APPLYING THE ECOPATH ECOSYSTEM MODELLING APPROACH TO THE MEDITERRANEAN BASIN

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Abstract

This paper discusses the applications of the Ecopath-with-Ecosim ecosystem modelling approach to assess the role of fisheries targeting top-predators as drivers of ecological change across the Mediterranean basin. The Ecopath model consists of a generic basin-wide model, with large pelagic, highly-migratory species as key functional groups. The ways in which this model can be used to assess fisheries impacts on the ecosystem at the basin level was outlined.

Keywords: Mediterranean Sea; Ecosystem impacts; Fisheries; Ecopath

Introduction

The Mediterranean Sea is undergoing a fundamental ecosystem change (1), a consequence of environmental and human factors acting on the local, regional and global scales. Fisheries is one key factor that is known to impact marine ecosystems worldwide, yet despite its importance in driving ecosystem changes very few studies have tackled fisheries impacts at the basin-ecosystem level in the Mediterranean Sea. Landings of capture fisheries provide an indication of the possible impacts of fisheries on the ecosystem. The mean trophic level of landings from the Mediterranean has significantly decreased over the last fifty years (2). This implies an increasing diversity of species in landings composition possibly a result of fishing-down-the-food-web but also of other factors including changes in primary production, changes in exploitation patterns and the introduction of new gear technologies (3, 4).

The Ecopath-with-Ecosim (EwE) ecosystem modelling approach has been used to assess the trophic impacts of fisheries across a range of geographical and temporal scales (5).

This paper highlights the possible applications of an Ecopath model for the Mediterranean ecosystem in assessing the role of fisheries targeting top-predators as drivers of ecological change in the basin.

Modelling protocol

The Ecopath model for the entire Mediterranean basin is generic and represents an annual average of the present-day ecosystem. The model structure is primarily based on communities of the central region, which is considered to be “typical” Mediterranean and not significantly in?uenced by adjacent seas as are the extreme ends of the basin (1). It includes both coastal and offshore components and describes predator-prey interactions between functional groups (aggregates of similar species) across the food-web. The model incorporates all species of commercial importance with the primary focus on large pelagic, highly migratory species. Key functional groups are top-predators of commercial importance in the Mediterranean and include bluefin tuna, swordfish, albacore, bonito, other tuna-like species, billfishes and sharks.

Applications of the model

At this geographical scale the Mediterranean model represents a gross simplification of ecological interactions that occur at the local and individual-species level. However it provides a tool to assess fishery-mediated trophic responses of the ecosystem at the larger geographical scale in the Mediterranean. The geographical range of large-pelagic fish spans the whole basin. These species constitute an important biological link between coastal and offshore sub-systems and support an important fishery in the Mediterranean, with very high levels of exploitation. Their biological characteristics and the importance of the fishery targeting them implies potentially significant ecosystem impacts at the basin level resulting from the fishery.

The Ecopath model is the basis for simulated fisheries experiments using Ecosim, the dynamic component of the model. Ecosim simulations show the extent of top-down control mechanisms and the type of cascade effects occurring across the food-web. Fisheries simulation experiments identify target and non-target functional groups in the Mediterranean coastal and offshore areas that are likely to be vulnerable to fishing of bluefin tuna, swordfish and other top-predators, as well as those which are likely to benefit. The simulations also highlight key ecosystem linkages and functional groups that are vital to ensure ecosystem integrity.

Ecopath incorporates a number of routines based on classical theoretical ecology that quantify ecosystem properties such as gross primary production, respiration and biomass, total system throughput and system ratios (e.g. Production/Respiration, Biomass/Respiration, etc.) (6). Quantification of ecosystem attributes for the Mediterranean Sea provides a general measure of the status of ecosystem health and provides useful ecosystem indicators. The change in such ecosystem indicators as a result of different top-predator harvesting strategies re?ects the extent to which such fishing can alter the general structure and performance of the ecosystem.

A third application of the model concerns the role of coastal nutrient enrichment from land discharges in enhancing the overall productivity across the basin (7). The key issue with respect to fisheries impacts is the relative importance of bottom-up and top-down controls in promoting ecosystem changes at the Mediterranean basin level. Ecosim time-dynamic simulations are used to compare the responses of the ecosystem to increasing fishing pressure on top-predators (top-down control) with ecosystem responses to increased nutrient enrichment (bottom-up control). The latter can be simulated in Ecosim through a forcing function. Comparing the results of model simulations to the actual trends in the Mediterranean where available, leads to a better understanding of the underlying ecological mechanisms that prevail at this geographical scale and hence of the role that fishing at the top of the food-web has in modifying marine ecosystems as opposed to environmental factors.

Conclusions

The large pelagics of the Mediterranean Sea constitute a shared resource that supports high value fisheries, however, declines in landings in recent years despite increasing fishing effort and a high incidence of juveniles and small fish in the catch indicate that the resource is overexploited. This trend is likely to continue in the future, with little control over fishing effort. There is therefore a real need to understand how the Mediterranean ecosystem could respond to high fishing pressure at the top of the food-web. Ecopath-with-Ecosim provides the ideal simulation tool in this context and the results will not only shed light on the role fisheries have in modifying ecosystems at the basin level; they can also provide a general framework for the development of strategic fisheries policy in the Mediterranean basin.

References

1-Bianchi, C. N. and Morri, C., 2000. Marine Biodiversity of the Mediterranean Sea: situation, problems and prospects for future research. *Mar. Pollut. Bull.,40(5): 367-376.*
2-Pauly, D., V. Christensen, Dalsgaard, J., Froese, R. and Torres, F. Jr., 1998. Fishing Down Marine Food Webs. Science,279: 860-863.
3-Pinnegar, J.K., Polunin, N.V.C. and Badalamenti, F., 2003. Long-term changes in the trophic level of western Mediterranean fishery and aquaculture landings. Can. J. Fish. Aquat. Sci., 60: 222-235.
4-Caddy, J.F. and Garibaldi, L., 2000. Apparent changes in the trophic composition of world marine harvests: the perspective from the FAO capture database. Ocean Coast. Manage., 43: 615-655.
5-Pauly, D., V. Christensen, and Walters, C., 2000. Ecopath, Ecosim, and Ecospace as tools for evaluating ecosystem impact of fisheries. ICES J. *Mar. Sci.,57: 697-706.*
6-Christensen V., 1995. Ecosystem maturity – towards quantification. *Ecol. Model.,77: 3-32.*
7-Caddy, J. F., R. Refk, and Do-Chi, T., 1995. Productivity estimates for the Mediterranean: evidence of accelerating ecological change. Ocean *Coast. Manage., 26(1): 1-18.*