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Does fisheries selectivity affect food web dynamics in a way that needs to be managed?

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Summary
A comparative analysis of fishing pressure versus fishing impact metrics across a range of temperate exploited shelf communities suggests that fisheries selectivity and the biodiversity in exploited communities are linked.

Introduction
There is increasing awareness that developing an ecosystem approach to fisheries management might require broadening our perspective on selectivity from the gear and haul level to the fishery and exploited community scale (Garcia *et al.*, 2012). Indeed, recent modelling results suggest that selectively targeting restricted ranges of species or sizes may be more harmful to marine communities than a more "balanced" exploitation apportioning extraction across the food web. This study seeks empirical evidence supporting these results by means of a comparative study across communities exploited in different ways. In this analysis the ecological units are distinct communities with defined fishing patterns. The temporal units are periods of time with a consistent fishing pressure, with a time lag between fishing pressure and impact. The question is whether there is evidence of a link between metrics of fishing pressure, including selectivity metrics, and metrics of fishing impacts.

Materials and methods
Time series of fishing pressure and impact metrics (FPMs and FIMs) were calculated from 13 temperate shelf sea communities from the Western and Eastern North-Atlantic and the Mediterranean. Catch statistics were used to calculate FPMs: *TotCatch* total catch weight per surface area; two selectivity metrics that measure the dispersion of catch across species: *NbSpDom85* number of most caught species that make up 85% of total catch, and *D* % total catch accounted for by the two most caught species; and *pred* % catch from predator species. Bottom trawl survey data were used to estimate FIMs: *Btot* biomass and *Ntot* abundance per surface area, average individual weight *meanWbar*, *SRE* Simpson Reciprocal Evenness, and *pred* % biomass of predator species. Time series of FPMs were examined to identify ~10 years time periods with consistent levels, or at least consistent trends, in fishing pressure. FPMs were averaged over these periods; FIMs were averaged across the subsequent 10-year period, allowing for a 10-year lag between pressure and impact. The relationship between pressure and impact metrics was examined by a cannonical correlation analysis with 27 data points (ecological units × time periods).

Results and Discussion
The eastern Atlantic communities were exploited more selectively than the Mediterranean ones, while more predators were removed from the western Atlantic than from European waters (Figure 1). The Mediterranean communities consisted of smaller animals of more species, while the highest evenness was found in the North Sea and English Channel, and the most abundant were the Bay of Biscay (not shown). The canonical correlation analysis suggested a link between fishing selectivity and the

community biodiversity 10 years later (Figure 2): communities from which a more diverse catch (high *NbSpDom85)* was taken, had higher biodiversity (high *S* and *SRE*), while communities from which more predators were extracted (high *pred)* had a higher total biomass (high *Btot*).

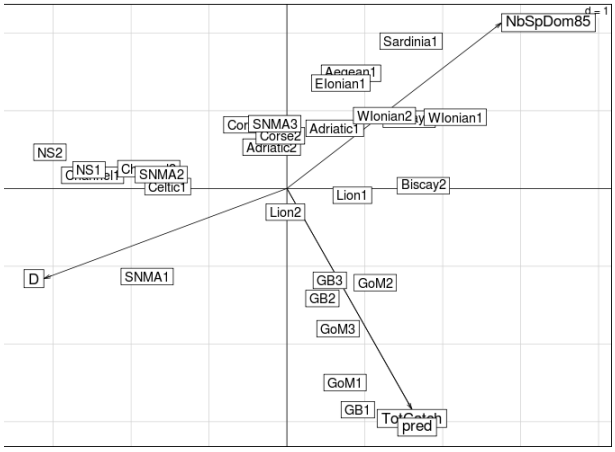

Figure 1. Principal Component Analyis (axes 1-2, 84% total variance) of normalized FPMs. Individuals are labelled by area: Adriatic, Aegean, Biscay (Bay of Biscay), Celtic (Celtic Sea), Channel (Eastern English Channel), Corse (Corsica), Eionian (Eastern Ionian), GB (Georges Bank), GoM (Gulf of Maine), Lion (Gulf of Lions), NS (North Sea), Sardinia (FAO div.), SNMA (Southern New England-Mid Atlantic), WIonian (Western Ionian Sea), and time period numbered chronologically. For variable names see text.

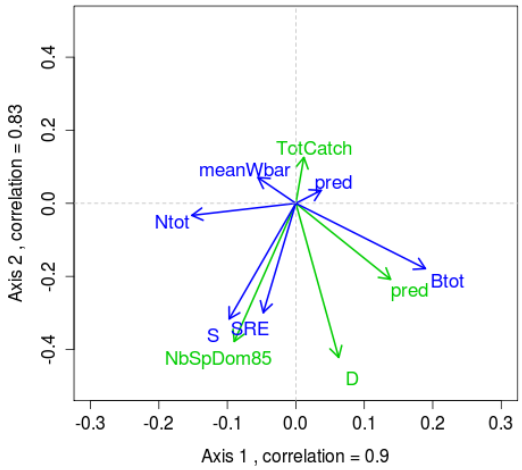

Figure 2. Cannonical correlation analysis of FPMs (green arrows and labels) versus FIMs (blue arrows and labels), axes 1-2. For variable names see text.

Although we examined fishing impacts with a reasonable time lag after fishing pressure metrics, there is still a suspicion that these results mostly reveal that fisheries extract from a community what is available – if there are more species in a community, then more species may have some value and be targeted and caught. This question needs to be further examined by (i) weighting the analyses to downweight the communities with longer time series (thus more individual points in our comparative analyses); (ii) including environmental variables that would explain the "natural" differences between the communities, and perhaps lessen the importance of fishing pressure; and (iii) develop more explanatory analyses and models.

If confirmed these results would suggest that fisheries management needs to address these impacts by designing appropriate objectives and strategies at the community scale – to conserve biodiversity, some management of fisheries selectivity at the community level might be useful.

Reference

Garcia, S. M., Kolding, J., Rice, J., Rochet, M. J., Zhou, S., Arimoto, T., Beyer, J. E., Borges, L., Bundy, A., Dunn, D., Fulton, E. A., Hall, M. A., Heino, M., Law, R., Makino, M., Rijnsdorp, A. D., Simard, F., and Smith, A. D. M. 2012. Reconsidering the consequences of selective fisheries. Science, 335: 1045-1047.