

The hake semi-pelagic ("pedra - boia") longline fishery in Algarve (southern Portugal) waters: catch composition, catch rates, discards, hook selectivity, and inter-annual variability

by

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Abstract

A two year study of the European hake (*Merluccius merluccius*) semi-pelagic ("pedra - boia") longline fishery is being carried out in the Algarve (southern Portugal). This fishery takes place on the continental slope at 200 to 700 m depths, using monofilament longlines which are lifted off the bottom at regular, 48 hook, intervals by glass buoys. Hook selectivity trials were carried out with 4 hook sizes (SIAPAL brand N° 10, 9, 7 and 5) from March to August 1997 and May to July 1998. At least 27 species of fish and invertebrates were caught, with hake dominating the catch (41% and 44% of the catch in numbers), followed by *Galeus melastomus* (23% and 21%), *Micromesistius poutassou* (10% and 8%), *Benthodesmus elongatus* (8% and 5%), *Etmopterus pusillus* (6% and 8%) and *Scyliorhinus canicula* (5% and 7%). Apart from the hake, and some species of commercial value such as *Galeus melastomus* (only the large individuals), Ray's bream (*Brama brama*, 2-3% of the catch), the wreckfish (*Polyprion americanus*, <1% of the catch), conger eel (*Conger conger*, <1%), and bluemouth rockfish (*Helicolenus dactylopterus*, <1%), most of the other species are discarded, used as bait in traps or consumed by the fishermen. Catch rates (number of fish per 100 hooks) for hake and for all species combined decreased significantly with hook size. Hake catch size frequency distributions for the different hook sizes in 1997 and 1998 were highly overlapped, with the four different hooks catching a wide range of sizes. Although catch size frequency distributions for the different sized hooks were not significantly different in 1997, hake caught in 1998 were characterised by smaller sizes and size ranges.

Key words: European hake, *Merluccius merluccius*, longline, continental slope, hook, selectivity, discards, catch rate, Portugal

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Introduction

The European hake (*Merluccius merluccius* Linnaeus, 1758) has an extensive geographic distribution, ranging from approximately 61° N near the Shetland Isles to 22° N in Mauritania and throughout the Mediterranean (Casey and Pereiro 1995, Oliver and Massuti 1995, Papaconstantinou and Stergiou 1995, Martos and Peralta 1995). Throughout its range, the European hake is of considerable commercial importance and is fished with a variety of gears at depths ranging from less than 50 m to more than 500 m. Based on the location of two main spawning areas and the existence of a geographic barrier in the southern corner of the Bay of Biscay, the Cape Breton Canyon, European hake in the North-east Atlantic are divided into a Northern and a Southern stock (Casey and Pereiro 1995). The Southern stock (ICES divisions VIIIc and IXa) landings have decreased from 50,000 to 60,000 tonnes per year from 1965 to 1970 to less than 10,000 tonnes in recent years (Casey and Pereiro 1995, Lopes et al. 1996).

In Portugal, the European hake is fished by trawl, gill net, trammel net, and longline. Landings peaked at 10,400 tonnes in 1975 and have decreased steadily since, with 3,100 tonnes in 1994. The Portuguese "artisanal" fleet, which employs static gears (gill nets, trammel nets and longline), accounts for more than 60% of hake landings (Lopes et al. 1996). Due to concerns about the spawning biomass and recruitment, TACs for the Southern stock have been set lower and lower, from 29,300 tonnes in 1986 to 9,000 tonnes in 1996 (Lopes et al. 1996). Management measures include a 27 cm total length minimum size, a 65 mm minimum mesh size for trawls, seasonal closed areas, minimum mesh size for gill nets and trammel nets, maximum height and length of fixed nets, maximum time that fixed nets can remain in the water, and minimum operating distances from the coast.

Although there is some information on the catches of hake with trawls, gill nets and trammel nets in Portuguese waters, there is little or no information on hook and line fisheries. In February 1997, a two-year project focusing on hake longline fisheries in Portugal and Spain was initiated (DG XIV/C1, Ref. No. 96-062, "Hake semi-pelagic longline selectivity and evaluation of selectivity models for hook and line gear"). Some of the objectives of this project are: 1) to study and compare the species composition and size distributions of catches of the semi-pelagic longline used for fishing hake (*Merluccius merluccius*) in Portugal (Algarve) and Spain (Gulf of Biscay), 2) to evaluate the size selective properties of the different types and sizes of hooks used in these fisheries, 3) to evaluate the differences in efficiency (catch-per-unit-effort) between different sized hooks in terms of number and weight of the main species caught per longline unit, and 4) to study the way the fish are hooked (i.e. position of the hook in the mouth, throat or stomach), and to determine if there are differences due to hook type and size.

Longline selectivity trials were carried out from March to August 1997 and from May to July 1998 in the Algarve. In this paper, we report preliminary results concerning catch composition, catch rates, discards, hook selectivity, and inter-annual variability.

Methods

Fuzeta (Figure 1) fishermen were surveyed in February and March 1997 in order to characterise the fishing gear used in this longline fishery for hake. A fishing boat was contracted for the selectivity trials and the crew were paid to construct the experimental longline.

The semi-pelagic longline ("pedra e bola") used in the Algarve consists of a 1.60 mm diameter monofilament main line with 0.90 mm diameter monofilament gangions of approximately 1.2 m attached directly to the mainline (i.e. without swivels) at intervals of approximately 1.8 m. The longline is lifted off the bottom by glass buoys ("bolas") at intervals of 48 hooks (1997 trials) and 40 hooks (1998 trials), and weighted down with small rocks ("pedras") in between (Figure 2). The longlines are stored in plastic tubs with cork rims; each tub containing 144 hooks (1997) / 120 hooks (1998). Eyed hooks are used in order to facilitate recoiling of the longline after fishing; the hooks can be easily removed since they are not tied (a loop is made at the end of the gangion and passed through the eye).

The most commonly used hooks in this fishery are SIAPAL Brand numbers 7, 8, and 9. After discussion with the commercial fishermen, we decided to use 4 hook sizes: 10, 9, 7 and 5 (Figure 3). In terms of hook height, gape, maximum width and overall maximum size (height x maximum width), the number 5 hook is respectively 1.69, 1.67, 1.77 and 2.98 times larger than the smallest hook used (number 10).

Since large numbers of hooks per set (4,000 to 8,000 depending on the currents and on the weather) are normally used in this fishery, we decided to make a total of 56 tubs in 1997, giving a total of 7,728 hooks. However, the mean number of tubs used per set was 44. To avoid confusion when separating the catch by hook size, each tub consisted of only one size of hook. Thus for each hook size there were 16 tubs (1,932 hooks).

Normal fishing practices were followed. The fishing boat left Fuzeta during the night, stopping in the Ria Formosa lagoon in order to put a layer of wet sand in each tub. This helps maintain the longline coiled properly and reduces tangling when the longline is being set. Frozen sardines are thawed on the way to the fishing grounds, and cut in half with scissors. The longline is baited on the way to the fishing grounds by the crew of 4 to 5 men. This involves starting with the first hook (bottom of the coiled longline), passing the hook once through the bait and then leaving the baited hook hanging over the side of the tub.

The longline is set by placing a tub on a platform at the stern and using the momentum of the boat to pay out the longline. The crew attach the glass buoys, weights, and surface buoys at regular intervals, and link the longlines in each tub. Thus the total length of the longline may be between 10 and 15 km. To retrieve the longline, a hydraulic hauler is used to lift the large weights ("poitas"). Then the longline is retrieved from both the "mother" boat and from a skiff with an outboard engine. The longline rises to the surface with the expanded gas bladders of the fish which are caught. As the longline comes on board, the glass floats and the weights are removed, and the longline is stored in the empty tubs to be properly coiled later. Typically, the fishing trips last 17 to 21 hours.

Members of the research group accompanied the fishermen in order to separate the catches coming on board the main boat and the skiff, and to record the data. The position of each of the surface buoys (intervals of 3 tubs) was recorded using a GPS, for implementation in a GIS. The sequence of hook sizes / tubs fished was the following: 10 - 5 - 9 - 7 - 10 - 5 - 9 - 7 etc..

A preliminary analysis of the catch size frequency distributions was carried out. The Kolmogorov-Smirnov test was used to compare the catch distributions for 1997 and 1998 for the same sizes of hook and to compare the catch distributions for the 1997 trials of the four different hook sizes (Siegel and Castellan 1988).

Results

Fishing took place on the continental slope at depths from 200 to 700 m (Figure 1). A total of 64,224 hooks were fished in 10 fishing trips in 1997, while 24,076 have been fished to date in 5 fishing trips in 1998. It was not possible to fish exactly the same number of hooks of each size due to gear loss during fishing; mainly due to interaction with other gears (gill nets) and fouling on the bottom.

A total of 3,757 fish and invertebrates (27 species in all) were caught in 1997 (Table 1). The hake (*Merluccius merluccius*) dominated the catch with 1,524 (41%) fish, followed by *Galeus melastomus* (23%), *Micromesistius poutassou* (10%), and *Benthodesmus elongatus* (8%) (Table 1, Figure 4). So far in 1998, 1,538 fish of 19 species have been caught with the same 6 species dominating the catch (Figure 4).

Overall, catch rates (number of all species of fish per 100 hooks) decreased significantly with hook size: 7.13, 6.18, 5.60, and 4.09 and 7.55, 6.68, 6.26, and 5.02 respectively for hooks N° 10, 9, 7 and 5 in 1997 and 1998. The same occurred for the hake: 3.33, 2.38, 1.97, and 1.61% in 1997 and 3.29, 3.13, 2.59, and 2.16 in 1998.

Catch size frequency distributions for the different hook sizes were highly overlapped, with all hook sizes catching a wide range of sizes and little or no evidence of differences in size selectivity. The hake standardised catch size frequency distributions for 1997 and 1998 are given in Figure 5. Hake ranging in size from 27 to 94 cm total length (TL) were caught in 1997 and from 34 to 66 cm TL in 1998. However, the majority ranged in size from 30 to 65 cm, with mean total lengths of 47.4 (n=580, SD=5.89), 47.7 (n=415, SD=6.24), 47.0 (n=309, SD=6.83), and 47.4 (n=220, SD=6.70) cm total length for hook sizes 10, 9, 7, and 5 (Table 1). Mean sizes in 1998 were 45.3 (n=205, SD=4.97), 45.1 (n=175, SD=4.81), 44.5 (n=165, SD=4.73), and 44.4 (n=127, SD=4.42) cm total length, with a smaller size range of hake.

Results of the Kolmogorov-Smirnov test are given in Tables 2 and 3. No significant differences were found between any of the 1997 catch size frequency distributions. However, all inter-annual comparisons were significant.

Discussion

The hake semi-pelagic longline fishery is perhaps the most physically demanding of all the artisanal fisheries in European waters. Although hydraulic haulers are used to lift the heavy weights off the bottom, the entire operation, from baiting, setting, retrieving, to preparing the longline for the next set is manual. Due to the length of the longline, number of hooks, and distance to the fishing grounds, trips are long, usually from 15 to 20 hours from departure to arrival at the landing site, with the fishermen working practically non-stop the whole time. In the Algarve, this is a traditional fishery, especially for boats operating from Fuzeta, which have access to the Beirinha fishing grounds (Figure 1) where only longlining is permitted. However, due to the above mentioned characteristics of this fishery and a number of other factors, including low catches, variable prices, and alternative fisheries (e.g. octopus), the number of boats has decreased steadily in recent years.

Even though the hake dominates the catches in this fishery, catch rates are extremely low, with less than 3.5 fish per 100 hooks for the most successful hook size (number 10), and less than 2.5 fish per 100 hooks for the least successful hook size (number 5). It is interesting to note that the number 10 hook is not generally used in this fishery, with the fishermen

favouring the larger numbers 9 and 8. Even after more than 12 hours in the water, a high percentage of the hooks were often retrieved still with bait.

The hake caught in this fishery are of a large size, with no illegal sized (less than 27 cm) individuals caught in the 15 fishing trials. This is probably due to the fact that smaller fish are found in shallower waters on the continental shelf where they are susceptible to trawls, gill nets and trammel nets. As pointed out by Pitcher and Alheit (1995), cannibalism is characteristic of hakes and in most hake species there are clear depth-related differences in size, with the larger fish found in deeper waters.

These preliminary results suggest that there are no differences in size selectivity due to hook size even though the range of hook size used in this study was considerable. This is not surprising since the hake is an ambush predator with a very large mouth and which can swallow fish more than half its size. Thus, all four hook sizes used in this study caught a similar and wide size range, resulting in the observed highly overlapped catch size frequency distributions. The use of even larger hooks than the number 5 in the selectivity study is not justified since number 5 or larger hooks are not used in this fishery due to the low catch rates.

The significant differences in the catch size frequency distributions between 1997 and 1998 are difficult to explain, particularly since we are dealing with the same stock and the fishing trials took place in the same season and location. Decreasing mean size over time is an indication of heavy fishing pressure, especially if all fish above a certain size are equally vulnerable to the gear (i.e. logistic type selectivity), which is probably the case for longline gear used for the European hake. Although there is considerable fishing pressure nowadays due to deepwater gill netting as well as some deepwater crustacean trawling, it is difficult to accept that fishing pressure alone can have such a dramatic effect from one year to the next. These differences may also be due to movements of hake and variation in recruitment to these deeper waters.

The overlapping catch size frequency distributions have important implications for the modelling of selectivity. As reported by Millar (1995) and Boje et al. (1998), strongly overlapping size distributions result in identical fits of a variety of models using the SELECT approach (Millar 1992). Methodologies where it is assumed that parameters of selectivity curves are a function of gear size (e.g. Wulff 1986, Erzini and Castro 1998) will not give reasonable results or may not even allow parameter estimation. In addition, it is probable that the 1997 data will result in different selectivity parameter estimates to that of 1998.

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Table 1. Catches in 1997 fishing trials with 4 hook sizes. N is the number of fish caught, TL is the mean total length (cm), and SD is the standard deviation.

Species	Hook												Total	% N°
	5			7			9			10				
	N	TL	SD	N	TL	SD	N	TL	SD	N	TL	SD		
CARCHARHINIDAE														
<i>Prionace glauca</i>	1	103.00		1	60.50		1	63.40		1	79.50		4	0.11
RAJIDAE														
<i>Raja clavata</i>										2	69.10	3.68	2	0.05
<i>Raja sp.</i>	1	86.00		1	58.90					2	84.50	12.02	4	0.11
SCYLIORHINIDAE														
<i>Galeus melastomus</i>	148	47.12	11.81	262	47.22	10.76	238	47.37	12.62	210	50.35	11.05	858	22.84
<i>Scyliorhinus canicula</i>	71	40.57	7.47	63	40.57	7.88	41	43.45	9.24	17	42.38	10.65	192	5.11
SQUALIDAE														
<i>Etmopterus pusillus</i>	17	35.14	5.30	47	33.52	4.33	76	33.95	5.48	70	34.15	5.09	210	5.59
TRIARIDAE														
<i>Mustelus mustelus</i>				1	143.00								1	0.03
CHIMAERIDAE														
<i>Chimaera monstrosa</i>	1	66.40					1	78.00		1	99.70		3	0.08
BRAMIDAE														
<i>Brama brama</i>	1	45.00		9	47.49	4.68	18	45.22	4.81	25	46.16	5.52	53	1.41
<i>Taractichthys longipinnis</i>	1	69.10		1	75.50		4	65.93	3.13	3	68.43	2.56	9	0.24
CARANGIDAE														
<i>Trachurus trachurus</i>				1	38.90								1	0.03
CENTROLOPHIDAE														
<i>Centrolophus niger</i>							1	32.00					1	0.03
CONGRIDAE														
<i>Conger conger</i>	3	66.93	24.09	5	84.00	30.61	4	69.40	12.27	5	83.20	39.71	17	0.45
GADIDAE														
<i>Micromesistius poutassou</i>	23	36.76	2.10	61	36.79	2.05	114	36.65	2.28	170	36.72	2.79	368	9.80
<i>Phycis phycis</i>	5	34.44	1.44	3	32.40	4.01	14	40.35	11.00	14	36.99	10.55	36	0.96
GEMPYLIDAE														
<i>Ruvettus pretiosus</i>	8	88.30	13.55	8	79.89	11.41	6	82.78	12.67	3	82.27	25.78	25	0.67
MERLUCCIIDAE														
<i>Merluccius merluccius</i>	220	47.36	6.70	309	47.04	6.83	415	47.72	6.24	580	47.35	5.89	1524	40.56
MOLIDAE														
<i>Mola mola</i>				1	53.60								1	0.03
OPHICHTHIDAE														
<i>Ophisurus serpens</i>	2	158.50	2.12										2	0.05
SCORPAENIDAE														
<i>Helicolenus dactylopterus</i>	1	28.50		3	24.10	3.84	4	24.60	2.79	4	24.05	1.53	12	0.32
SCOMBRIDAE														
<i>Scomber japonicus</i>	5	26.88	2.62	17	26.22	2.64	19	27.69	2.69	33	26.52	2.71	74	1.97
SERRANIDAE														
<i>Polypterus americanus</i>				3	59.97	2.46	2	57.00	5.66	1	49.30		6	0.16
SPARIDAE														
<i>Boops boops</i>	1	22.60											1	0.03
TRICHIURIDAE														
<i>Lepidopus caudatus</i>	5	144.00	4.64	7	147.47	13.09	10	144.15	11.90	14	146.93	11.00	36	0.96
<i>Benthodesmus elongatus</i>	44	81.78	7.57	75	80.89	5.92	106	80.41	6.15	86	80.78	6.58	311	8.28
CRUSTACEA														
<i>Nephrops norvegicus</i>	1	9.00					2	9.75	0.35	2	6.90	0.99	5	0.13
CEPHALOPODA														
<i>Illex sp.</i>				1	13.50								1	0.03
Total	559			879			1076			1243			3757	

Table 2. Results of the Kolmogorov-Smirnov test used to compare the 1997 and 1998 catch size frequency distributions. The null hypothesis is that the distribution of the catch of a certain hook size is the same from one year to the next.

hook	1997 m	1998 n	D	critical values of $D_{m,n}$ level of significance=0.05 (Table Liii, Siegel and Castellan, 1988)	
10	580	200	0.21	0.112	Reject H_0
9	414	163	0.26	0.126	Reject H_0
7	308	159	0.27	0.133	Reject H_0
5	219	123	0.25	0.153	Reject H_0

Table 3. Results of the Kolmogorov-Smirnov test used to compare the 1997 catch size frequency distributions. The null hypothesis is that the size distributions of the catch of different sized hooks are the same.

hooks	m	n	D	critical values of $D_{m,n}$ level of significance=0.05 (Table Liii, Siegel and Castellan, 1988)	
10,9	580	414	0.03	0.088	H_0 not rejected
10,7	580	308	0.06	0.096	H_0 not rejected
10,5	580	219	0.04	0.108	H_0 not rejected
9,7	414	308	0.06	0.102	H_0 not rejected
9,5	414	219	0.05	0.114	H_0 not rejected
7,5	308	219	0.05	0.120	H_0 not rejected

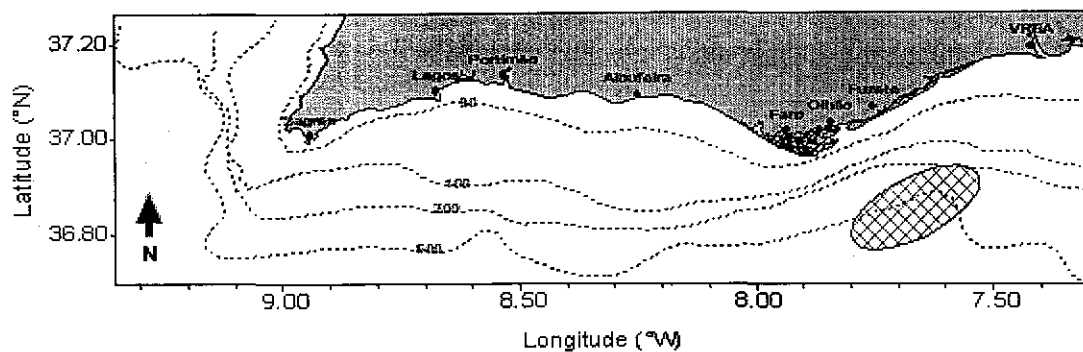


Figure 1. Map of the Algarve, with indication of the main fishing ports. The dashed lines represent the isobaths. The gridded ellipse represents the location of the fishing grounds.

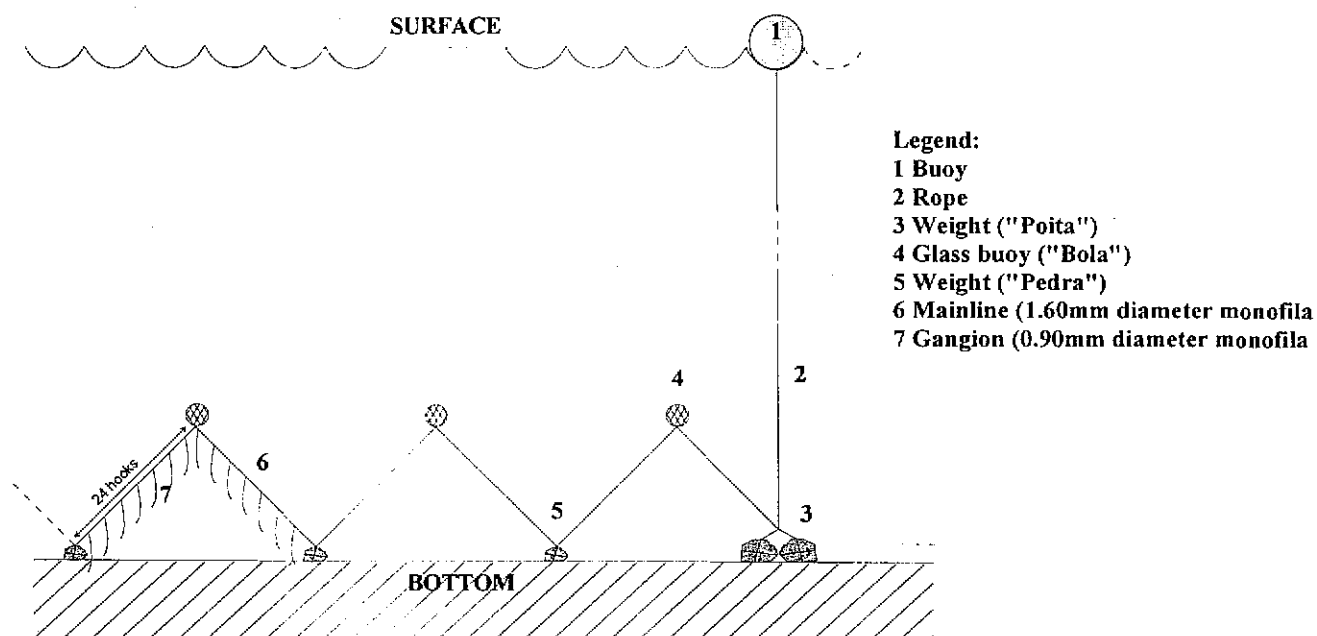


Figure 2. Schematic representation of the semi-pelagic longline ("pedra e bola") used in the selectivity study.

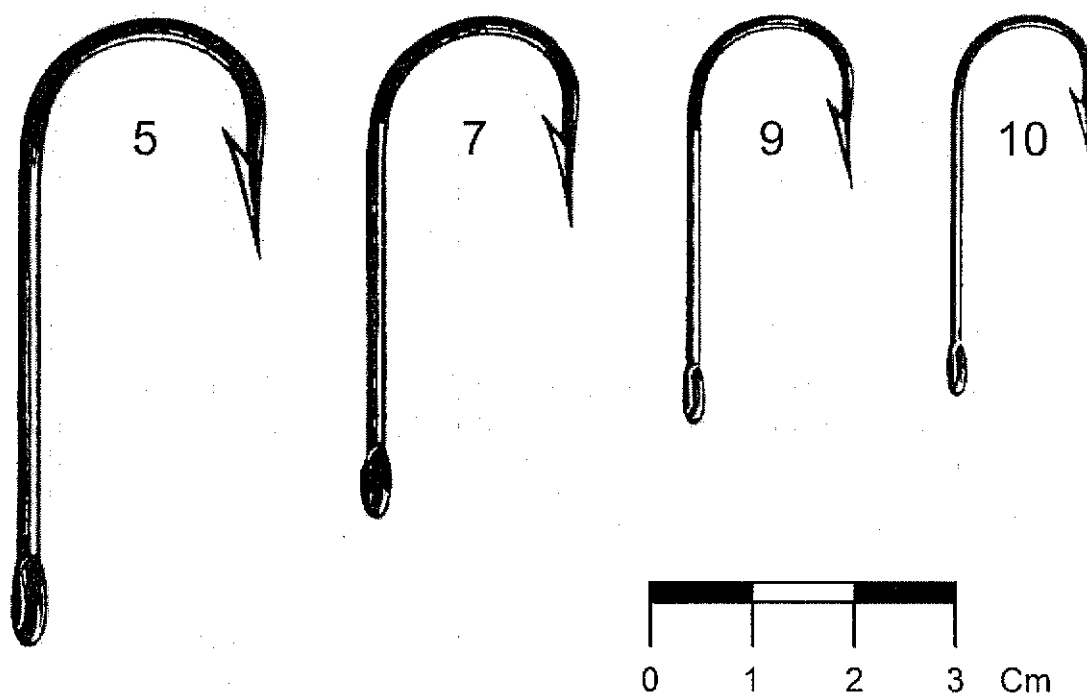
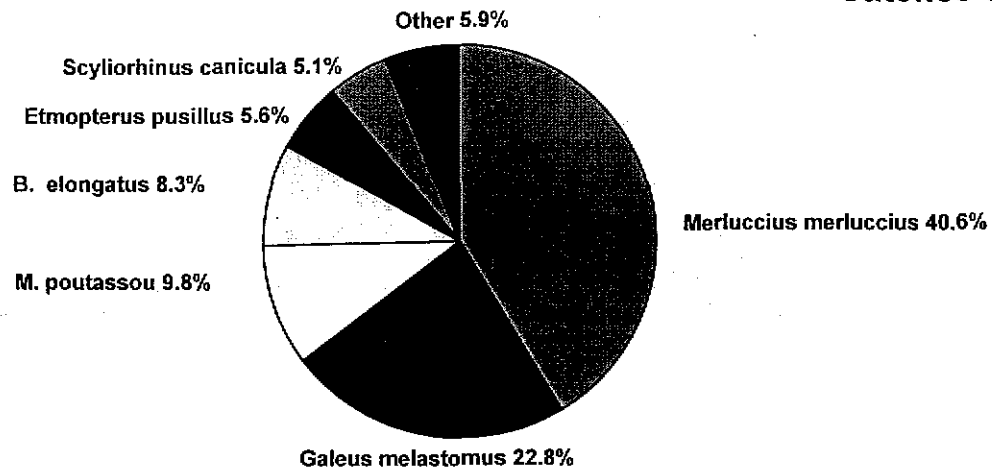


Figure 3. Representation of the different hook sizes used.

Catches 97



Catches 98

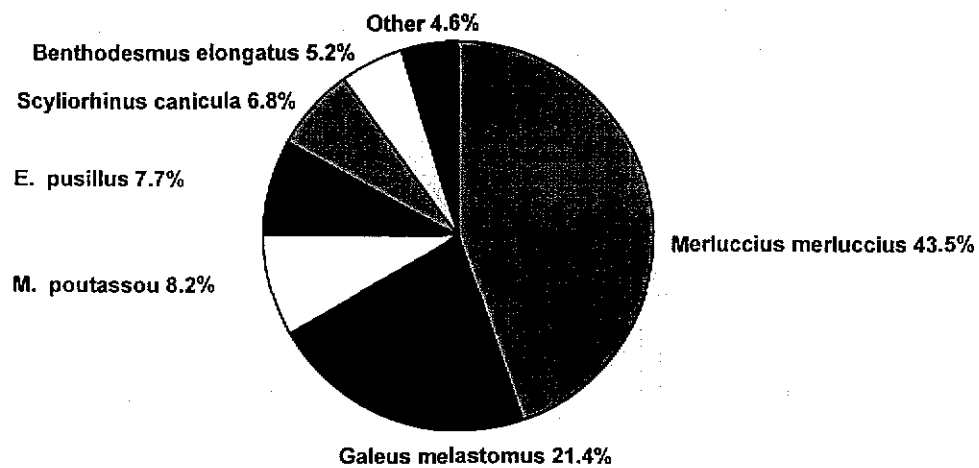


Figure 4. Composition of the catches (all hook sizes combined) for 1997 and 1998.

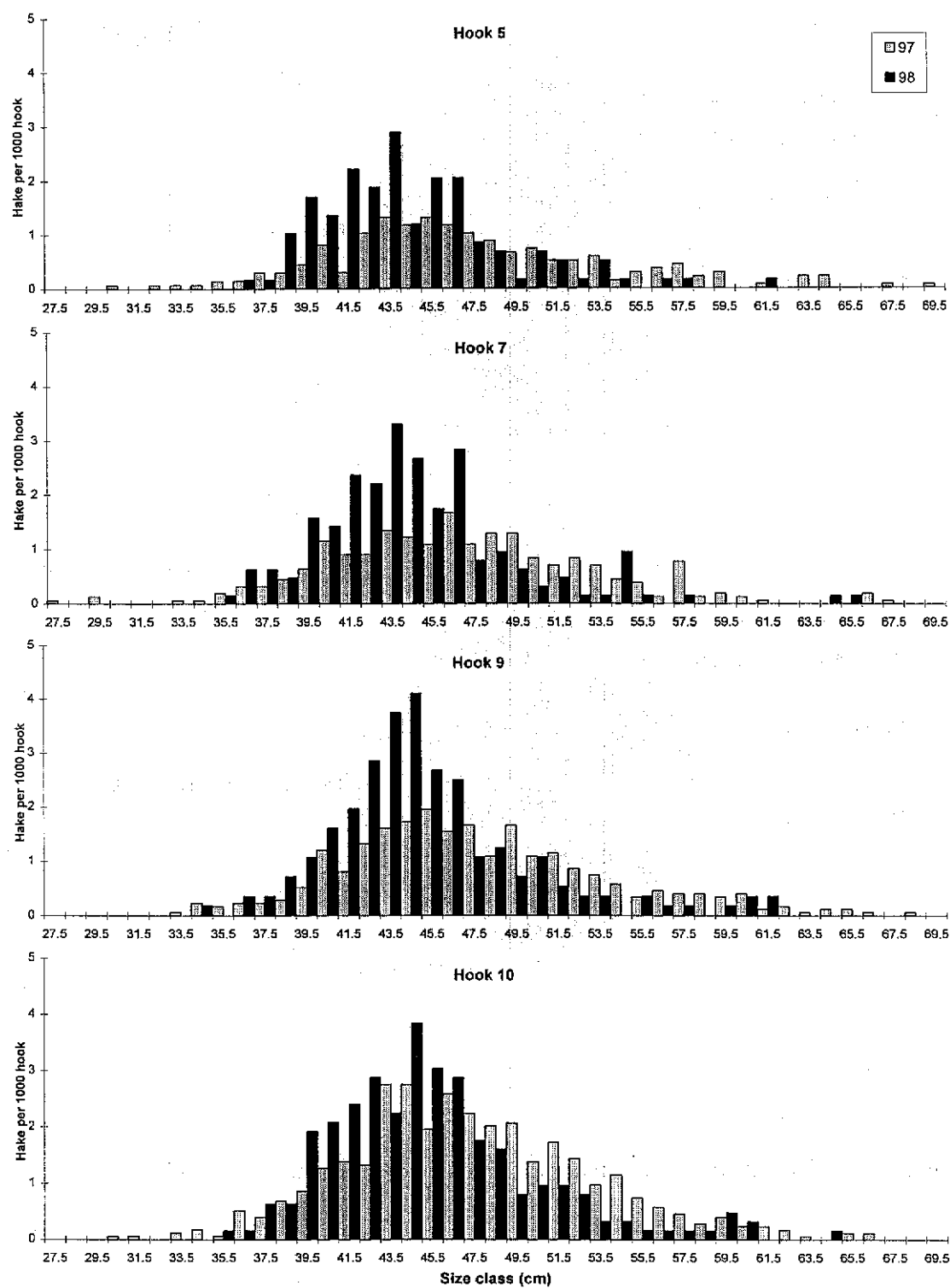


Figure 5. Standardised catch size frequency distributions for 1997 and 1998.