Food web structure and functioning in an invaded ecosystem of the South Aegean Sea: Insights gained with Ecopath ecosystem modeling

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Introduction

- Understanding the impacts of alien species on invaded ecosystem structure and functioning and their interactions with the native species and human activities is a central goal of invasion ecology and a prerequisite for their efficient management[1].
- This study aims to advance the current state of knowledge regarding the impacts and controls of biological invasions in the South Aegean Sea by the development of an Ecopath model of the coastal shelf of the Dodecanese islands.

Methodology

- The study area was the coastal shelf (0 – 200 depth range) of the Dodecanese islands (Fig 1).
- A total of 41 functional groups were defined in the model, including top predators (4), native (11) and alien (8) demersal and benthic fishes, native (3) and alien (1) pelagic fishes, benthic invertebrates (7), zooplankton (3), primary producers (2), and non-living (2) groups (Fig 2).
- Five fishing fleets were also defined, including bottom trawlers (BT), purse seiners (PS), boat seiners (SB), small-scale coastal fisheries (SSF: hooks, nets, traps), and recreational fisheries (R).
- Data for biomass densities, production/biomass & consumption/biomass rates, fisheries landings and discards per fleet, and trophic preferences for every functional group were collected from a wide variety of sources (primary and grey literature, unpublished data, on-line services, other models), and harmonized.
- A mass-balanced, static model representing the study area ecosystem during 2014 – 2016 was built with Ecopath[2].

Results and Discussion

- The alien species' shares of the total fish biomass and catches were much lower than the values given in other models in the Levantine[3-5].
- Alien pufferfishes and cornetfish had the highest keystoneness index among the alien species groups, but alien fish species were not classified among the most important keystone species of the study ecosystem.
- The cornetfish was an effective predator of alien barracudas, siganids, small benthopelagics, and native mullids, as revealed by the results of the mixed trophic impact analysis[6] (Fig. 3).
- Alien pufferfishes had a moderate direct negative impact on their prey octopuses and cuttlefish and siganids on macrophytobenthos. The alien pufferfishes also had an indirect negative impact on monk seal, due to competition for shared prey.
- Total system throughput, biomass density and mean trophic efficiency in our model (Fig. 4) were within the range of the other ecosystem models in the region[3-5, 7]. The ranking of the study ecosystem in terms of total biomass density reflects the known productivity gradients between Western and Eastern Mediterranean[8], as well as the North and South Aegean Seas[9].
- Based on the primary production/respiration and primary production/respiration ecosystem metrics, the Dodecanese coastal shelf ecosystem was found to be less mature[10] than the ecosystems of the North Aegean Sea[7] and Cyprus coastal shelves[3], and more mature than the coastal shelf ecosystem of Israel[4].
- The present work revealed important local quantitative data deficiencies regarding mainly species biomass densities, catches and discards, especially for the alien species. Despite these limitations, the Ecopath model developed depicts the best representation of the study ecosystem yet, which can nevertheless be updated and enhanced as new information arises.

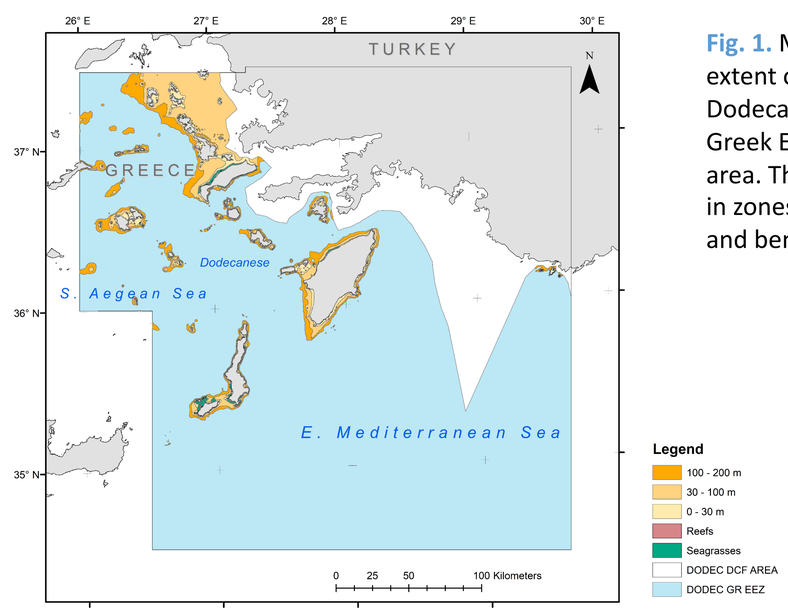

Fig. 1. Map of the study area, the extent of the coastal shelf of the Dodecanese islands within the Greek EEZ and the EU DCF DODEC area. The study area is subdivided in zones according to bathymetry and benthic habitat type.

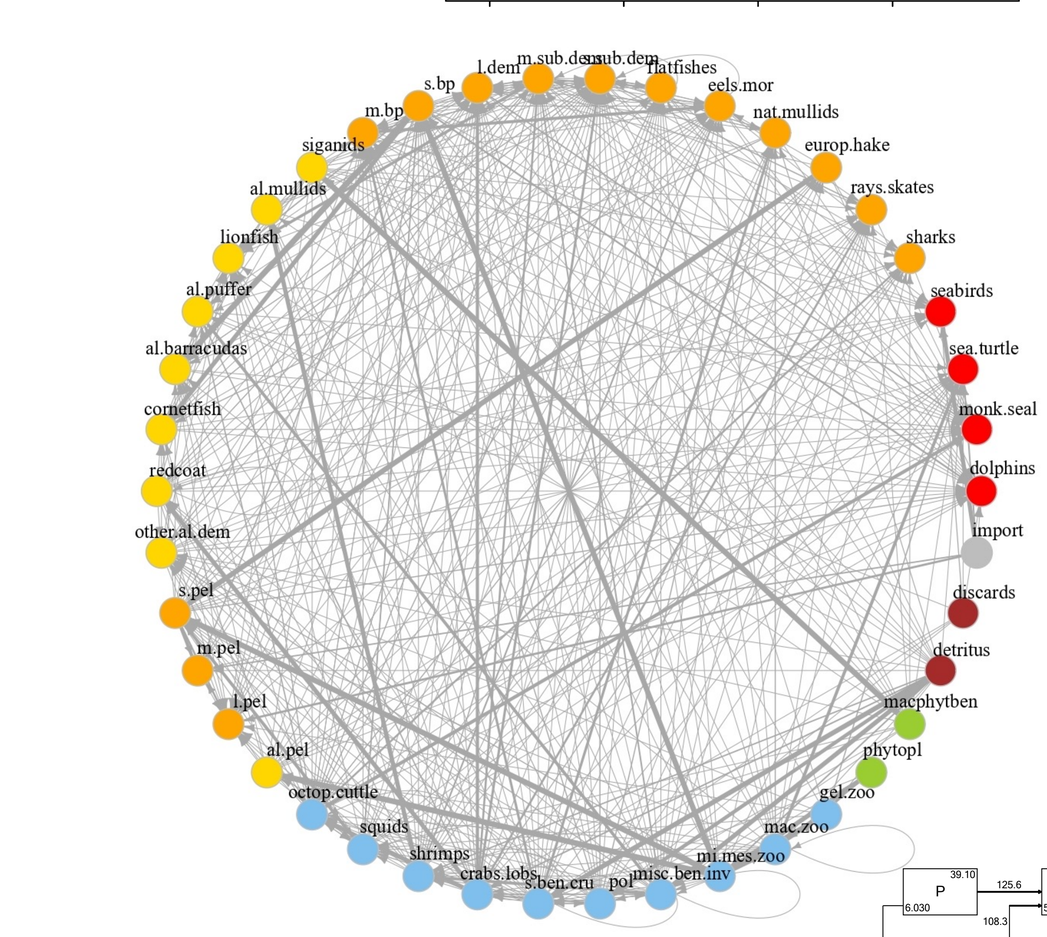

Fig. 2. The food web of the study ecosystem represented as a graph plot (circular layout) of the diet matrix used as the adjacency matrix. Nodes are functional groups and edges represent trophic links. Edge line width is a function of prey importance in the diet of the predator. Functional group categories are distinguished by node color: native fishes (orange), alien fishes (yellow), invertebrates (blue), top predators (red), primary producers (green), non-living groups (dark red).

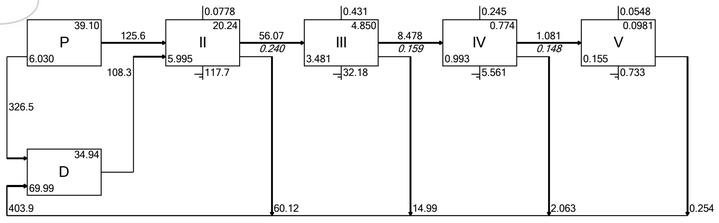

Fig. 3. Lindeman spine diagram of the model, representing flows between trophic levels I - V. TROPH I is split into primary producers (P) and detritus (D). Flows are in t km^{-2} yr^{-1} and biomasses in t km^{-2}. TE is transfer efficiency and TST is total system throughput.

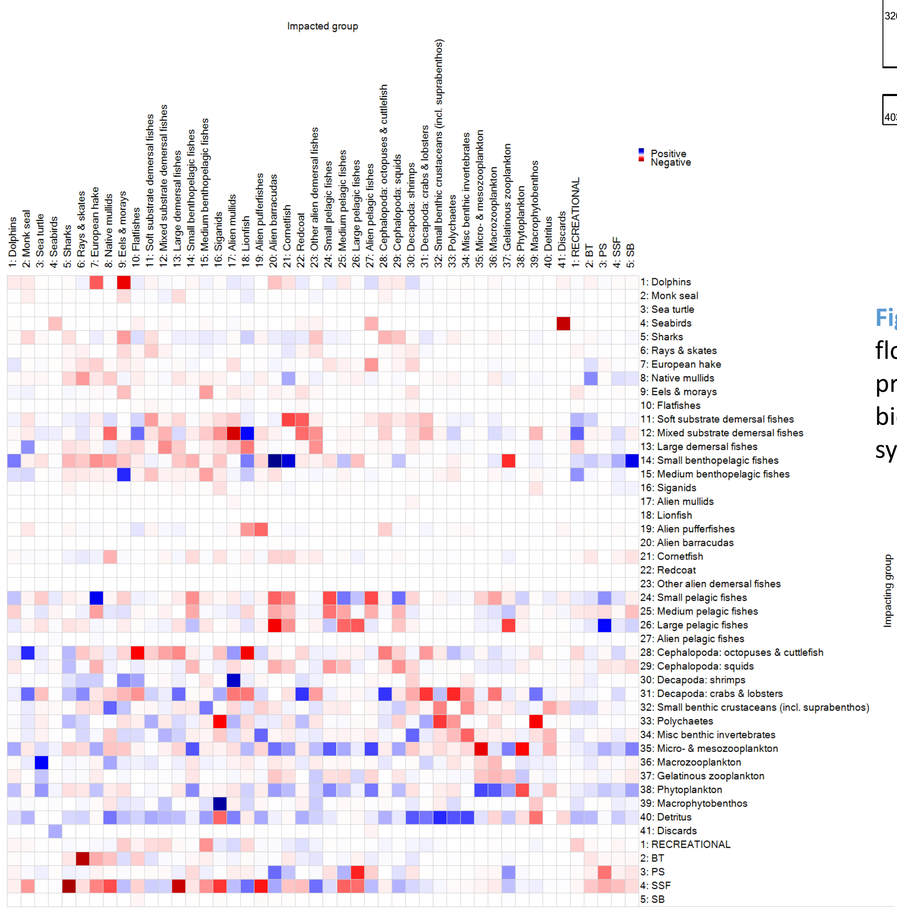

Fig. 4. Heatmap of the mixed trophic impact analysis results. Both negative (red) and positive (blue) impacts are presented in the plot.

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This project has received funding from the Hellenic Foundation for Research and Innovation (HFRI) and the General Secretariat for Research and Technology (GSRT), under grant agreement No 711.