

Contrasting patterns in fish size spectra across geographic and bathymetric gradients: an Atlantic - Mediterranean comparison

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Summary

Size spectra of fish communities are among the most robust size-based metrics to assess potential effects of fishing on the marine communities and ecosystems. However, it is still challenge to evaluate how the relative contribution of size-selective removal of predators and the release of preys affect size-spectra at temporal and spatial scale. In addition, few studies focus on the relevance of the spatial variance of the slope, rather than mean values, as an indicator of the spatial heterogeneity of the community. We use information of trawl surveys to compare five contrasting ecosystems around Spain, two in the Atlantic (Galician-Cantabric Sea and Gulf of Cadiz) and three in the Mediterranean (Alboran Sea, Balearic Islands, and north-eastern Iberian Peninsula). For each ecosystem, we calculate spatial and temporal variation of the mean slope of size spectra and its coefficient of variation, which were compared with the relative biomass of preys and predators to assess the relevance of drivers shaping both strength of the slope and its variability. Due to the sharp bathymetric gradient all over the studied systems that delineates different fish communities, we analyse separately the inner shelf, the middle shelf, the shelf edge and the middle slope to investigate potential contrasting responses of size-spectra indicators of different communities. Results evidence contrasting patterns in the size-spectra, as well as in the relative contribution of the drivers, across geographic and bathymetric gradients. We discuss potential causes and consequences of the observed patterns, taking into account the context-dependent characteristics of each ecosystem.

Introduction

Current marine science calls for a better understanding of the community and ecosystem structure consequences due to depletion of fish stocks but also to their ongoing recover. In this sense, size-based metrics are commonly use to track temporal and spatial variation of impacted communities and thus to assess potential effects of fishing (e.g. Rochet and Trenkel, 2003). However, it is often difficult to evaluate the effect of fishing on the community structure since its effect can be both direct by triggering disproportional mortality on larger individuals, or indirect as fishing may increase abundance of small prey species through predation release (Shin et al., 2005). These processes can affect both mean slope of size spectra but also coefficient of variation over a surveyed area. Here, we used trawl surveys information to compare size spectra of fish communities of contrasted and impacted shelf and slope ecosystems of both Atlantic and Mediterranean Spanish coasts. We calculate spatial

and temporal variation of the mean slope of size spectra and its coefficient of variation, which were compared with the relative biomass of preys and predators to assess the relevance of drivers shaping both strength of the slope and its variability.

Material and Methods

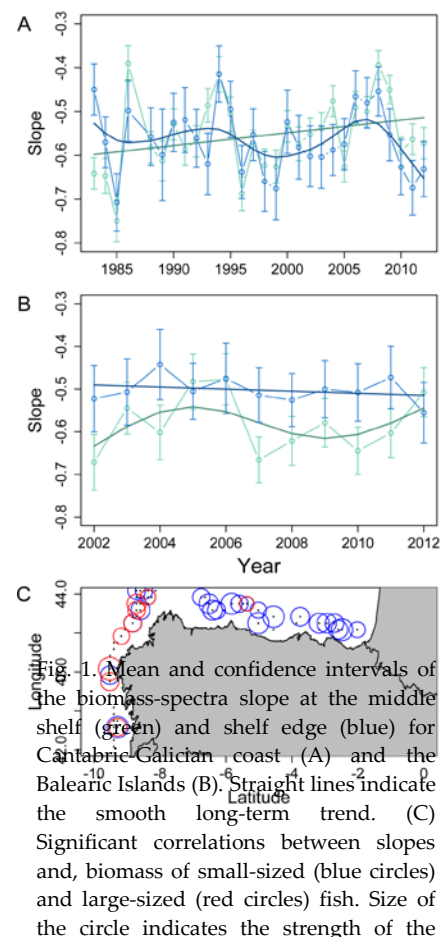
The study uses information of four different annual fishery-independent bottom trawl surveys carried out to of the Spanish shelf and slope ecosystems. In the Atlantic, surveys are carried out in autumn (September-October) from 1983 in the Cantabrig-Galician coast and from 1994 in the Gulf of Cádiz. In the Mediterranean, bottom surveys are carried out in spring (May-June) since 1994 in Iberian Peninsula and since 2002 in the Balearic archipelago. Hauls were separately analysed on the basis of four bathymetric strata that are representative nekto-benthic communities: inner shelf (50-100 m), middle shelf (100-200 m), shelf edge (200-500 m) and upper slope (below 500 m).

Data used consisted in number of fish caught by species and length category per trawl sample on a given footprint. Catch at length (L) were converted to weight at length using weight-length relationships ($W = aL^b$), where a and b parameters are obtained at each specific survey or from FishBase (www.fishbase.org). Catch weight at length for each species and length class in each trawl was standardized as density ($g\ km^{-2}$) dividing by the trawl footprint. To calculate biomass spectra, standardized catch weight at length was allocated to \log_2 0.5 body mass classes from 0 (1 g) to 17 (131072 gr), a total of 34 body classes. The biomass-spectra analyses are only applicable to data in the size range over which the gear effectively samples the community (Jennings and Dulvy 2005). Annual values of the slope of the biomass-spectra were obtained applying linear models with year as a grouping factor. To calculate the annual coefficient of variation, haul-specific slopes of the biomass-spectra were obtained applying linear models with haul as a grouping factor. Estimates of biomass small-sizes and large-sized components of the spectra per haul and year were also calculated to analyse their influence on the temporal and spatial variation of the biomass-spectra slopes.

Results and Discussion

Our study evidences that the temporal dynamics of the biomass-spectra slope displays a similar pattern between bathymetric strata in the Atlantic areas such as in the Cantabrig Sea (e.g., $Cor=0.61$, $p<0.05$, Fig. 1A), displaying a monotonic behaviour. By contrast, in the Mediterranean systems such as the Balearic Islands, the temporal variation contrasts across strata ($Cor=0.03$, $p=0.91$, Fig. 1B). This suggests that, in the Atlantic, communities are bathymetrically more connected in the middle shelf and the upper slope, while community dynamics can be comparatively more segregated across bathymetric gradients in the Mediterranean Sea. A complementary interpretation is that external drivers, such as fishing impact, are being unlikely impacted in the Mediterranean while the effect may be more regional in the Atlantic systems.

In all the systems analysed, mean biomass of small-sized individuals drives short-term temporal variation of the mean slope, while mean biomass of large-sized



fish constraints the long-term pattern of size spectra as well as the variability (i.e., coefficient of variation). Finally, our results also reveals certain segregation in the drivers with areas with high influence of the biomass of small-sized individuals on the size spectra. An exception was the shelf edge of the Galician-Cantabric Sea, where an evident spatial segregation of the influence small-sized and large-sized components of the spectra was observed. While the Galician area was more influenced by large fish, the Cantabric Sea was more influenced by the small fish (Fig. 1C).

Our study stresses the contrasting patterns in fish size spectra across geographic and bathymetric gradients between Atlantic and Mediterranean fish communities as well as the potential drivers behind.

References

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