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The Spanish Multi-species Deep-sea Fishery on Hatton Bank (North East Atlantic): 1996-2000

by

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ABSTRACT

This document describes the Spanish deep-sea fishery performed in international waters on the Hatton Bank and proximities (NE Atlantic) during the period 1996-2000. This is a multi-species fishery, carried out by stern bottom trawlers, mainly between June and September, in depths mainly between 800 m to 1600 m. The importance of the fishing activity in this area is increasing notably. This fishery has been monitored since the beginning in 1996, with the collaboration of the fishing industry, by means of a scientific observer programme. The observers on board provide data on catches, discards, location and depth, haul by haul. Length samples of the main species and biological material are also collected. The species composition of the catches is presented. In terms of weight, the roundnose grenadier *(Coryphaenoides rupestri*s) and the bairdii smoothhead *(Alepocephalus bairdi*i) are the most important species in the catches. Other less important species are the Portuguese dogfish *(Centroscymnus coelolepi*s) and the blue ling *(Molva dypterygi*a). In addition to the total catch, the composition of the retained catch and the discard are studied. For the main retained species, the dressing types are described and the conversion coefficients are presented. The length distribution of the catches and the discards, length-weight relationships and other biological aspects of some of the main species are analysed.

Keywords**:** Deep-sea species, Northeast Atlantic, Hatton bank, bottom trawl, *Alepocephalus bairdi*i, *Coryphaenoides rupestris, Centroscymnus coelolepis, Molva dypterygi*a, discards, conversion coefficients, length distribution, length-weight relationships.

INTRODUCTION

Since the early '90's, deep-water fisheries have become relevant for the Spanish fishing fleets particularly for the freezer trawlers (Iglesias y Paz, 1995, Piñeiro *et al.,* 2001). In view of the increasing difficulties involved in exploiting its traditional demersal resources, this industry set out to take more advantage of accompanying species, searching for new grounds and alternative or complementary resources. In this setting, where many of the resources on the continental platforms were overexploited, in moratorium or subject to strict regulations, activity has gradually extended to deep-waters. As regards the search for new resources, recently diverse research activities entailing co-operation between the Spanish Institute of Oceanography (IEO) and the fishing industry, particularly highlighting the deep-water exploratory fishing conducted by commercial vessels, with the scientific planning, monitoring and analysis of the IEO. The main objectives of these explorations were to obtain biological information on new species and explore the possibilities of exploitation (Durán Muñoz y Román, 2000, Duran Muñoz *et al*., 2000). Some of these experiences have led start new fisheries for the freezer fleet, as is the case of the multi-species deep-sea fishery studied in this paper, conducted in international waters on Hatton Bank and proximities (Northeast Atlantic) at depths of over 800 m. In this fishery, the main fish species are smoothhead *(Alepocephalus bairdi*i) and roundnose grenadier *(Coryphaenoides rupestri*s), and including a wide variety of species (Table 1), considered "deep-sea species" by the Group on the Biology and Assessment of Deep-Sea Fisheries Resources of the International Council for the Exploration of the Sea (Anon., 1994).

MATERIAL AND METHODS

Area and period studied

This paper studies the geographical area where the deep-water multi-specific fishery of the Spanish freezer trawler fleet is developed during the period 1996-2000 (Figure 1). This area is located from 53º 30`N and 59º 30`N, in international waters of the Northeast Atlantic Ocean, west of the British Isles. The area mainly covers Hatton Bank on the SW side, and the proximities of Fangorn and Lorien Banks further S. These three Banks comprise an extensive submarine region of deep-waters known as the Rockall Plateau. Hatton is orientated SW-NE and has an elongated configuration. It is separated from the Rockall Bank by the Hatton-Rockall basin. Fangorn and Lorien are less extensive areas, both being located to the extreme SW of the Rockall Plateau. Depths mainly ranging from 800 to 1600 metres were studied in these areas.

Description of the fishing fleet and the gear

During the study period, in this fishing ground was chiefly operated by stern freezer trawlers. In 2000, two pair trawlers occasionally operated. The operations of this fleet are based in three ports located in Galicia (Northwest Spain). These are high-seas vessels, most having been built in the mid '70`s and late `80`s, with autonomy for long term sea trips far from their base ports, with overall lengths ranging from 46 to 84 m, power ratings of 800 and 2555 horsepower, and gross registered tonnages from 264 to 1866 tons (Table 2). Average number of crew on board is 24. Figure 2 shows the evolution of the average power rating values and gross tonnage during the study period. It is noted that it was the smaller vessels, which initially accessed the fishery, later followed by the more powerful, greater tonnage vessels. Ships were equipped with electronic instrumentation monitor the fishing methods and detection systems. Fishing activity was followed by satellite, a system set up by the Spanish administration. These vessels have a fish plant or processing room with machinery for handling, processing, freezing and packing catch at sea. In the factory, the catch in each fishing operation is selected by species and size. Retained catch is processed in a highly diverse number of ways, and is placed on trays and ultrafrozen. It is finally packed and stored in coldstore holds on board. Bottom trawl gear is used in this fishery, similar to that used in the Spanish NAFO fishery, adapted to the topography and depths found on Hatton Bank. Figure 3 shows a general diagram of this type of gear, including the trawl doors and groundropes normally used, depending on the preferences of each skipper. Groundrope may be fitted with iron bobbins or, alternatively, rubber disks (rockhopper). Long bridles are used and polyvalent oval or Viking type trawl doors. The weight of these trawl doors and the size of the gear depend on the characteristics of each particular ship. Approximately, vertical opening ranging from 2.5 to 4 metres, and horizontal opening from 20 to 40 metres.

Data collecting

Two sources of information have been used in this study:

Data provided by the Spanish Fisheries Administration: Data has been collected on the number of Spanish ships authorised to operate on Hatton Bank fishing grounds, with the access and departure dates of each of the vessels concerned. This information was used to estimate the number of fishing days and to calculate the following ponderation factor applied to estimate commercial Fishing efforts and Catches in terms of the data observed:

$$Factor = Fishing\ days / Observed\ days$$

Data collected by the Spanish scientific observers: The observer programme for this fishery was established in 1996 by agreement between the Spanish Fisheries Administration and the Shipowners' Associations, at the same time industrial exploitation commenced. The mission of the observers was to collect the data required for the monitoring the fishery (Van Helvoort, 1988). The IEO in Vigo was responsible of the scientific tasks, while funding was taken on by the Institute, Administration and the Shipowners' Associations. Considering the sum total for the study period, 20% of the total fishing days were sampled, the annual sampling rate fluctuating from 12% in 1999 and 40% in 1996, (Table 3). A total of 14 observers were put on board, who sampled 29 vessels during 890 fishing days, observing 2590 hauls (Table 4). Each observer took note the characteristics of the hauls (haul by haul), such as gear used, location (longitude, latitude), time (UTC), depth (m), species caught and discarded (kg live weight), sightings and incidental catches of megafauna (where applicable), describing the characteristics of the vessel and the gear

used. Data on positions and depths were obtained from the instruments of the ship. Species were identified with the help of specific bibliography. In certain cases, individuals difficult to identify were frozen for subsequent classification at the laboratory (Compagno 1984, Cohen *et a*l. 1990, Nielsen *et a*l. 1999, Nakamura *et a*l. 1993, Moreno 1995, Whitehead *et a*l. 1984). At the end of each fishing operation, the number and weight of trays processed with each species and type of presentation were noted, calculating the catch retained as live weight, multiplying the catches processed by the different conversion coefficients. Discards were mainly estimated by observation and weighing samples which was extrapolated. Total catch was calculated as the sum of retained catch plus discard. On board, calculation of the conversion coefficients of processed weight on live weight was made by selecting samples of 40 individuals in the size range processed, which were previously weighed and later processed by operators and weighed (Conversion coefficient = sample weight prior to processing / processed weight). The coefficients presented in this paper were estimated as the mean of the values calculated on board by the observers, in the entire fishing area, during the whole study period. Length frequencies were obtained by taking random samples of the main species and measuring individuals with an ichthiometer, separating specimen by sex, measuring the total length to the cm below, except in the case of roundnose grenadier, where preanal length was measured to the 0.5 cm below and chimaeras, where the length of the dorsal fin end was measured. Length frequency samples were carried out on a total of 20 fish species, 8 of which correspond to bony fish species and 12 on cartilaginous species. Biological data was obtained by selecting stratified samples by size class, according to IEO protocol (Table 5). Biological samples of 17 species were taken, having collected otoliths and ovaries of roundnose grenadier and smoothhead. Based on biological sampling, the Length-Weight relationship parameters were estimated, following the model:

$$\text{Weight (g)} = a \times \text{Length}^{\,b}$$

To the length at maturity estimates, the proportion of mature females by size were adjusted to a logistic equation (Ashton, 1972):

$$\hat{P} = \frac{e^{a+bL}}{e^{a+bL}}$$

and the logarithmic transformation:

$$In\frac{\hat{P}}{1-\hat{P}} = a + bL$$

where $P\hat{}$ is the predicted mature proportion, a and b are the coefficients estimated of the logistic equation and L the length. The length at maturity can be estimated as the minus ratio of the coefficients ($-a$ / b) by substituting $P\hat{} = 0.5$ in equation. The curves fitting have been made using the Statistical package (StatSoft, Inc., 1995).

RESULTS

Fishing effort

This fishery started in the second half of 1996. The Spanish Fisheries Administration regulates access to this fishery, on an annual basis, by assigning temporary fishing authorisations. In recent years, activity has gradually increased, from the initial 5 ships to a total annual number of 24 in the year 2000. It is important to point out that the presence of the majority of these vessels in this fishery has been discontinued, and for the entire duration of the study period, the maximum number of active vessels per month was 13 (Table 6). The fishing strategies adopted by the vessels were highly varied, the feature in common being that fishing activity was discontinuous since the majority of the vessels rotated operating on Hatton Bank and other North Atlantic grounds (NAFO, Reikjanes, Svalbard), according to fishing opportunities. As a result of the increase in the number of vessels accessing the grounds, there has been a gradual increase in the total number of total days of fishing activity estimated throughout the fishing area during the study period (Table 7). Out of the 352 fishing days estimated for the first year, 1363 days were taken up in the year 2000. Peak activity occurred chiefly between June and September, although an increase in activity and fishing effort in the first half of the year is observed. The trend in an increase in number of vessels and fishing days was most

evident from 1996 to 1999 (Figure 4). Despite the increase in the number of ships and total fishing effort, the average number of fishing days per active vessel and year has fallen from 70 days in 1996 to 57 in the year 2000, due to the increase of mobility of the fleet towards other grounds and to discontinuous activity. Vessels conducted 1-4 fishing trips per year, each trip ranging from approximately one week to four months. Fishing effort was estimated in terms of trawling hours, depth and year (Table 8). To study this, five depth strata were defined (from <800m to 1600m).

The table shows that this fishery is mainly developed at depths of 1000 to 1400 metres, and that throughout the study period an evident movement of the fishing effort towards the deeper bottoms. During the initial two years, fishing operations were conducted mainly to 1000-1200 metres. Later, a gradual notable increase in fishing hours on the deeper strata occurred (Figure 5). In 1996, only 9% of the estimated fishing effort took place at depths of over 1200 metres, whereas in the year 2000 an estimated 60% of fishing hours were conducted over 1200 metres. As this was a new fishery, the period 1996-97 may be considered as a period of fleet adaptation to the new grounds. It was from 1998 onwards when a more clear-cut pattern was observed in the distribution of fishing effort, which may indicate a greater knowledge of the fishing grounds and target species, as well as a consolidation of activity in deep-waters.

Catches

This is a multi-specific fishery. In terms of weight, the 43% of the Catches corresponded to roundnose grenadier *(Coryphaenoides rupestris)*, the 41% to smoothhead (mainly *Alepocephalus bairdii*), the 5% to Portuguese dogfish *(Centroscymnus coelolpsis)*, the 4% to blue ling *(Molva dypterygia)*, the 2% to various deep-water sharks and the 5% to others fishes. Table 9 shows the estimated total catches in live weight for the period 1996-2000. Estimated catches of the two main species (roundnose grenadier and smoothhead) increase during the first four years, decreasing in the year 2000 setting values approaching 7000 and 5500 tones respectively. In recent years, annual catches of Portuguese dogfish have maintained certain stability with a maximum of 820 tons in 1998, whereas blue ling shows a high interannual variability with a maximum of 804 tons in 1999. The other species were caught in far less quantities.

The final two years have increased catches of Greenland halibut *(Reinhardtius hippoglossoides)* and deep-water sharks (319 tons and 378 tons in the year 2000, respectively), in line with the increased effort in deep-waters.

Under the term "various deep-water sharks" species mainly from the genera *Etmopterus*, *Centroscymnus*, *Apristurus* and *Deania* have been grouped together. In the year 2000, an increase in catches of black scabbardfish *(Aphanopus carbo)*, roughsnout grenadier *(Trachyrhynchus trachyrhynchus)* and North Atlantic codling *(Lepidion eques)* was noted. The chimaeras and, to a lesser extent, the skates, were also present in catches. The other fish species (Table 1) were grouped together under the heading "Various".

Composition of retained catch and discards

The majority of roundnose grenadier and smoothhead catches were retained, as show Table 10. It is important to highlight the high degree of retention of smoothhead, which ranged from 75% to 98% throughout the study period, which is infrequent in fleets in other countries (Anon. 2001). Retention rates of this species have equalled or even been higher than those for grenadier, which points to the consolidation of fishing interest in smoothhead. In their entirety, Portuguese dogfish, blue ling and Greenland halibut were retained on board. A high percentage of black scabbardfish was also retained. The "various deep-water sharks" were retained in high proportions in relation with their variety of types of elaboration. The roughsnout grenadier and the North Atlantic codling were mainly discarded.

The chimaeras present a variable discard rate (21%-41%). As regards the other fish species, the pattern is highly variable, depending on market conditions and the catch success for the main species.

Yields

Annual yields estimated in kilograms of live weight per trawling hour are shown in Table 11. Three groups of species are noted in terms of their respective yield values. The first group comprising roundnose grenadier and

smoothhead, presents the highest values with a maximum of 479 kg/hr. In the second group, comprising Portuguese dogfish and blue ling, yields ranged from 18 to 66 kg/hr. In the third group, which includes the other species, yields were, in all cases, very low.

Roundnose grenadier shows a gradual increasing for the first four years, noting a decrease in their values at the end of the study period. Smoothhead remained stable for 1998-99 and decreased in 2000. Portuguese dogfish remained stable for the first three years. Data on blue ling is difficult to analyse, since catches of this species are highly seasonal and depend on accessibility of the spring aggregations. It was noted that yields of Greenland halibut, black scabbardfish and various deep-water sharks have recently increased. The trends observed in the evolution of values for total yields may be due to the expected stabilisation of the fishery and to the change in fishing depths. Yields have been estimated per depth stratum for the two main species (Table 12). In order to summarise the results, five depth strata are defined (from <800m to 1600m). It is noted that Roundnose grenadier yields are higher at greater depths, whereas smoothhead presents less differences in relation with these strata.

Sightings and incidental catches of megafauna

The observers collect information on sightings and incidental catches of megafauna (marine mammals, birds and tortoises) in order to study the interactions between the fishing operations and these fauna. During the period studied only was registered one incidental catch of one individual of dolphin *(Tursiops truncatus)*, without mortality. In relation with the megafauna sightings, the most sighted species were the common dolphin *(Delphinus delphis)* and the pilot whales *(Globicephala melas)*.

Conversion coefficients

Conversion coefficients are the factors used to estimating the live weight of fish caught (Anon., 1996). Fifteen types of products processed on board the sampled vessels was noted. This is a developing fishery, so that the processed species and the types of fish processing involved have varied over time (Table 13). The two most frequently processed products during the study period were headed, tail off, gutted fish (skin on or off), and skinned fillet.

Processing of headed, gutted and tail off fish involved cutting the head and tail with a mechanical saw, removing guts by hand, and in the case of skinning, skin was generally removed mechanically. Hand fillet processing involved cutting the two flanks of the fish, with a knife, on both sides of the dorsal spine (discarding the spine), skinning the two resulting portions. Table 14 presents the average conversion coefficients for the products normally processed from the main species taking the fishing area as a whole. The coefficients of headed, tail off, gutted fish were 1.5 for smoothhead, 2.7 for grenadier, 3.5 for Portuguese dogfish and 1.6 for blue ling. The coefficients of hand fillet skinned for smoothhead and roundnose grenadier were 2.3 and 4.7 respectively. In general terms, each individual retained on board was processed in one single manner, except in the case of the sharks (mainly of the genera *Centroscymnus* and *Etmopterus*) and blue ling. In the case of the sharks, from the same individual, up to three different products were processed (the trunk was processed as the main product, and sometimes the fins and liver were also processed). For blue ling, up to two different products were processed from the same individual (trunk, main product, and head).

Biological aspects of some fish species

Length distributions: The length distributions of the total Catches and discards were analysed for both roundnose grenadier and smoothhead during the period 1996-2000. The length range, mode, percentage by sex and sampled individuals by sex and year in the total Catch and discards are shown in the Tables 15 and 16 respectively. In the total Catches, roundnose grenadier sizes ranged from 3.5 to 27 cm, with a predominance of males, represented a 53.7%.

This predominance of males is accentuated in smaller sizes. The females presented a range of 5-27 cm with a mode of 17 cm. The males ranged from 3.5 to 24.5 cm with a mode of 14 cm. In all years the female mode was higher than male mode. The length of smoothhead individuals ranged from 15-100 cm. Males ranged from 20 to 97 cm and females from 15 to 100 cm, with modes of 60 cm for both sexes. The males percentage represented 45.3% and females 54.6%. The plots of the length distributions of both species in the catch and in the discards (by year) are presented in the Figures 6 and 7. Is significant the scarce presence of smoothhead individuals of minor size of 30 cm

in all years and for both sexes, the absence of recruits probably is due to the area of prospecting doesn't correspond to the nursery area. The figures shows that the range of sizes of the discards diminishes from 1996 to 2000 for the two species, indicating that the commercial interest by both species increases with the years.

Length-weight relationships: Based on the biological sampling, a preliminary study of Length-Weight relationships for the whole period was carried out. In the Table 17 were shown the length-weight parameters, the number of individuals sampled and their length–weight range.

Preliminary observations on maturity: Roundnose grenadier and smoothhead female length at maturity estimates based data collected in the period 1996-2000 are presented. On board, fish were classified as mature or immature by visual examination of the gonads. A simple four-point scale (Table 5) was used to do it, where the first stage is designed as immature and all the others (maturing, spawning and post-spawning) as mature. The number of sampled females is shown in the Table 18. For the smoothhead, about 71% of the females were mature and 83% for the roundnose grenadier. The smoothhead and roundnose maturity curves for females are shown in the Figure 8, and the parameters of the fitted curves in Table 19. Smoothhead and roundnose maturity doesn't adjust any logistic model. Female's length at 50% maturity (L50) was of 49 cm for smoothhead and 11 cm for the roundnose grenadier. At this moment, is tried to carry out a histological study in the laboratory, based on gonads collected since year 2000.

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REFERENCES

Anon., 1994. Report of the study group on the biology and assessment of deep-sea fisheries resources CM 1995/Assess 4.

Anon., 1996. Comparative study of the conversion coefficients used for estimating the live weight of fish caught by Community fishing vessels. Final report of the project 95/02. Commission of the European Communities. Directorate General for Fisheries.

Anon., 2001. Report of the working group on the biology and assessment of deep-sea fisheries resources CM 2001/Assess 8.

Ashton, W.D. 1972. The Logit transformation with special reference to its uses in bioassay. Hafner Publishing Co. Inc., New York, 88 pp.

Cohen, D.M., T. Inada, T. Iwamoto and N. Scialaba, 1990. Species catalogue. Vol 10. Gadiforms fishes of the world (order Gadiformes). An annoted and illustrated catalogue of cods, hakes, grenadiers and other gadiforms fishes know to date. *FAO Fish. Synop*., (125) Vol 10. 442 pp.

Compagno, L.J.V., 1984. FAO Species catalogue. Vol 4. Sharks of the world. An annoted and illustrated catalogue of shark species know to date. *FAO Fish. Synop*., (125) Vol 4, Pt.1 and 2.

Duran Muñoz, P. and E. Román. 2000. Spanish experimental fishing: a cooperative research initiative between scientists and the local fishing industry. *ICES CM 2000/ W:03.*

Duran Muñoz, P., E. Román and F.González. 2000. Results of a deep-water experimental fishing in the North Atlantic: An example of a Cooperative research initiative with the fishing industry. *ICES CM* 2000 W 04.

Iglesias, S. and J. Paz. 1995. Spanish North Atlantic Deep-water fisheries, in Hooper, A.G. (ed.): Deep-water fisheries of the North Atlantic Oceanic Slope. *NATO ASI Serie*s. 296:287-295.

Nielsen, J.G., D. M. Cohen, D.F.Markle, C.R. Robins, 1999. FAO Species catalogue. Vol 18. Ophidiiformm fishes of the world (order Ophidiiformes). An annoted and illustrated catalogue of pearlfishes, cusk-eels, brotulas and other ophidiiforms fishes know to date. *FAO Fish. Syno*p., (125) Vol 18. 178 pp.

Nakamura, I. and N.V. Parin, 1993. FAO Species catalogue. Vol 15. Snake mackerels and cutlass fishes of the world (Families Gempilidae and Thichuridae). An annoted and illustrated catalogue of the snake, mackerels, snoeks, escolars, gemfishes, sacfishes, domine, oilfish, cutlassfishes, scabbardfishes, hartails and frotfishes know to date. *FAO Fish. Syno*p., (125) Vol 15. 136 pp.

Moreno García, J.A. 1995. Guía de los tiburones de aguas ibéricas, Atlántico Nororiental y Mediterraneo. *Ed. Piramid*e. Madrid 1995. 310 p.

Piñeiro, C.G. Casas, M. and Bañon, R. 2001.The deep-water fisheries exploited by Spanish fleets in the Northeast Atlantic: A review of the current status. *Fisheries Researc*h. 51: 311-320.

StatSoft Inc. 1995. STATISTICA for Windows (Computer program manual). Tulsa, OK.

Van Helvoort, G. 1988. Manual de operaciones de un programa de observación. *FAO Doc.Tec. Pesc*a, (275):226 p.

Whitehead, P.J.P., Bauchot, M.L., Hureau, J.C., Nielsen, J., Tortonese, E. (ed.), 1984. Fis hes of the North-Eastern Atlantic and the Mediterranean. Vol. I-III. *UNESCO*.

TABLE 1.- Preliminary list of fish species found during the period 1996-2000 in the Spanish multi-species deep sea fishery on Hatton Bank. The presence of that specie in that year is noted as 1. The species considered "Deep-sea" by the ICES Group on the Biology and Assesment of Deep-Sea Fisheries Resources is noted as a circle in the ICES Column.

			Year				
ICES	Latin name	English name	1996	1997	1998	1999	2000
▬	*Alepocephalus bairdii*	baird´s smoothhead	1	1	1	1	1
▬	*Aphanopus carbo*	black scabbardfish	1	1	1	1	1
—	*Centroscymnus coelolepis*	Portuguese dogfish	1	1	1	1	1
▬	*Centroscymnus crepidater*	longnose velvet dogfish	1	1	1	1	1
▬	*Coryphaenoides rupestris*	roundnose grenadier	1	1	1	1	1
—	*Deania calcea*	bird beak dogfish	1	1	1	1	1
▬	*Etmopterus princeps*	great larnternshark	1	1	1	1	1
▬	*Hoplostethus atlanticus*	orange roughy	1	1	1	1	1
—	*Molva dipterygia*	blue ling	1	1	1	1	1
▬	*Reinhardtius hippoglossoides*	Greenland halibut	1	1	1	1	1
▬	*Trachyrhynchus trachyrynchus*	roughsnout grenadier	1	1	1	1	1
	Lepidion eques	north atlantic codling	1	1	1	1	1
	Raja sp	skate	1	1	1	1	1
	Alepocephalus sp	smoothhead	1	1		1	1
	Anarhichas sp	wolffish	1	1	1		1
	Cataetix laticeps	-		1	1	1	1
	Centrophorus squamosus	leafscale gulper shark	1	1	1		1
▬	*Chimaera monstrosa*	rabbit fish	1	1	1		1
	Rhinochimaera sp	-		1	1	1	1
	Apristurus sp	catshark		1	1		1
▬	*Centroscyllium fabricii*	black dogfish		1	1		1
	Cottunculus thompsoni	pallid sculpin		1	1		1
	Etmopterus sp	laternshark	1		1		1
▬	*Macrourus berglax*	roughead grenadier	1		1		1
▬	*Mora moro*	common mora		1	1		1
	Notacanthus sp	-		1	1		1
	Antimora rostrata	blue antimora			1		1
▬	*Brosme brosme*	cusk	1		1		
	Cottunculus sp	-			1		1
	Hydrolagus mirabilis	large-eyed rabbitfish			1		1
▬	*Lophius sp*	angler		1	1		
	Lycodes reticulatus	arctic eelpout			1		1
	Nezumia sp	grenadier			1		1
	Synaphobranchus kaupi	-			1		1
	Anoplogaster cornuta	common fangtooth					1
	Chimaera sp	rabbit fish				1	
	Etmopterus pusillus	smooth laternshark					1
	Gadus morhua	cod	1				
	Gaidropsarus ensis	rockling					1
	Glyptocephalus cynoglossus	witch flounder					1
	Helicolenus dactylopterus	blackbelly rosefish					1
	Hidrolagus affinis	smalleyed rabbitfish			1		
	Hippoglossus hippoglossus	atlantic halibut					1
	Hydrolagus sp	chimera					1
	Lycodes sp	eelpout					1
	Notacanthus nasus/chemnitzi	spiny eel	1				
	Rhinochimaera atlantica	spearnose chimaera	1				
	Sebastes sp	redfish					1
	Trachypterus arcticus	deal fish			1		

TABLE 2.- Mean technical characteristics of the Spanish deep-sea fishing fleet on Hatton Bank (1996-2000).

Specifications	Range	Mean
Engine (HP)	800 - 2555	1544
Tonnage (GT)	264 - 1866	703
Length (m)	46 - 84	58
Beam (m)	8 - 13	10
Fish hold capacity (m^3)	400 - 2488	1065
Freezing capacity (ton./day)	10 - 58	28
Crew	17 - 31	24

TABLE 3.- Percentage of fishing days sampled. Hatton Bank Spanish observer programme (1996-2000.)

	Month												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1996	-	-	-	-	-	-	40	51	37	33	45	-	40
1997	-	-	94	64	37	26	50	26	9	0	0	0	26
1998	-	0	37	34	41	24	18	25	37	0	0	0	25
1999	-	-	0	0	15	17	12	10	28	28	0	0	12
2000	0	0	8	7	5	26	22	63	0	4	0	0	15
Total	0	0	18	19	21	23	22	26	23	15	10	0	20

TABLE 4.- Summary sheet of the sampling activities. Hatton Bank Spanish observer programme (1996-2000.)

	Year					
	1996	1997	1998	1999	2000	Total
No observers on fishing grounds	2	2	3	1	6	14
No sampled vessels	5	6	8	2	8	29
No sampled days	142	171	224	151	202	890
No observed hauls	426	532	657	459	516	2590
Length samples (No indiv.)	16474	22771	56170	46760	47947	190122
Biological samples (No indiv.)	4313	6541	13953	8648	9632	43087
No otoliths	934	553	1626	750	3524	7387
No gonads	-	-	-	-	347	347

TABLE 5.- Main biological data collected on board and methods used.

Biological characteristic	Data collected	Method used
Length	Total length to the cm below, preanal length to the 0.5 cm below (grenadiers) or length to end of the first dorsal fin (chimaeras).	Measured table (ichthiometer)
Sex	Male, female, indeterminated.	Disection and visual examination of the gonads
Maturity stage	Inmature, maturing, spawning, post-spawning (*)	Disection and visual examination of the gonads
Live weight	gr	Mechanic scale. (2-5 g. acuracy)
Stomach content	Empty, medium, full, evert.	Disection and visual examination of the stomach

(*): Table used for roundnose grenadier and smoothhead.

TABLE 6.- Estimated number of fishing vessels on fishing grounds by month and year. Spanish multi-species deep-sea fishery on Hatton Bank (1996-2000).

	Month												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1996	0	0	0	0	0	0	2	3	5	3	3	0	5
1997	0	0	1	2	3	6	5	6	6	5	1	1	11
1998	0	2	3	4	4	6	10	9	7	2	2	2	14
1999	0	0	3	3	7	8	8	12	6	4	4	2	18
2000	1	4	7	10	8	11	13	7	6	6	3	3	24

TABLE 7.- Estimated total fishing days by vessel, month and year. Spanish multi-species deep-sea fishery on Hatton Bank (1996-2000).

	Month												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1996	0	0	0	0	0	0	50	63	84	93	62	0	352
1997	0	0	18	47	76	94	60	118	123	72	30	17	655
1998	0	20	65	83	76	115	169	159	115	19	34	33	888
1999	0	0	80	90	93	169	215	224	92	58	66	27	1234
2000	11	50	120	145	115	222	277	81	77	116	90	59	1363

TABLE 8.- Estimated fishing effort (trawl hours) by depth strata and year. Spanish multi-species deep-sea fishery on Hatton Bank (1996-2000).

	Year				
Depth strata	1996	1997	1998	1999	2000
< 800 m	0	307	0	0	0
800-1000 m	1280	670	368	2061	293
1001-1200 m	3747	7732	5348	5630	8498
1201-1400 m	527	2094	5881	7299	7989
1401-1600 m	0	48	1188	4635	5342
Total	5555	10852	12784	19625	22122

TABLE 9.- Estimated total catch (ton) in live weight. Spanish multi-species deep-sea fishery on Hatton Bank (1996-2000).

	Year				
Species	1996	1997	1998	1999	2000
Roundnose grenadier	872	2407	4189	9392	7320
Smoothhead	348	4878	4839	7420	5569
Portuguese dogfish	345	712	820	660	538
Blue ling	282	530	349	804	394
Greenland halibut	2	42	89	225	319
Roughsnout grenadier	22	45	161	161	270
Black scabbardfish	46	126	120	92	240
North atlantic codling	37	41	36	54	123
Various deep-water sharks	165	179	176	267	378
Chimaeras	22	73	61	110	83
Skates	1	17	5	0	17
Various fish species	1	28	48	195	108

TABLE 10.- Estimated retained catch and discards in percentages. Spanish multi-species deep-sea fishery on Hatton Bank (1996-2000). % R = Percentage retained, % D = Percentage discarded

	Year									
	1996		1997		1998		1999		2000	
Specie	% R	% D	% R	% D	% R	% D	% R	% D	% R	% D
Roundnose grenadier	94	6	96	4	91	9	75	25	93	7
Smoothhead	77	23	97	3	98	2	75	25	92	8
Portuguese dogfish	100	0	100	0	100	0	100	0	100	0
Blue ling	100	0	100	0	100	0	100	0	100	0
Greenland halibut	100	0	100	0	100	0	100	0	100	0
Roughsnout grenadier	0	100	0	100	2	98	0	100	1	99
Black scabbardfish	100	0	99	1	98	2	100	0	99	1
North atlantic codling	37	63	0	100	9	91	0	100	33	67
Various deep-water sharks	98	2	82	18	69	31	77	23	67	33
Chimaeras	79	21	69	31	57	43	89	11	58	42
Skates	98	2	99	1	34	66	-		29	71
Various fish species	93	7	99	1	67	33	63	37	34	66

TABLE 11.- Estimated yields (Kg/hr) in live weight. Spanish multi-species deep-sea fishery on Hatton Bank (1996-2000).

	Year				
Species	1996	1997	1998	1999	2000
Roundnose grenadier	157	222	328	479	331
Smoothhead	63	450	379	378	252
Portuguese dogfish	62	66	64	34	24
Blue ling	51	49	27	41	18
Greenland halibut	0	4	7	11	14
Roughsnout grenadier	4	4	13	8	12
Black scabbardfish	8	12	9	5	11
North atlantic codling	7	4	3	3	6
Various deep-water sharks	30	16	14	14	17
Chimaeras	4	7	5	6	4
Skates	0	2	0	0	1
Various fish species	0	3	4	10	5

TABLE 12.- Estimated yields (Kg/hr) in live weight for roundnose grenadier and smoothhead by depth strata and year. Spanish multi-species deep-sea fishery on Hatton Bank (1996-2000).

	Roundnose grenadier				
	Year				
Depth strata	1996	1997	1998	1999	2000
< 800 m	-	45	-	-	-
800-1000 m	258	126	227	395	163
1001-1200 m	125	209	184	283	146
1201-1400 m	142	325	411	497	412
1401-1600m	-	265	591	724	512
Total	157	222	328	479	331
	Smoothhead				
	Year				
Depth strata	1996	1997	1998	1999	2000
< 800 m	-	-	-	-	-
800-1000 m	36	263	286	164	160
1001-1200 m	74	478	387	404	309
1201-1400 m	49	481	374	443	265
1401-1600m	-	-	394	340	145
Total	63	450	379	378	252

TABLE 13.- Main type of products obtained on board of the sampled fleet, by year. Spanish multi-species deep-sea fishery on Hatton Bank (1996-2000). The presence of that product in that year is noted as a circle.

	Year				
Description of the product	1996	1997	1998	1999	2000
1.- Whole					○
2.- Open & gutted	○				
3.- Head off, tail off & gutted					
3.1.1.-With skin	○	○	○	○	○
3.1.2.- Skinless	○	○	○	○	○
3.1.2.1.- Dorsal bone off & ventral area off					○
4.- Fillet					
4.1.- Produced by machine					
4.1.1.- With skin	○				
4.1.2.- Skinless	○		○	○	○
4.2.- Produced by hand					
4.2.1.- With skin	○	○	○		
4.2.2.- Skinless	○	○	○	○	○
5.- Fish sausage	○	○			○
6.- Wings (Rays)					
6.1.- With skin		○			○
6.2.- Skinless		○			
7.- Fins and tails (Sharks)		○			○
8.- Livers (Sharks)		○	○		○
9.- Heads (Blue ling)		○		○	

TABLE 14.- Mean conversión coeficients for four fish species. Spanish multi-species deep-sea fishery on Hatton Bank (1996-2000). N = number of estimations considered.

Species	Description of the product	Conversión coeficients	N
Smoothhead	Head off & gutted, tail off, with skin	1.5	9
	Fillet produced by hand, skinless	2.3	17
Roundnose grenadier	Head off & gutted, tail off, skinless	2.7	17
	Fillet produced by hand, skinless	4.7	12
Portuguese dogfish	Head off & gutted, tail off, skinless	3.5	14
Blue ling	Head off & gutted, tail off, with skin	1.6	8

TABLE 15.- Characteristics of the the length distributions of the total Catches for the roundnose grenadier and the smoothhead. Spanish multi-species deep-sea fishery on Hatton Bank (1996-2000).

	Roundnose grenadier				Smoothhead			
	Range (cm)	Percentage	No Indiv. sampled	Mode (cm)	Range (cm)	Percentage	No Indiv. sampled	Mode (cm)
Year 1996								
Males	8 - 22.5	69.7 %	6463	16	35 - 97	49 %	389	59
Females	8 - 26.5	28.8 %	3059	20	36 - 90	47 %	374	62
Indt.	5 - 23.5	1.5 %	151	-	30 - 84	4 %	219	-
Total	5 - 26.5	100 %	9673	16	30 - 97	100 %	982	59
Year 1997								
Males	6 - 23	60.3 %	3372	14	28 - 93	47.1 %	740	61
Females	6.5 - 24.5	39.2 %	2424	18	29 - 94	52.7 %	844	61
Indt.	4.5 - 18	0.5 %	22	-	30 - 38	0.2 %	4	-
Total	4.5 - 24.5	100 %	5818	15	28 - 94	100 %	1588	61
Year 1998								
Males	3.5 - 23	54.6 %	5718	14	22 - 92	42.1 %	9328	60
Females	5.5 - 26	44.8 %	4671	17	22 - 100	57.8 %	13237	64
Indt.	3.5 - 8	0.6 %	65	-	23 - 67	0.1 %	19	-
Total	3.5 - 26	100 %	10454	14	22 - 100	100 %	22584	60
Year 1999								
Males	5.5 - 24	44 %	5396	18	30 - 88	45.96 %	4778	60
Females	6 - 25	55.2 %	6532	18	32 - 87	54.03 %	5556	60
Indt.	6 - 14	0.8 %	76	-	46 - 50	0.01 %	2	-
Total	3.5 - 25	100 %	12004	18	30 - 88	100 %	10336	60
Year 2000								
Males	4 - 24.5	53.1 %	10633	14	20 - 94	47.63 %	7180	65
Females	5 - 27	46.4 %	8346	15	15 - 94	52.35 %	7767	64
Indt.	4 - 24	0.5 %	138	-	39 - 66	0.02 %	3	-
Total	4 - 27	100 %	19117	14	15 - 94	100 %	14950	65
TOTAL								
Males	3.5 - 24.5	53.7	31582	14	20 - 97	45.3	22415	60
Females	5 - 27	45.6	25032	17	15 - 100	54.6	27778	60
Indt.	3.5 - 24	0.7	452	-	23 - 84	0.1	247	-
Total	3.5 - 27	-	57066	15	15 - 100	-	50440	60

TABLE 16.- Characteristics of the the length distributions of the discards for the roundnose grenadier and the smoothhead. Spanish multi-species deep-sea fishery on Hatton Bank (1996-2000).

	Roundnose grenadier				Smoothhead			
	Range (cm)	Percentage	No Indiv. sampled	Mode (cm)	Range (cm)	Percentage	No Indiv. sampled	Mode (cm)
Year 1996								
Males	7.5 - 17	82.7 %	469	14.5	25 - 90	45.5 %	323	58
Females	7 - 20	7.2 %	58	12	29 - 94	52.1 %	380	60
Indt.	6 - 14	10.1 %	88	-	24 - 37	0.4 %	15	-
Total	6 - 20	100 %	615	14.5	24 - 94	100 %	718	55
Year 1997								
Males	5.5 - 17.5	64.4 %	1251	12	24 - 58	46.2 %	265	46
Females	5 - 16	34 %	512	10	24 - 62	53.8 %	309	41
Indt.	5 - 10	1.6 %	41	-	-	-	-	-
Total	5 - 17.5	100 %	1804	12	24 - 62	100 %	574	46
Year 1998								
Males	3.5 - 20	71 %	5238	12	23 - 66	45.6 %	2342	33
Females	4 - 23.5	28.1 %	2342	13	23 - 84	54.1 %	2890	36
Indt.	4 - 9.5	0.8 %	119	-	22 - 35	0.3 %	17	-
Total	3.5 - 23.5	100 %	7699	13	22 - 84	100 %	5249	38
Year 1999								
Males	5.5 - 17	52 %	4846	10	30 - 61	50.1 %	3649	40
Females	6 - 17	43.3 %	4588	10	30 - 63	49.9 %	3760	40
Indt.	5.5 - 11	4.7 %	332	-	-	-	-	-
Total	5.5 - 17	100 %	9766	10	30 - 63	100 %	7409	40
Year 2000								
Males	5 - 17	69.8 %	3258	11	19 - 67	49 %	1032	35
Females	5.5 - 18	28.6 %	2064	11	23 - 73	50.4 %	1106	37
Indt.	4.5 - 12	1.6 %	98	-	24 - 29	0.6 %	14	-
Total	4.5 - 18	100 %	5420	11	19 - 73	100 %	2152	37
TOTAL								
Males	3.5 - 20	58.5	15062	10	19 - 90	49.1	7611	39
Females	4 - 23.5	37.8	9564	10	23 - 94	50.6	8445	40
Indt.	4 - 14	3.7	678	-	22 - 37	0.3	46	-
Total	3.5 - 23.5	-	25304	10	19 - 94	-	16102	40

TABLE 17.- Length-Weight relationships (sex combined) of the main fish species. Spanish multi-species deep-sea fishery on Hatton Bank (1996-2000).

Specie	No Indiv.	a	b	R^2	Length range (cm)	Weight range (g)
Roundnose grenadier	22642	0.204	2.9636	0.9504	3.5 - 28	15 - 3268
Smoothhead	11514	0.0028	3.2246	0.9725	14 - 94	18 - 5855
Blue ling	1296	0.0006	3.3765	0.9447	58 - 120	635 - 8900
Portuguese dogfish	86	0.0029	3.2168	0.9043	77 - 125	3755 - 16000

TABLE 18.- No of Individuals (females) of Roundnose grenadier and smoothhead sampled by length. Spanish multi-species deep-sea fishery on Hatton Bank (1996-2000).

Roundnose grenadier		Smoothhead	
Length range (cm)	No Indiv. (females) sampled	Length range (cm)	No Indiv. (females) sampled
5	2	18-20	0
6	25	21-23	1
7	72	24-26	3
8	95	27-29	22
9	113	30-32	54
10	239	33-35	100
11	293	36-38	154
12	413	39-41	204
13	614	42-44	227
14	887	45-47	260
15	1095	48-50	360
16	1024	51-53	434
17	1106	54-56	444
18	1036	57-59	531
19	981	60-62	651
20	924	63-65	533
21	700	66-68	507
22	465	69-71	436
23	203	72-74	268
24	100	75-77	182
25	26	78-80	130
26	7	81-83	67
27	1	84-86	37
28	1	87-89	22
		90-92	12
		93-95	2
Total general	10422		5641
Inmature	1766		1653
Mature	8656		3988
L50	11		49

TABLE 19.- Parameters of the females maturity curves. Roundnose grenadier and smoothhead in the Spanish multi-species deep-sea fishery on Hatton Bank (1996-2000). "a" and "b" =coefficients of the adjusted logistic curve; St.Error = standard error of the estimates;L 50 = length at 50% maturity; Var.exp = variance explained by the model; r = correlation coefficient and N = numbers sampled.

	Roundnose grenadier		Smoothhead	
	a	b	a	b
Estimate	-5.23	0.46	-5.81	0.12
St. Error	0.18	0.01	0.22	0.004
L_{50}	11		49	
Var. Exp.	22%		26%	
r	0.47		0.51	
N	10422		5641	

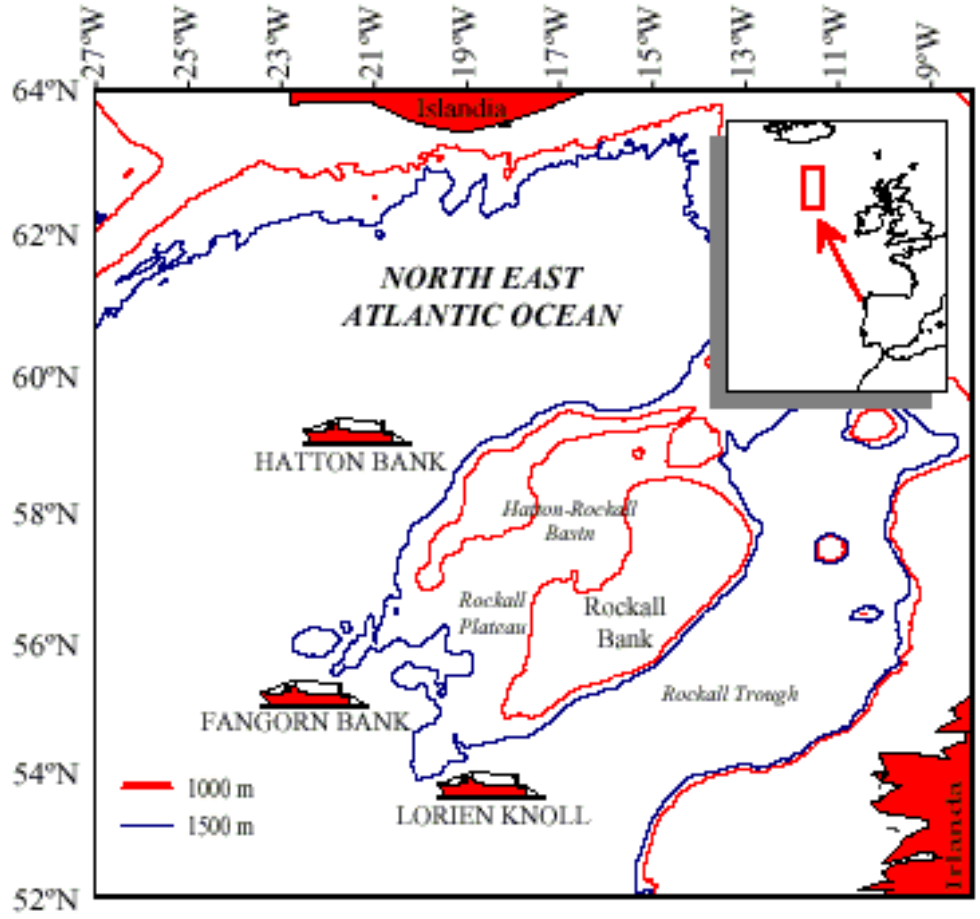

FIGURE 1.- Map showing the geographical location of the studied area: Hatton Bank and proximities of Fangorn Bank and Lorien Knoll.

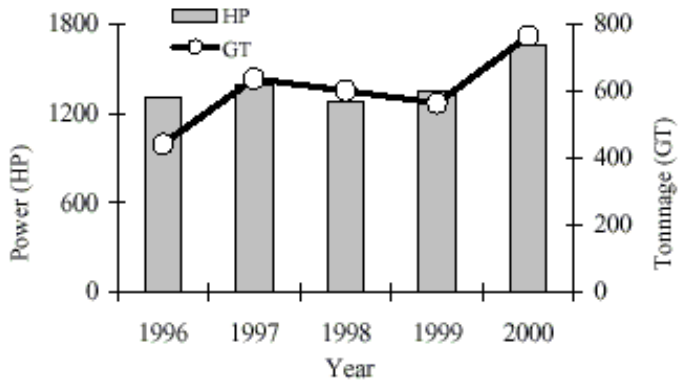

FIGURE 2.- Evolution of the mean values of power (HP) and tonnage (GT) of the fleet. Spanish multi-species deep-sea fishery on Hatton Bank (1996-2000).

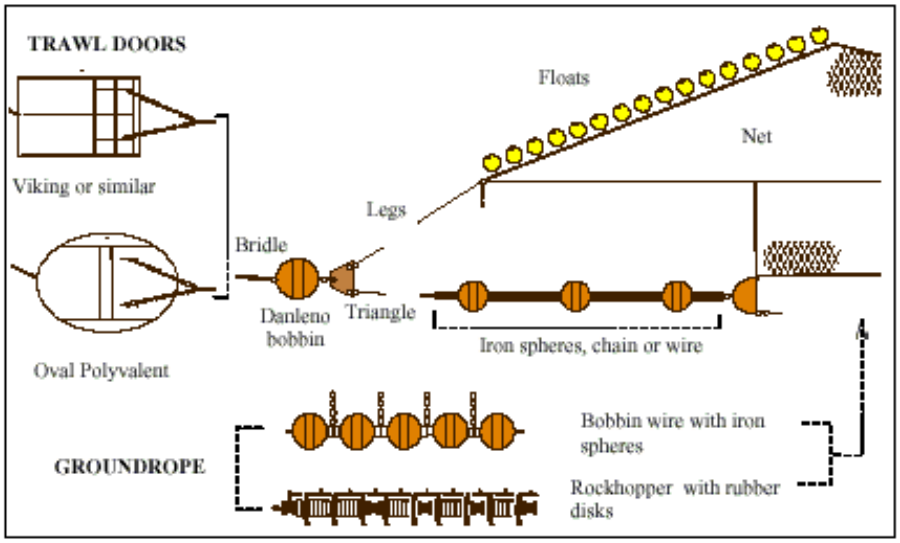

FIGURE 3.- General scheme of the fishing gear, showing the diferent trawl doors and groundropes used. Spanish multi-species deep-sea fishery on Hatton Bank (1996-2000).

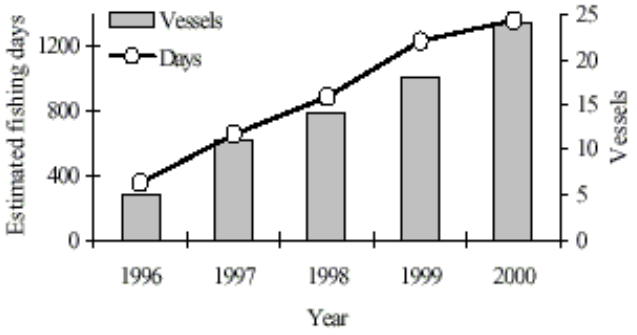

FIGURE 4.- Estimated fishing effort (No fishing days and No vessels). Spanish multi-species deep-sea fishery on Hatton Bank (1996-2000).

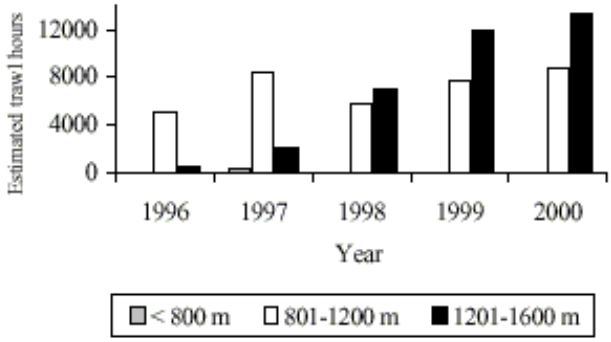

FIGURE 5.- Estimated fishing effort (trawl hours) by deep strata and year. Spanish multi-species deep-sea fishery on Hatton Bank (1996-2000).

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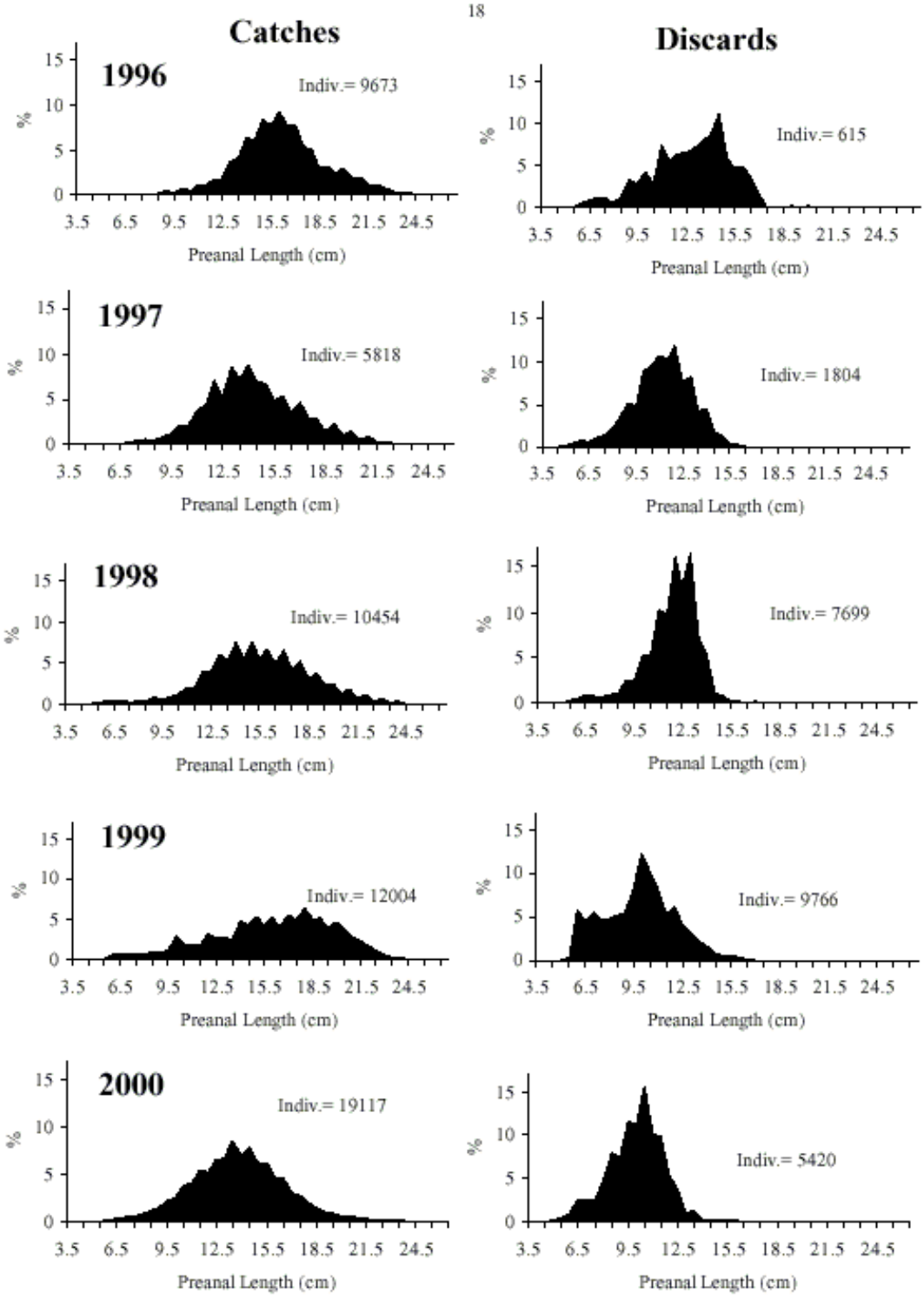

FIGURE 6.- Length distributions of roundnose grenadier in the Total Catches and in the discards. Spanish multi-species deep-sea fishery on Hatton Bank (1996-2000).

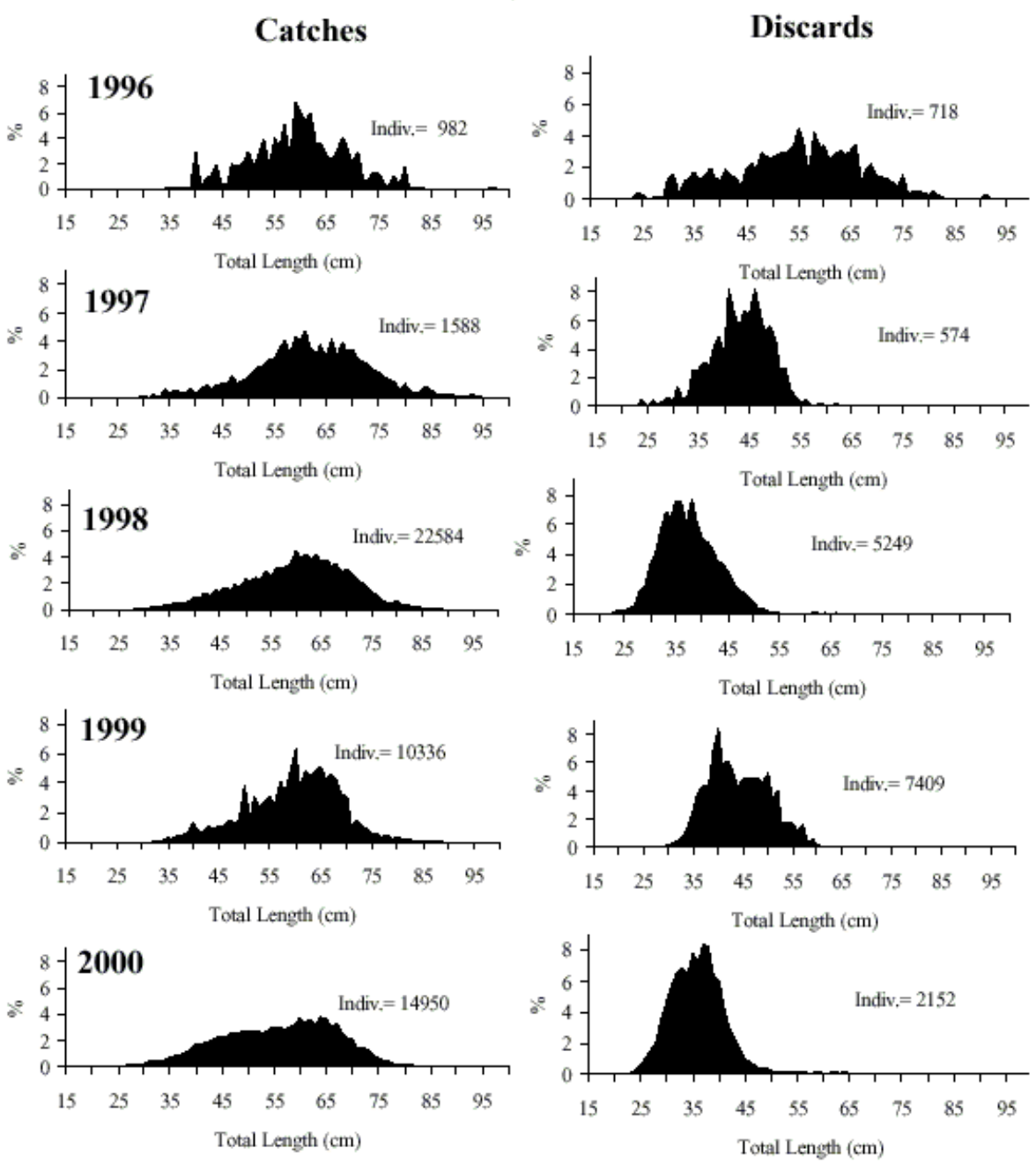

FIGURE 7.- Length distributions of smoothhead in the Total Catches and in the discards. Spanish multi-species deep-sea fishery on Hatton Bank (1996-2000).

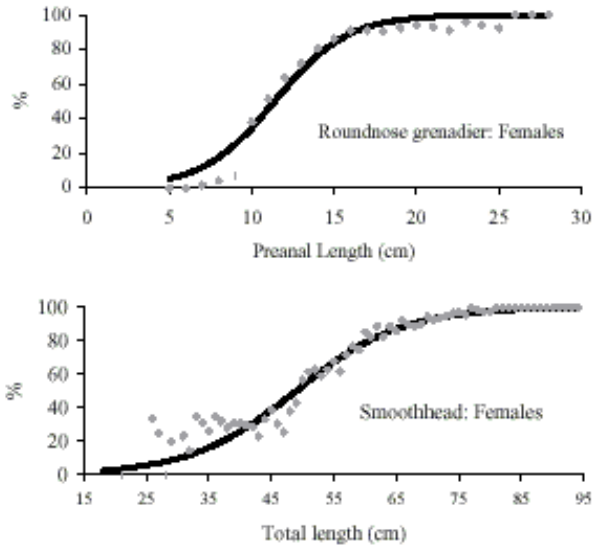

FIGURE 8.- Female maturity curves for the roundnose grenadier and smoothhead. Spanish multi-species deep-sea fishery on Hatton Bank (1996-2000).