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NOTE

Commercial testing of a sorting grid to reduce catches of juvenile hake (*Merluccius merluccius*) in the western Mediterranean demersal trawl fishery

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Abstract – Mediterranean demersal fisheries have experienced an ongoing decline in catches over the past 20 years as a result of excessive increases in effort caused both by growth in trawler engine power and by rapid technological advances in fish finding and fishing technology. This has led to an overexploitation of these resources. An increasing share of the catches consists of immature individuals. This study was undertaken to test a sorting grid with a bar spacing of 20 mm as a means of excluding juveniles in the commercial hake (*Merluccius merluccius*) fishery in the Catalan Sea, western Mediterranean. The grid was placed in the extension section of the gear 5 m in front of a cod-end. Divided cod-end design was used to collect the escapees and target species. The mean selection length (L_{50}) of the ten hauls was 14.2 ± 0.7 cm SE, with a selection range of 7.3 cm ± 0.4 SE. The biomass of hake under L_{50} that escaped through the grid represented 50.1% ± 6.7 SE of the total hake biomass. These results are promising and indicate that a sorting grid can be used in excluding young hake. This was a first step toward implementation of sorting grids in commercial trawl gears as means of avoiding unwanted catches of small individuals in the hake fisheries in the Mediterranean Sea. Further trials are required to improve the sorting efficiency of the grid.

Key words: Trawling / Grid / Selectivity / Hake / *Merluccius merluccius* / Juveniles / Mediterranean Sea

Introduction

Over the past 20 years catches in the western Mediterranean fishery have steadily declined due to excessive fishing effort resulting from both increased trawler engine power and major technological advances in vessels, nets and electronic equipments (Bas 2003; Maynou et al. 2003). This has led to what is known as growth overexploitation, in which immature individuals (particularly hake) support a large portion of the catches (Oliver 1991; Recasens 1992; Lleonart 1993; Irazola et al. 1996). Small individuals are taken all year round at depths ranging between 50 and 300 m by a large number of bottom trawlers having medium and high engine power (400–1500 HP). While the sale of undersized individuals is prohibited, there is nonetheless a landing dynamic that is invariably difficult to control and correct. The difficulty is not just the sale of illegal catches but the discards produced. Small and immature individuals of different species, hake in particular, are often discarded dead before vessels return to port, either because of large catches that cannot be sold or because of damage to small individuals, making them unsuitable for sale. Studies and simulations of selectivity systems for Mediterranean hake (Cheret et al. 2002) have suggested that allowing small fish to escape could result in 30 to 50% increases in catches of larger individuals four or five years after implementation.

Development of selection technology based on fish sorting grids has been undertaken in different parts of the world during the last two decades for various purposes (reviewed by Valdemarsen and Suuronen 2003). The applications range from excluding large protected species such as sharks and turtles (e.g. Villaseñor 1997) to allowing the juveniles to escape in demersal and pelagic fisheries (e.g. Larsen and Isaksen 1993; Broadhurst et al. 1996, 1999; Suuronen et al. 1996; Kvalsik et al. 2002; Graham et al. 2004), as well as simply separating certain species of crustaceans, e.g., shrimp (Isaksen et al. 1992; Broadhurst et al. 1996; Ercoli et al. 1997; Polet 2002; Graham 2003).

Following an experimental study using different grids in the Catalan region (Sardà et al. 2004), the present study tested

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a sorting grid to help juvenile hake to escape from commercial trawl gears off Catalonia in the western Mediterranean.

Materials and methods

The study area was located on the fishing grounds off the fishing port of Vilanova i la Geltrú (Catalan coast, western Mediterranean) at depths between 40 and 160 m, where juvenile hake are usually found (Lleonart 2001; Maynou et al. 2003). Ten hauls were carried out by the commercial trawler "José y Virgilio" (19.5 m, 43.4 GRT) from 8 to 13 May 2003 along a section from 41.13 °N, 1.75 °E to 41.13 °N, 1.84 °E. The mean towing speed was 3.7 ± 0.1 knots with a towing duration between 60 and 135 min. Trials were carried out in the month of May because the small hake are most abundant in this period of the year (Recasens 1992).

The grid was composed of two sections hinged together (Fig. 1) and was installed in the extension piece in the net, 5 m ahead of the cod-end. The device was fitted into the trawl according to the design presented by Isaksen et al. (1992) and Ercoli et al. (2000). The grid bar spacing was 20 mm, i.e., the same as the distance between two knots in legal diamond-shaped netting in the Mediterranean. The type of grid used in this trial has been widely used in selectivity experiments (e.g., Ercoli et al. 2000; Graham et al. 2004). To measure grid selectivity the cod-end was divided in two parts (Fig. 2). Small fish that were passing through the grid were directed towards the lower cod-end and larger fish (that were not passing through the grid) were being guided towards the upper cod-end. The stretched mesh size in both upper and lower cod-ends was 40 mm. Rigging of the gear under working conditions was monitored with two sets of acoustic sensors (Scanmar). The catch was sorted on board by haul and cod-end and weighed (±1 kg) using a digital dynamometer. The total length of all hake was measured with a precision of ±0.5 cm.

Standard logistic curves for each haul were fitted using a selectivity model (Fryer 1991) that is based on the relationship between the retention probability r of a fish entering the upper cod-end (see Fig. 2) and fish length l in the i-th haul: $r_i(l) = \exp(a_i + b_i l)/1 + \exp(a_i + b_i l)$, where $r(l)$ is the probability that a fish of length l that has entered the net will be retained by the net. Constants a and b are selection parameters used to calculate the 50% selection length (L_{50}) and the selection range $SR = L_{75}-L_{25}$, described by $-a/b$ and $(2ln3)/b$, respectively. The selectivity curve parameters (a_i and b_i) were estimated by maximising the log-likelihood function as described by Tokai (1997), assuming that the proportions observed are binomially distributed. Maximization was performed using SOLVER in MS-Excel.

The number of individuals in the length classes below 9 cm in hauls P6, P7, P8, and P10 deviated sharply from expected selectivity curves; this was most likely associated with poor sorting. Because these size groups had a marked effect on the standard errors, they were omitted from the analysis. The limited data for each of the individual hauls affected the maximum likelihood estimates. This prevented the application of mixed effects selectivity model for between-haul variability analysis (Fryer 1991).

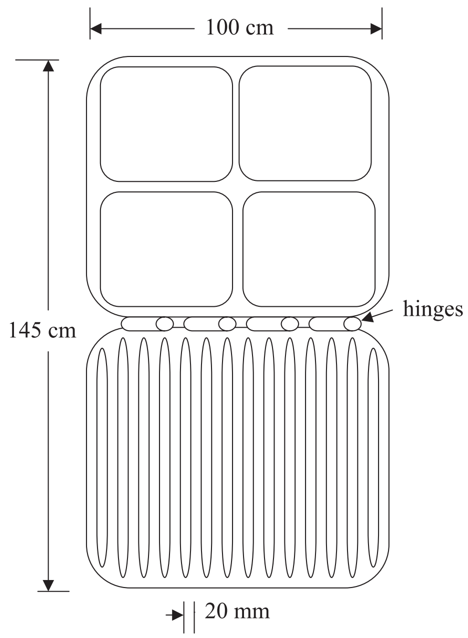

Fig. 1. Construction and dimensions of the sorting grid tested in this study. The two parts of the grid were joined together by hinges. This grid had a bar spacing of 20 mm.

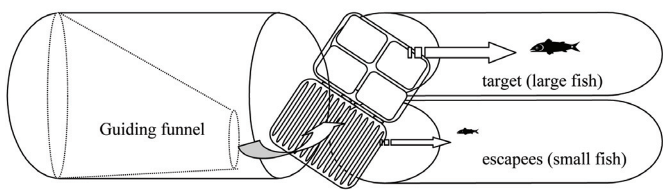

Fig. 2. Schematic diagram of grid operation. Fish enter the trawl from the left. Large target fish were guided along the grid into the upper cod-end while small escape fish passed through the sorting grid and were retained by the lower cod-end.

Over-dispersion correction for the standard errors in the selection curve parameters was performed using the replication estimate of over-dispersion parameter (REP), namely, the ratio of model deviance to the degrees of freedom (d.f) (Millar et al. 2004). This approach is equivalent to fitting a single selection curve to all the individual data, allowing a replicate estimation of between-haul variability that offsets the possible effect of between-haul variation and extra-Poisson variation in the catches (Millar et al. 2004).

Results

Individuals smaller than 21 cm were able to swim through the grid, with the maximum escape ratio for fish under 12 cm. This coincides with the modal length value for the escaped population (Fig. 3).

There was substantial variation in selectivity between the hauls (Figs. 4 and 5). Individual logistic selection curves (Fig. 4) show L_{50} values in the range of about 7 to 19 cm and a selection range of about 4.5 to 10 cm (Fig. 5). Haul P8 had

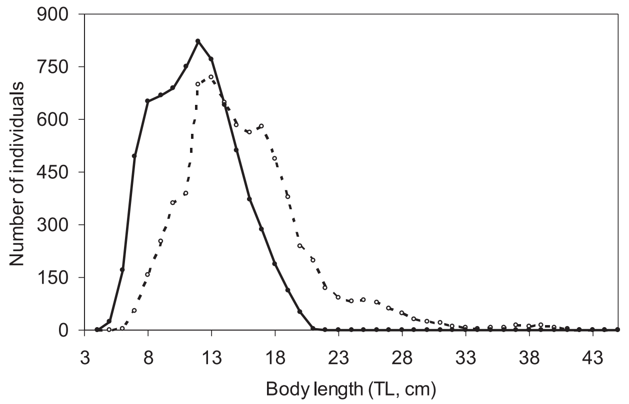

Fig. 3. Pooled size frequency distribution of the hake catches. Solid line indicates individuals that were caught in the lower cod-end (grid-escapees); dotted line shows individuals not selected by the grid.

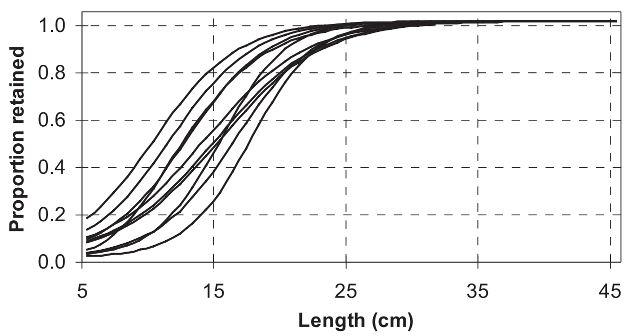

Fig. 4. Individual logistic curves for hake in 10 experimental hauls when using a sorting grid with a bar spacing of 20 mm.

the highest standard error in L_{50}, matching the highest standard error in the selection range.

To provide an estimate of between-haul variation a selection curve was fitted to the combined hauls. The model deviance for the logistic selection curve, which quantifies the relatively lack of fit around the estimated combined-hauls selection curve, was 80.6 on 16 d.f. Pearson's chi-square for the curve fit was 1216.07 on 168 d.f. ($p = 0.016$). This suggests that REP provides an estimate of over dispersion caused by between-haul variations in the combined hauls analysis.

The summation required for REP was calculated using length classes having three or more fish in order to avoid problems associated with low numbers of fish in the smaller length classes, which would otherwise increase the degrees of freedom. This yielded a REP of 7.240. The errors in the coefficient values were multiplied by the square root of REP (2.691) to offset the effect of between-haul variation in the catches. The pooled model fit to the catches yielded the following model coefficient values (with standard errors multiplied by 2.691 in brackets):

$$a = -4.298\,(0.210), \qquad b = 0.302\,(0.015),$$
$$L_{50} = 14.20\text{ cm}\,(0.69), \text{ and } SR = 7.26\text{ cm}\,(0.37).$$

SR: selection range

The biomass of hake under the mean retention length escaping through the sorting grid was 50.1% ± 6.7 SE of the total catches (when all 10 hauls were pooled together). For all size groups, the escapees accounted for 25.7% ± 6.1 SE of total hake biomass.

Discussion

This experiment demonstrated the potential usefulness of a sorting grid to improve the size-selectivity in commercial hake trawl fishery in the Mediterranean. The mean selection length of the ten hauls was 14.2 cm. The mean selection range was relatively high (7.3 ± 0.4 cm SE), indicating that the sorting performance of the grid was not yet fully satisfactory.

The sorting area of the grid occupied half of the grid total surface area, allowing roughly 50% of the smallest individuals (<14 cm) to escape. A previous experiment using a smaller grid but with a sorting surface area of 75% yielded higher escape rates and L_{50} of approximately 18.6 cm (Sardà et al. 2004). These results suggest that the overall grid surface area should be larger than was in our trials. It is notable that the differences in size and design of the guiding funnel in front of the grid could in part account for the differences observed in the results of the two experiments. Furthermore, in the earlier experiment, a twin gear was used while in the present experiment a commercial gear was used.

Ercoli et al. (2000) obtained promising results on Argentine hake (*Merluccius hubbsi*) using a similar grid as we but with a bar spacing of 36 mm. They attained an L_{50} of ca 35 cm, close to the length at first maturity for Mediterranean hake (Recasens 1992). Generally, grids designed particularly for the sorting of the target species have been observed to outperform other grid and cod-end designs (Anonymous 1996; Isaksen et al. 1992). Diamond mesh codend, even when constructed of larger mesh size, are likely not very effective in improving selectivity on Mediterranean hake trawl fishery. Campos and Fonseca (2003) obtained an L_{50} of 18 cm for the Atlantic hake when using 80 mm stretched diamond mesh. Moreover, the use of such a large mesh size is not realistic in Mediterranean fisheries. Halliday and Cooper (2000) demonstrated that square mesh codend had a better selectivity than corresponding diamond mesh codend in the *Merluccius bilinearis* fishery in Canada.

Juvenile hakes smaller than 4 cm were not collected in the cod-ends (see Fig. 3). These fish either occupy a pelagic environment or are transported inshore where recruitment take place (Recasens 1992; Maynou et al. 2003; Olivar et al. 2003). In either case, early juveniles remain outside the legally permitted fishing areas. Hence individuals smaller than 4 cm are scarce in the catches of demersal fishery in the NW Mediterranean (Bas et al. 2003; Bozzano et al. in press).

In conclusion, our results demonstrate that a sorting grid design tested here improves the escape of immature hake below the legal size limit (20 cm in Spain). To our knowledge, this is the first time this type of sorting grid system has been used in a standard commercial gear in the NW Mediterranean. Further experiments to improve the performance of the grid system should be conducted.

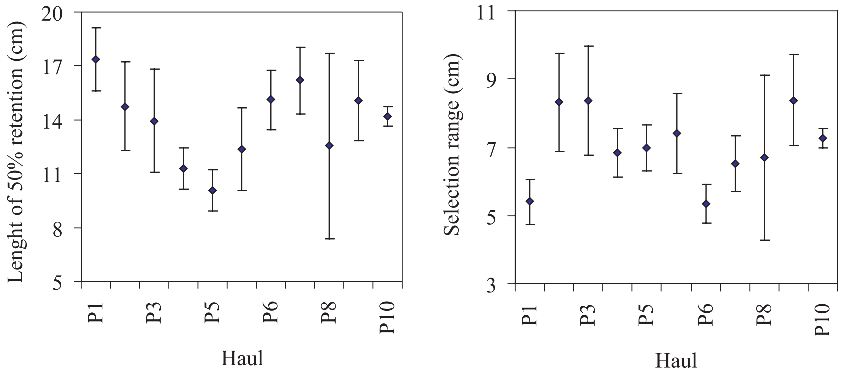

Fig. 5. Estimates of the 50% selection length (L_{50}) and the selection range (*SR*) for each experimental hauls using a grid. Vertical bars indicate 95% confidence intervals.

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