

Short Communication

Potential benefits from improved selectivity in the northwest Mediterranean multispecies trawl fishery

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The management scheme in the northwest Mediterranean multispecies demersal fishery is based largely on technical measures such as minimum mesh and landing sizes. However, selectivity of the trawls used is poor, and large numbers of juvenile fish are caught. We assess the consequences of improved gear selectivity for European hake, Norway lobster, poor cod, and greater forkbeard by assuming that the whole fleet would switch from the current 40 mm diamond-mesh to a 40 mm square-mesh (SM40) codend. The results suggest that, immediately after implementation, the yield-per-recruit (Y/R) would be reduced by up to 20% for the three fish species but that, within five years, the Y/R of European hake would increase by >50%, provided fishing effort did not change markedly. For poor cod and greater forkbeard, the comparable increases would be more moderate, whereas for Norway lobster, the gains would only be small. Overall, marked long-term benefits might be obtained by changing to SM40 codends.

Keywords: European hake, improved selectivity, multispecies trawl fishery, Norway lobster, yield predictions.

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Introduction

The northwest Mediterranean demersal trawl fishery is characterized by diverse local fleets fishing on heavily exploited stocks in a highly multispecies environment (Leonart and Maynou, 2003). The current management scheme is based largely on technical measures such as minimum mesh size and landing sizes. However, the selectivity of the demersal trawling fleet is poor, and many young, small fish are caught (Leonart and Maynou, 2003; Bahamon *et al.*, 2006; Guijarro and Massuti, 2006).

Currently, vessels may use a legally prescribed 40 mm diamond-mesh (DM40) codend, but it has poor size selectivity. For instance, the mean selection length (L_{50}) of about 10 cm for European hake (*Merluccius merluccius*; Bahamon *et al.*, 2006) is well below the minimum landing size (MLS) of 20 cm, and even further from the mean size at first maturity ($L_m = 29$ cm for males; 38 cm for females; Recasens *et al.*, 1998). Norway lobster (*Nephrops norvegicus*) is caught from a size of about 16 mm (carapace length, CL), also below the MLS of 20 mm and the L_m of 31 mm (Orsi-Relini *et al.*, 1998). The L_{50} for poor cod (*Trisopterus minutus*) is 9 cm (Bahamon *et al.*, 2006), whereas the MLS is 11 cm and the L_m 20 cm (Froese and Pauly, 2005). The L_{50} for greater forkbeard (*Phycis blennoides*) is 10 cm, MLS is not regulated, and the L_m is between 18 and 33 cm (Cohen *et al.*, 1990).

Fishing experiments with square-mesh codends and sorting grids have demonstrated a significant reduction in trawl catches

of undersized fish (Sardà *et al.*, 2005, 2006; Bahamon *et al.*, 2006; Guijarro and Massuti, 2006). The Scientific Advisory Committee (SAC) of the General Fisheries Commission for the Mediterranean (GFCM) recently advised a gradual implementation of the SM40 codend for the bottom-trawl fishery (GFCM, 2006). Nevertheless, interest among the fishing industry to adopt more selective fishing gears is low. Thus far, the longer-term effects of improved selectivity in the Mediterranean fisheries have not been evaluated properly, so the potential benefits are poorly understood.

We used an age-structured model to assess the effects of shifting from the current DM40 codend to a 40 mm square-mesh (SM40) codend on the four target species mentioned above.

Material and methods

The selectivity patterns were obtained from experiments carried out with the two types of codend (Bahamon *et al.*, 2006) on commercial fishing grounds at depths of about 100 m (continental shelf; target species, European hake and poor cod) and 400 m (upper slope; target species, Norway lobster and greater forkbeard). Lognormal density curves of size frequency distributions of the catches were fitted by maximizing the log-likelihood of the lognormal function (Figure 1, Table 1). The preferred model was chosen based on the goodness-of-fit between the probabilities given by the theoretical model and current proportions, using the Akaike Information Criterion.

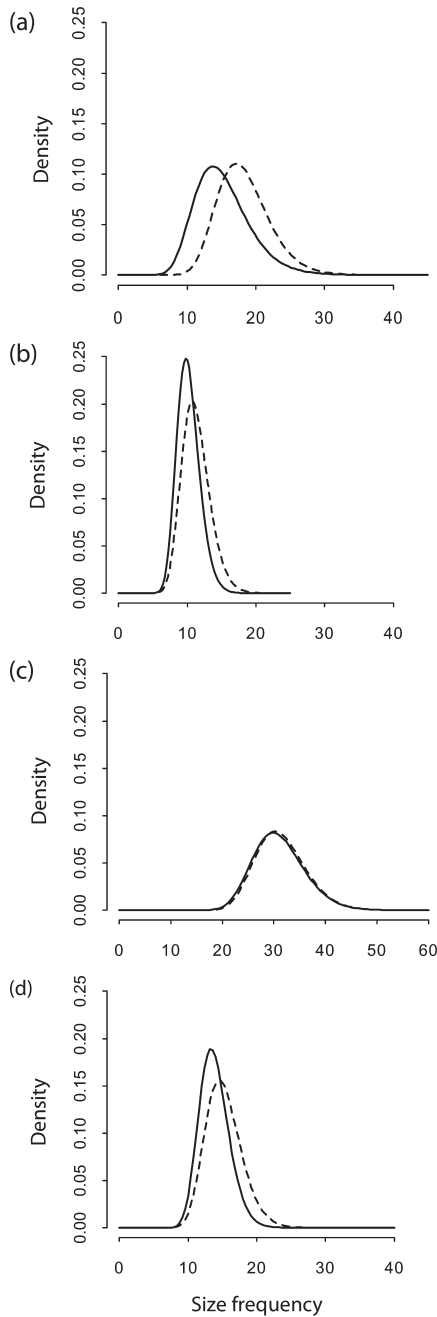


Figure 1. Lognormal length frequency distributions in DM40 (continuous line) and SM40 (broken line) catches: (a) hake (total length, TL in cm); (b) poor cod (TL in cm); (c) Norway lobster (CL in mm); and (d) greater forkbeard (TL in cm).

Table 1. Parameter values (given as the inverse of the logarithms) of lognormal distribution curves by species fitted to length frequency distributions in the catches. Exact standard errors of parameter values were indistinguishable from 1 in all cases.

Species	DM40, mean (s.d.)	SM40, mean (s.d.)
European hake	14.7 (1.3)	17.9 (1.2)
Poor cod	10.06 (1.18)	11.1 (1.2)
Norway lobster	30.7 (1.2)	31.0 (1.2)
Greater forkbeard	13.7 (1.2)	15.0 (1.2)

Table 2. Biological parameters (sexes combined) used in VPA and Y/R analyses.

Parameter	European hake ^a	Poor cod ^b	Norway lobster ^c	Greater forkbeard ^d
Growth				
L_{∞} (cm)	84.8	33.3	6.39	57.7
K (y^{-1})	0.135	0.18	0.16	0.168
t_0 (y)	-0.364	-0.91	-1.395	-0.66
Length-weight relationship				
a	0.0069	0.0059	0.000613	0.0012
b	3.03	3.217	3.040	3.3160
Mortality				
M (y^{-1})	0.20	0.36	0.2	0.22
Terminal F (y^{-1})	0.15	0.15	0.15	0.15
Maturity				
L_{50} (cm)	35	19.6	3.1	26
L_{25-75} (cm)	32-39	17-22	2.1-4.1	24-28

^aCatalan Sea (Recasens et al., 1998).

^bEastern Mediterranean (Froese and Pauly, 2005).

^cCatalan Sea (Orsi-Relini et al., 1998; Sardà et al., 1998).

^dGulf of Lions, NW Mediterranean (Froese and Pauly, 2005).

Table 3. Estimated total catches for 2005 (based on 215 d fishing by 20 vessels).

Species	Catch (t)
Continental shelf	
European hake	620.5
Poor cod	33.2
Upper slope	
Greater forkbeard	2.1
Norway lobster	12.6

The instantaneous fishing mortality (F) by age class (Figure 2) was estimated by conducting a virtual population analysis (VPA) using VIT software (Leonart and Salat, 1997), assuming steady-state recruitment and constant fishing effort. The program first calculates size-at-age from the length distributions according to von Bertalanffy growth curves. To determine mortality-at-age, the lognormal size frequencies were divided into age classes by intervals. Stock numbers-at-age were then reconstructed using the biological parameters of each species (Table 2) and the estimated catches in 2005 (Table 3). The yield-per-recruit (Y/R) was expressed as a function of the fishing effort factor ϕ that has a linear scale with value 1 assigned to current conditions (Leonart and Salat, 1997).

Immediate and medium-term (1–7 y) effects of changing mesh regulations on Y/R were simulated by a transition analysis using VIT software, in which the mortality-at-age obtained with DM40 were replaced by those obtained with SM40.

Results

The analysis suggests that the three fish species are currently subject to extremely high rates of exploitation ($F \approx 3$ for some age groups; Figure 2), whereas the Norway lobster is exploited

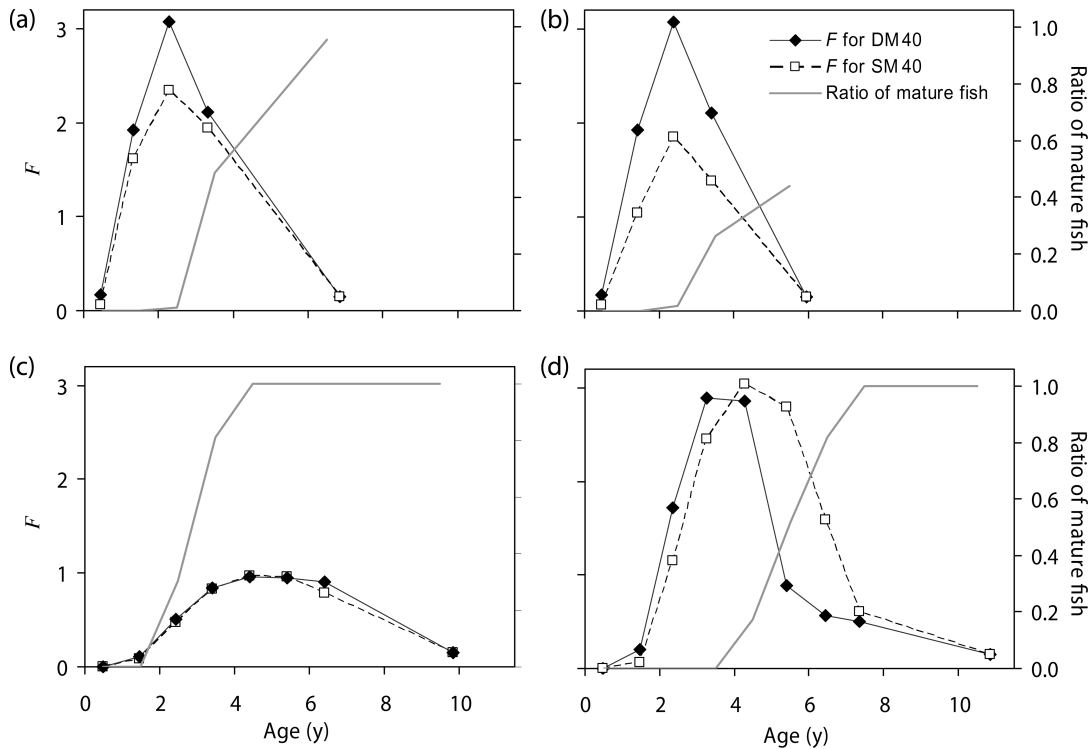


Figure 2. Fishing mortalities for DM 40 and SM 40 codends, and ratio of mature fish by age: (a) hake; (b) poor cod; (c) Norway lobster; and (d) greater forkbeard.

less heavily ($F \approx 1$). Hake, greater forkbeard, and poor cod reach 37, 50, and 70% of their maximum Y/R, respectively (Figure 3), and Y/R for Norway lobster is close to its maximum. Reducing the current effort would increase the Y/R of the fish species considerably.

The Y/R of the three fish species would be reduced by 10–20% during the first year after implementing SM40, whereas for Norway lobster there would be no change (Figure 4). However,

within 4–5 years, the Y/R of hake is predicted to increase by 55%, and that of poor cod and greater forkbeard by 20–30%. For Norway lobster, the increase would be just 7%.

Discussion

Improving size selection in the demersal trawling fleet in the northwestern Mediterranean would seem particularly appropriate for the heavily exploited European hake. For hake, and to a lesser extent for poor cod and greater forkbeard, a substantial increase

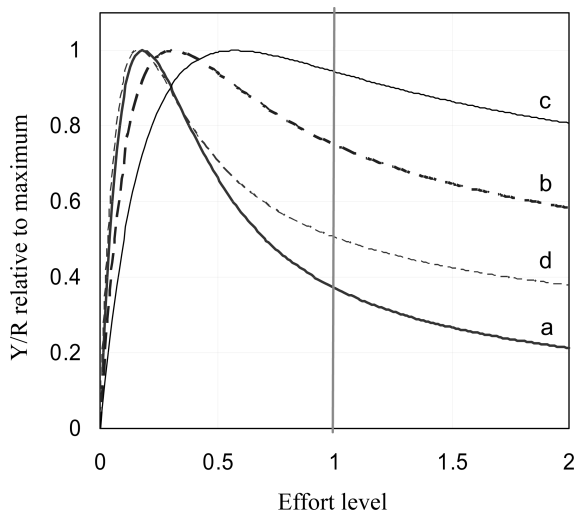


Figure 3. Plot of Y/R relative to maximum (i.e. 1) based on the selection-at-age for the current DM40 codend: (a) hake; (b) poor cod; (c) Norway lobster; and (d) greater forkbeard. The current effort level is indicated by the vertical line.

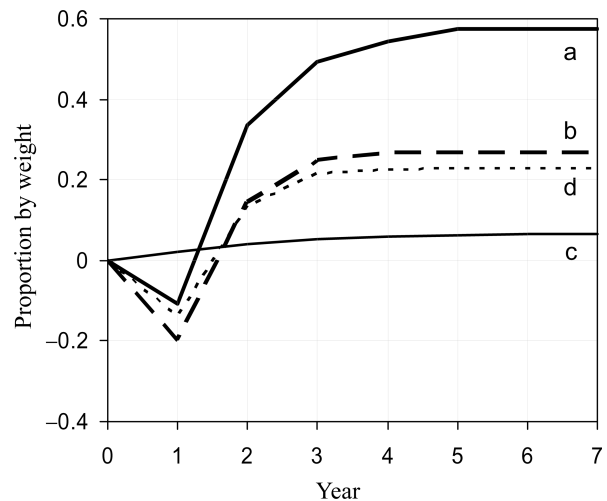


Figure 4. Development of Y/R for (a) hake; (b) poor cod; (c) Norway lobster; and (d) greater forkbeard, after replacing the current DM40 codend with a SM40 codend.

in yield might be attained through changing mesh type, in the medium term, provided effort and recruitment did not change markedly.

The 6 cm increase in L_{50} of hake that could be achieved by using the SM40 (Bahamon *et al.*, 2006) would substantially improve the current exploitation pattern within a few years, because the Y/R would increase markedly. Hake are subject to heavy growth over-exploitation on the continental shelf (Caddy, 1993; Aldebert and Recasens, 1996), but equally high rates of exploitation are unlikely on the upper-slope fishing grounds, because these are less accessible to local fleets. Those grounds are also the principal habitat of mature hake.

For Norway lobster, changing to SM40 would barely affect the Y/R. Apparently, this species is currently exploited on the continental slope just slightly above the level associated with maximum Y/R, so would show only slight gains in yield (<10%). The estimated improvement in yield is lower than the 12–15% gain expected after an effort reduction by 20% (Sardà *et al.*, 1998). Overall, the exploitation on the upper slope seems to be low compared with the heavy exploitation reported in continental-shelf fisheries (Sardà *et al.*, 1998).

Some of the biological parameters used for the different species may not be entirely accurate for the area investigated. Moreover, several important species were not included in the analysis because of lack of data, nor have species interactions been taken into account. To assess more realistically the potential benefits of improved gear selectivity, a wider ecological framework would be required (Coll *et al.*, 2006), including survival of juvenile fish escaping through the meshes (Suuronen, 2005), seasonal variations in selectivity, and aspects of recruitment variability.

Nevertheless, the results suggest that marked benefits might be obtained by improving selectivity in the demersal trawling fleet in the northwest Mediterranean. However, a change to square mesh would not resolve all management problems. Additional management measures such as control of total fishing effort and/or appropriately designed fisheries closures are likely to be required to safeguard juveniles and sub-adults. In addition, different fisheries may require different solutions.

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