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The Distribution of Chondrichthyan Fishes Around the British Isles and Implications for Conservation

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Abstract

Over 50 species of chondrichthyan fishes are known from waters around the British Isles, of which 26 have been recorded in The Centre for Environment, Fisheries and Aquaculture Science (CEFAS) trawl surveys. The distribution and relative abundance of dogfishes, skates and rays are described from groundfish surveys in the North Sea, English Channel, Irish Sea and Celtic Sea. The contemporary distribution of species in relation to their biogeography and major changes in the distribution are discussed. Nursery areas of elasmobranchs were typically in shallower water than adult habitats, a pattern evident for blonde (*Raja brachyura*), thornback (*R. clavata*), small-eyed (*R. microocellata)* and spotted ray (*R. montagui*). In contrast, juvenile cuckoo ray *Leucoraja naevus* occurred further offshore and were most abundant in the western Irish Sea and northern St George's Channel. Oviparous species require a suitable substratum for the deposition of eggs, and the distribution of egg-cases is illustrated and important egg-laying substrates identified.

Key words: abundance, biogeography, British Isles, distribution, dogfish, eggs, elasmobranchs, nursery, rays, skates

Introduction

Elasmobranch fish typically have a slow growth rate, late age at maturity and low reproductive output, and, therefore are generally considered to be vulnerable to over-fishing (Holden, 1974). In UK waters, the populations of several species have been observed to decline in response to commercial fisheries (e.g. Holden, 1974; Rogers and Ellis, 2000) and, in more extreme cases, this has resulted in extirpation from areas within their biogeographical range (Brander, 1981). Due to the low fecundity of elasmobranchs, there is a closer relationship between the stock size of mature females and recruitment than for most commercially important teleosts. Teleost fish are usually more fecund and recruitment is strongly dependent on environmental conditions. Spawning, parturition and nursery areas are important habitats for fishes, because they play a key ecological role in maximising the survivorship and/or growth of neonates and juveniles. Nursery areas are often areas with high production, abundant and suitable food and habitat resources and reduced predation (Castro, 1993; Simpfendorfer and Milward, 1993). Nevertheless, the role of nursery areas in the demography and life-history of elasmobranch fishes has been little studied, and little is known about the location and importance of such areas around the British Isles.

The present work uses data collected during annual groundfish surveys to examine the distribution and relative abundance of demersal elasmobranchs, in order to identify those sites that are important for species of conservation interest and the early life-history stages (i.e. egg-cases and juveniles) of the dominant species. Regional patterns in the species diversity of elasmobranchs are described.

Materials and Methods

The data used in this study were derived from research vessel surveys carried out by The Centre for Environment, Fisheries and Aquaculture Science (CEFAS) in the North Sea, Celtic Sea, English Channel and Irish Sea during the period 1967–2002 (Table 1). Surveys were undertaken by RV *Cirolana* and RV *Corystes*, except for the western English Channel survey which was undertaken by the MFV *Carhelmar*. Currently, annual groundfish surveys are undertaken in the Celtic Sea (March, Portuguese high headline trawl (PHHT)), North Sea (Grande Ouverture Verticale (GOV) trawl), and in the southern North Sea/eastern English Cannnel (July/August), Irish Sea and Bristol Channel (September) and western English Channel (October) using a 4 m beam trawl. During surveys, elasmobranch were identified to species level, following

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TABLE 1. List of bottom-trawl surveys incorporated in data analyses.

Survey area	ICES Division	Time of year	Years sampled	Depth range	Gear	Survey details and gear description
North Sea	IV a–c	Qtr 1	1967–90/2001–02	20–320 m	GOV trawl	Anon (1996)
		Qtr 3	1977–1991		Granton trawl	
		Qtr 3	1992–2002		GOV trawl	
Celtic Sea	VII e–j [1]	Qtr 1	1982–2002	50–590 m	Portuguese high headline trawl (PHHT)	Warnes and Jones (1995)
		Qtr 4	1982–1988			
Eastern English Channel	VII d, IV c	Qtr 3	1989–2002	10–75 m	4 m Beam trawl	Rogers *et al.* (1999)
Irish Sea	VII a, f, g	Qtr 1	1993–1999	10–135 m	4 m Beam trawl	Rogers *et al.* (1999)
		Qtr 3	1988–2001		4 m Beam trawl	
Western English Channel	VII e	Qtr 4	1990–2001	6–82 m	4 m Beam trawl	Rogers *et al.* (1999)

[1] with occasional stations in the Bay of Biscay (VIII) and north-western areas (VII b and VI a)

Wheeler (1969) and Whitehead *et al*. (1986), and sexed, weighed and measured.

Catch rates of each species were converted to numbers caught per hour. The actual duration of each haul varied from 15–60 minutes depending upon the survey, gear type, and sampling station. Within each survey, the same locations were fished each year, wherever possible. The distribution of sampling effort is illustrated in Fig. 1 and the shaded areas show the ICES rectangles fished and the number of hauls made from 1967 to 2002. The boundaries of ICES divisions and location of places mentioned in the text are illustrated in Fig. 2. Data from these surveys were used to describe the distribution and relative abundance of chondrichthyan fishes, where the relative abundance of fish was represented as the mean number of fish caught per hour by ICES rectangle. This index was considered the most appropriate for examining regional distribution patterns, given that these data were collected by several gear types and different vessels. Obviously, each gear will sample the different species with varying catch efficiencies, and beam trawls for example fish approximately 50 cm above the sea floor and are not appropriate for sampling the larger, fast-moving species (e.g. spurdog and tope).

Data from these surveys were also used to determine the distribution of juvenile elasmobranchs. Species were classed as juveniles if their total length was ≤ 15 cm (*Scyliorhinus canicula*), ≤ 20 cm (*Scyliorhinus stellaris*, *Leucoraja* spp. and *Raja* spp.), ≤ 25 cm (*Dipturus* spp.) and ≤ 40 cm (*Squalus acanthias* and triakid sharks). Additionally, the egg-cases of oviparous elasmobranchs were recorded during beam trawl surveys in the eastern English Channel and Irish Sea (1998–99).

Results

Distribution of chondrichthyan fishes around the British Isles

The surveys covered extensive areas of the North Sea, English Channel, Irish Sea, Bristol Channel and

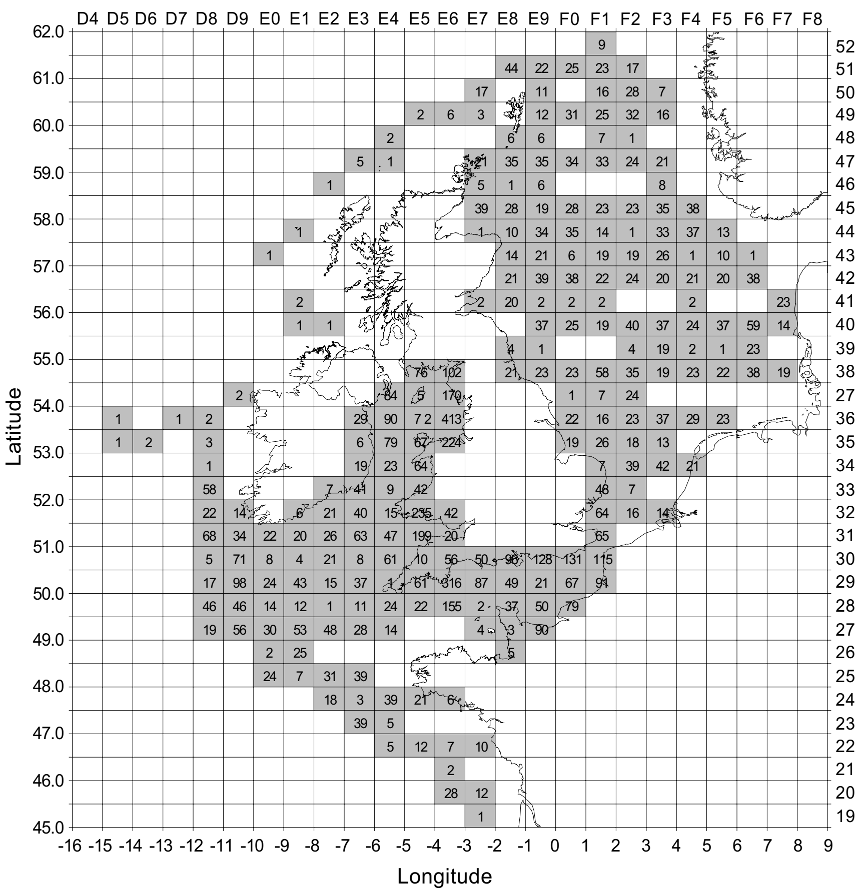

Fig. 1. Distribution of bottom-trawl survey effort around the British Isles (Table 1) as indicated by the number of hauls by ICES rectangle.

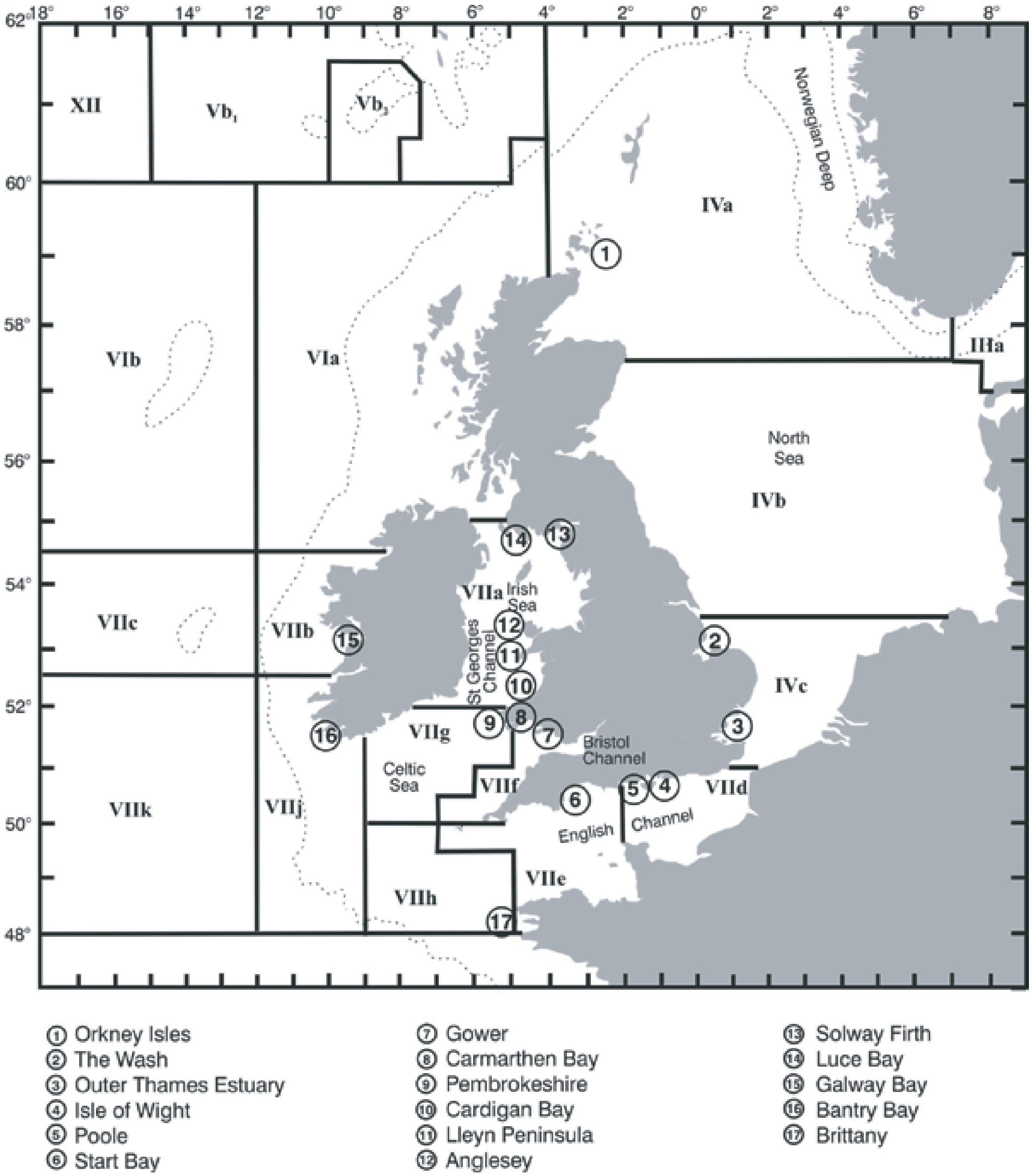

Fig. 2. ICES divisions surrounding the British Isles and place names referred to in the text.

Celtic Sea, although data for some areas (e.g. northern Bay of Biscay and North-western Scotland) were more limited. Twenty-six species of chondrichthyan fishes were recorded (Table 2). Six-gill shark (*Hexanchus griseus*) was recorded occasionally in the Celtic Sea in waters of 148–581 m depth, and kitefin shark (*Dalatias licha*) was also only recorded in deep water (ca. 420 m) in the Celtic Sea (Fig. 3a). Velvet belly (*Etmopterus spinax*) was caught regularly along the shelf edge of the Celtic Sea (317–581 m deep) and in the Norwegian Deep (Fig. 3b), with catch rates of up to 162 ind.hr^{-1}. Spurdog (*S. acanthias*) was widespread around the British Isles in waters 15–528 m deep (Fig. 3c), although it was caught infrequently in beam trawl surveys. Although the maximum catch was >2 800 ind.hr^{-1}, more than 80% of positive catches were comprised of <10 ind.hr^{-1}.

TABLE 2. Taxonomic list of chondrichthyan fishes recorded from the British Isles during CEFAS groundfish surveys in Table 1.

Family	Species	Common name
Hexanchidae	*Hexanchus griseus* (Bonnaterre, 1788)	Six-gilled shark
Squalidae	*Squalus acanthias* Linnaeus, 1758	Spurdog
Etmopteridae	*Etmopterus spinax* (Linnaeus, 1758)	Velvet belly
Dalatiidae	*Dalatias licha* (Bonnaterre, 1788)	Kitefin shark
Scyliorhinidae	*Galeus melastomus* Rafinesque, 1810	Blackmouthed dogfish
	Scyliorhinus canicula (Linnaeus, 1758)	Lesser-spotted dogfish
	Scyliorhinus stellaris (Linnaeus, 1758)	Nurse hound
Triakidae	*Galeorhinus galeus* (Linnaeus, 1758)	Tope shark
	Mustelus asterias Cloquet, 1821	Starry smooth hound
	Mustelus mustelus (Linnaeus, 1758)	Common smooth hound
Torpedinidae	*Torpedo marmorata* Risso, 1810	Marbled electric ray
	Torpedo nobiliana Bonaparte, 1835	Common electric ray
Rajidae	*Amblyraja radiata* (Donovan, 1808)	Starry ray
	Dipturus batis (Linnaeus, 1758)	Common skate
	Dipturus nidarosiensis (Collett, 1880)	Black skate
	Dipturus oxyrinchus (Linnaeus, 1758)	Long-nose skate
	Leucoraja circularis (Couch, 1838)	Sandy ray
	Leucoraja fullonica (Linnaeus, 1758)	Shagreen ray
	Leucoraja naevus (Müller & Henle, 1841)	Cuckoo ray
	Raja brachyura Lafont, 1873	Blonde ray
	Raja clavata Linnaeus, 1758	Thornback ray
	Raja microocellata Montagu, 1818	Painted ray
	Raja montagui Fowler, 1910	Spotted ray
	Raja undulata Lacepede, 1802	Undulate ray
Dasyatidae	*Dasyatis pastinaca* (Linnaeus, 1758)	Common stingray
Chimaeridae	*Chimaera monstrosa* Linnaeus, 1758	Rabbitfish

Three species of scyliorhinid were recorded. Blackmouth dogfish (*Galeus melastomus*) was caught in the northern North Sea and Celtic Sea at depths of 106–433 m (Fig. 3d) and in the North-western Irish Sea during the late 1980s, although there were no recent records. Lesser-spotted dogfish (*S. canicula*) was widespread and abundant (maximum catch rates were ca. 500 ind. hr^{-1}) along the southern and western seaboards of the British Isles at depths of 6–308 m, although its distribution in the North Sea was patchy (Fig. 4a). Greater-spotted dogfish (*S. stellaris*) was caught occasionally, predominantly in the shallow waters (13–100 m depth) off the southern and western coasts of the British Isles (Fig. 4b), and it was rare in the North Sea. This species was most common on rough inshore grounds (e.g. Gower, Pembrokeshire, Lleyn Peninsula) where maximum catch rates were 18 ind.hr^{-1}.

Three species of triakid shark were recorded. Tope (*Galeorhinus galeus*) was caught regularly from depths of 17–200 m around the British Isles (Fig. 4c), although it was caught infrequently in beam trawl surveys. Starry smoothhound (*Mustelus asterias*) was widespread around the British Isles in waters of 10–199 m depth, and most abundant along the southern and western coasts of the UK with high catch rates recorded in the outer Thames Estuary and Bristol Channel (Fig. 4d). Smoothhound (*Mustelus mustelus*) was recorded less frequently than the starry smoothhound, but was relatively common along the southern and western coasts of the UK in waters of 9–421m depth. It was rarely recorded in the North Sea (Fig. 5a).

Marbled electric ray (*Torpedo marmorata*) was caught occasionally in the English Channel and off Brittany in waters of 13–109 m depth, whereas electric ray (*Torpedo nobiliana*) was more common in the Celtic Sea where its bathymetric distribution extended to deeper waters (28–413 m) (Fig. 5b–c).

Twelve rajid species were recorded on the continental shelf around the British Isles. Starry ray (*Amblyraja radiata*) was abundant in the North Sea (Fig. 5d) in waters of 32–209 m, with maximum catch rates of 232 ind.hr^{-1}. This species was not recorded from the southern and western survey areas. Common skate (*Dipturus batis*), long-nosed skate (*Dipturus oxyrinchus*) and black skate (*Dipturus nidarosiensis*) were absent from inshore

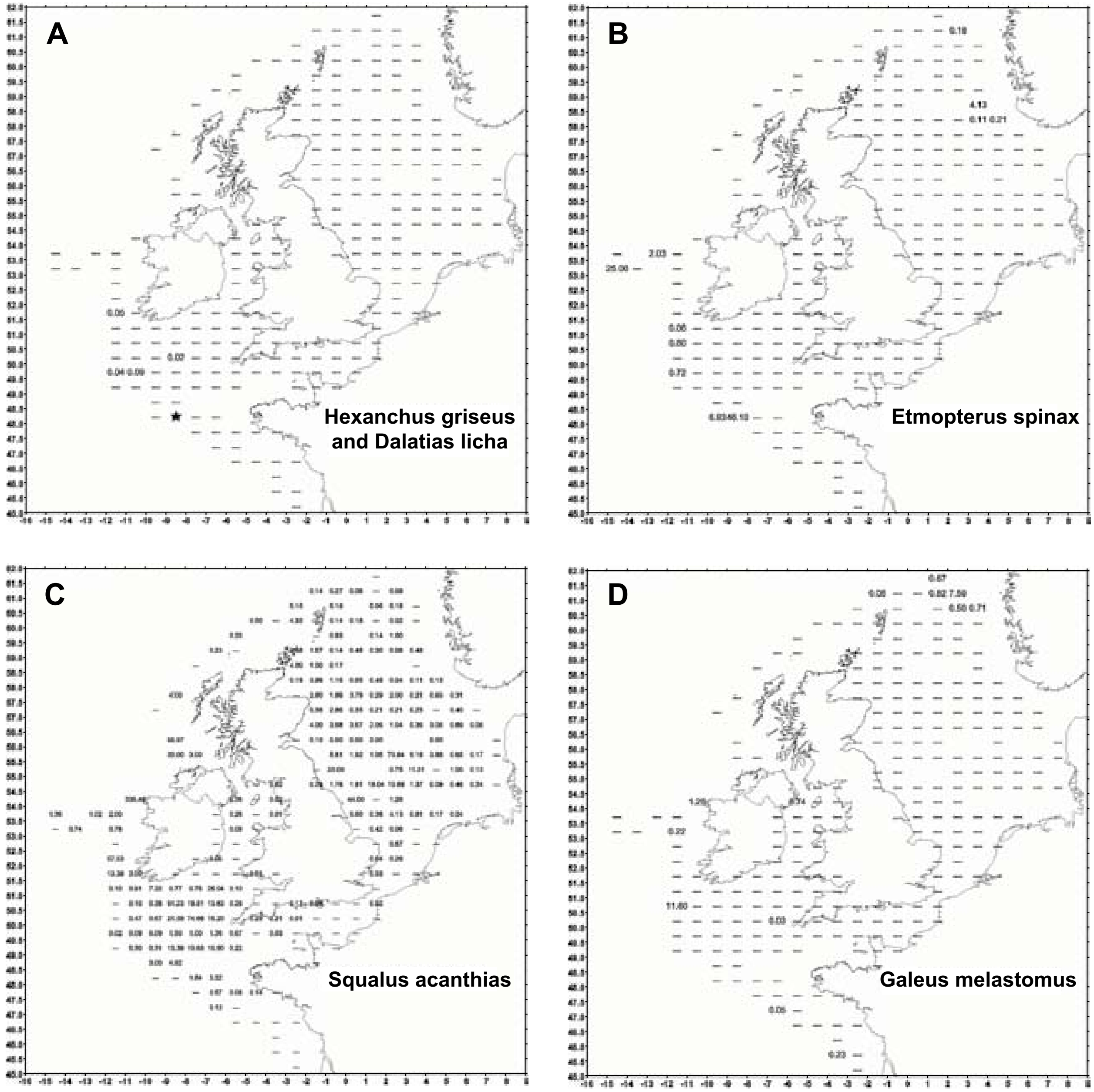

Fig. 3. Distribution and relative abundance of (**A**) *Hexanchus griseus* and *Dalatias licha* (denoted with an asterisk), (**B**) *Etmopterus spinax,* (**C**) *Squalus acanthias* and (**D**) *Galeus melastomus.*

waters of England and Wales. Catches of common skate were restricted to the northern North Sea and Celtic Sea (Fig. 6a) in waters of 84–271m, where the maximum catch rate was 4 ind.hr^{-1}. Long-nosed skate was recorded occasionally in the northern North Sea and Celtic Sea in waters of 111–159 m, and one specimen of black skate was caught in the Celtic Sea at 124 m depth (Fig. 6b).

Sandy ray (*Leucoraja circularis*) was only caught occasionally, with individuals caught in the northern North Sea and Celtic Sea (Fig. 6c) at depths of 108–432 m. Shagreen ray (*Leucoraja fullonica*) was also absent from the shallow waters of England and Wales, and catches were restricted to northern North Sea and Celtic Sea (Fig. 6d) in waters of 90–424 m. Maximum catch rates were 7 ind.hr^{-1}. Cuckoo ray (*Leucoraja naevus*) was common in the Irish Sea, Celtic Sea and northern North Sea (Fig. 7a) at depths of 12–290 m. The maximum catch rate was 58 ind.hr^{-1}. This species was rarely recorded in the eastern English Channel and southern North Sea.

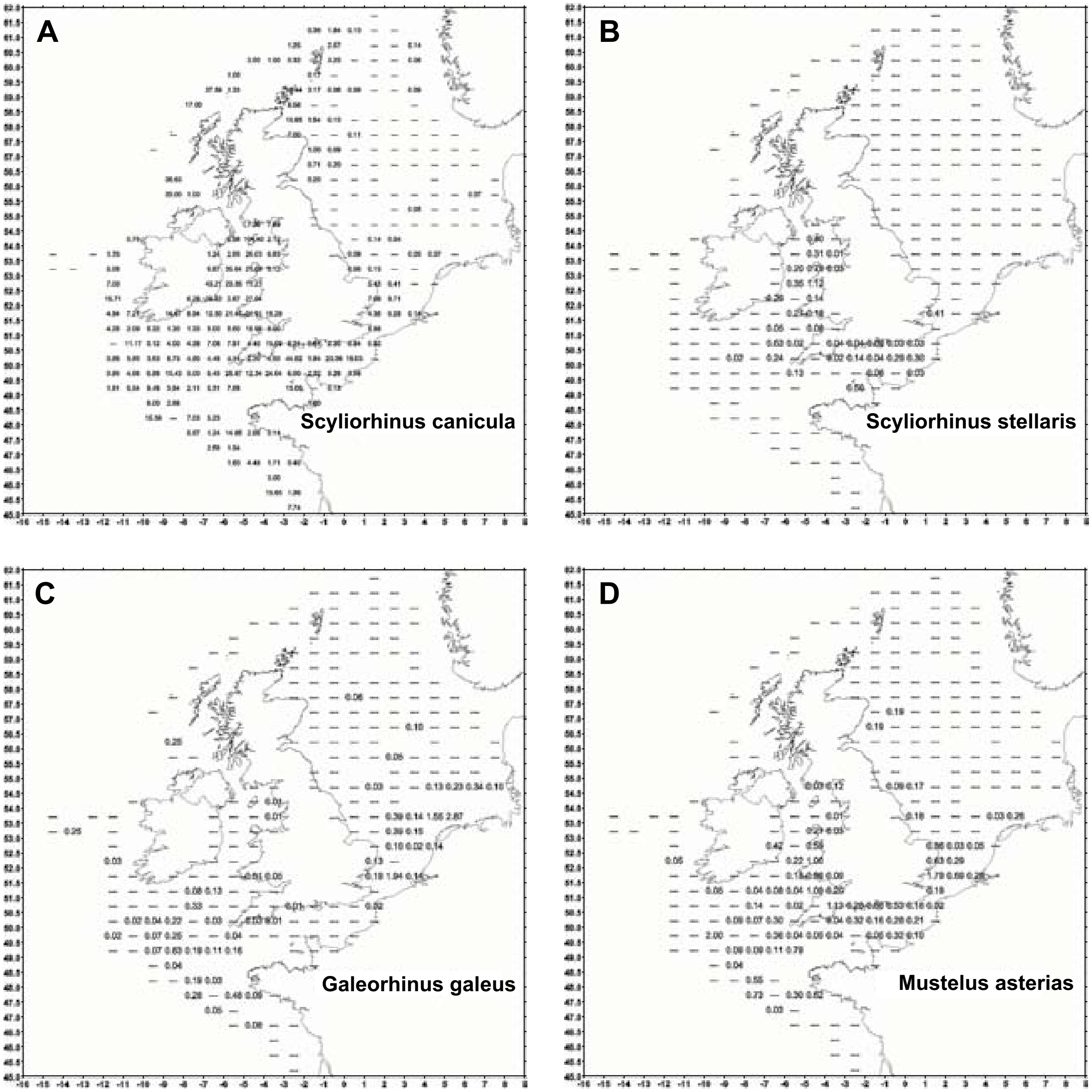

Fig. 4. Distribution and relative abundance of (**A**) *Scyliorhinus canicula,* (**B**) *Scyliorhinus stellaris*, (**C**) *Galeorhinus galeus* and (**D**) *Mustelus asterias.*

Blonde ray (*Raja brachyura*) was common in the inshore waters (14–146 m) off southern and western England (Fig. 7b), with maximum catch rates of 72 ind. hr^{-1} in the Bristol Channel and St George's Channel. It was caught infrequently in the North Sea and Celtic Sea. Thornback ray (*Raja clavata*) was widespread around the British Isles at depths of 7–192 m (Fig. 7c), although more abundant along the southern and western coasts, where maximum catch rates were ca. 200 ind.hr^{-1}. Spotted ray (*Raja montagui*) had a similar distribution (Fig. 8a), being found in waters of 8–283 m and with maximum catch rates of 88 ind.hr^{-1}. Catches of both species in the central and northern North Sea were patchy. Smalleyed ray (*Raja microocellata*) was common in the Bristol Channel (Fig. 7d), where catch rates attained 40 ind.h^{-1}. It was caught only occasionally in the English Channel and St George's Channel, and the maximum depth recorded was 112 m. Undulate ray (*Raja undulata*) was recorded frequently in the English Channel (Fig. 8b), albeit at low abundance (<8 ind.hr^{-1}) with occasional specimens recorded from

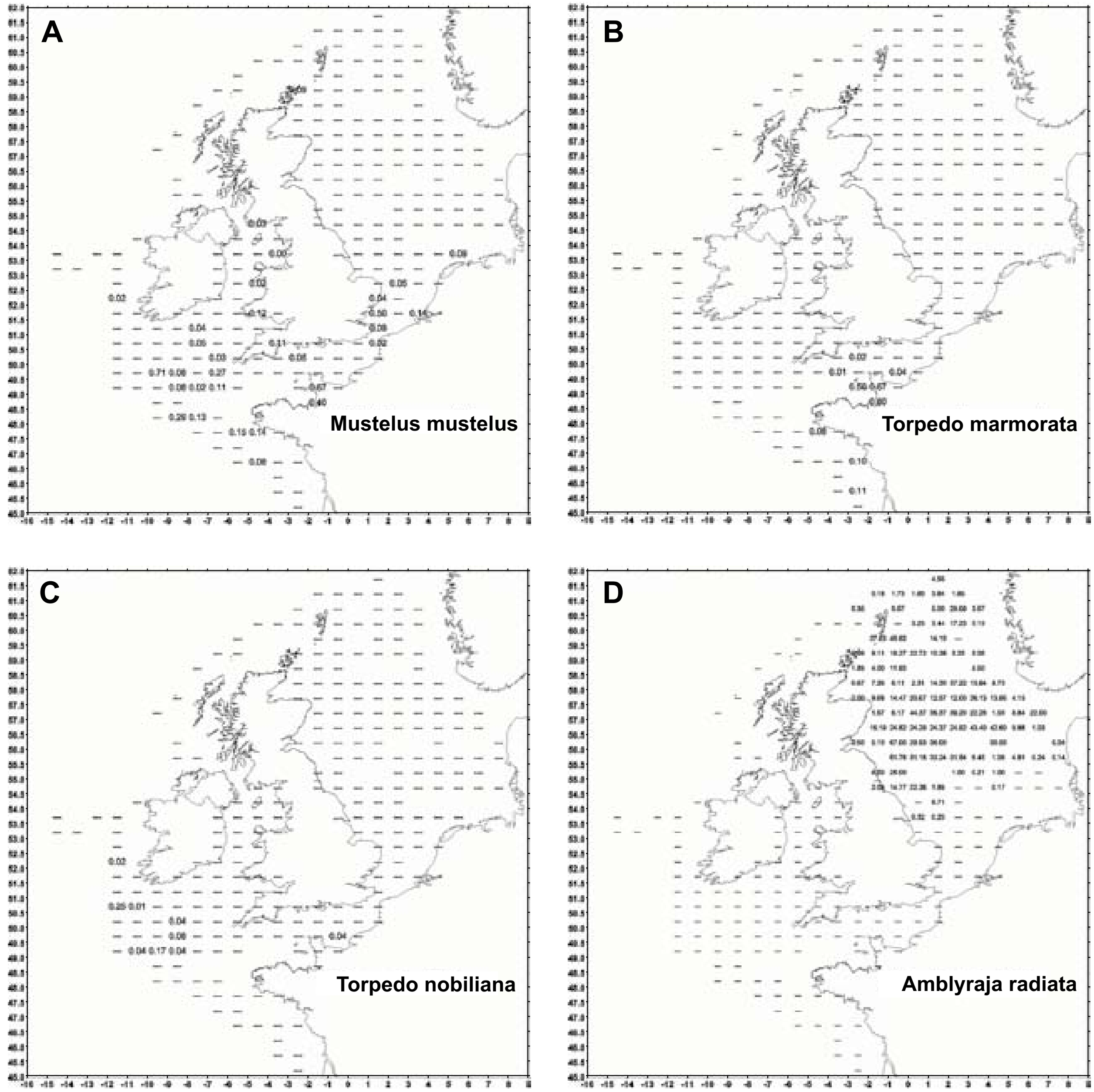

Fig. 5. Distribution and relative abundance of (**A**) *Mustelus mustelus*, (**B**) *Torpedo marmorata*, (**C**) *Torpedo nobiliana* and (**D**) *Amblyraja radiata.*

the southern North Sea. The maximum observed depth was 72m.

Stingray (*Dasyatis pastinaca*) was only recorded occasionally in the western English Channel (Fig. 8c), at depths of 17–160 m. Rabbitfish (*Chimaera monstrosa*) was the only holocephalan recorded, and was restricted to the northern North Sea and Celtic Sea (Fig. 8d) in waters of 156–592 m depth.

Overall, the diversity of elasmobranchs was greater in the south-western waters of the British Isles (Fig. 9), and the mean number of elasmobranch species recorded per ICES rectangle was 5.9 (range: 1–13). The diversity for the North Sea as a whole was slightly less, with an average of 3.3 species per rectangle (range: 1–9), with more species recorded in the southern and northern North Sea and fewest recorded in the central North Sea.

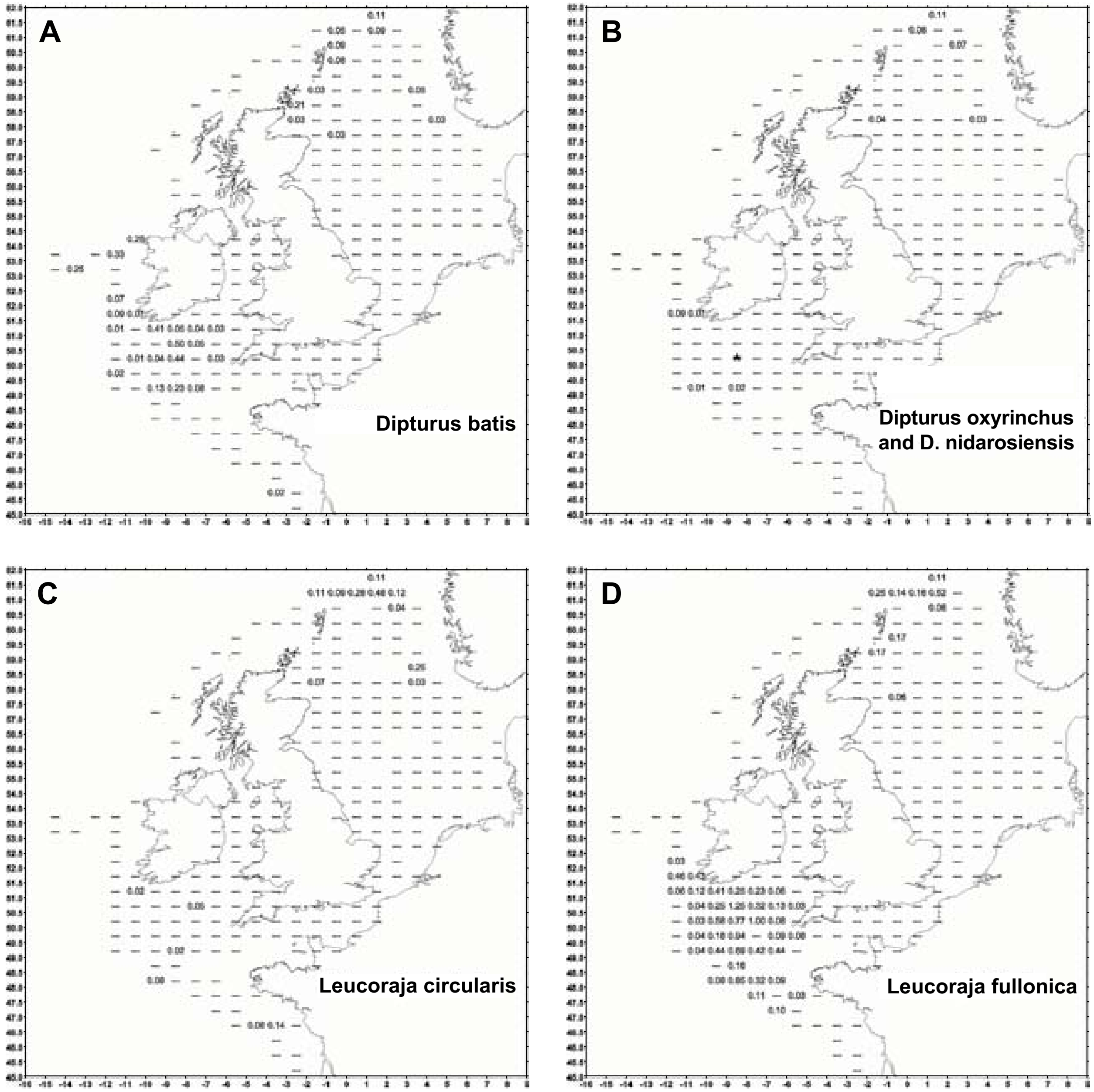

Fig. 6. Distribution and relative abundance of (**A**) *Dipturus batis*, (**B**) *Dipturus nidarosiensis* (denoted with an asterisk) and *Dipturus oxyrinchus*, (**C**) *Leucoraja circularis* and (**D**) *Leucoraja fullonica.*

Distribution of juvenile elasmobranchs

Raja clavata was the most abundant rajid in the surveys, and sites with a high relative abundance of juveniles included the Thames Estuary, north-eastern English Channel, northern Bristol Channel, Cardigan Bay, Luce Bay and Solway Firth (Fig. 10a). The distribution of *R. montagui* was broadly similar to that *of R. clavata*, and a high abundance of juveniles was recorded in Cardigan Bay, off the east coast of Ireland and around Anglesey (Fig. 10b). Juvenile *R. brachyura* were caught infrequently, although they were recorded in the Bristol Channel, Cardigan Bay and Irish Sea, and off Poole and in Start Bay within the English Channel (Fig. 10c). Juvenile *R. microocellata* were most common in the Bristol Channel and especially in Carmarthen Bay (Fig. 10d).

Juvenile *S. canicula* were caught frequently in the Celtic Sea (Fig. 11a), but seldom caught during beam

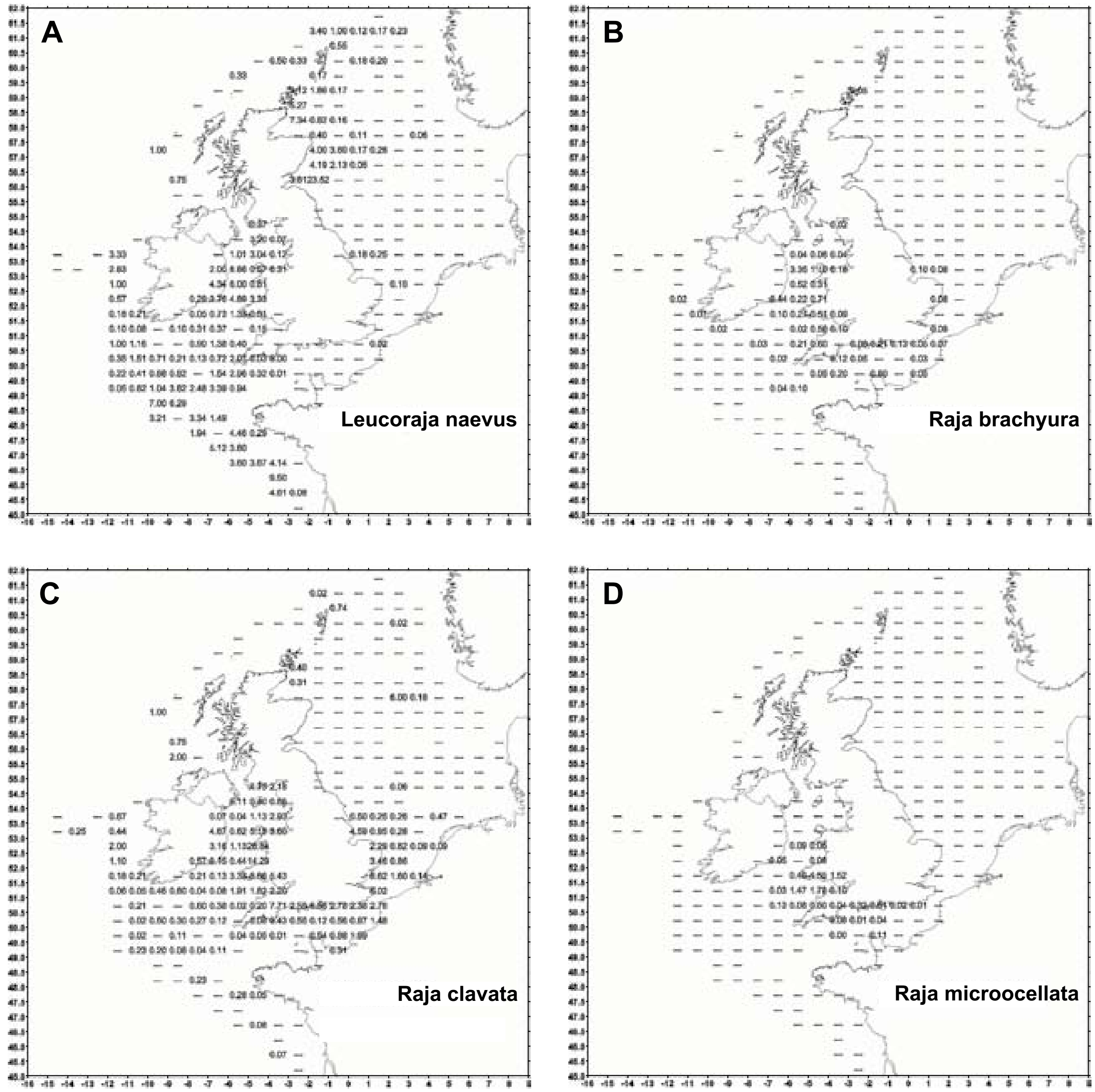

Fig. 7. Distribution and relative abundance of (**A**) *Leucoraja naevus*, (**B**) *Raja brachyura*, (**C**) *Raja clavata* and (**D**) *Raja microocellata.*

trawl surveys, although this gear catches large numbers of mature and maturing specimens. Juvenile *S. acanthias* were recorded regularly from the North Sea and Celtic Sea (Fig. 11b), though their apparent absence from the English Channel and Irish Sea is probably due to beam trawls not sampling this species effectively. Areas with high catch rates of juveniles occurred in the Celtic Sea, off south-west Ireland and east of the Orkney Islands. The high catch rate north of Ireland was based on low sampling effort. Juvenile *L. naevus* were rarely caught in the English Channel and Bristol Channel and were more abundant in the southern Irish Sea and St George's Channel (Fig. 11c). Juveniles were also caught in the Celtic Sea and north-western North Sea, although these areas are surveyed by PHHT and GOV trawl respectively, which may not be the most suitable gears for sampling juvenile rajids. There were few instances of juvenile *D. batis*, and all specimens caught were from the Celtic Sea (Fig. 11d).

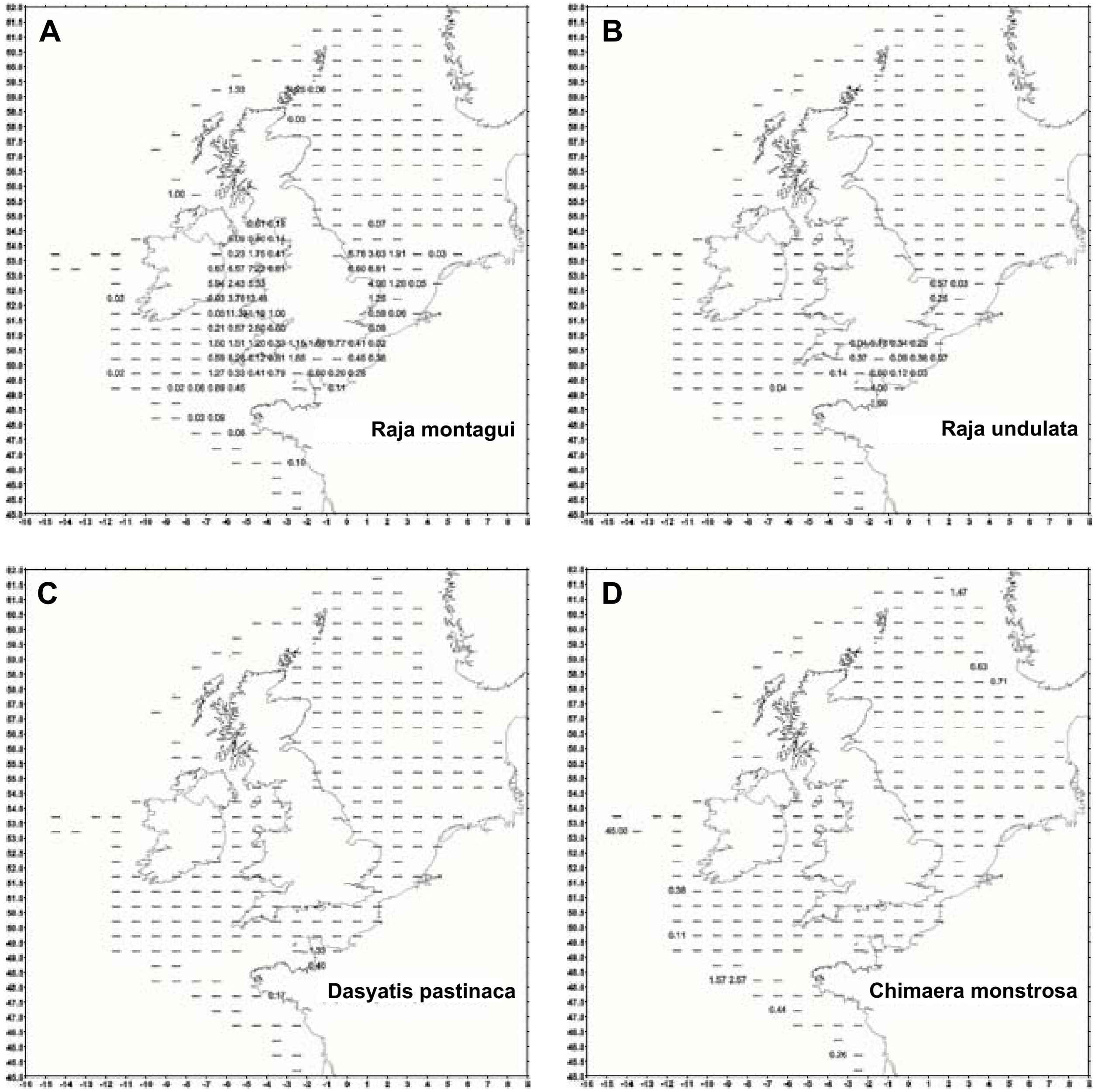

Fig. 8. Distribution and relative abundance of (**A**) *Raja montagui*, (**B**) *Raja undulata*, (**C**) *Dasyatis pastinaca* and (**D**) *Chimaera monstrosa.*

Triakid sharks are an important component of UK recreational fisheries, although very little published information exists for the location of parturition areas or nursery grounds. Juvenile *G. galeus* were caught routinely in the southern North Sea (Fig. 12a). *M. asterias* were caught frequently in the inshore waters of England and Wales, particularly off the south coast of England, outer part of the Thames Estuary and Bristol Channel (Fig. 12b). Juvenile *M. mustelus* were only caught occasionally, usually in coastal areas (Fig. 12c). Juveniles of *S. stellaris* were caught occasionally in the southern North Sea, the central parts of the eastern English Channel and around the Lleyn Peninsula and Anglesey (Fig. 12d). *S. canicula* egg-cases were caught regularly during beam-trawl surveys. Large numbers of egg cases were caught at certain sites in the northern Bristol Channel and English Channel (Fig. 13), and the largest catches of egg cases were associated with dead man's fingers (*Alcyonium digitatum*) and the

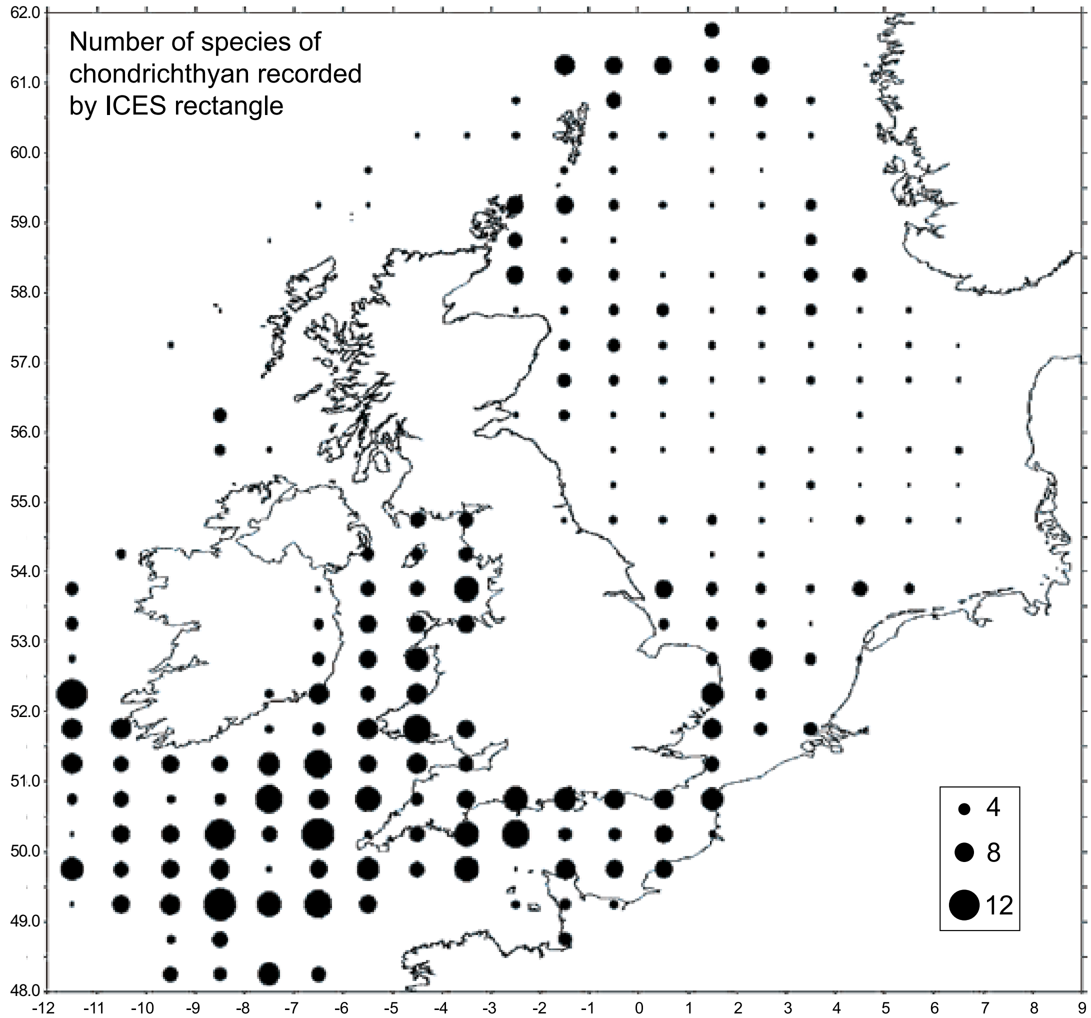

Fig. 9. Spatial variation in the number of chondrichthyan species recorded by ICES rectangle during CEFAS groundfish surveys.

bryozoan *Flustra foliacea*. Other substrates important for the deposition of eggs included the bryozoan *Cellaria* sp., hydroids (including *Hydrallmania falcata, Nemertesia antennina* and *Tubularia indivisa*) and sponges (e.g. *Haliclona oculata*).

Discussion

Knowledge of the distribution and relative abundance of fishes can assist fisheries managers with the identification of i) stocks, ii) areas of high biological production and diversity, iii) areas with species of conservation interest and iv) sites where particular life-history stages (e.g. spawning and egg-laying sites, nursery areas) occur. In the absence of accurate commercial landings data for many elasmobranch species, the information from fishery-independent groundfish surveys is especially important. Furthermore, the data collected in such surveys can be incorporated into stock assessments (Pastoors, 2002). The elasmobranch fauna in the waters surrounding the British Isles can be broadly attributed to the following groups:

a) Boreo-Arctic species; occurring in the North Sea only (*A. radiata*).

b) Deep-water species; distributed along the outer continental shelf and shelf edge of the Celtic Sea and, for some species, the northern North Sea (*H. griseus, D. licha, E. spinax, G. melastomus, D. oxyrinchus, D. nidarosiensis,* and *C. monstrosa*). *D. batis* also exhibited this distribution pattern, although it is known to have been more widespread in inshore areas at the beginning of the 20th century (Brander, 1981; Dulvy *et al.,* 2000).

c) Offshore species found along the continental shelf, but which are not abundant in inshore waters (*L. circularis, L. fullonica* and *L. naevus*).

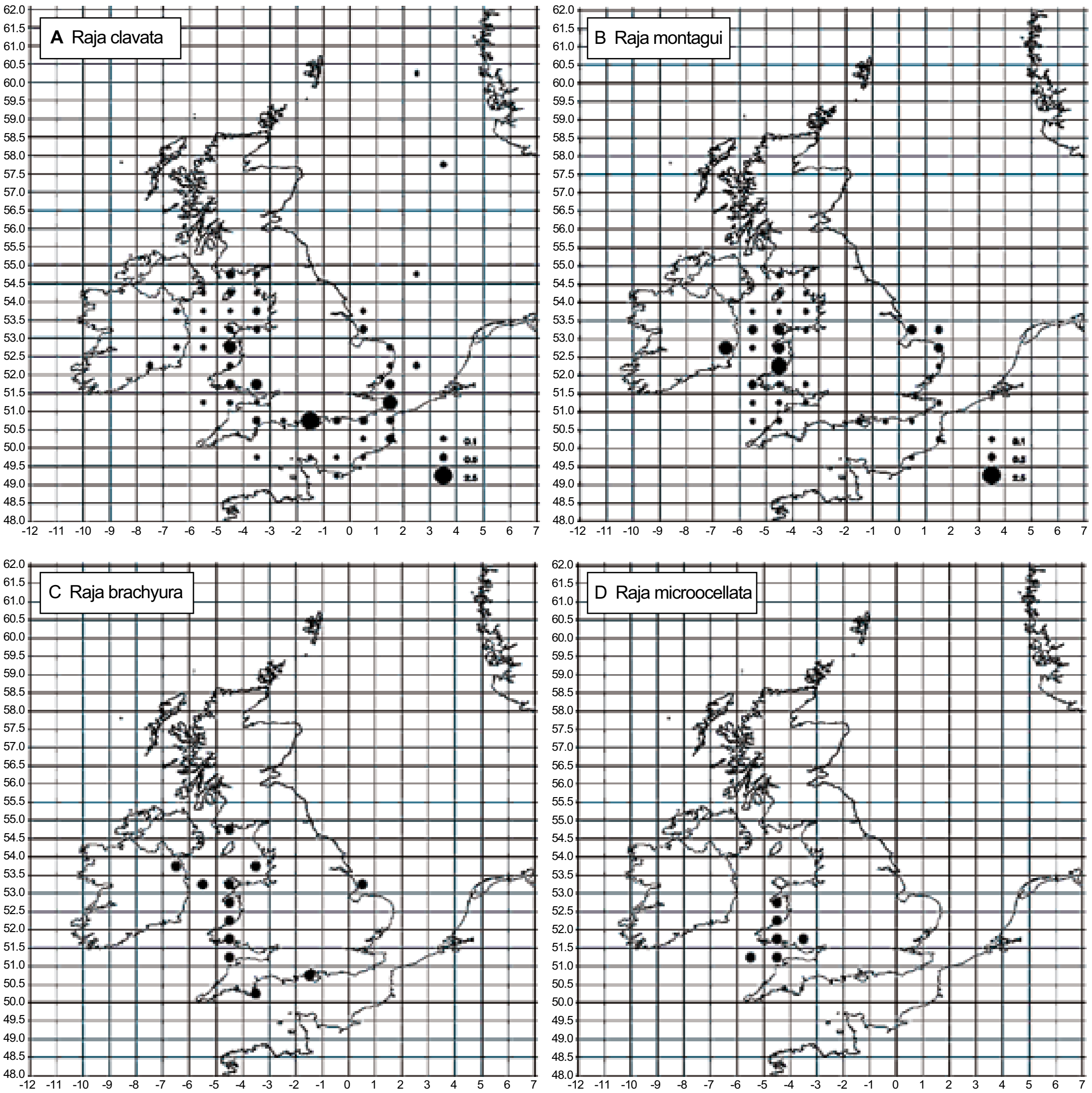

Fig. 10. Distribution and relative abundance (total number of individuals/total number of tows) of juvenile (≤ 20 cm) (**A**) thornback ray and (**B**) spotted ray, and distribution of juvenile (**C**) blonde ray and (**D**) smalleyed ray from CEFAS groundfish surveys.

d) Boreal/Lusitanean species; occurring all around the British Isles (*S. acanthias, S. canicula*, *G. galeus, M. asterias, R. clavata* and *R. montagui*).

e) Southern species that were more abundant along the south-western coasts of the British Isles and rarely recorded in the central and northern North Sea (*S. stellaris, M. mustelus, R. brachyura, R. microocellata* and *R. undulata*).

f) Southern vagrants that were only occasionally recorded and are more common further south (*T. marmorata, T. nobiliana* and *D. pastinaca*).

The chondrichthyan fauna of the British Isles is comprised of approximately 50 species (Wheeler, 1992). Although pelagic sharks and most deep-water species were not sampled by our surveys, demersal species that would be expected to have been caught by the gears used in our study, if present in the area, include white skate (*Rostroraja alba*) and angel shark (*Squatina squatina*). Both these species are known to have declined during the 20th Century (Dulvy *et al.,* 2000; Rogers and Ellis, 2000) and neither was recorded in the survey data sets analysed. One juvenile angel shark was captured in Cardigan Bay during a charter vessel survey in 1999,

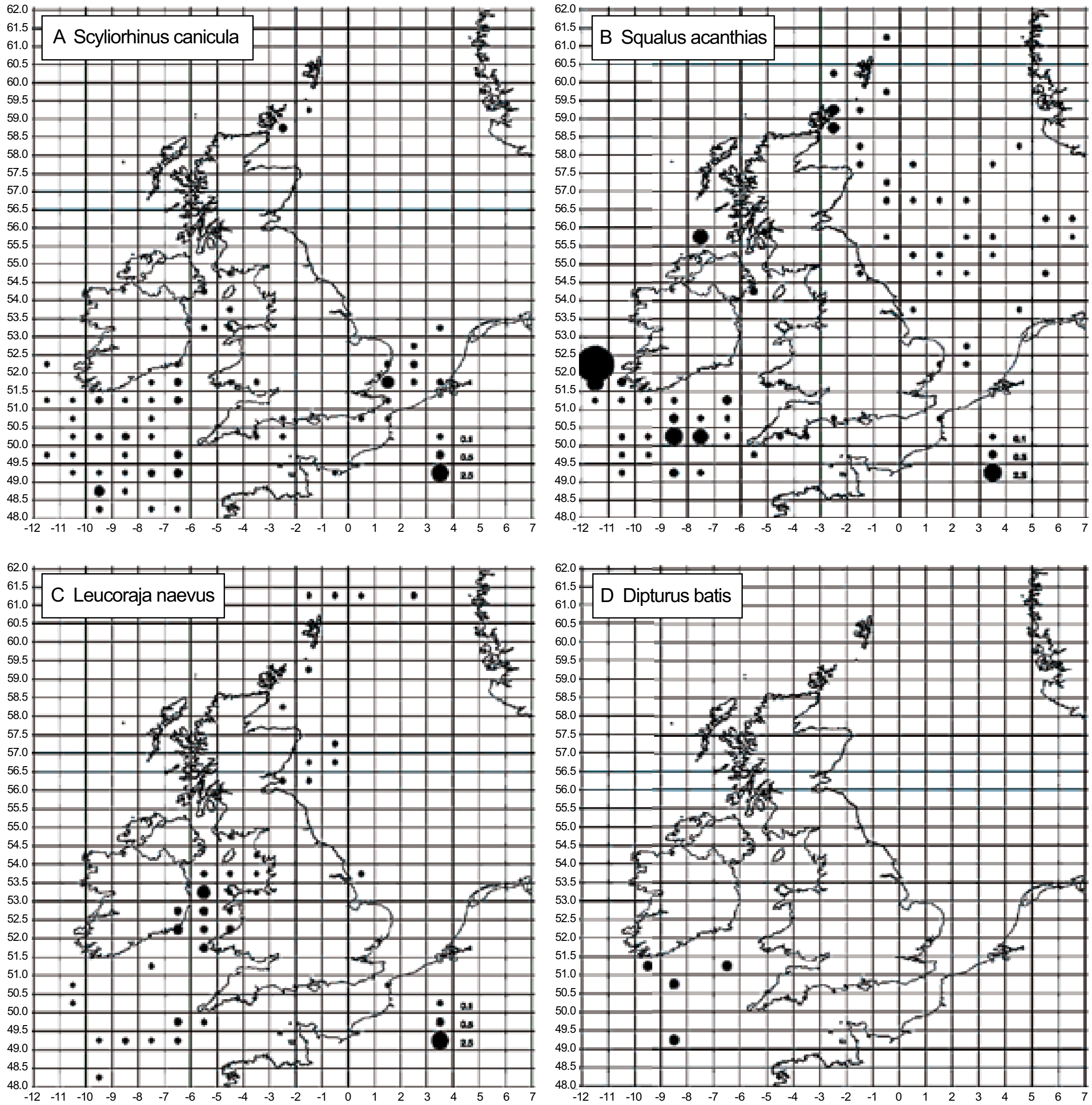

Fig. 11. Distribution and relative abundance (total number of individuals/total number of tows) of juvenile (**A**) lesser-spotted dogfish (≤ 15 cm), (***B***) spurdog (≤ 40 cm) and (**C**) cuckoo ray (≤ 20 cm), and (**D**) distribution of juvenile common skate (≤ 25 cm) from CEFAS groundfish surveys.

and they were occasionally caught in this area during earlier surveys in the 1980s (Ellis *et al.*, 1996). Further information regarding the current distribution of these species is required.

Overall, elasmobranch species (except *A. radiata*) were more abundant in the western parts of the study area, and a greater number of species were also recorded there. These results confirmed the observations of Rogers *et al.* (1998, 1999), who examined spatial differences in demersal fishes from beam-trawl surveys. The current study included data from other gears, which increased the survey area to include the central and northern North Sea and Celtic Sea.

Knowledge of the location of nursery areas of elasmobranch fishes has been identified as a research requirement for the management of elasmobranch fisheries (e.g. Castro, 1993). Previously published studies have focused on sharks in the North-west Atlantic (Castro, 1993) and Australian waters (Simpfendorfer and Milward, 1993) and there is little information on nursery areas in North-west European waters. The most commercially important elasmobranchs in British fisheries are rajids

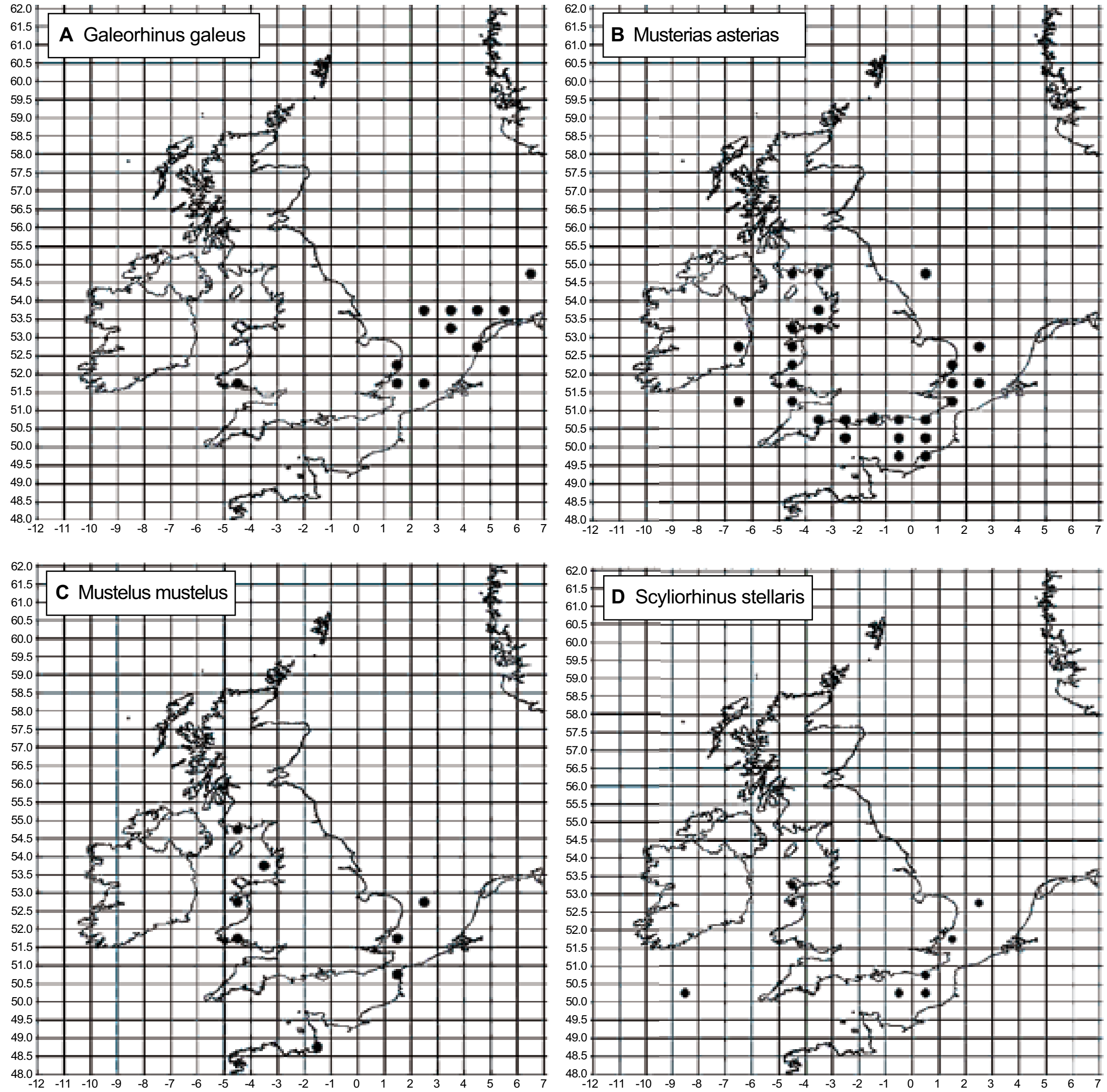

Fig. 12. Distribution of juvenile (**A**) tope (≤ 40 cm) (**B**) starry smoothhound (≤ 40 cm), (**C**) common smoothhound (≤ 40 cm) and (**D**) greater-spotted dogfish (≤ 20 cm) from CEFAS groundfish surveys.

and *S. acanthias*. Most other demersal elasmobranchs in British waters are non-target species, occasionally landed as by-catch. Several species of demersal elasmobranch, including triakid sharks and rajids, are, however, important species in recreational fisheries.

There is anecdotal evidence suggesting that rajids and other oviparous chondrichthyans, including chimaeroids, heterodontiform sharks and some orectolobiform sharks, have discrete spawning grounds (Dean, 1906; Smith, 1942). McLaughlin and O'Gower (1971) reported that the eggs of the Port Jackson shark (*Heterodontus portusjacksoni*) occurred in traditional oviposition sites, which were situated on shallow, sheltered reefs with well-aerated water. Able and Flescher (1991) reported 300 egg cases of the chain catshark (*Scyliorhinus retifer*) attached to the hydroid *Eudendrium* being caught in a bottom trawl, and suggested that *S. retifer* deposited their eggs in structured habitats which also served as nursery areas after hatching. *S. canicula* also deposit their eggs on a variety of upright structures, including macro-algae and, on offshore grounds, erect sponges, hydroids, soft corals and bryozoans (Ellis and Shackley, 1997).

Beam trawls retain many of these biogenic organisms, thus identifying the locations of certain oviposition sites. Large numbers of egg cases were collected from an *Alcyonium digitatum* bed in the Bristol Channel and

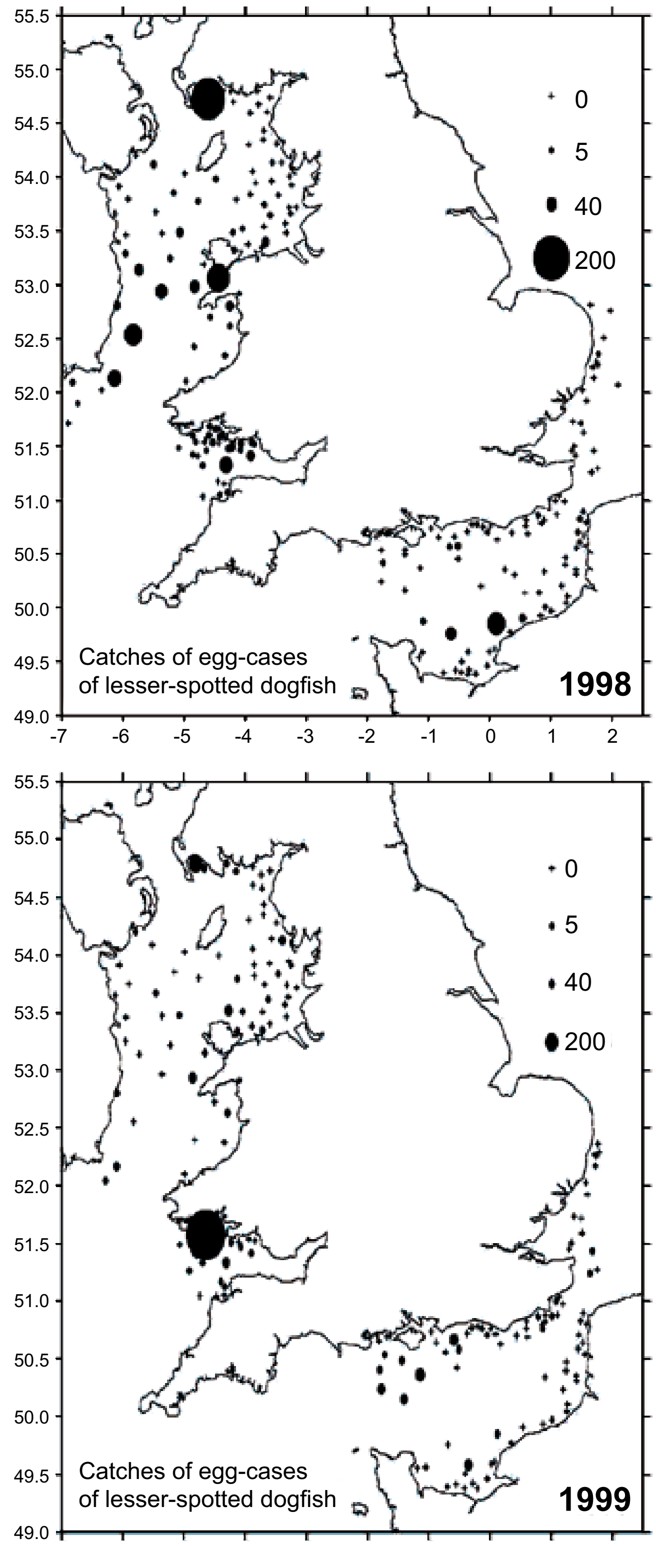

Fig. 13. Distribution and relative abundance of the egg-cases of lesser-spotted dogfish (*Scyliorhinus canicula*) from CEFAS beam trawl surveys in 1998 and 1999.

Flustra foliacea beds in the eastern English Channel. There were, however, insufficient data from beam trawl surveys regarding the distribution of neonatal *S. canicula,* which hatch at 90–112 mm length (Ellis and Shackley, 1997), and it is possible that juveniles occur on grounds that are too rough to fish with beam trawl. Juvenile (≤ 15 cm) *S. canicula* were frequently caught by PHHT in the Celtic Sea. The egg-cases of *S. stellaris* were never caught in large numbers, and it is likely that they are laid primarily in shallow water, attached to macroalgae (Ford, 1921; Orton, 1926). Large numbers can be found on the strandline on beaches along the Lleyn Peninsula (Ellis, pers. obs.), supporting the view that this is an important area for this species.

Despite the economic importance of rajids in the North-east Atlantic, their reproductive biology, including egg-laying habits, is poorly known. In captivity, *R. clavata* tend to lay one pair of eggs on alternate days over a spawning period of a few weeks (Ellis and Shackley, 1995), although, for the population as a whole, the egg-laying season is more protracted (Holden, 1975). Spawning migrations have been suggested for several species and, for example, Holden (1975) described parts of the Wash as grounds where female *R. clavata* would congregate. Rajid egg cases have horns and an "adhesive film" for anchorage, but little is known about the types of substrates on which they are laid and whether certain sites are preferred. Williamson (1913) reported that large numbers of skate eggs were taken off the shoal water on Aberdeen Bank. Similarly, large numbers of egg cases (up to 152 per 30 minute tow of a scallop dredge) of '*Raja*' *binoculata* have been reported off the coast of Oregon (Hitz, 1964).

Although rajid egg cases were caught occasionally in the current study, they were not caught in large quantities and additional information identifying egg deposition sites is required for the accurate identification of important egg-laying sites. Data for the distribution of juvenile rajids were more comprehensive and the present study indicated some of the areas that were important for juveniles. Such areas included the northern Bristol Channel (*R. clavata, R. microocellata* and *R. montagui*), St George's Channel (*R. brachyura* and *L. naevus*), and Cardigan Bay, Luce Bay/Solway Firth and the north-east English Channel (*R. clavata* and *R. montagui*). Neonatal *R. microocellata* were caught infrequently, and they may prefer shallower waters than those surveyed, as they are comparatively abundant in beach seine surveys along the sandy shores of the northern Bristol Channel (Ellis, pers. obs.).

Data on the distribution of juveniles of other species were limited. There were some instances of large numbers of juvenile (≤ 40 cm) *S. acanthias* in the Celtic Sea and off the Orkney Islands. *S. acanthias*, however, school by sex and size (Hickling, 1930) and whether or not there are discrete parturition and nursery areas requires further study. Hickling (1930) caught large numbers of new-born and pregnant *S. acanthias* in relatively shallow waters (e.g. Bantry Bay and Galway Bay), and postulated that the young moved away from shallow waters after parturition. Juvenile triakids, including specimens with umbilical scars, were regularly caught in shallower areas (e.g. southern North Sea/Thames Estuary and Bristol Channel). Although juvenile triakids were not generally captured in the Celtic Sea, gravid *G. galeus* and *M. asterias* with near-term embryos were caught during these March surveys (Ellis, pers. obs.).

Current conservation measures for elasmobranchs in UK waters principally involve Sea Fisheries Committees' byelaws stipulating a minimum landing size in certain coastal areas, and an EC TAC for "skates and rays" in the North Sea. Once the locations of spawning and nursery areas are known and delineated, and if juveniles are known to reside in these areas, then closed areas would be a possible option to reduce fishing mortality on juveniles of these species, if necessary. Such measures, however, may not reduce the mortality of mature females, which is another important consideration for elasmobranch fisheries (Cortés, 1999; Simpfendorfer, 1999). Marine Protected Areas and No Take Zones have been suggested as measures for protecting biodiversity, habitats, ecosystems and endangered species, and it has been suggested that closed areas could be an effective method for the management of some elasmobranch species, providing that they are used in conjunction with other management techniques (Bonfil, 1999; Horwood, 2000). However, closed areas do not necessarily decrease the overall fishing effort, but may displace fishing activities to other areas, and so the potential effects of increased fishing effort in surrounding areas should always be considered.

Potentially useful closed areas for elasmobranchs could include sites that are important for parturition/egg-laying, juveniles, species of conservation importance (e.g. *D. batis*), and species with localised distributions. Several inshore grounds, including the outer Thames Estuary and Bristol Channel (including Carmarthen Bay) had a high relative abundance of juvenile *Raja* spp. and triakid sharks, and juvenile *L. naevus* were most abundant in St George's Channel. Sites with a high relative abundance of species with localised distributions included the Lleyn Peninsula and Anglesey (*S. stellaris*), Bristol Channel (*R. microocellata*) and English Channel (*R. undulata*). The distribution of ICES rectangles that were important for demersal elasmobranchs (Fig. 14) indicated that

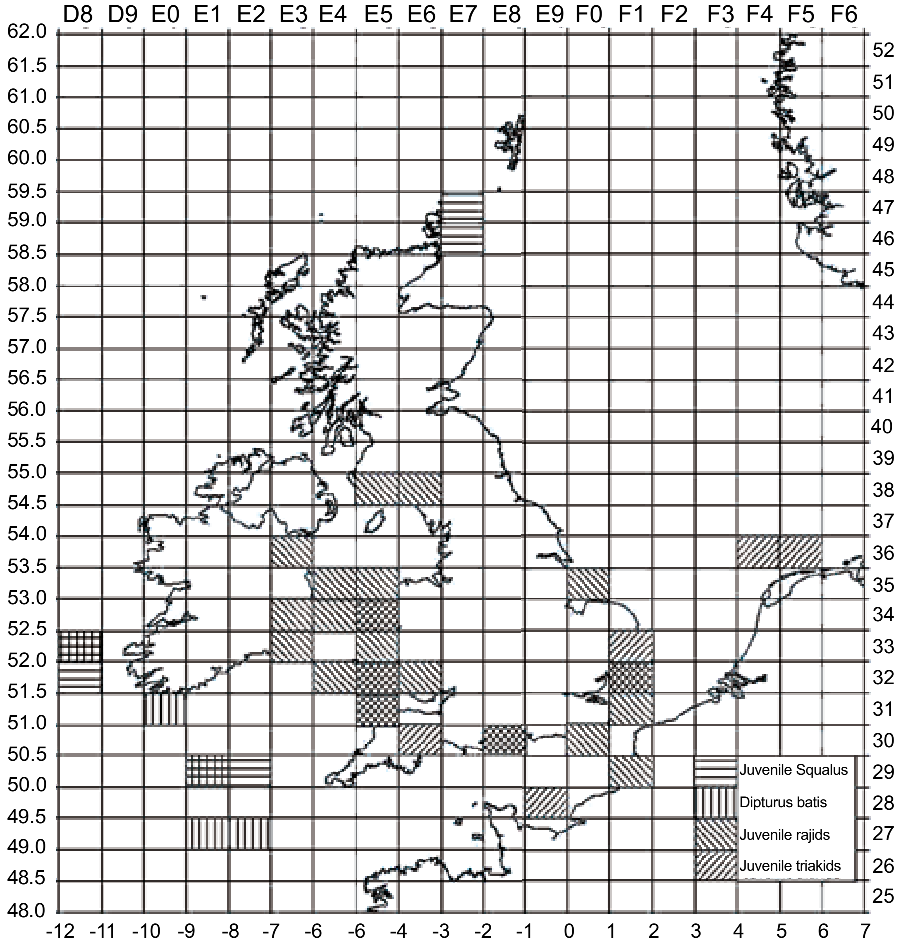

Fig. 14. ICES rectangles that contain important grounds for *Dipturus batis* and juvenile rajids, triakids and *Squalus acanthias*.

the outer Thames estuary (32F1), Isle of Wight (30E8). Bristol Channel (31E5–32E5) and Lleyn Peninsula (34E5) contained important nursery grounds for rajids and triakids, juvenile *S. acanthias* occurred in the Celtic Sea and off Scotland, and that *D. batis* were caught most regularly in the Celtic Sea.

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