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Comparison of Long-line and Monofilament Gill Net Selectivity for Hake (*Merluccius merluccius*) in the Algarve (Southern Portugal)

by

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Abstract

As part of ongoing studies concerning the Atlantic hake (*Merluccius merluccius*) deep-water fisheries in the Algarve (Southern Portugal), experimental fishing was carried out during the summer of 1998, with monofilament gill nets and semi-pelagic long-lines, within the same area on the upper continental slope. Both set gears caught large sized hake, with no catch consisting of illegal sized fish (under 27 cm of total length). Both fishing gears used in the study caught hake in a wide range of sizes, resulting in highly overlapped catch size frequency distributions. Significant differences were found between the catch size frequencies of the two gears. The results of the hook selectivity trials showed that there were no differences in size selectivity due to hook size, even though the range of hook sizes used was considerable. The mean total lengths found were 45.6 cm (n=369, SD=4.98), 45.6 cm (n=353, SD=4.71), 44.1 cm (n=289, SD=4.61) and 45.3 cm (n=247, SD=4.97) for SIAPAL brand hooks numbers 10, 9, 7 and 5, respectively. For the gill nets hake mean size increased with mesh size even though a significant proportion of the hake were caught by entanglement, independently of their body size and the mesh size used. The mean total lengths found were 41.1 cm (n=422, SD=5.64), 44.9 cm (n=278, SD=7.00) and 46.5 cm (n=202, SD=7.28) for the 70, 80 and 90 mm stretched mesh sizes, respectively.

Introduction

The European hake is one of the most important demersal fisheries in the North-eastern Atlantic waters. Its bathymetric range extends from shallow waters to about 1000m, but it is most common at depths of 100-500m (Moreira, 1987; Sanches, 1992). Off the Algarve coast (south Portugal) this fishery assumes particular economic relevance. According to DGPA (2000), a total of 222.3 tons of hake were caught by trawlers and 460.6 tons by gill nets and long-lines during 1999 off the Algarve coast, accounting for 685,314 and 1,964,905 Euro respectively. These hake catches represented 22% of the total landings of this species in Portugal.

The fleet targeting hake with set gears in the Algarve waters (ICES sub-area IXa) operates mainly on the south-eastern part of the coast, between the meridians 7º 25' W and 8º 00' W and the parallels 36º 31' N and 36º 55'N. The minimum legal stretched mesh size for gill nets is 80 mm year-round with a maximum height of 10 m (6 m is

the standard). The total length of the nets depends on the boat GRT, varying from 1,500 to 13,000 m. These nets are not allowed to fish for more than 12 consecutive hours in each 24 h period. For long-lines, currently there is no regulation in force concerning neither the size nor the number of hooks.

Aspects of the biology, ecology, population dynamics and fisheries of the European hake are currently being studied by the Institute of Marine and Fisheries Research (IPIMAR) and the University of the Algarve. Herein we report on the comparison of hake selectivity for long-line and gill net, on the Algarve coastal waters (Southern Portugal).

Materials and Methods

Experimental fishing was carried out during the summer of 1998, with monofilament gill nets and semi-pelagic long-lines, within the same area on the upper continental slope, at depths ranging from 250 to 700 m.

Three mesh sizes were used: 69.5, 81.0 and 88.5 mm, measured between opposite knots when fully stretched. This meshes are commercially referred as 70, 80 and 90mm. The net twine was light green with a diameter of 0.35 mm. The hanging ratio of these nets was 0.50 on the float rope and 0.52 on the lead rope. Sixty panels (15 of each mesh size) were used, randomly distributed along the net. Each panel was approximately 50 m long and 6.3 m high. The adopted soak time was that used by the commercial fishermen, that consisted in setting the nets in the afternoon and retrieve them in the next day after sunrise. A total of 20 sets were made. Net characteristics are given in Table 1.

The long-lines used had the following characteristics: 1.6 mm main line (polyamide, monofilament), 1.6 m gangions of 0.9 mm polyamide monofilament, and 1.8 m spacing between hooks. Four hook sizes of SIPAL brand, round bent, spade end hooks (nº. 10, 9, 7 and 5) were used (1,320 of each size). Hook characteristics are given in Table 2. The long-line was semi-pelagic, consisting of a main line with snoods directly attached at regular intervals. A loop is made at the end of each snood, which is passed through the eye of a hook and can be easily removed to facilitate recoiling of the long-lines after fishing. The long-line is kept off the seabed by a glass buoy (bola) at intervals of 40 hooks, and weighed down with small rocks (pedras) in between. The equipment is anchored in position by rocks, and surface floats (bóias) are attached to the main line at intervals of 360 hooks. The gear is stored in plastic tubs with cork rims. The hooks were baited with frozen sardine (*Sardina pilchardus*) strips. The long-line was set in a zig-zag pattern, starting one hour before sunrise (5.00-6.00 am) and taking approximately 2 hours to complete. Immediately after setting, the first buoy was lifted using a hydraulic hauler, and the gear was hauled by hand starting at the first hook set. The retrieving operation takes from 8 to 12 hours, depending on the weather conditions and the size of the catch, typically corresponding to fishing trips of a total of 15 to 20 hours. The sequence of hook size tubs fished was as following: 10-5-9-7-10-5-9-7- etc. A total of 10 sets were made corresponding to 52,800 hooks (11 tubs of each hook size).

A number of statistical analysis were used to evaluate the results obtained. The Kolmogorov-Smirnov test was used to compare the catch size frequency distributions of the different gears used in this study, and the two-sample Z-test was used to compare the mean sizes, with a 95% interval of confidence (Siegel & Castellan, 1988).

Results

A total number of 1208 hakes were caught by the long-lines, ranging in size from 34 to 66 cm. The catch size frequency distributions for the different hook sizes were highly overlapped, with a wide range of sizes caught. The minimum size at first capture was not related to hook size, neither the maximum size. Hake was caught within the following size class intervals: 35-66 cm, 34-65 cm, 35-65 cm and 36-66 cm, by hook numbers 10, 9, 7 and 5 respectively. No statistical differences were found between the different catch size frequency distributions (Table 3). The mean total lengths found were 45.6 cm (n=369, SD=4.98), 45.6 cm (n=353, SD=4.71), 44.1 cm (n=289, SD=4.61) and 45.3 cm (n=247, SD=4.97) for hooks numbers 10, 9, 7 and 5, respectively. No differences were found between mean total lengths (Table 4). Catch of immature hake were minimal and no undersized fish were caught by the long-lines (Figure 2).

A total number of 902 hakes were caught by gill nets, with their size ranging between 30 and 63 cm. As observed for long-lines, the catch size frequency distributions for the different mesh sizes were also highly overlapped. The

minimum size at first capture was not related to mesh size. Hake was caught within the following size class intervals: 30-57 cm, 31-61 cm and 33-63 cm, by the 69.5, 81 and 88.5 mm mesh sizes respectively. The comparison of the catch size frequency distributions showed significant differences between all the mesh sizes used (Table 3). Contrasting with the results found for long-lines, and besides the fact that a large proportion of the catch was due to entanglement (between 35% and 40% of the catch in number), selectivity was observed for the gill nets (Figure 2). An increase of the catch size range was observed with the increase of the mesh size. The mean total length observed also increased with the mesh size: 41.1 cm (n=422, SD=5.64), 44.9 cm (n=278, SD=7.00) and 46.5 cm (n=202, SD=7.28), for the 70, 80 and 90 mm stretched mesh sizes, respectively. Differences were found between the mean total lengths from used mesh sizes (Table 4). No undersized fish were caught by the gill nets (Figure 2).

The comparison of the catch size frequency distributions from the long-lines and the gill nets, showed significant differences between all them (Table 3). However, the comparison between the mean total length for hake from the different hooks and mesh sizes used, showed significant differences between the 69.5 mm mesh size and all four hooks, as well as between the 88.5 mm mesh size and hooks numbers 5 and 7 (Table 4).

Discussion

Hake selectivity for long-lines and gill nets differed significantly. In fact, long-lines showed no evidence of differences in size selectivity, even though the range of hook size used in this study was considerable. This is not surprising since hake is an ambush predator with a very large mouth and which can swallow fish more than half its size (Casey & Pereiro, 1995; Martos & Peralta, 1995; Olivier & Massutí, 1995; Papaconstantinou & Stergiou, 1995; Pitcher & Alheit, 1995). This means that even the largest hooks used could be easily engulfed by even the smallest hake caught. Due to these reasons, no relationship was found between minimum size at first capture or maximum size of capture and hook size. Thus, all four hook sizes used in this study caught hake with a similar mean total length and within a similar wide size range, resulting in the observed highly overlapped catch size frequency distributions. In terms of management the adoption of a particular hook among those used in the present study, will on have consequences on the fishing yield, with the smaller hooks catching more fish. It is interesting to note that the number 10 hook (the smallest used in this study) is not generally used in this fishery, with fishermen favouring the larger numbers 9 and 8. This is due to the fact that hook no.10 is harder to handle, causing more entangling of the gear.

The gill nets catch showed that these gears are more selective for hake than the long-lines. In fact, the mean total length increased and the selection range became wider as mesh size increased, as also reported in other studies (Hamley, 1972; Rudstam *et al*., 1984; Wulff, 1986; Jensen, 1986; Saila & Erzini, 1988; Ehrhardt & Die, 1988; Santos *et al*., 1995, 1998). However, an important portion of the catch is due to tangling. As a consequence, selectivity for this species is not as pronounced as in the case of species in which the majority of the individuals are wedged (eg. Santos *et al*., 1995). In terms of management it is worthy of note the fact that, an eventual change on the mesh size will mainly be reflected in terms of fishing yields, since the smaller mesh sizes catch more individuals. However, the use of larger mesh sizes might result in a higher fishing pressure on the reproductive females, due to a shift of sex-ratio towards a prevalence of females on the larger individuals.

As a result of hake complex life cycle, ecology and behaviour toward the different fishing gears, and also some of socio-economic aspects, further studies to improve our knowledge are required in order to identify proper management rules for this important deep-water fishery on the Algarve.

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Table 1 – Characteristics of the nets used.

Commercial mesh size (mesh size in mm when fully stretched)	70 (69.5)	80 (81)	90 (88.5)
Float rope length	47.84	50.61	49.96
Lead rope length	49.91	52.92	51.24
Number of bolshes	230	210	183
Number of meshes per bolsh	6	6	6
Number of meshes in height per panel	90.5	77.5	70.5
Number of floats	24	25	25
Hanging ratio on the float rope	0.50	0.50	0.50
Hanging ratio on the lead rope	0.52	0.52	0.52

Table 2 – Dimensions of the hooks (mm) with standard deviations values in parenthesis.

Hook reference	Length	Width	Gap	Thickness
5	61.77 (0.52)	22.79 (0.24)	18.58 (0.25)	2.39 (0.00)
7	48.41 (0.25)	19.62 (0.15)	16.87 (0.19)	1.79 (0.01)
9	37.62 (0.40)	15.20 (0.13)	12.67 (0.20)	1.45 (0.01)
10	35.43 (0.47)	13.04 (0.12)	11.16 (0.25)	1.22 (0.02)

Table 3 – Results of the Kolmogorov-Smirnov test used to compare the catch size frequency distributions for *M.merluccius*. **#** for mesh size; **H** for hook number.

Gear	m	n	Dmax	Critical value of Dm,n	
H10 vs H9	360	335	0.036	0.103	Ho not rejected
H10 vs H7	360	278	0.046	0.109	Ho not rejected
H10 vs H5	360	235	0.024	0.114	Ho not rejected
H9 vs H7	335	278	0.051	0.110	Ho not rejected
H9 vs H5	335	235	0.047	0.116	Ho not rejected
H7 vs H5	278	235	0.036	0.121	Ho not rejected
#69.5 vs #81	422	278	0.528	0.089	**Ho rejected**
#69.5 vs #88.5	422	202	0.530	0.096	**Ho rejected**
#81 vs #88.5	278	202	0.528	0.113	**Ho rejected**
#69.5 vs H5	422	235	0.173	0.107	**Ho rejected**
#69.5 vs H7	422	278	0.146	0.102	**Ho rejected**
#69.5 vs H9	422	335	0.149	0.098	**Ho rejected**
#69.5 vs H10	422	360	0.136	0.097	**Ho rejected**
#81 vs H5	278	235	0.173	0.117	**Ho rejected**
#81 vs H7	278	278	0.146	0.113	**Ho rejected**
#81 vs H9	278	335	0.129	0.109	**Ho rejected**
#81 vs H10	278	360	0.123	0.108	**Ho rejected**
#88.5 vs H5	202	235	0.173	0.127	**Ho rejected**
#88.5 vs H7	202	278	0.146	0.124	**Ho rejected**
#88.5 vs H9	202	335	0.151	0.120	**Ho rejected**
#88.5 vs H10	202	360	0.134	0.119	**Ho rejected**

Table 4 – Results of the Z-test used to compare the mean total length for *M.merluccius*. **#** for mesh size; **H** for hook number.

Gear	m	n	z	P (Z ≤ z)	
H10 vs H9	360	335	-0.090	> 0.050	Ho not rejected
H10 vs H7	360	278	1.128	> 0.050	Ho not rejected
H10 vs H5	360	235	0.745	> 0.050	Ho not rejected
H9 vs H7	335	278	1.227	> 0.050	Ho not rejected
H9 vs H5	335	235	0.832	> 0.050	Ho not rejected
H7 vs H5	278	235	0.281	> 0.050	Ho not rejected
#69.5 vs #81	422	278	-7.550	< 0.001	**Ho rejected**
#69.5 vs #88.5	422	202	-9.267	< 0.001	**Ho rejected**
#81 vs #88.5	278	202	-2.410	< 0.050	**Ho rejected**
#69.5 vs H5	422	235	-9.663	< 0.001	**Ho rejected**
#69.5 vs H7	422	278	-10.220	< 0.001	**Ho rejected**
#69.5 vs H9	422	335	-11.820	< 0.001	**Ho rejected**
#69.5 vs H10	422	360	-11.618	< 0.001	**Ho rejected**
#81 vs H5	278	235	-0.595	> 0.050	Ho not rejected
#81 vs H7	278	278	-0.349	> 0.050	Ho not rejected
#81 vs H9	278	335	-1.339	> 0.050	Ho not rejected
#81 vs H10	278	360	-1.264	> 0.050	Ho not rejected
#88.5 vs H5	202	235	2.113	< 0.050	**Ho rejected**
#88.5 vs H7	202	278	2.406	< 0.050	**Ho rejected**
#88.5 vs H9	202	335	1.634	> 0.050	Ho not rejected
#88.5 vs H10	202	360	1.685	> 0.050	Ho not rejected

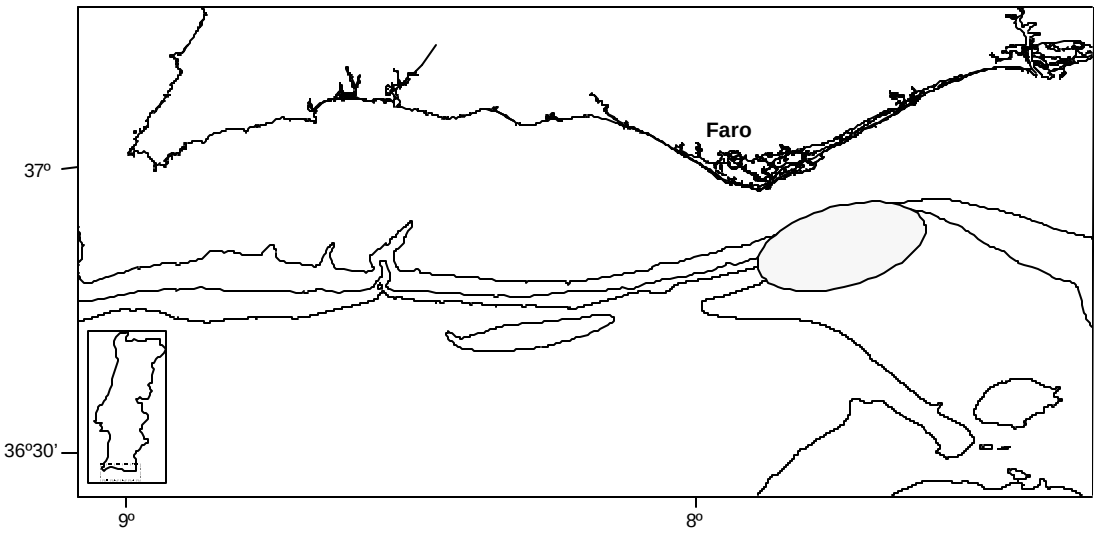

Fig. 1. Map of the Algarve and location of the fishing grounds (dotted ellipse). Lines represent the isobaths (300, 500 and 700 m).

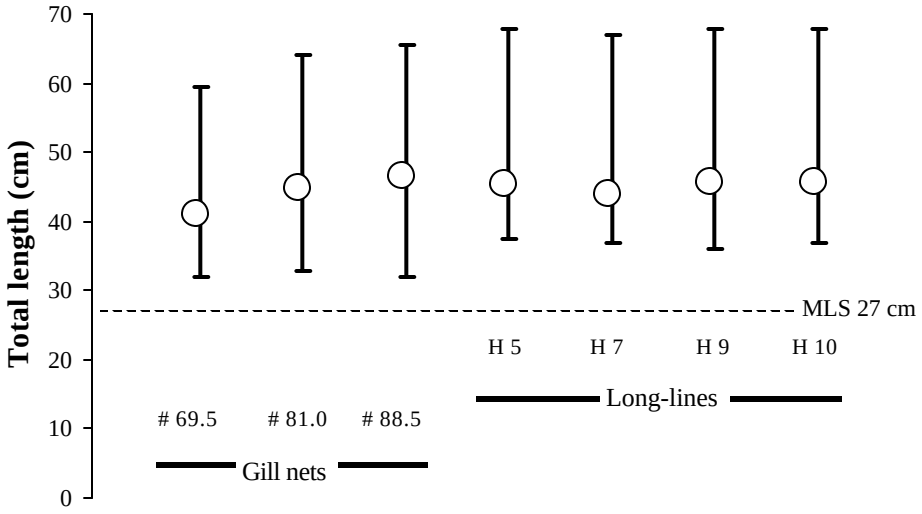

Fig. 2. Mean length and size range of *M. merluccius* caught by gill nets and long-lines. MLS is the minimum landing size.