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IS THE LESSER SPOTTED DOGFISH (*Scyliorhinus canicula*) FROM THE CANTABRIAN SEA, A UNIQUE STOCK ?

by

Rodríguez-Cabello, C., F. Sánchez, A. Fernández and I. Olaso

Instituto Español de Oceanografía
Apdo. 240. Santander. Spain

ABSTRACT

A summary of the information recorded from tagging surveys since 1993 for *S. canicula* in the VIIIc ICES area is presented. A total of 6619 specimens have been tagged, the recapture rate being around 2.3 %. The maximum distance recorded has been 158.9 miles while the 70 % of the specimens recaptured were in less than 15 miles and 56 % less than 10 miles. From this data, a priori, we can affirm that this specie remains in certain areas, making short movements. At the moment no differences are found between males and females and no seasonal pattern is detected. Apparently, there is no a relation between time at liberty and distanced covered. Spatial and bathymetrical distribution of both juveniles and adults of this specie is presented and combined with the previous one to describe the habitat of this specie.

INTRODUCTION

One of the essential requirements in stock assessments is to define the area of distribution and its limits. A number of stock definitions have been proposed ranging from those focus on fish stock management to those that deal with genetic discreteness and biological characteristics. The general definition is a species group or population of fish that maintains and sustains itself over time in a definable area (Booke, 1981).

Among the methods used in trying to identify stocks are: population parameters, abundance and distribution, tagging, natural marks (parasites), physiological and behavioural characters, morphometric and meristic studies, genetic studies (a good review can be found in (Anon, 1996; Begg *et al*., 1999; Ihssen *et al*., 1981; Marr, 1957 and Pawson and Jennings, 1996) among others.

Dogfish is an extremely common shark on the NE Atlantic coast, it extends from Senegal northward along African and European coasts to the Shetlands and southern Norway (Springer, 1979), it is also found in whole of Mediterranean and Adriatic sea, except for the Black Sea (Bänarescu, 1969) and the Red Sea (Gohar and Mazhar, 1964). Wheeler (1969,1978) and Compagno (1984) suggested that this species is found particularly over sandy, gravely or muddy bottoms at depths of a few meters to 400 m, mainly 110 m. In the Cantabrian Sea *S. canicula* is quite an abundant specie found at depths ranging from 50-500 m, commonly from 150-300 m (Sánchez, 1993; Sánchez *et al*., 1995).

The Cantabrian Sea is considered as the southern region of the Bay of Biscay (ICES Division VIIIc) its western limit corresponds to adjacent waters of the Galician shelf (the upper limit of subtropical area) and to the east it is delimited by the beginning of the French shelf (Cap Breton canyon). The continental shelf is relatively small in comparison to adjacent areas and very abrupt. By its situation in the Bay of Biscay it is not only a well delimited area but a geographical zone with particular characteristics that difference it from the rest of the Atlantic. Biologically the Cantabrian Sea area is the subtropical-boreal transition zone of the Eastern Atlantic.

One of main objectives of DELASS project (Development of Elasmobranch Assessments, CFP 99/055) is to look for stock discrimination or stock identity among different elasmobranch species in European waters. Within the framework of this project the aim of this study was to define the area and distribution limits of this specie (based on data from bottom trawl surveys and in data obtained from mark and recaptured experiments) as well as to describe the movement pattern of this specie in order to identify the stock which might serve for management purpose.

MATERIAL AND METHODS

a) Scientific surveys

The Spanish Institute of Oceanography (IEO) carries out annually bottom trawl surveys along the continental shelf of the Cantabrian Sea in order to estimate the abundance index of the commercially interesting demersal and benthic species. These surveys are based on the stratified sampling methodology, using bottom trawl gear and haul duration is 30 minutes and the depth covered range from 30 m to 600 m (Sánchez *et al*., 1995; ICES, 1999). The historical survey series starts in 1983 and regularly are carried out in autumn although some surveys were also accomplished in spring during the 80's. A preliminary analysis demonstrates that the abundance distribution pattern is quite similar over the years, for that reason in this study surveys corresponding to last three years 1997, 1998 and 1999 are taken as example of autumn features and surveys from 1986, 1987, 1988 are chosen for spring. With the data obtained from this surveys geostatistical analysis have been performed. To discriminate among juveniles and adults, juveniles were considered less than 20 cm (1 year old). No bottom temperatures were recorded during spring surveys.

b) Tagging data

Since 1993 a dogfish tagging program is also being carried out in these surveys. A total of 6619 specimens have been tagged with T-bar anchor tags using a Mark II regular tagging gun (Table I). From 168 recaptures received till date, 142 provide information of the capture position and have been used in this study. To describe the movement and directional pattern of this specie different analysis have been applied (Jones, 1959; 1976; Sheridan and Castro, 1990). Once the direction for each individual was obtained all the recaptures were grouped in eight sectors. Chi-square analysis was performed to test different hypothesis ($P<0.05$) concerning to seasonal trends or sex bias. The assumption that dogfish moved equally into all octants was also tested by Watson´s U^2 test for uniform circular distributions to compare the results (Zar, 1984).

RESULTS

a) Scientific Surveys

Despite spring and autumn surveys correspond to different time periods, the historical abundance serie indicates that the abundance index remains more or less stable without large variations in the last twenty years (fig. 1). The spatial distribution of juveniles and adults of this specie is shown in figures 2 and 3 respectively. Concerning to the spatial distribution it draws the attention that juveniles are mostly located in the eastern area of the Cantabrian Sea. The same pattern is found either in spring or summer, the only difference is the number of individuals per haul which is higher in spring.

The adult population does not present signs of discontinuity along the continental shelf. A patched distribution is observed with higher concentrations in certain areas which are recurrent each year. Similar abundance and distribution is found in both seasons with minor differences probably due to common variability among years. The less abundance is found in the western area (Galician waters) and particularly in the southern area.

The bathymetrical distribution of this specie is shown in figures 4a and 4b respectively. In the Cantabrian Sea the juveniles (< 20 cm) are mostly found in depths around 200 m, with a slight difference between spring (200-300 m) where there is also a peak at 300 m and autumn (150-200 m), being more abundant in spring. In less than 100 m depth only adults (> 20 cm) appear, being more abundant in autumn. Between 100 m and 200 m most of the population is well represented in both seasons. In more than 200 m juveniles are clearly more abundant and also a fraction of adults composed of mature fish (50-65 cm) is present. In general terms this specie tends to move to deeper waters in spring than in autumn, this was already reported by (Sánchez *et al*., 1995).

Temperature distribution for this specie in the study area range from 11ºC to 18 ºC in autumn surveys. Juveniles are preferably found in waters around 12 ºC while adults have a wider range of temperature being more abundant in waters around 14-15ºC. In general terms juveniles occupied colder waters than adults and have a narrower temperature range (fig. 5).

b) Mark-Recapture data

All the recaptures are located in the same tagging area along the continental shelf of the Cantabrian Sea (fig. 6). The majority of the specimens recaptured were adults of both sexes ranging from 44 cm to 68 cm (fig. 7).

The analysis of the recapture data displays that this specie does not make long trails, being the 70 % of the recaptures in less than 15 miles (fig. 8). The minimum and maximum distance covered by a dogfish in this study has been 0 miles and 158.9 respectively. In fact four specimens were recaptured in the same position a year later. No differences were found between sexes. Also no relationship is found between time at liberty and distance covered (fig. 9).

The chi-square analysis based on the octant distribution shows that the dogfish has not a random movement ($P>0.05$), (fig 10). The same hypothesis based on vector analysis gives identical result thus, rejecting the null hypothesis that data are distributed uniformly.

Considering only the recaptures made by the commercial fleet and assuming that the effort is more or less constant along the year a chi-square test was performed to test the null hypothesis that the number of recaptures was independent of the month, we obtain a P=10.2. ($P<0.05$) thus, not rejecting the null hypothesis. The same test realised to find out if Ho: the number of recaptures by month is independent of the sex provide a chi value=4.4 ($P<0.05$) thus, not rejecting Ho (fig. 11).

DISCUSSION

Geographical and bathymetrical distribution.

There is no clear discontinuity in the distribution of lesser spotted dogfish in the Cantabrian Sea. This specie usually presents unisexual aggregations and less frequently aggregations by size (de la Gándara *et. al*.,1994). Spatial distribution of adults obtain from surveys made in different seasons show no differences at all. On the contrary juveniles are much less abundant than adults independent of the season and are found in high concentrations in the south east corner of the Bay of Biscay. A priori this area combines a series of conditions which favour greater abundance of juveniles, although at the moment the cause is not known since the sea bed, the depth and bottom temperature are very similar to other adjacent areas. One theory is that this area is characterised by the occurrence of many deep rocky patches (>200 m) close to soft bottom grounds which would favour egg-laying. This hypothesis is based in the fact that is quite frequent to find egg-capsules attached to the bottom fauna on sessile erected invertebrates like sponges, hydroids and bryozoans. This circumstance has also been reported by other authors (Ellis and Shackley, 1997, Rodríguez-Cabello *et al.*,1998). The minor abundance of juveniles with respect to adults is probably due to the difficult accessibility of this fraction of the population to the fishing gear for being in rocky bottoms.

Spawning is supposed to take place in shallow waters near the coast (Wheeler, 1969, Compagno, 1984, Múñoz-Chápuli, 1984, Capapé *et al*., 1991). Compagno (1984) reported that juveniles were distributed in shallower water than adults which often occurred in unisexual schools. Múñoz-Chápuli (1984) in the NE Atlantic and Alboran Sea found adult female and male near the slope although females ascended to shallower waters on the continental shelf for egg-laying. D'Onghia *et al.* (1995) found juveniles and adults of both sexes and sizes together at depths greater than 200 m in the north Aegean Sea suggesting that spawning takes places mainly in the slope.

Unfortunately we do not have information from shallow waters or hard bottoms, so we can not conclude if juveniles are concentrated in these areas along the coast which might be the case since it is no reasonable that all the adults belong to this nursery area overall considering this specie has not a wide dispersion.

The segregation's of sharks into aggregations of the same sex and/or size, has been well described since long time, particularly for pelagic sharks (Backus *et al*., 1956; Bullis, 1967; Muñoz-Chápuli, 1984; Lessa *et al*., 1998), however in the case of demersal or bottom sharks not a general pattern can be defined. *Raja clavata* is known to lay the eggs in shallow waters and once the egg laying season is completed they segregated into single sex shoals in deeper water (Walker and Hessen, 1996). Springer (1967) hypothesis, derived from observations made on pelagic sharks, explains that the segregation of adult males and females during spawning avoids intraspecific predation. In the case on bottom sharks this has not been tested and although it might be the case for some species *S. canicula* diet in the Cantabrian Sea is based on a great proportion of discarded material (Olaso *et al*., 1998).

It is well-known that dogfish is an eurybathial specie found at depths of a few meters to 400 m (Wheeler, 1969,1978; Compagno,1984). In the Cantabrian Sea it is mostly found at depths from 100 to 300 m in both seasons, however juveniles (<20 cm) are more estenobatial than the adults and are more abundant in deeper waters and in spring which differs from juveniles of many other demersal species which are mostly found in shallower waters than the adults (Sánchez., 1993, de la Gándara *et al*., 1995). In less than 100 m depth only adults (> 20 cm) appear, being more abundant in autumn and in general terms this specie has a tendency to move to deeper waters in spring than in autumn (Sánchez *et al*., 1995) .

A study carried out by Sánchez *et al*. (1999) demonstrates that no significant differences exist between the abundance indices of commercial species on both sides of Cap Breton canyon, although significant differences exist in the length distributions.

As Sánchez and Gil (1994) pointed out lesser spotted dogfish has a wide range of temperature (11-17 ºC) although it prefers the warm waters on the medium continental shelf. Based on autumn surveys, juveniles are mainly found in colder waters than adults with less temperature interval. However this is expected since there is a strong relationship between bottom temperature and depth.

Mark-Recapture data

Both analysis based on circular statistics and number of recaptures in octants demonstrate that this specie has not a random movement. In fact the continental shelf narrower in the eastern area while is a little broad in the western part of the Cantabrian Sea, and this circumstance is also reflected in figure 10 where sectors 4 and 8 follow 3 and 7 in number of recaptures. As the continental shelf extends from east to west is not strange to find out more recaptures in these directions. Another point is that most of the recaptures have been reported from commercial trawlers (48.8 %) that work in soft bottoms at depths of 100 m or more (Table II). For this reason this directional pattern must be taken with caution since there exists some gear selectivity.

However this specie is supposed to move inshore waters or deeper areas for egg laying, which means that some directional movement towards the coast should be detected but not any outcome can be drawn out with the present data. The analysis of the number of recaptures per month, assuming a constant effort, indicates that there is not a seasonal basis for migration nevertheless more data is needed to check this assumption.

Octant analysis and vector analysis assumed uniform fishing effort in time and space as well as equal likelihood of movement in any direction (Sheridan and Castro, 1990). According to these authors catch and fishing effort have a critical influence on movement patterns that are estimated from recaptures by fishing fleets. For this reason they recommend to use recaptures per effort o per unit landings instead of other methods preferably restricted to determine qualitative directional movement.

Although individual movements of *S. canicula* can be up to 286 km the majority of the dogfish do not move further than 30 km. Four adult specimens recaptured were in the same position a year later, which supports the idea that they tend to remain in the same grounds if the conditions are suitable for them. Studies made on the thornback ray (*R. clavata*) stock in the North Sea provide similar results but in this case the majority of the rays move no further than 50-60 km and there are no long range or synchronised migrations of large group of rays (Walker *et al*., 1997). In the case of *R. clavata* one individual was recaptured on the same grounds on six occasions in a period of 14 months (Pawson, 1995).

The fact that the recapture rate is rather low (2.5%) and that all the specimens recaptured are adults is probably due to the discard of this specie by most of the fleet. The released and returned dogfish show good agreement in length composition except young specimens which are not usually reported probably due to the fact that the retained catch is usually composed by the biggest specimens (Rodriguez *et al*., 2001). There was not enough data to estimate movement patterns for juveniles and adults.

CONCLUSIONS

Lesser spotted dogfish is a quite abundant specie in the Cantabrian Sea (VIIIc ICES Division) found at depths ranging from 50-500 m, commonly from 100-300 m. It is distributed continuously along the continental shelf frequently forming unisexual groups and less regularly segregation's by size. The spawning or nursery areas are unknown; it is supposed to spawn in shallow waters near the coast. In the Cantabrian Sea juveniles are found in deeper waters (200-300 m) and mostly in the south east corner of the Bay of Biscay, although data from shallow waters (< 50 m) or hard substrates is not available.

Since 1993 a total of 6619 fish have been tagged, of which 151 were recaptured, often within a distance of 10 miles from the release area. Lesser spotted dogfish do not show a clear geographical migration. There is no relationship between time at liberty and distance travelled. There is no indication of sesonal trend in movement and not differential pattern is found between males and females. Not enough data is available to estimate movement parameters for juveniles and adults.

In general the species is not commercially exploited. The percentage discarded in commercial fishery is very high (90 %) and only bigger specimens (> 40 cm) are retained. For this reason the recapture rate is rather low (2.3 %) and the interpretation of tagging data must be taken with care.

There have been few studies on life history parameters on this specie. Some population differentiation exists between specimens from the Atlantic and the Mediterranean Sea. Apparently the latitudinal gradient has a notable influence in growth, maximum length and maturity length. Garman (1913) was perhaps the first one who pointed out that specimens from the Atlantic were considerably larger than those from the Mediterranean as far as to name a new species, *Catulus duhameli*, for Mediterranean *S. canicula*. This is generally not recognised although some population differentiation of this shark apparently exists as it is reported by other authors (Leloup et Oliverau, 1951; Mellinger and Wrisez, 1984; Muñoz-Chápuli et. al., 1984; Capapé et al., 1991; Springer, 1979). .

Landing data is available for Spain (VIIIc) and some data is obtainable from France and Portugal. For fisheries management purposes we suggest the population of the Cantabrian Sea should be treated as a single stock.

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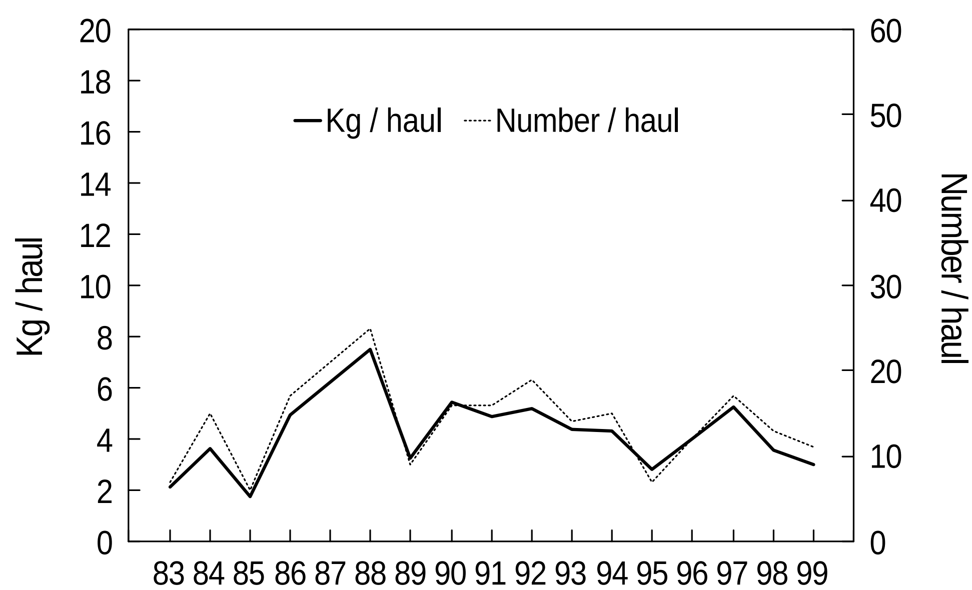

Figure 1. Historical series of abundance index for *S. canicula* based on autumn trawl surveys.

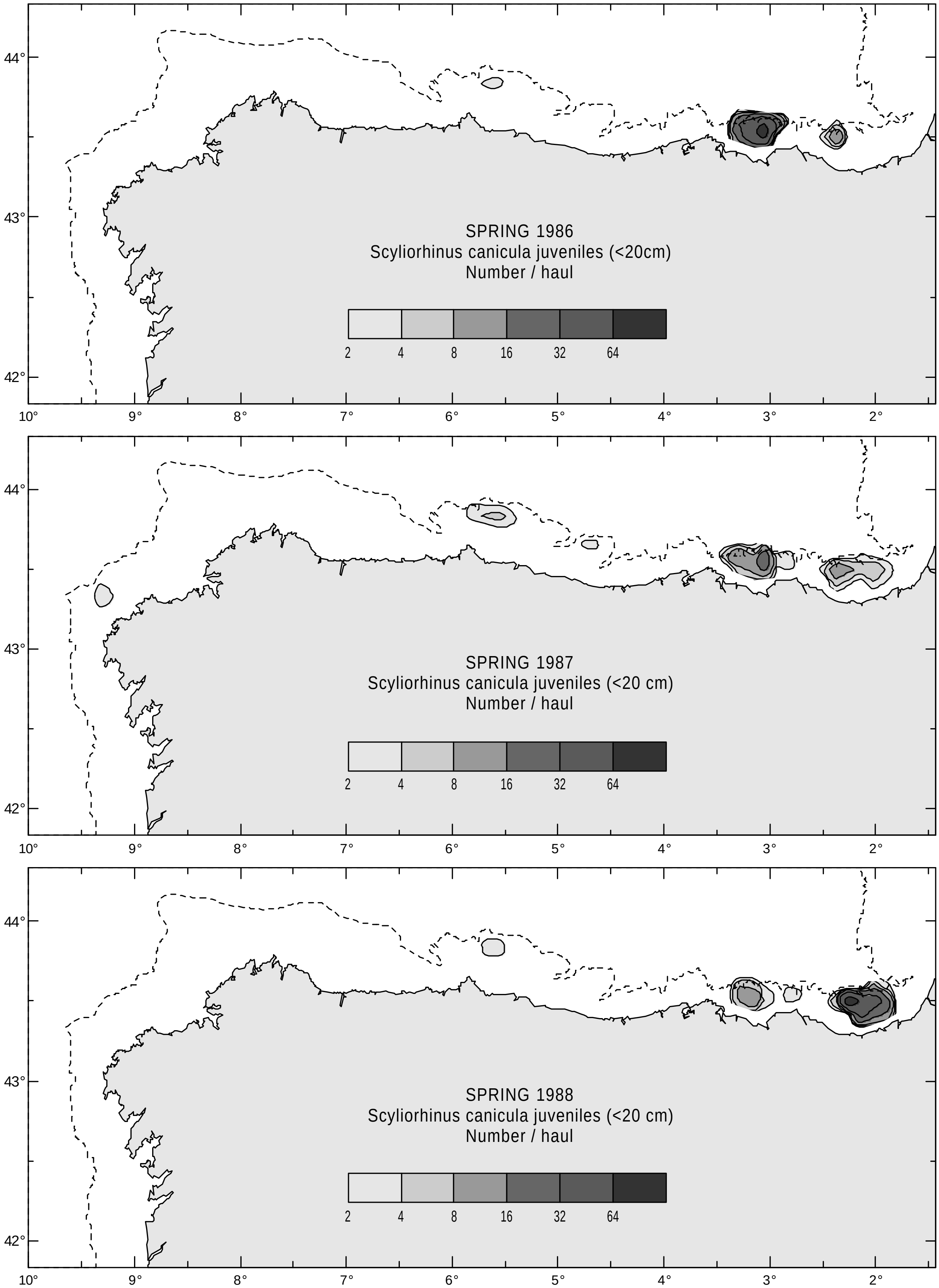

Figure 2a. Spatial distribution of juveniles in spring.

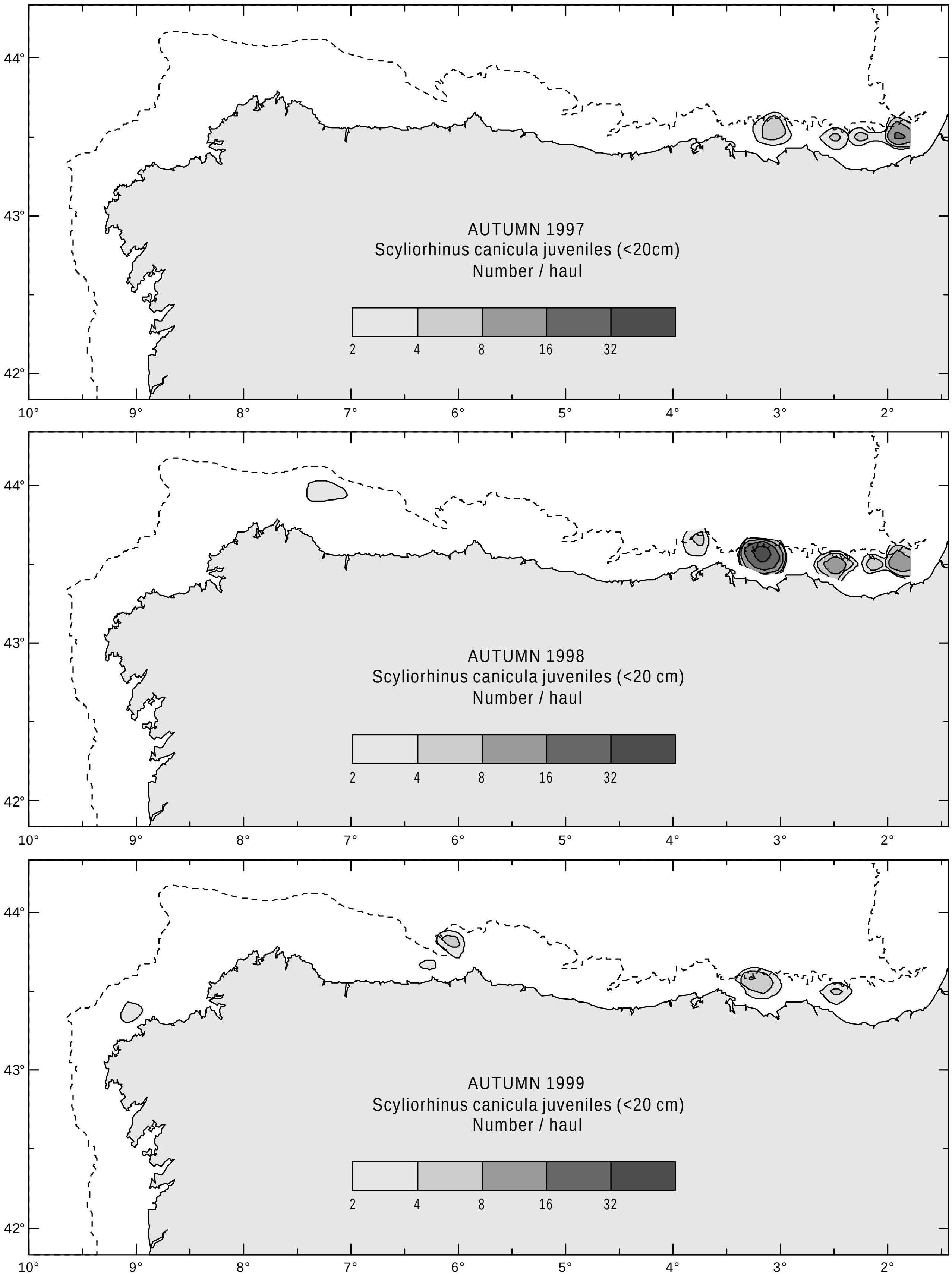

Figure 2b. Spatial distribution of juveniles in autumn.

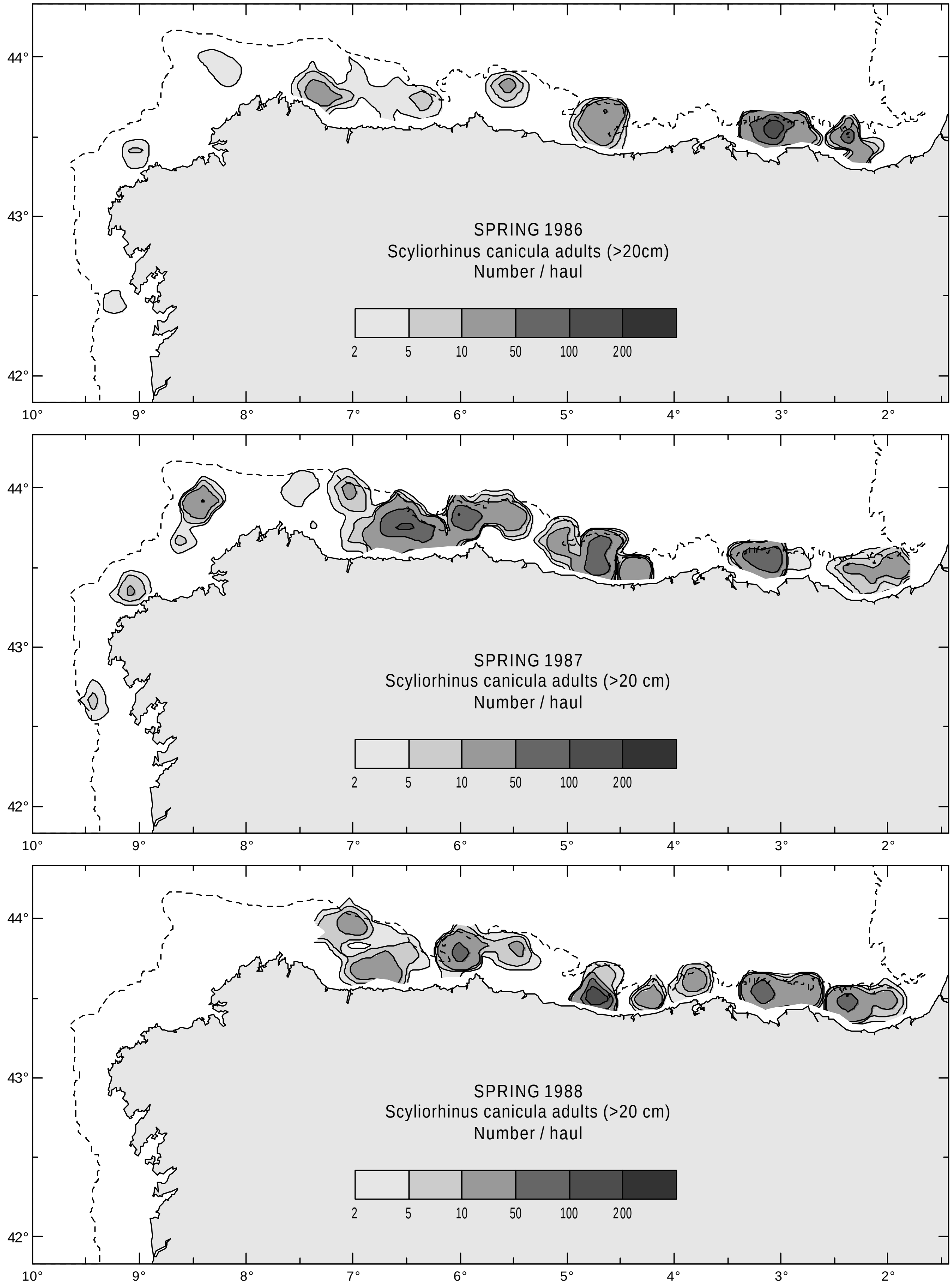

Figure 3a. Spatial distribution of adults in spring.

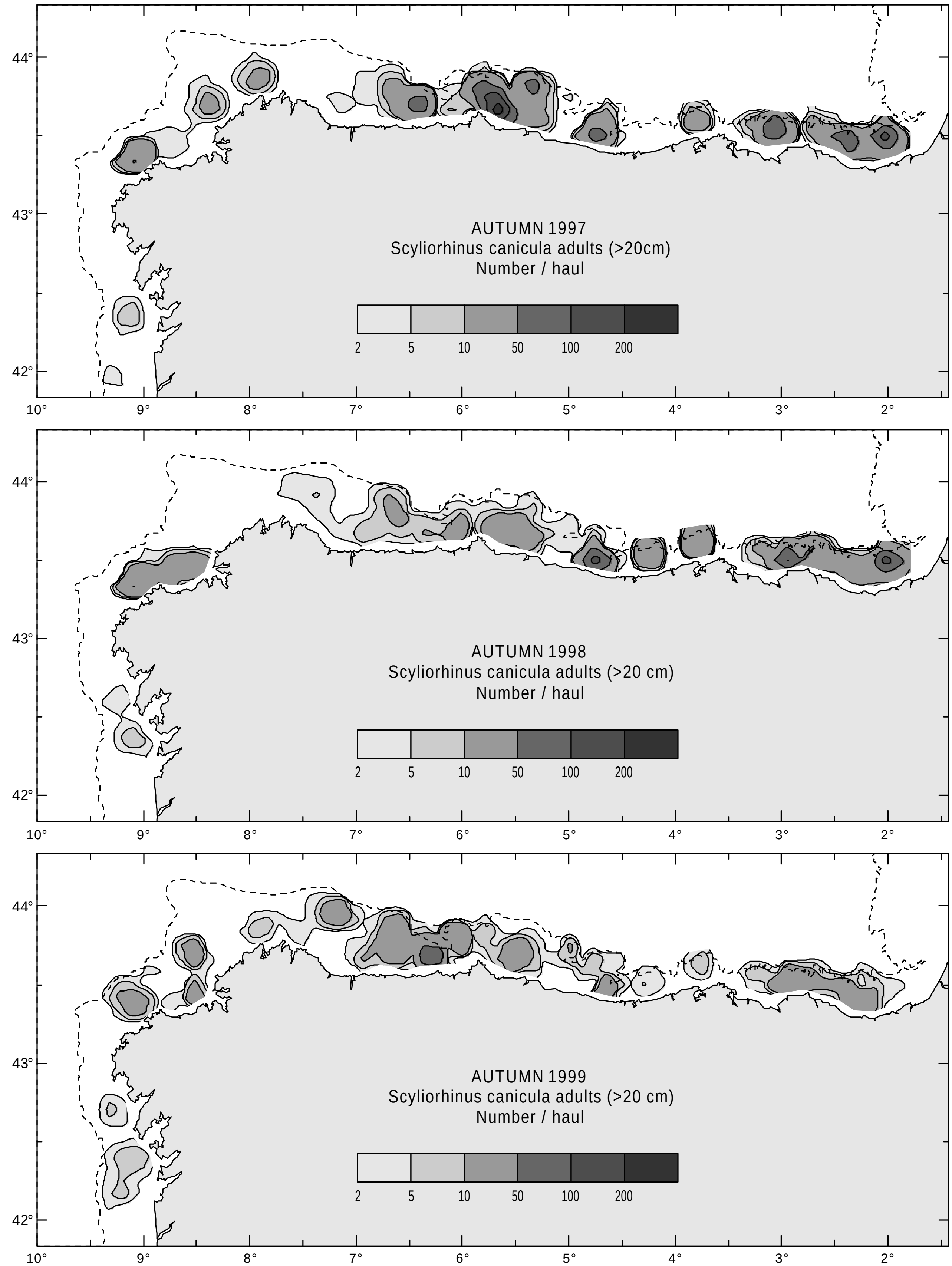

Figure 3b. Spatial distribution of adults in autumn.

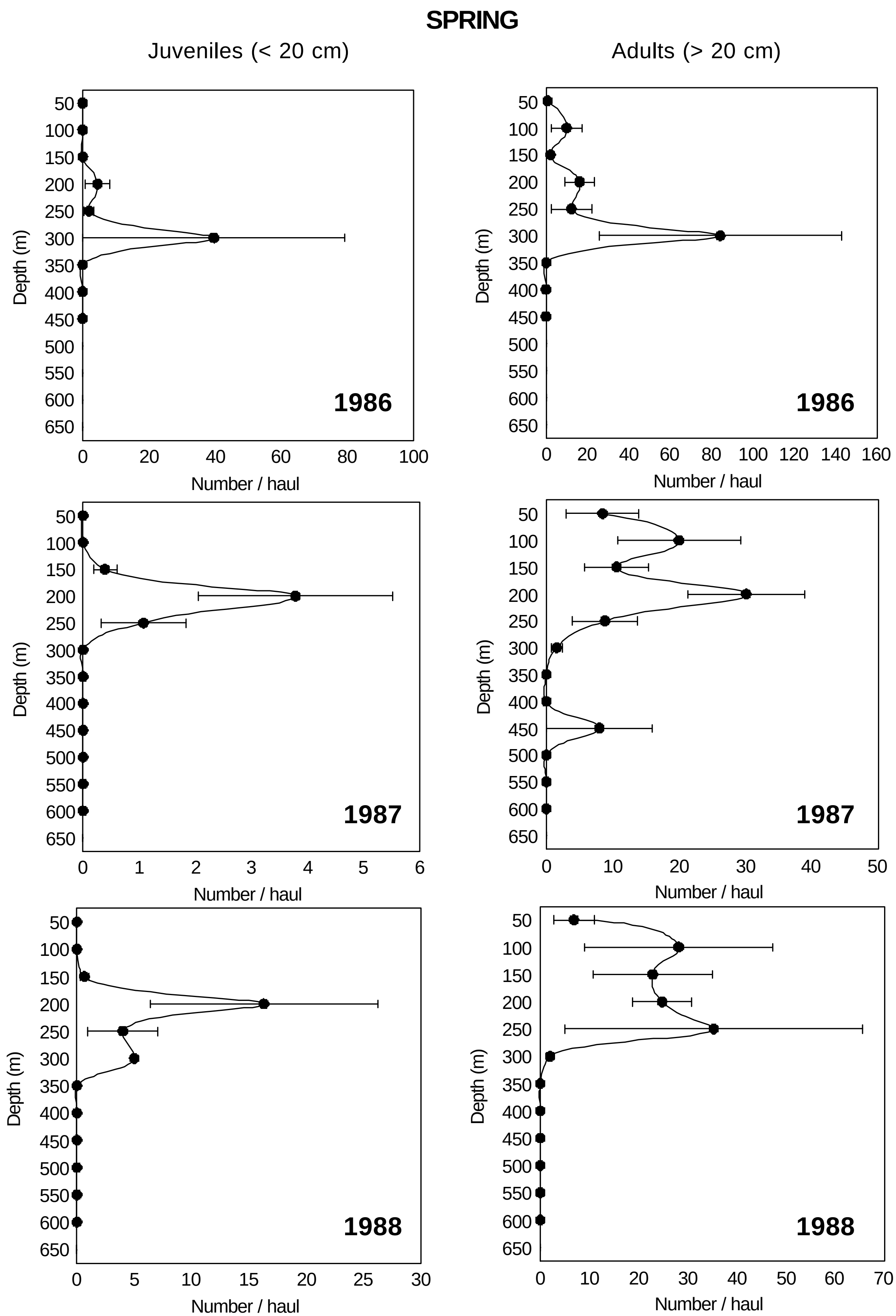

Figure 4a. . Bathymetrical distribution of juveniles and adults in spring.

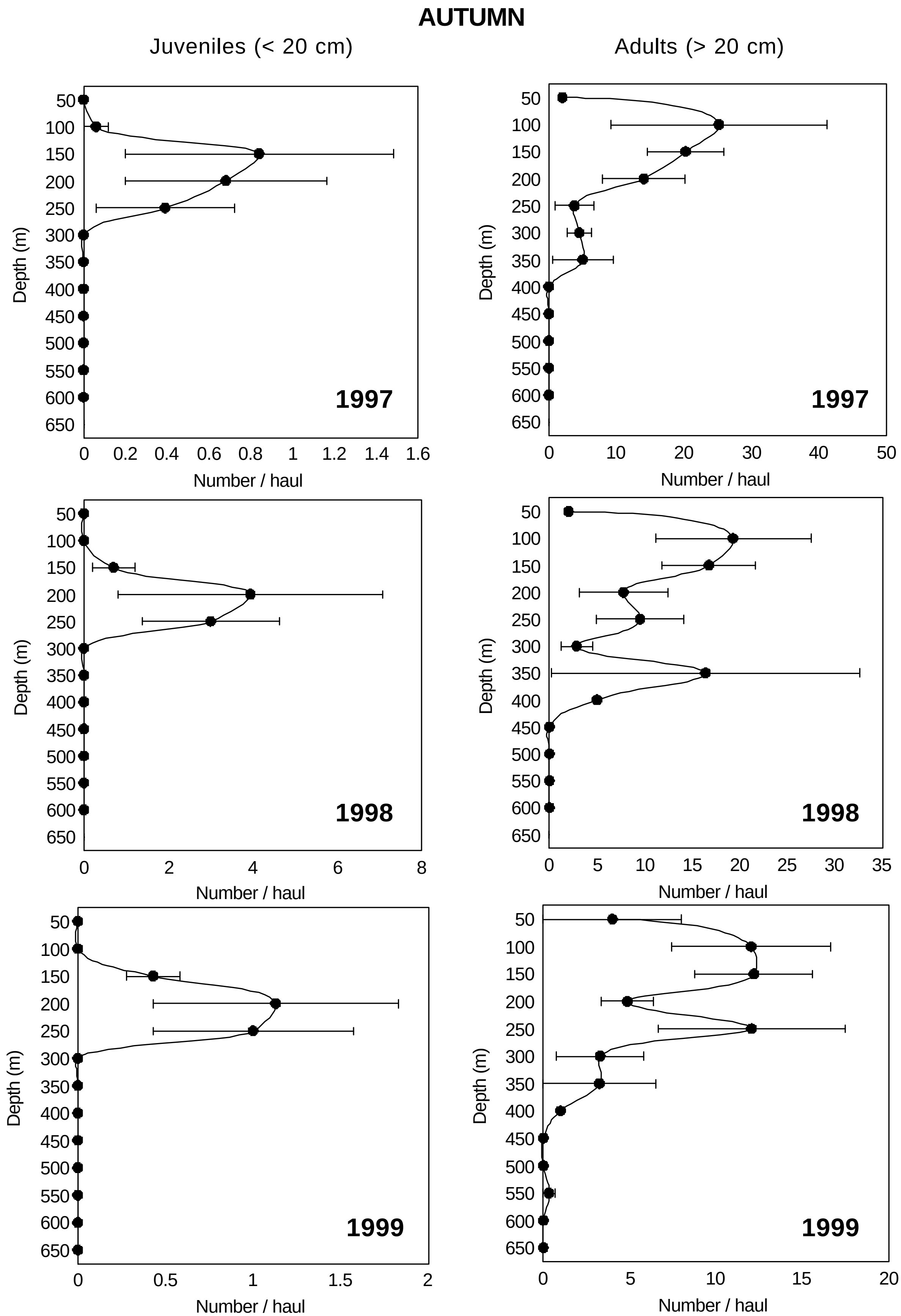

Figure 4b. Bathymetrical distribution of juveniles and adults in autumn.

AUTUMN

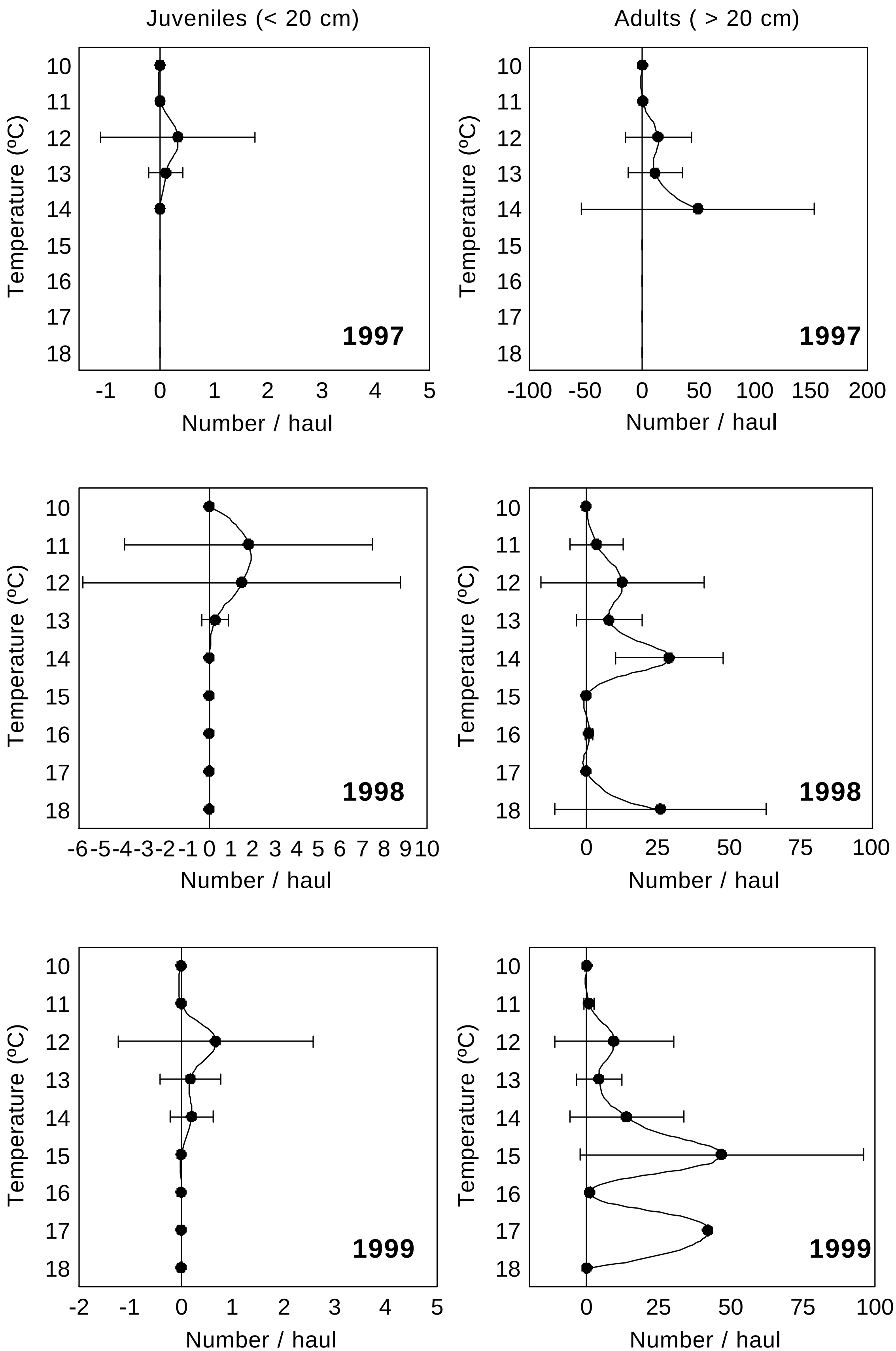

Figure 5. Termic habitat of juveniles and adults based on autumn surveys.

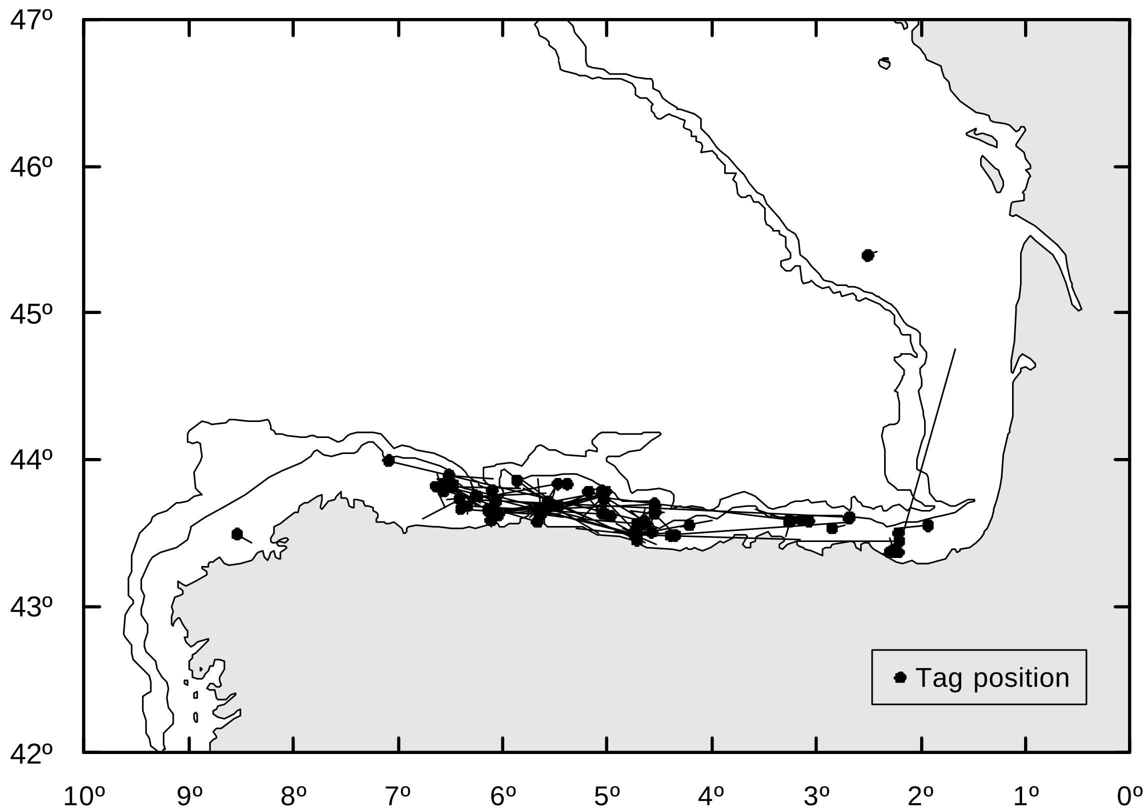

Figure 6. Situation of the dogfish tag and recaptured.

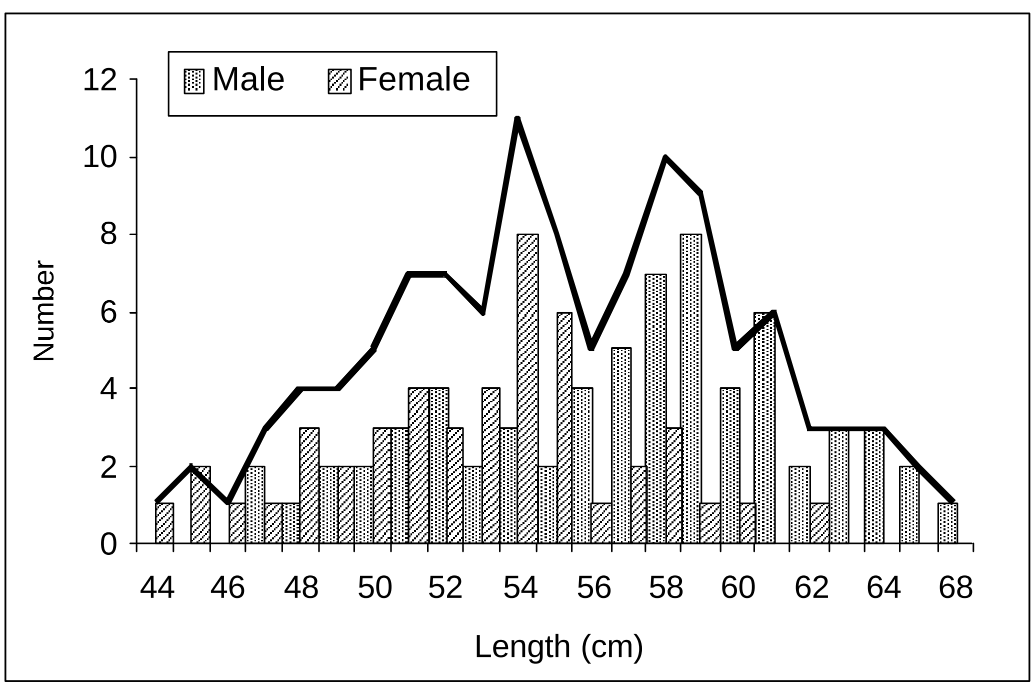

Figure 7. Length distribution of the specimens recaptured.

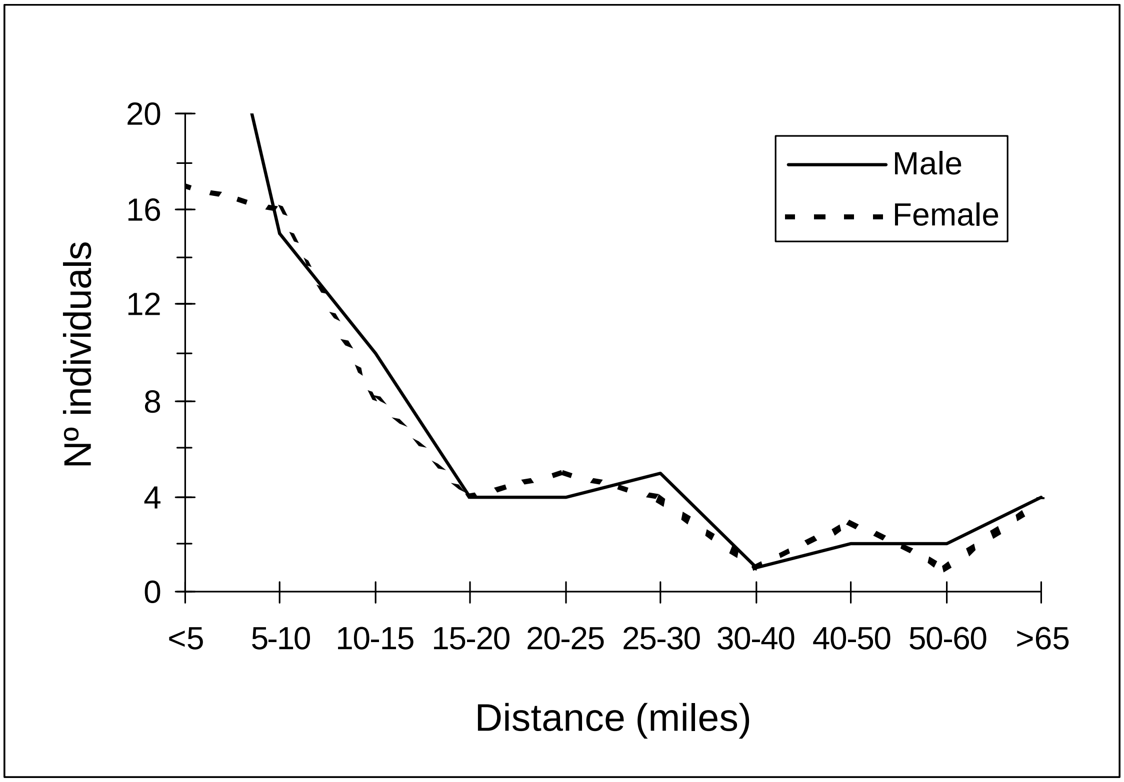

Figure 8. Distance covered by dogfish recaptured.

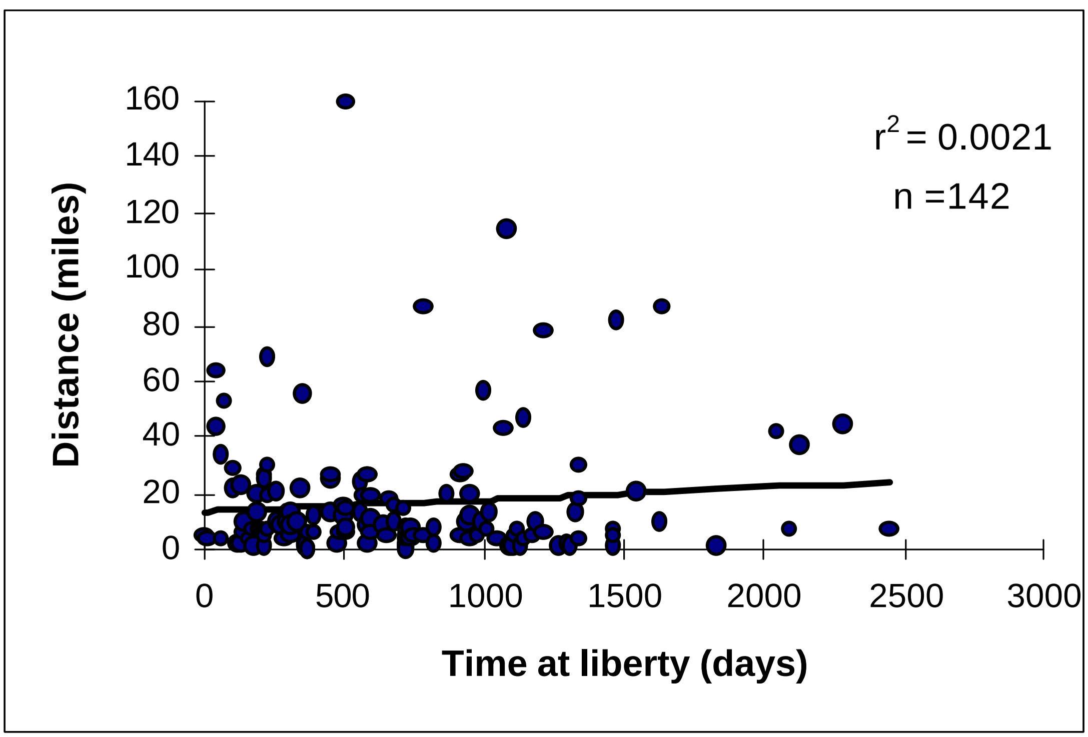

Figure 9. Relationship between time at liberty and distance covered by the dogfish.

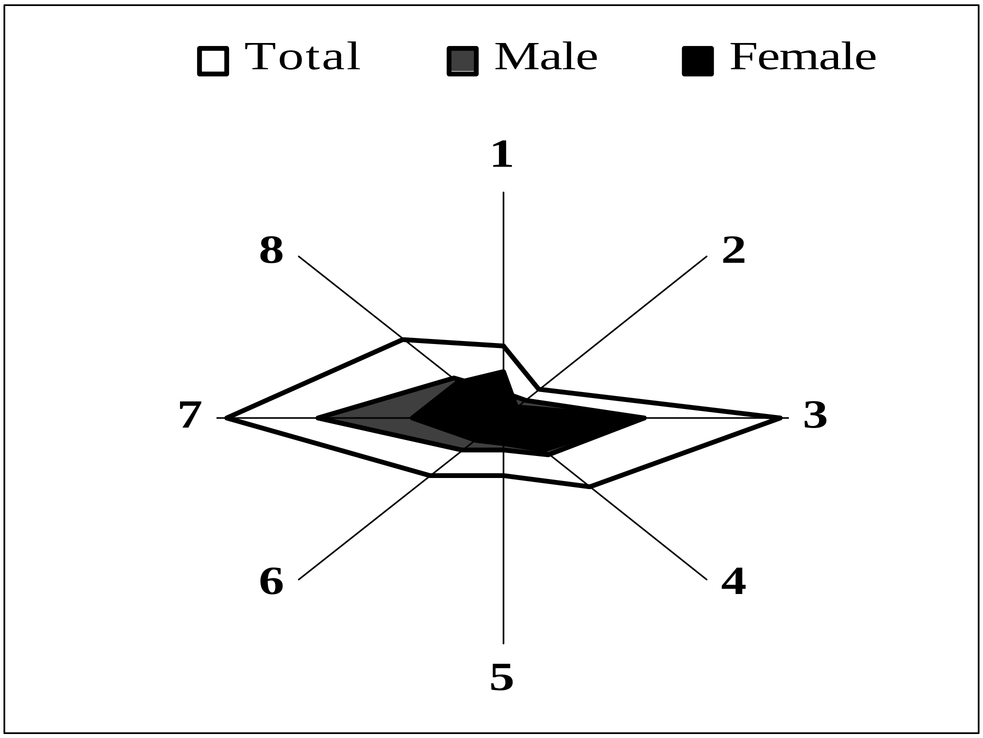

Figure 10. Distribution of the recaptures by geographical sectors.

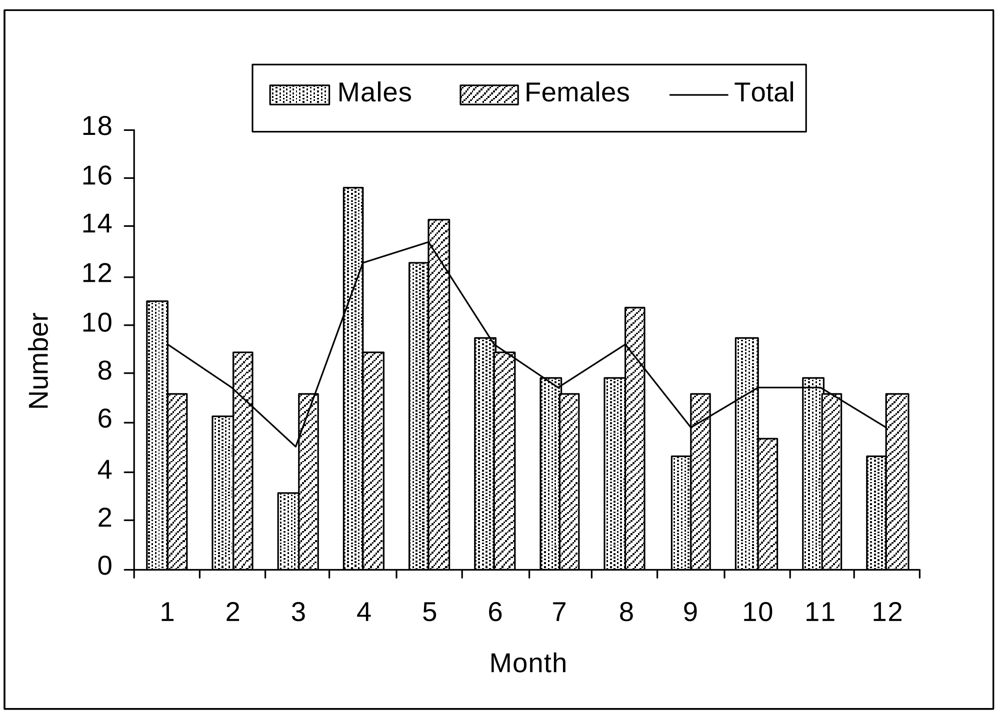

Figure 11. Number of recaptures obtained monthly.

Table I. Summary of the tagging data.

Year	Male	Female	Total	Recap	% Recap
1993	428	475	903	4	0.44
1994	357	426	783	4	0.51
1995	242	224	466	11	2.36
1996	375	454	829	16	1.93
1997	650	600	1250	28	2.24
1998	394	390	784	30	3.83
1999	290	233	523	31	5.93
2000	659	422	1081	27	2.50
Total	3395	3224	6619	151	2.28

Table II. Number of recaptures collected from the commercial fleet used in this study.

Year	Unknown	Trawl	Gillnet	Traps	Longline
1993	3	12	3		1
1994	2	9			4
1995		7	7		4
1996		11	7		3
1997	3	12	6	1	4
1998	2	2	2		4
1999	1	4	3		1
2000		2			1
Total	11	59	28	1	22