Modelling the Mediterranean marine ecosystem as a whole: addressing the challenge of complexity

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Introduction

The Mediterranean Sea is a semi-enclosed basin with unique characteristics: it is considered oligotrophic, highly diverse in species richness and yet a sea "under siege" due to multiple uses and stressors (Coll et al., 2012). The current study aims at quantifying the ecological mechanisms/interactions and pressures (e.g., in this case fishing) occurring in the whole basin using the best available data (**Figure 1**). Our goal was to 1) investigate main structural and functional characteristics of the Mediterranean marine food-web during two different periods of time, the 1950s and 2000s; 2) identify key species/functional groups and interactions for both time periods; 3) quantify the role of fisheries and its impact.

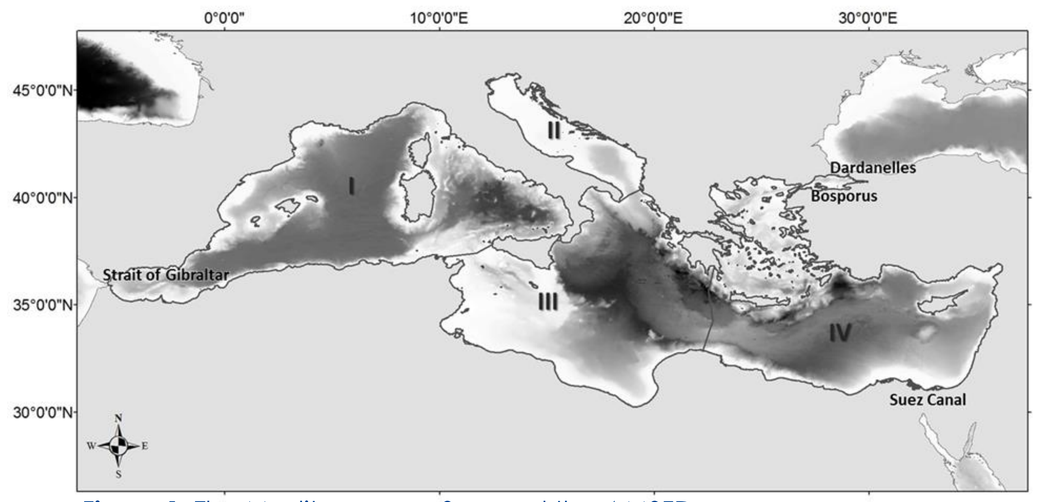

Figure 1. The Mediterranean Sea and the 4 MSFD areas

Methods

Two ***Ecopath*** models were constructed for the decades of 1950s and 2000s respectively. 103 functional groups (fg) from top predators to primary producers were described to represent the whole Mediterranean Sea ecosystem **(Figure 2)**. In addition to take into consideration differences in environmental and biological characteristics, both models were divided in 4 sub-models following the four sub-regions division given by the Marine Strategy Framework Directive (MSFD; 2008/56/EC): 1) Western Mediterranean Sea (W); 2) Adriatic Sea (A); 3) Ionian and Central Mediterranean Sea (I); 4) Aegean and Levantine Sea (E) **(Figure 1)**.

Here we present, for the period 2000s, the mean TL of the community (TLco and TLco>1) and total biomass for the four MSFD areas **(Figure 3)** and the keystone index **(Figure 4).** The cumulate impact of fisheries on the entire ecosystem **(Figure 5a)** and on commercially exploited species **(Figure 5b)** are shown comparing the two decades.

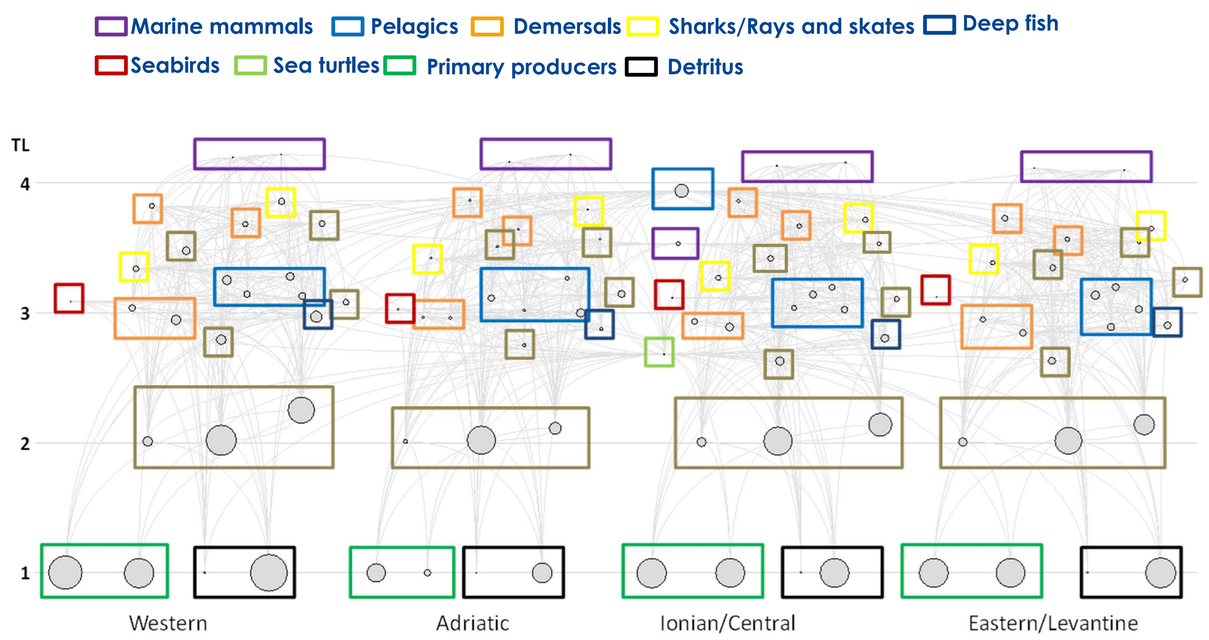

Figure 2. Flow diagram of the Mediterranean Sea ecosystem.

Results and Discussion

The Adriatic and the Western Mediterranean Sea were the modelled areas with the highest total biomass followed by the Ionian and Eastern Seas **(Figure 3)**. The mean TL of the community differed considerably if we looked either at mean TLco or at mean TLco > 1. In the first case, the Adriatic was the area with highest mean TLco followed by the Ionian, Eastern and Western Mediterranean. If TLco>1 is considered, the Western had the highest TLco, then the Eastern, the Ionian and the Adriatic Sea. The keystoneness analysis **(Figure 4)** revealed that large pelagic fish had the highest keystone role followed by lower trophic level groups and sharks. As for fisheries, if all the functional groups of the ecosystem were included in the analysis, artisanal fisheries seemed to be the fleets with greater negative impact particularly in the Western, Ionian and Eastern Mediterranean Sea **(Figure 5a)**. If only the commercially exploited functional groups were considered, results showed a greater impact of bottom trawlers, mid water trawlers and purse seiners **(Figure 5b)**.

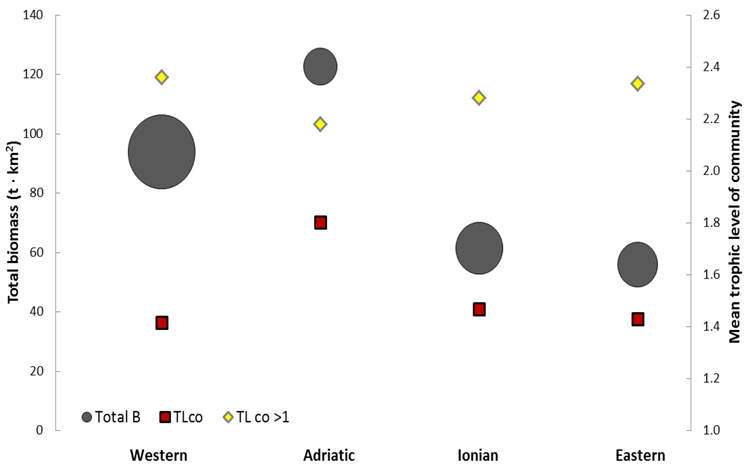

Figure 3. Total biomass and mean TL of the community per MSFD area for the period 2000s

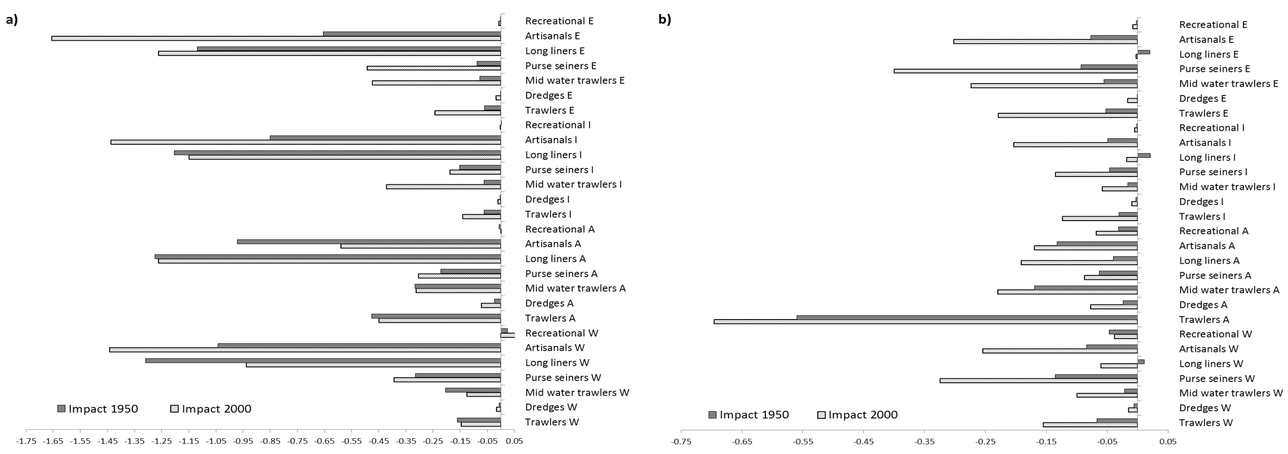

Figure 5. Cumulate impact of fishing gears on a)all ecosystem and b) commercially important species

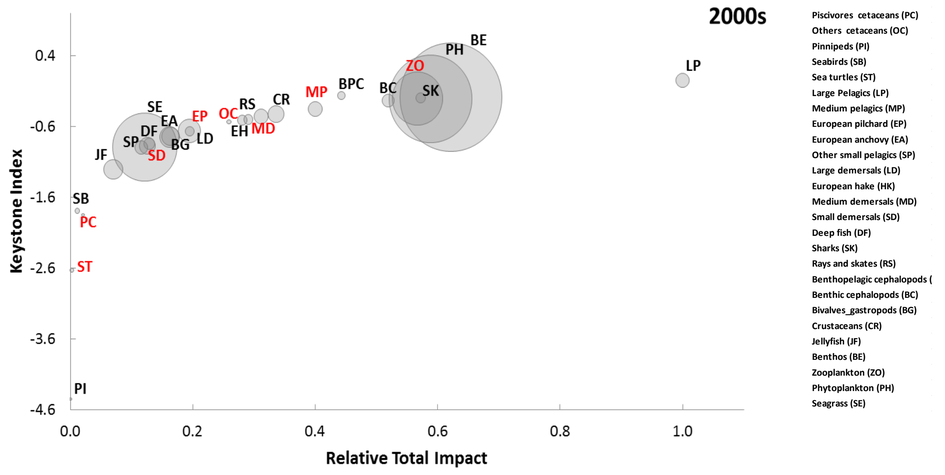

Figure 4. Keystone index for the 2000s period. In red, fg with a decline keystone role in comparison with the 1950s period

References Coll M, Piroddi C, Albouy C, Ben Rais Lasram F, Cheung WW, Christensen V, Karpouzi VS, Guilhaumon F, Mouillot D, Paleczny M. 2012. Global Ecology and Biogeography 21: 465-480.

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