MODELLING MARINE FOOD WEBS FOR AN ECOSYSTEM APPROACH IN THE MEDITERRANEAN SEA

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Abstract

This contribution aims at reviewing main applications of mass-balance and trophodynamic models for representing marine food webs in the Mediterranean Sea. This review allows evidencing the potential of these tools for an ecosystem approach to several human impacts and provides insights on future directions of research.

Keywords : Food Webs, Macroelements.

Mass-balance and trophodynamic models are used worldwide for describing marine food webs and studying ecosystem structure and functioning. In particular, Ecopath with Ecosim (EwE) enables to integrate large body of data and information in a coherent description of marine food webs and allows the study of direct and indirect anthopogenic impacts on ecosystems [1]. Therefore, although developed for understanding impacts of fishing activities, EwE represents a valuable tool for the theoretical analysis of food webs and for applying an ecosystem approach to different anthropogenic impacts [2]. Accordingly, several EwE applications have been developed in the Mediterranean Sea.

Mass-balance Ecopath models have been largely used to explore the trophic structure and apply network analysis at different scale on coastal and shelf areas. In the Venice Lagoon (Italy), Ecopath models were used to describe the trophic structure [3], to compare food webs of two habitats thus providing evidence of the high maturity of seagrass meadows [4] and to compare the same system through time evidencing the stress induced by a new fishery [5]. In the Orbetello Lagoon (Italy), the key role of cormorants and the decrease of eutrophication level were assessed by comparing mass-balance models for two different years [6]. Food web models for the Adriatic Sea [7] and the South Catalan Sea [8] allowed to evidence ecosystem effects induced by fishing through analysis of synthetic indices and cross-system comparison of standardized models enabled to examine differences between ecosystems [9-10] and ecosystem effects of protection [10]. An EwE model was also developed for the Gulf of Calvi [11] to place fishing within the ecosystem context and examine indirect effects of fishing and, analogously, a dynamic application to the Black Sea allowed exploring trophic cascade driven by fishing [12]. A mass balance model explored the energy flow controls of the Miramare Marine Protected Area [13] and a spatial one assessed the effectiveness of MPAs of different sizes in the North Adriatic Sea [14].

Few cases explore the effects of environmental forcings on ecosystem dynamics [8, 11, 14, 15] because of the general lack of time series of biological data long enough for the validation of time-dynamic simulations. Nevertheless, mass-balance Ecopath models proved to be a good basis for linking structure to dynamics and for identifying keystone species within food webs [16]. These models also gave basis for defining a new measure of ecosystem effects of fishing that has been applied extensively to landings data and models output in the Mediterranean Sea [17-18]. Moreover, trophic flows estimated by Ecopath permitted the direct coupling with ecotoxicological information thus providing a realistic representation of the bioaccumulation of organic pollutants in the food web, as in the Venice Lagoon case study [19].

Future research would benefit from the generalization of this methodology to the Mediterranean basin, through the development of new case studies (especially in the eastern part) and the standardized comparison of existing models. Moreover, fitting models to time series of data for their validation should be a priority, as well as the application of spatio-temporal dynamics for capturing ecosystem features and patterns. Finally, the assessment of uncertainty of model inputs and propagation of errors to results should be considered of overwhelming importance.

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