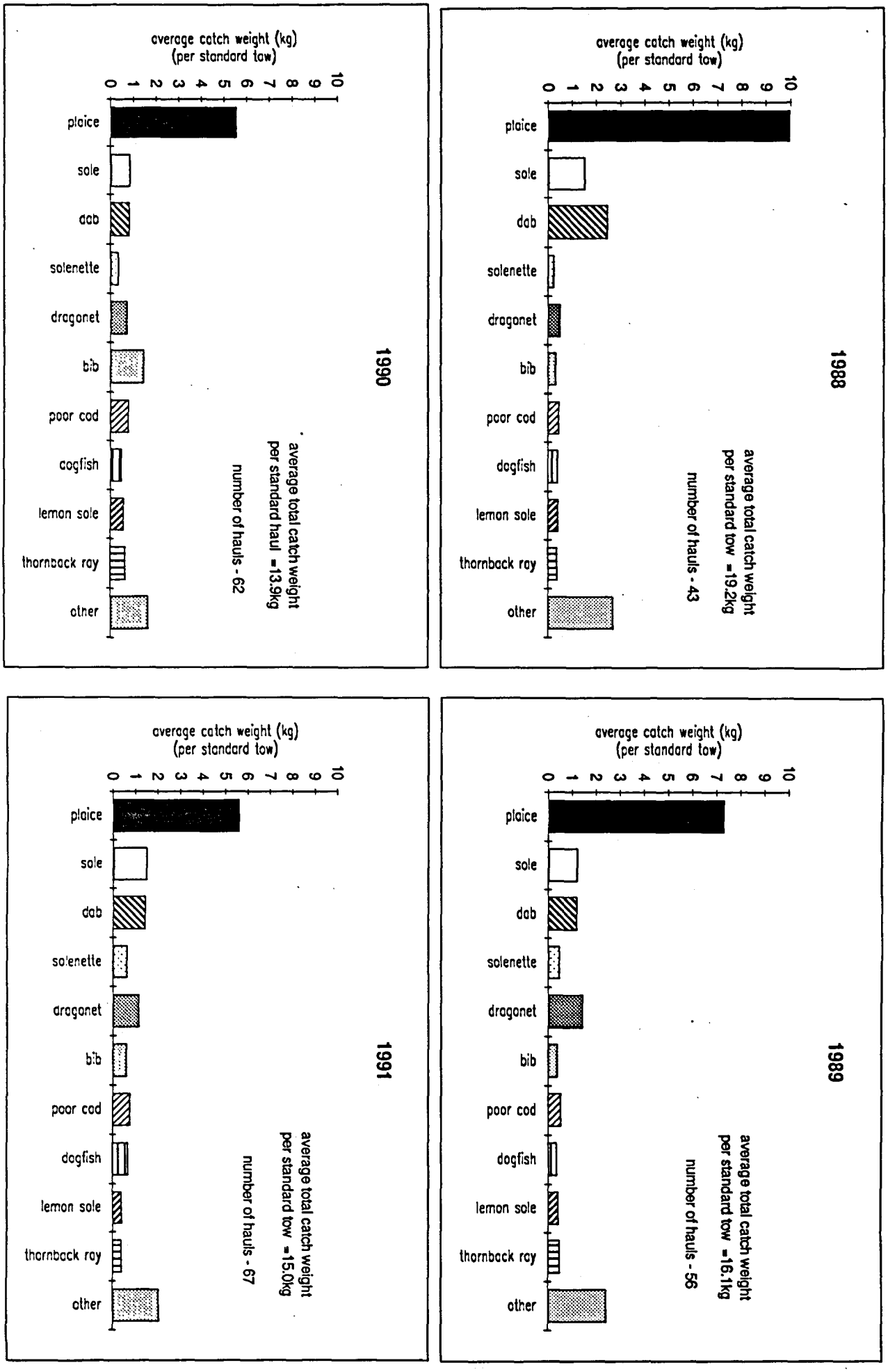

Figure 4. Average catch by weight of main species for 1988-1991

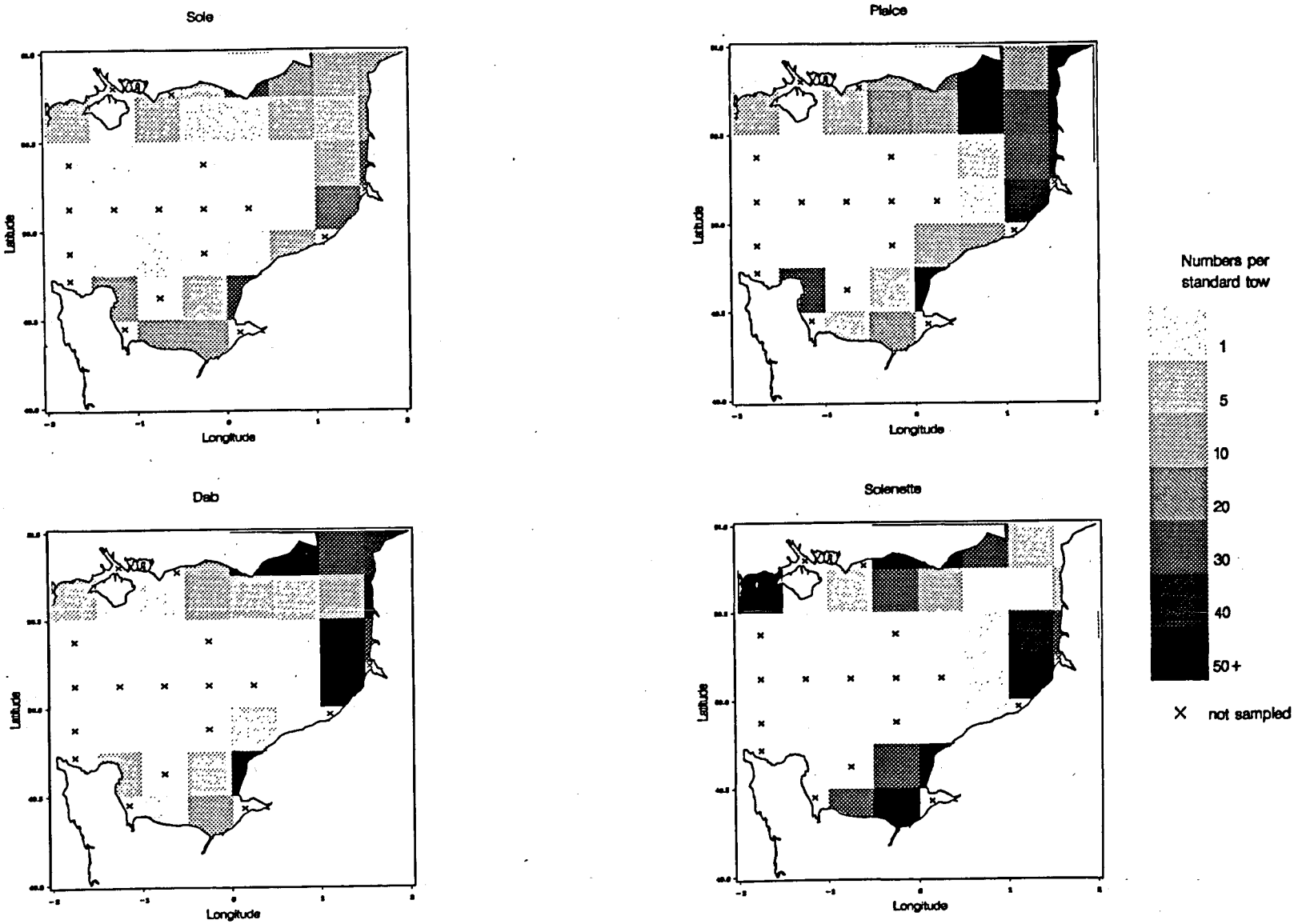

Figure 5. Catch numbers per standard tow averaged over four years by quarter rectangles

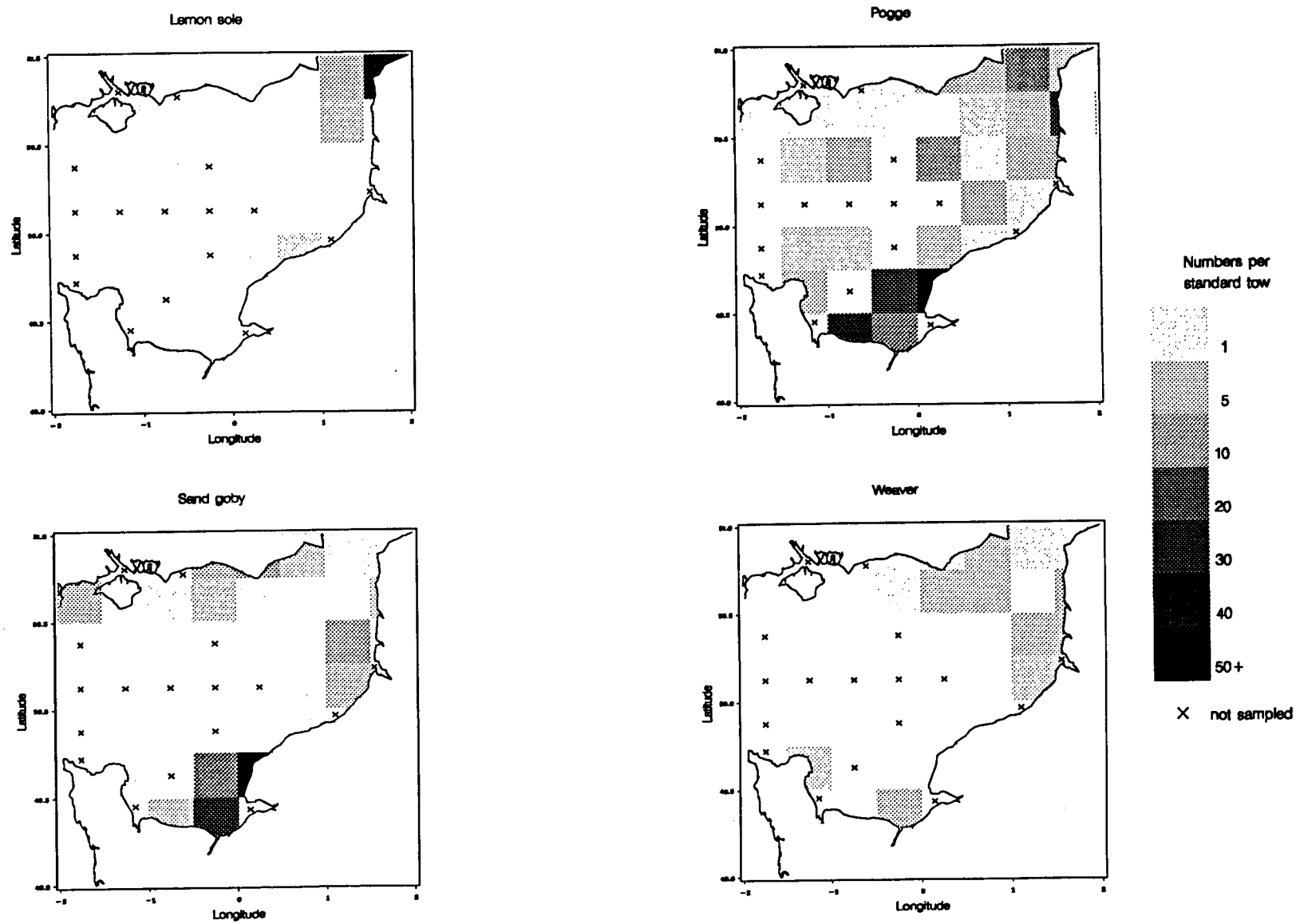

Figure 6. Catch numbers per standard tow averaged over four years by quarter rectangles

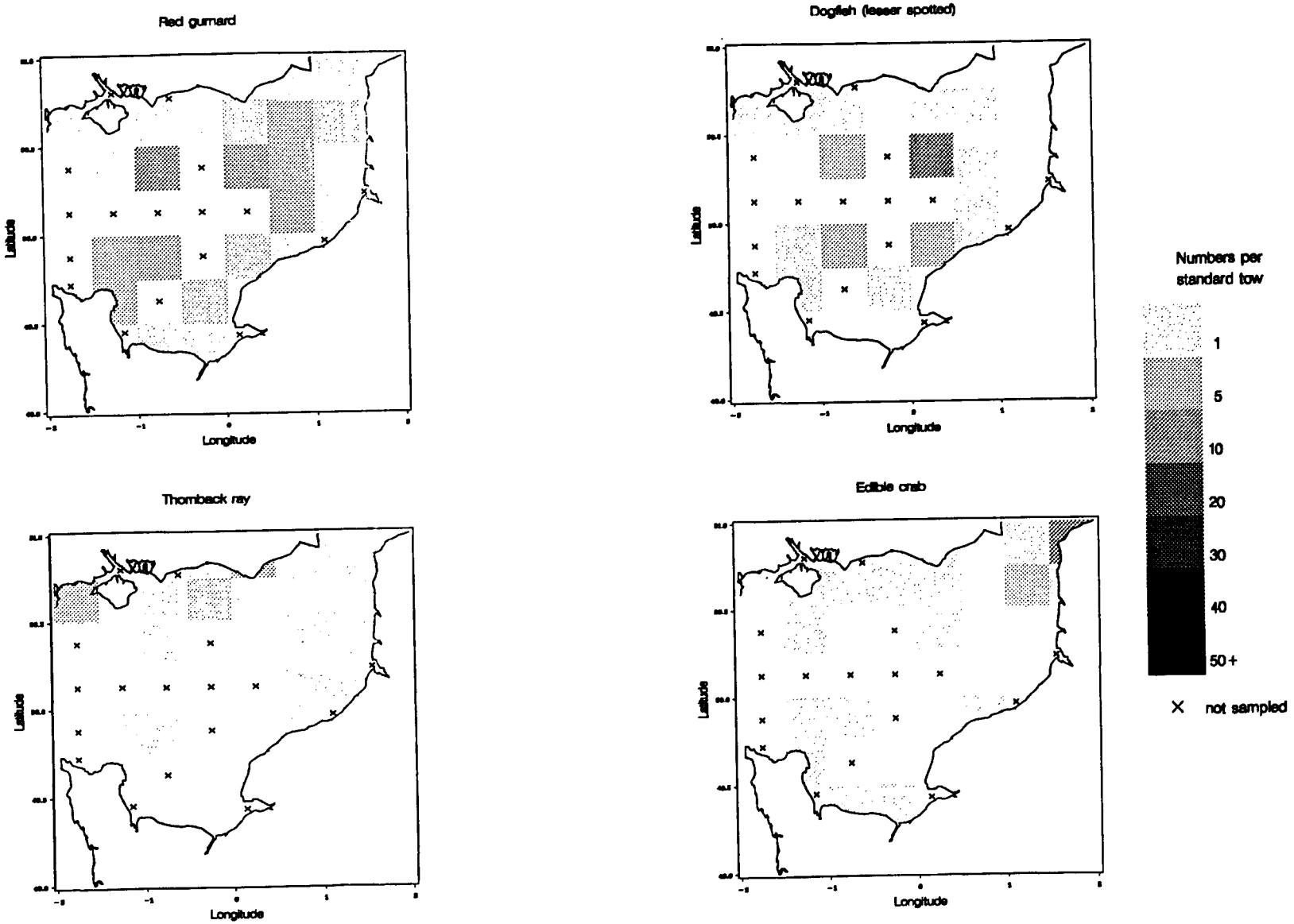

Figure 7. Catch numbers per standard tow averaged over four years by quarter rectangles

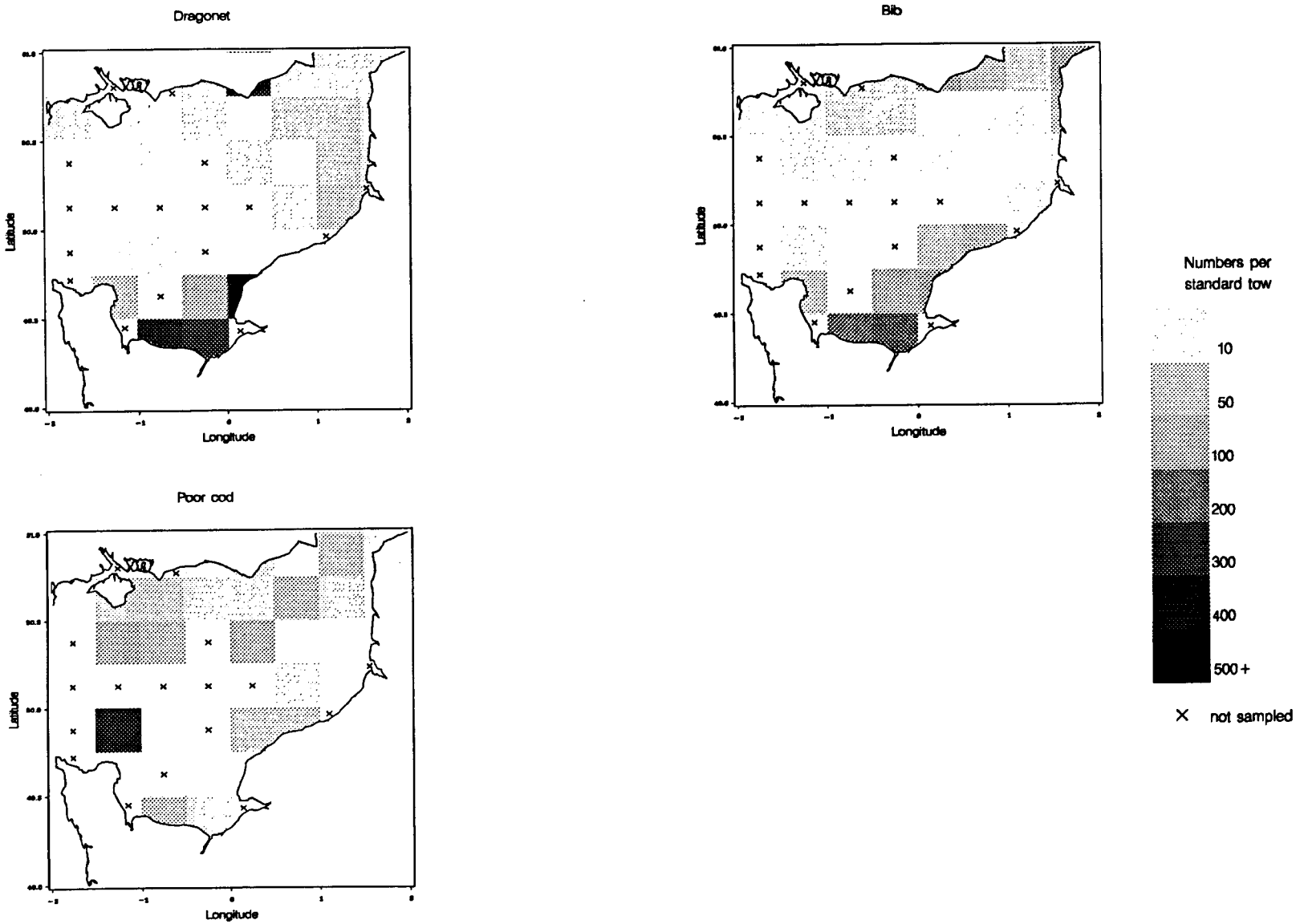

Figure 8. Catch numbers per standard tow averaged over four years by quarter rectangles

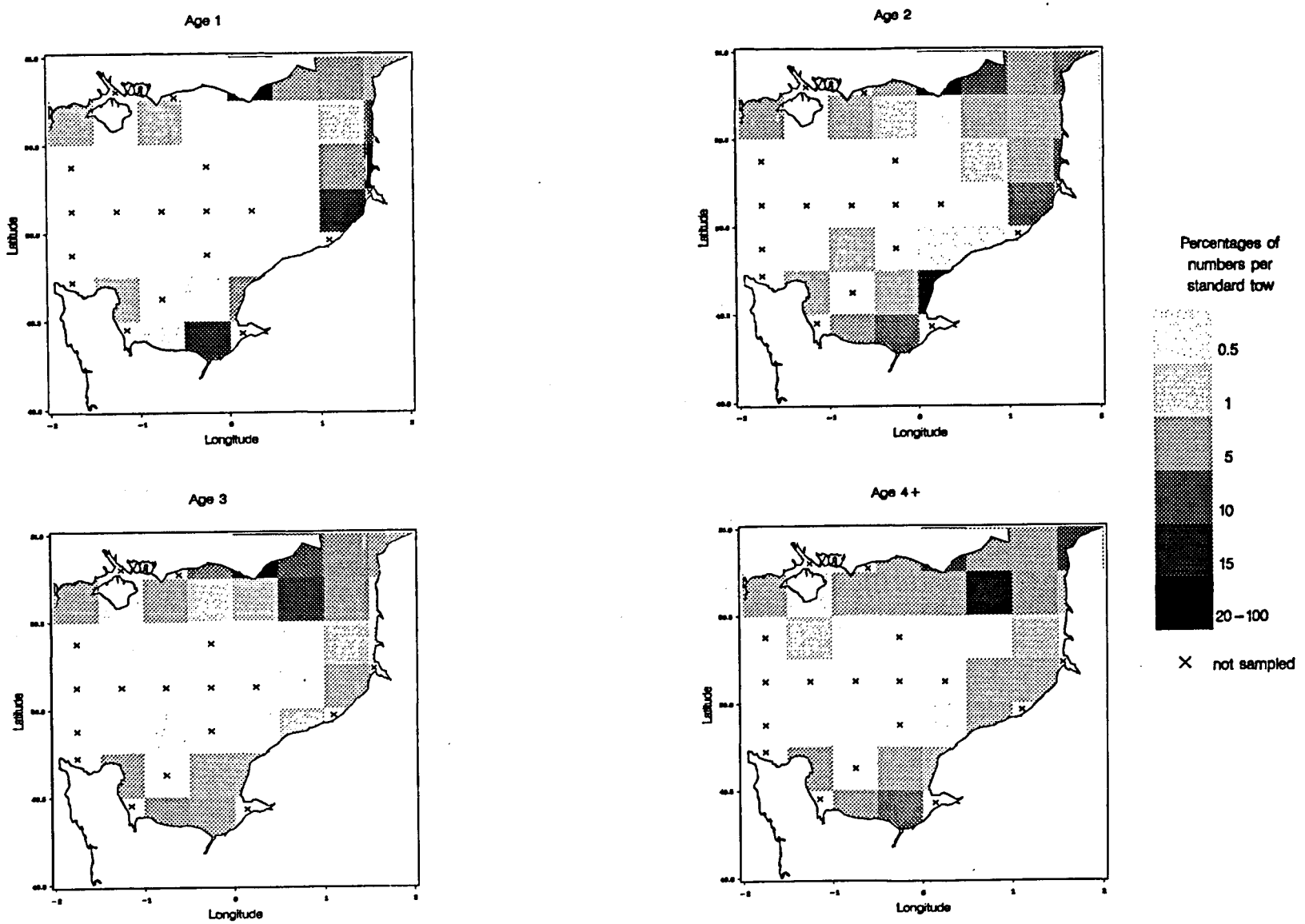

Figure 9. Average percentages of catch numbers in 1989-1991 for sole by age and by quarter rectangles

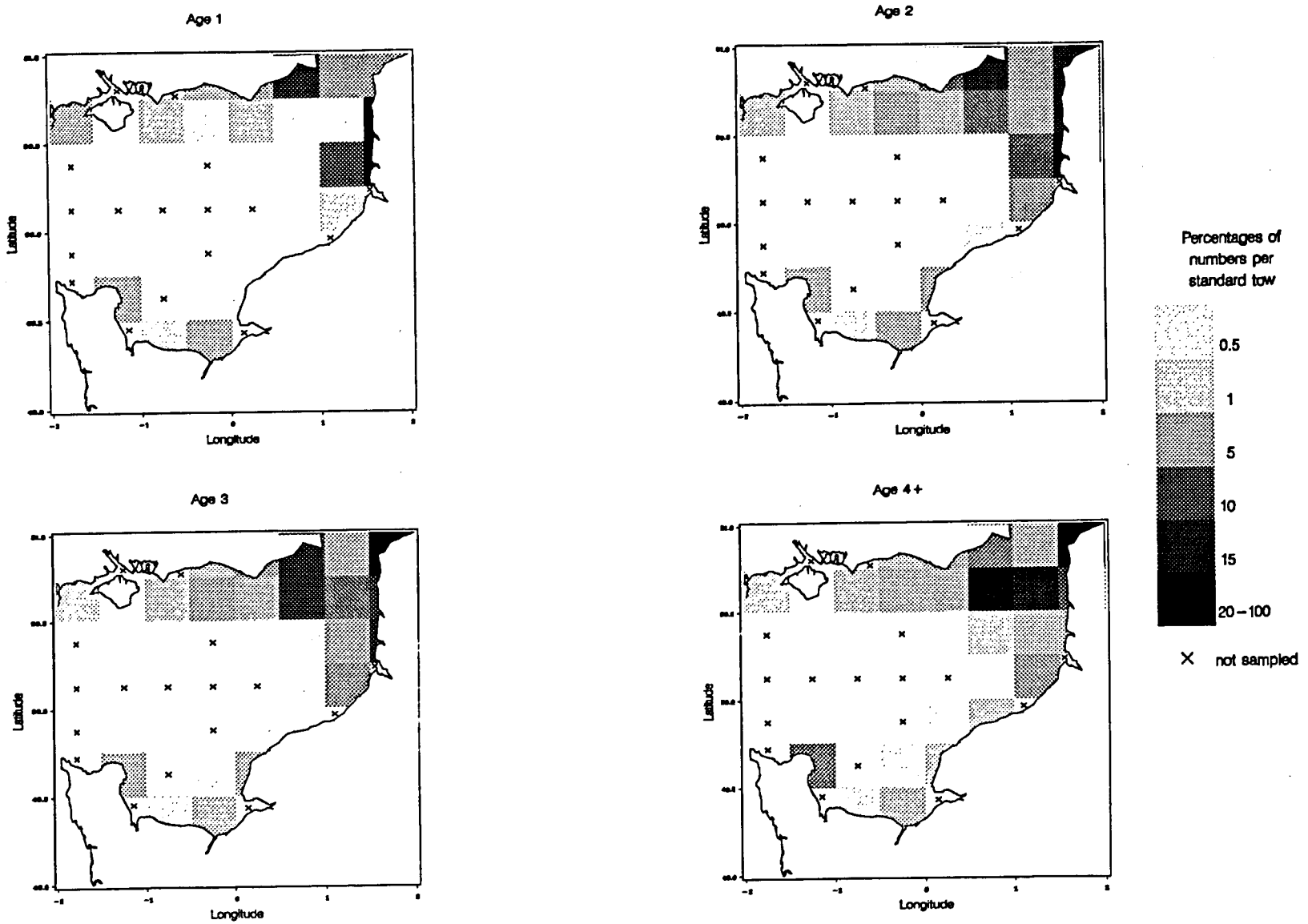

Figure 10. Average percentages of catch numbers in 1989-1991 for plaice by age and by quarter rectangles

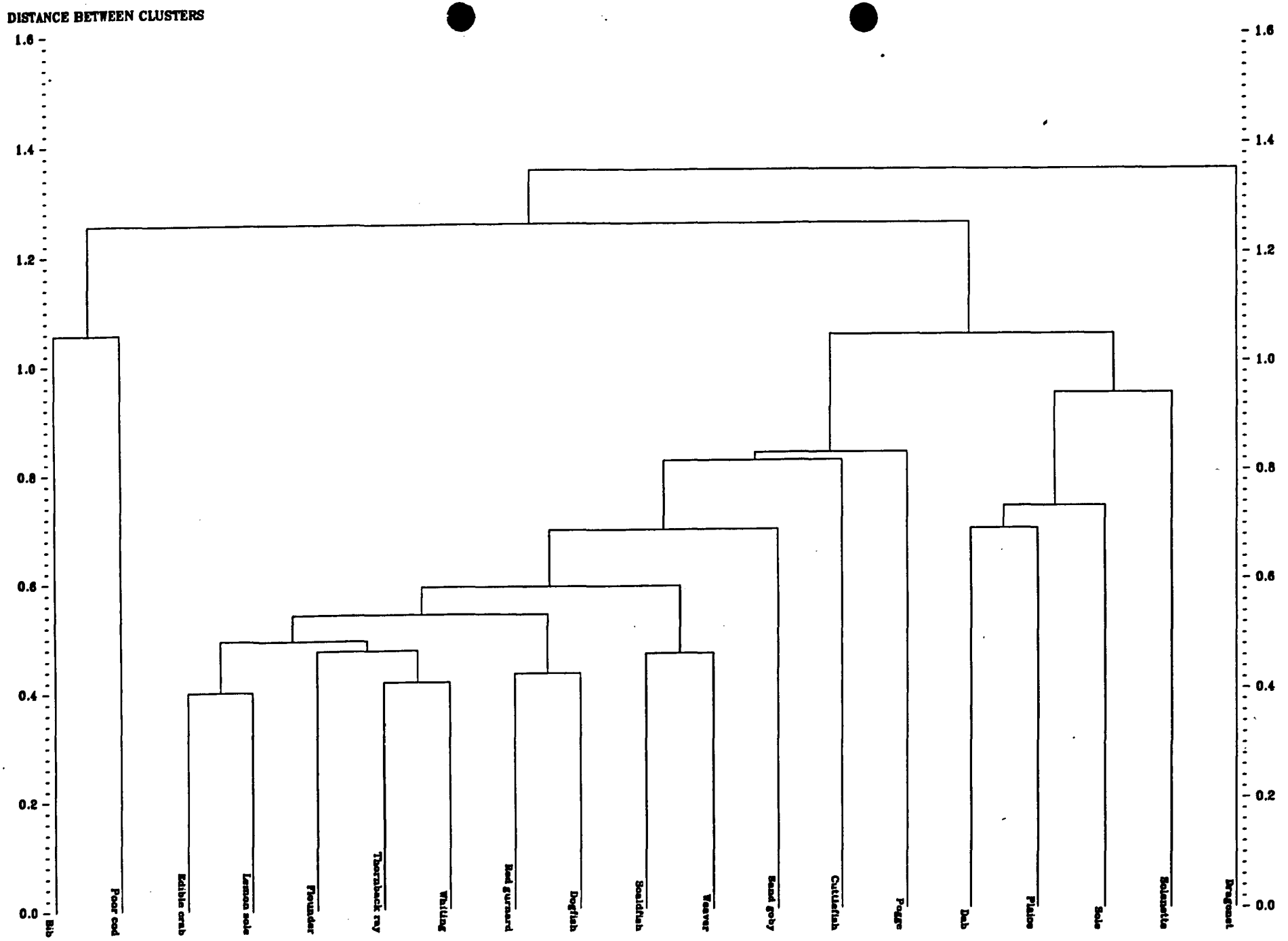

Figure 11. Dendogram of species groupings (calculated using the average linkage method on a log transformation of catch numbers).