Preliminary results on growth and movements of dogfish *Scyliorhinus canicula* (Linnaeus, 1758) in the Cantabrian Sea

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(Revised 11/09/97, accepted 23/09/97)

Abstract – In this paper we present the first results on growth of dogfish (*Scyliorhinus canicula* L.) obtained from size frequency distributions collected during bottom trawl surveys and from 19 recaptures to date from 2 153 tagged individuals. The surveys belong to a series carried out in autumn in the Cantabrian Sea by the Instituto Español de Oceanografía (1983–1995). The estimated parameters from the von Bertalanffy equation applying the Bhattacharya, Gulland and Holt and Ford–Walford methods were K of around 0.09–0.13, and a maximum length close to 89–98 cm. In addition, based on ten recoveries with reliable data of location we assume a priori that this species does not move long distances in the area of study © Elsevier, Paris

dogfish / growth / length-frequency / recapture / migration

Résumé – Résultats préliminaires sur la croissance et les déplacements de la petite roussette *Scyliorhinus canicula* (Linnaeus, 1758), dans la mer Cantabrique. Les premiers résultats sur la croissance de la petite roussette (*Scyliorhinus canicula* L.) proviennent de la répartition des tailles de 2 153 individus marqués, après chalutage et 19 recaptures. Les campagnes ont été effectuées en automne (1983–1995) dans la mer Cantabrique par l'Institut Espagnol d'Océanographie. Les méthodes de Batthacharya, Gulland–Holt et Ford–Walford, appliquées à l'équation de von Bertalanffy, donnent des valeurs de K de l'ordre de 0.09–0.13 et une longueur maximale de 89–98 cm. Les positions fiables d'une dizaine de recaptures indiquent que l'espèce n´effectue pas de grands déplacements dans la région étudiée. © Elsevier, Paris

roussette / croissance / répartition en taille / recapture / migration

1. INTRODUCTION

The dogfish (*Scyliorhinus canicula* L.) is an extremely common small shark in the Cantabrian Sea, found in particular over sandy, gravelly or muddy bottoms at depths ranging from 50 to 500 m, mainly from 150 to 300 m [23]. With its contribution to the global biomass of demersal fishes increasing in recent years, it has become the third species in importance in the bottom trawl surveys carried out annually in the north of Spain [9, 23]. For this reason, during these surveys, a tagging programme was carried out to improve the knowledge of the biology and ecology of this species.

Published information regarding the fecundity and the reproductive cycle of this species is fairly abundant, and many physiological experiments have been performed, but some aspects of its biology still remain unknown. Recently, some studies have shown that it plays an important role in the trophic scheme of the demersal fish community [20]. Its scavenging behaviour [16] suggests that

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Table I. Summary of the tag survey data.

Year	n° capt	n° tag	n° recap	% tag	% recap
1993	1 299	903	9	70	1.0
1994	1 359	783	7	58	0.9
1995	757	467	3	62	0.6

this species could be used as an indicator in the evaluation of the impact of fishing activity on the ecosystem [1].

Probably the first author who outlined the parameters of the von Bertalanffy growth equation was Zupanovic [30], who applied the modal class progression analysis and Petersen method. This author estimates a maximum length (in the Adriatic Sea) of 56.8 cm and $K = 0.53$. Lyle [18], using Holden's equation [15] and assuming a maximum length of 100 cm taken from Wheeler [29], obtained $K = 0.15$.

In this paper we analyse the tag-recapture data available to date and the length-frequency distributions (combined sexes) collected in the last decade. On the basis of this information, we make a growth estimation for this species.

2. MATERIAL AND METHODS

The length-frequency data used in this study were collected in the course of bottom-trawl surveys carried out in the north of Spain (Galicia and Cantabria Sea) during autumn 1983 to 1995 (except 1987). The abundance index (number per haul) by length class used here was the mean stratified captures during 30 minutes trawling following the methodology described by Cochran [7], Grosslein and Laurec [13], Cardador [6] and Sánchez and Olaso [24]. A complete description of the sampling technique and gear is given in Sánchez and co-workers [23, 25, 26].

In the last three surveys a total of 2 153 dogfish were tagged with a T-bar anchor tag using a Mark II regular tagging gun. *Figure 1* presents the locations where they were released. The length distribution of tagged dogfish is shown in *figure 2*; note that almost the whole range of size class is covered.

A total of 19 dogfish have been recaptured to date. Only 12 could be used for the purpose of growth estimation and also 12 include the location of recapture. Despite the limited number of recaptures, we have applied some of the classical methods that estimate growth from tag-recapture data [10, 14, 28].

The Bhatthacharya [3] graphical method was used as a first approach to identify the possible modes in the length-frequency distributions. The von Bertalanffy growth equation [2] was then fitted using a non-linear regression programme available in FISHPARM [22].

3. RESULTS AND DISCUSSION

3.1. Length-frequency distributions

The length-frequency distributions do not allow us to identify by sight the existence of clear modes (*figure 2*) since the dogfish is an oviparous species and egg-laying takes place throughout the year, albeit subject to seasonal changes [4, 5, 8, 11, 27]. Nevertheless, the Bhattacharya method was applied as a first attempt, taking into account the fact that this technique is quite useful when the modes are clear, although when there is a great overlapping it can lead to errors. Although the analysis of a single year does not provide any valuable information, the whole historical series reveals that the normal components are not completely at random but seem to be repeated each year (*table II*).

Bearing in mind that the dogfish's length at birth is approximately 9–11 cm [11, 19, 29] it has been assumed that this length would correspond to age 0, so the first normal component that appears would refer to age 1 and so on (*figure 3*).

The parameters of the von Bertalanffy growth equation obtained using the previous data are as follows:

Parameter	Estimate	Std. error	C.V.
L_∞	88.83	7.711	0.086
K	0.126	–0.022	0.174
to	–1.33	0.236	–0.178

Mean L(t): 40.2
Mean t: 3.7
R^2: 0.9844
Adjusted R^2: 0.9829

3.2. Tag-recapture data

The recapture rate was fairly low, never exceeding 1.00 %, probably because this species is not of commercial interest and therefore dogfish catches are rarely included in the landing statistics. Likewise, because it is a discarded species, it is returned to the sea without taking

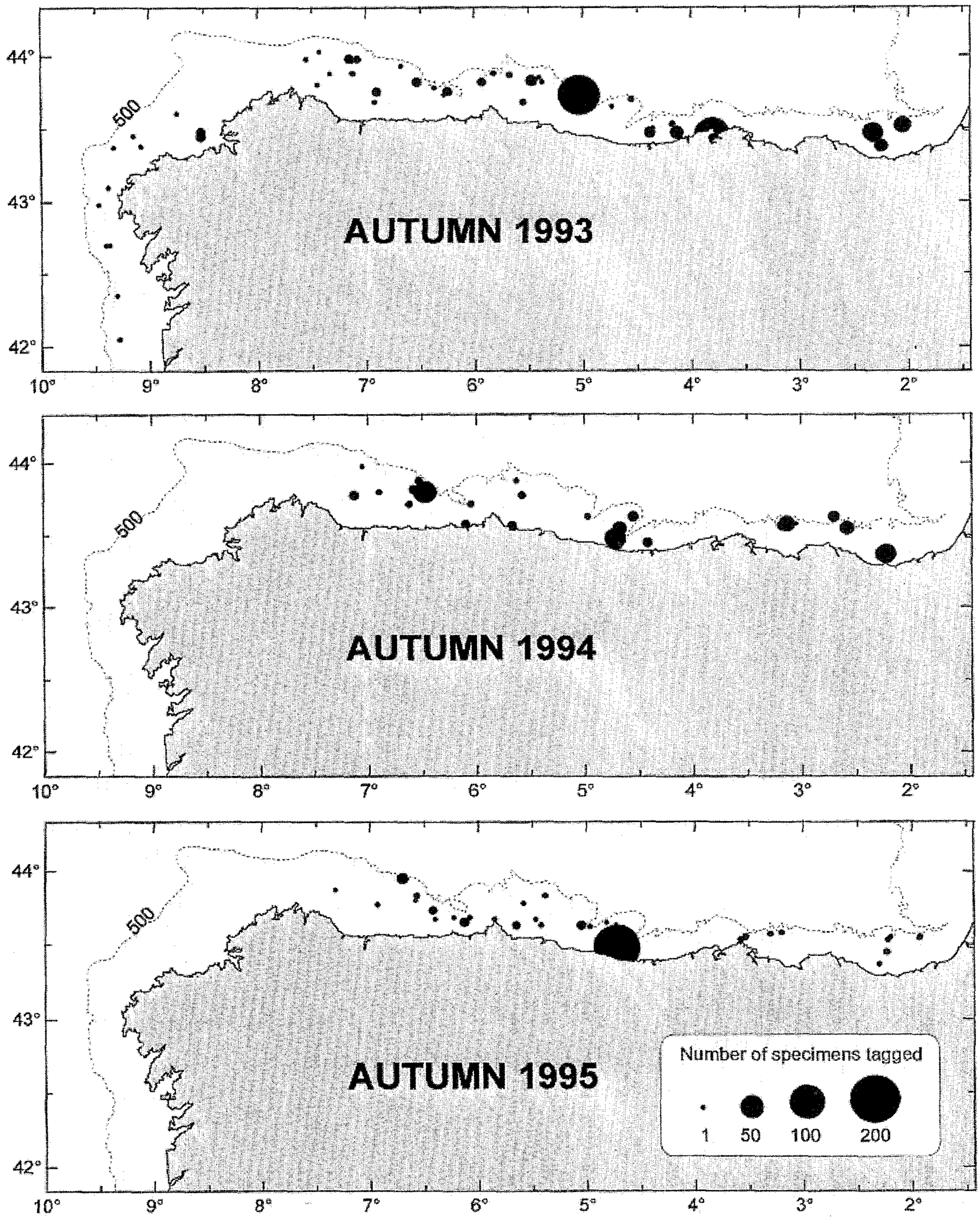

Figure 1. Spatial distribution of the dogfish tagged in each survey. Diameter of the circle proportional to the abundance.

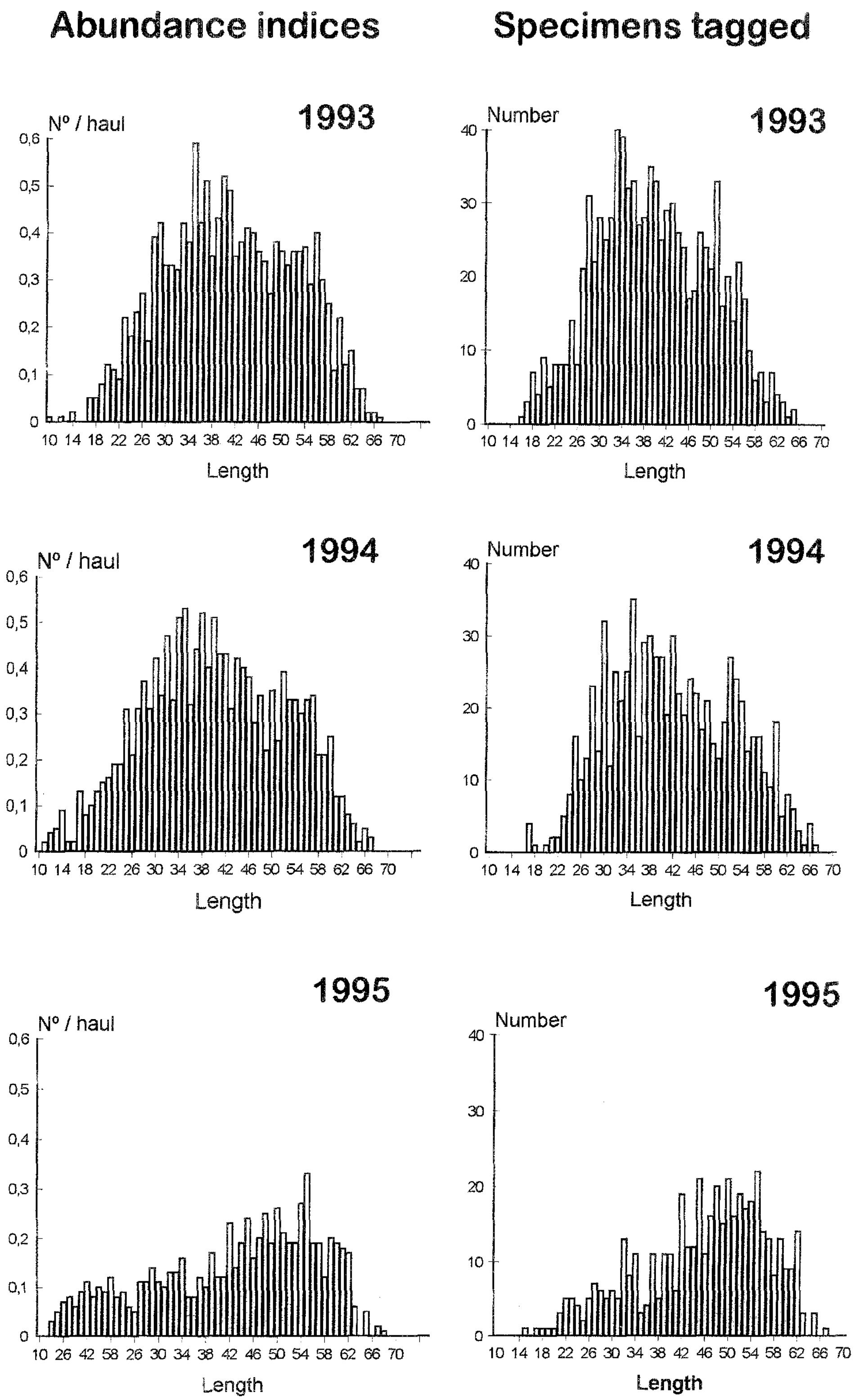

Figure 2. On the left, the indices of abundance by size class (number of individuals per haul) in the last three surveys; on the right, the size class distribution of the tagged dogfish in these surveys.

Table II. Normal components obtained from the Bhattacharya graphical method for each year.

Mode/Year	1983	1984	1985	1986	1988	1989	1990	1991	1992	1993	1994	1995
1	22		22			23		22				25
2	30	34	30		28	30		34	28			30
3		38	38		37	37	38			36		35
4	42			44				43				40
5				51					49			51
6						55						
7		58	57	58				58			59	
8						61						
9						63						

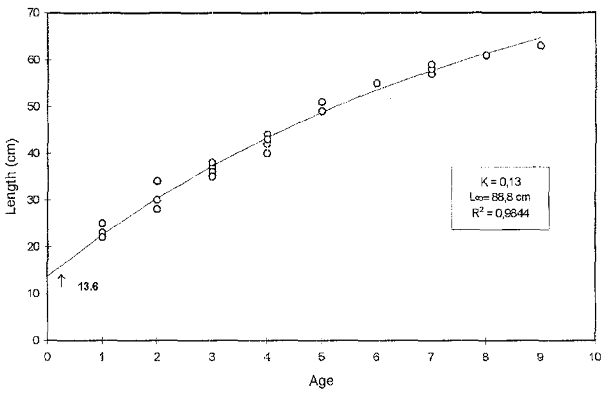

Figure 3. Growth curve fitted using the normal components obtained with the Bhattacharya method.

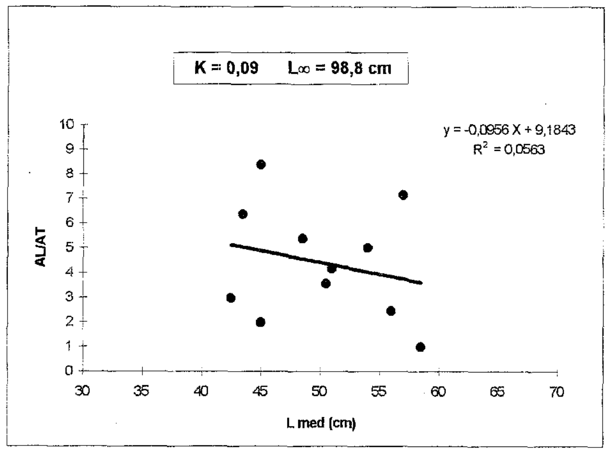

Figure 4. Linear regression between annual length increments (AL/AT) and the mean length (L med) of the specimens recaptured.

any notice of the tag. Experimental studies carried out under laboratory conditions suggest that a priori the rate of tag survival is fairly high.

Most of the dogfish were recaptured with trawl gear, only one with longline and three with gill-net. Four were recovered 1 year later in the same location.

In *figure 4* we present the results obtained using the Gulland method [14]. The parameters are $K = 0.098$ and $L_\infty = 98.8$ cm; however, the regression coefficient is rather low. The Ford–Waldford method (*figure 5*) was also used, working out the annual length increment corresponding to the mean length of each tag-recapture interval and then adding this value to the mean length. The outcomes were $K = 0.10$ and $L_\infty = 96.0$ cm. Both results are quite similar, and comparing them to the previous ones, we believe that the best approach should be among these values. Possibly, using the tag-recapture data, K could be underestimated since there is not a sufficient range of lengths at marking and recovering for young specimens and the maximum time at liberty is 2 years.

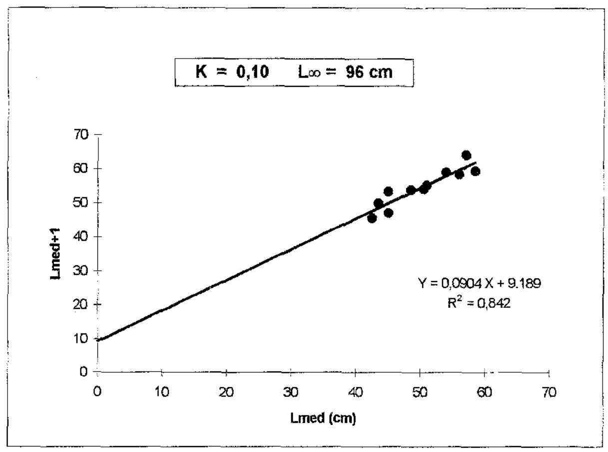

Figure 5. Plot of the mean length (L med) against its annual increment (L med + 1).

The empirical equation of Holden used by Lyle [18] gives a higher value of K and even so is not in total disagreement. However, he takes a maximum length of 100 cm,

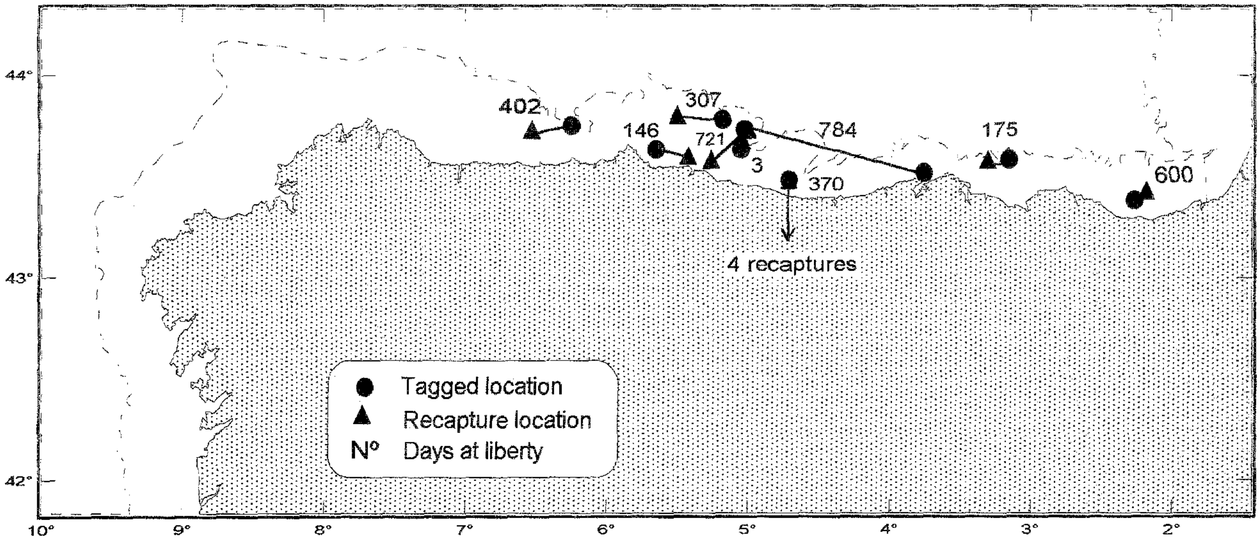

Figure 6. Location of the tagged and recaptured dogfish and days at liberty.

Table III. Tag returns of dogfish valid for the study of growth.

	Tag data			Recapture data				
Tag no.	**Sex**	**Length**	**Date**	**Length**	**Date**	**Days**	**D**	**L**
B3724	♀	48	28/09/93	49	5/12/94	66	–	1
B3737	♀	54	28/09/93	60	1/08/94	298	7.4	6
B3859	♂	49	28/09/93	53	14/09/94	341	–	4
B3598	♂	40	25/09/93	47	2/11/94	392	22.2	7
B3445	♂	54	5/10/93	58	28/05/95	584	9.3	4
B3796	♀	47	28/09/93	54	19/09/95	721	25.9	7
B1479	♀	44	14/10/94	46	19/10/95	370	0	2
B1486	♀	41	14/10/94	44	19/10/95	370	0	3
B1448	♂	58	14/10/94	59	19/10/95	370	0	1
Y0246	♀	55	18/10/95	55	21/10/95	3	5.6	0
B3321	♀	36	4/10/93	54	28/11/95	784	101.9	18
Y0194	♀	53	16/10/95	55	10/03/96	146	18.5	2

D: distance covered (km)
L: Length increment (cm).

whereas the maximum observed length found in the bottom trawl surveys and in the discards made by the Spanish fleet (trawl, gill-net and longline) [21] never exceeds 78 cm. Zupanovic's estimations [30] referred to specimens caught in the Adriatic Sea and, although the species is the same, many authors have found significant biometric differences between Atlantic individuals and those of the Mediterranean [17, 19].

We do not yet have enough data to verify whether there is differential growth between sexes, a widespread feature in many elasmobranch populations. This shortcoming has also been observed in the Mediterranean by Capape and his colleagues off Tunisian coasts [4] and in the Gulf of Lions [5]. We believe that such may be the case, because the sex ratio shows a lack of females in the longest sizes, which may be due to a different pattern of growth or mortality. Concerning the reproductive biology of this species, the length of first sexual maturity seems to be the same for males and females [5, 11, 17]. This suggests the hypothesis that once females reach sexual maturity, the rate of growth slows down in favour of egg-laying.

3.3. Movements

Information on tag-recapture locations allows us a priori to affirm that this species does not travel long distances (*figure 6*). In fact, four individuals were recaptured at exactly the same location as the previous year. The explanation for this coincidence is that this sampling point has been repeated each year since 1994 due to the establishment of dissuasive devices (artificial reefs) in the area to prevent trawling by the commercial trawl fleet. We must note that these specimens were recaptured in the same season, so they may move at some time of the year. The longest recorded distance covered by a dogfish was 101.9 km in 2 years.

The only information we have concerning the movements of *Scyliorhinus canicula* is that reported by Greer Walker et al. [12], who tracked two dogfish off the East Anglian coast. One swam 21.3 km in 4 h and the other 18.5 km in 6 h, following the tidal stream transport and making regular but brief descents to the sea floor during regular periods.

4. CONCLUSION

Length-frequency analysis and the tag-recapture results, independently, give similar values and provide a good estimation of growth for this species; we believe, however, that the values obtained applying the method of Bhattacharya are the most realistic. The tag-recapture methods probably have a tendency to underestimate K because the data available up to now does not cover a wide size range or a long time period. The growth parameters are in reasonable agreement with those estimated for other elasmobranchs. A priori, this species does not swim long distances, at least as far as the mean length range population is concerned, within a period of 1 year.

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