HINDCASTING THE DYNAMICS OF AN EASTERN MEDITERRANEAN MARINE ECOSYSTEM UNDER THE IMPACTS OF MULTIPLE STRESSORS: A BASELINE FOR FUTURE MANAGEMENT SIMULATIONS

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Abstract
In order to analyse the main historical ecosystem dynamics, a temporal dynamic ecosystem model representing the continental shelf of the Israeli Mediterranean coast was developed using Ecosim. Firstly, the model was fitted to available historical data. The historical model predictions satisfactorily matched the observed data, especially regarding the invasive species groups. The model showed an increasing proportion of invasive species in biomass and catch over time. Results highlighted the important role that fishing activities and climate change are playing in the ecosystem. Secondly, the dynamic ecosystem model was used to develop exploratory temporal analysis about future management scenarios. This study represents a baseline from where spatial-temporal simulations can be developed.

Keywords: Food webs, Fisheries, Invasive species, Global change, South-Eastern Mediterranean

The ecosystems of the Israeli Mediterranean coast have undergone significant ecological changes in recent decades caused primarily by the influx of a large number of invasive species through the Suez Canal, intense fishing activities and the effects of climate change (1,2). An important challenge for conservation and managing marine ecosystems is to advance our understanding of how multiple human stressors, environmental factors and marine resources interact and influence each other (3).
In this study, an Ecopath food web model representing the continental shelf of the Israeli Mediterranean coast was calibrated and fitted to the available time series from early 1990's to 2010 using the Ecosim temporal modeling approach. The baseline ecosystem model was composed of 41 functional groups, ranging from primary producers to top predator species and including eight invasive groups (crustaceans and fish species) (4). This model was used to explore the historical dynamics of the ecosystem considering the effect of invasive species, fishing activities and climate change (through historical changes in temperature and salinity) as the main drivers and to evaluate their historical cumulative effects. We then conducted 20yr simulations into the future in which we tested a number of scenarios. The first scenario served as a base run and used current fishing effort and environmental conditions; in the second scenario, the demersal trawl fishery was removed gradually within the first five years of the simulation; in the third scenario the temperature was increased gradually by 1 degree °C over the period of the simulation; and, in the fourth, both scenarios 2 and 3 were combined.

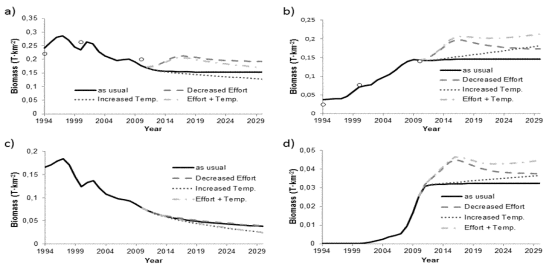

Fig. 1. Predicted (line) biomass trends (t·km^{-2}) by the Ecosim model of the Israeli marine continental shelf ecosystem and observed (dots) historical biomass estimates (t·km^{-2}) for small native demersal fishes (a), earlier invasive demersal fishes (b), horse mackerel (c) and invasive medium pelagic fishes (d). Biomass trends (t·km^{-2}) of the scenarios (dotted lines) are also showed.

The model historical predictions satisfactorily matched available historical data, especially regarding invasive species groups (Fig. 1). The model showed an increasing proportion of invasive species in biomass and catch over time while native species showed a decreasing trend (Fig. 1 and 2), with important effects on the food-web. However, data from the pelagic domain were not available to validate results. Results also highlighted the important role that fishing activities and climate change are playing in the ecosystem through overexploitation and displacements of native groups respectively.
The results of the future scenarios corroborated the large impacts of fishing activities, as a reduction of the trawl effort would show a recovery of several groups, especially high trophic levels organisms (Fig. 1). The increased sea surface temperature scenario would exacerbate the negative trends of native species and would amplify the impacts of invasive species (Fig. 1). In addition, the combination of the scenarios showed the cumulative impacts of the stressors (Fig. 1), suggesting synergistic effects between the impacts of invasive species, fishing and climate change.

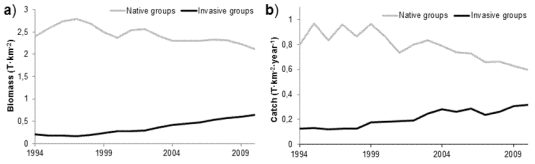

Fig. 2. Biomass trends (T·km^{-2}) (a) and Catch trends (T·km^{-2}·year^{-1}) (b) of native and invasive groups calculated from Ecosim model for the period 1994-2010. For Biomass we included only the groups that we differentiate between native and invasive species (fish, cephalopods and crustaceans (shrimps and crabs)) and therefore, it doesn't include all planktonic groups and benthic invertebrates groups.

Ecosystem modelling tools can provide governmental agencies and stakeholders useful results to explore the impact of potential management alternatives in order to inform the decision making process.

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