APPLYING THE MASS-BALANCE APPROACH TO STUDY THE EXPLOITED MARINE ECOSYSTEMS IN NW MEDITERRANEAN SEA

Marta Coll [1] *, Isabel Palomera [1], Sergi Tudela [2], Francesc Sardà [1]

[1] Institut de Ciències del Mar (CMIMA – CSIC), Barcelona, Spain - * mcoll@icm.csic.es

[2] WWF Mediterranean Program Office, Barcelona, Spain

Abstract

The mass-balance approach was applied to study the structure and function of the exploited ecosystem associated with the Delta of Ebro River, NW Mediterranean Sea. An ecological model composed of 45 functional groups related with pelagic, demersal and benthic domains was constructed and important ecosystem attributes and interactions within species and fisheries were underlined.

Keywords: Mass-balance model, Ecopath, NW Mediterranean

Introduction

There are few examples of the mass-balance approach applied to Mediterranean marine ecosystems (1-3). Yet it provides important knowledge on ecosystem-based management of fisheries within the Mediterranean context. This attempt aims to study the trophic structure and functioning of an exploited marine ecosystem, to analyze the ecosystem attributes related with the state of health and maturity theoretical frameworks (4) and to set the baseline to conduct dynamic simulations and fisheries policy analysis accounting for ecosystem trophic interactions (5, 6). The study area is important, related with fishing activity within the Spanish Mediterranean context and also especially relevant for conservation of seabird populations (7).

Methodology

The application was developed in the shelf and upper slope exploited area associated with the Delta of Ebro River (from 50-400 m depth), excluding the coastal region where the artisanal fleet operates. Semi-industrial fleets (i.e., bottom trawlers, purse seiners and longliners) are the most important in terms of catches. The troll bait fleet was also considered in the study.

The mass-balance model was constructed using the latest version of Ecopath (5, 6). The Automatic Mass Balance Procedure (8) (AMBP) was used to assess mass-balance, while the Pedigree routine was applied to describe the origin and quality of inputs and to assign confidence intervals to data to apply then while using AMBP. Biomass, P/B ratio, Q/B ratio, trophic information, assimilation rate and fisheries' data were recompiled for 1994 to 2000 from trawling and acoustic surveys and bibliographic sources mainly (9). Discards and estimation of catches from IUU fishing activities (illegal, unreported or unregulated catches) were also included to modify official catch data. Inputs were expressed on an annual basis per unit surface area and wet weight terms (T/km^2,$T/km^2/y$). Functional groups were defined from over 190 species of invertebrates, fish and other vertebrates considering ecological and biological features, trophic information and importance in fishery (9).

Results and discussion

45 functional groups were defined: 11 related with invertebrates, 20 of benthic, benthopelagic and pelagic fishes, 5 of non-fish vertebrates, 3 related with primary production, detritus and import biomass and 6 related with fisheries in terms of fleets and discards. The model was comprised between four trophic levels, the highest value belonging to anglerfish (4.53), followed by coastal dolphins and squids. Most functional groups occurred at trophic levels 2.80 to 3.83.

Flows ($T/km^2/year$) per trophic level underlined the importance of phytoplankton–zooplankton compartments in the ecosystem (with 47.2% of the absolute flows), of detritus (28.1%), of polychaete-other benthic invertebrate groups (12.2%), and to a lesser extent of small pelagic fishes (4.6%). These results could underline bottom-up and wasp-waist control situations, as well as competition between groups of similar trophic levels. The same conclusion arises when analyzing the mixed trophic impact routine that enables the qualitative exploration of impacts that a theoretical increase of the biomass of a functional group would have on the other biomasses (5, 6). Anchovy and sardine were also shown to have wide impacts on numerous functional groups of higher and lower trophic levels. Transfer efficiency (5, 6) (12.7%) was within the common values described in the literature (10).

The primary production required to support the fisheries was 49% of the primary production of the ecosystem, highlighting an intensive fishing pressure on marine resources. This value was high compared with other models and even higher than a preliminary estimate for the Catalan coast (11). The analysis of the relative consumption of target fish groups production by different predators showed that squids had the higher impact on consumption of benthic and demersal fish production (47%), followed by the fishery (27%). The first consumer of small and medium sized pelagic fish production was the fishery (39%), followed by adult hake (32%) and squids (17%). The analysis of catch per trophic level showed that the third trophic level provided the highest caught biomass (72.9%), followed by the second (15.2%). Therefore, the mean trophic level of the catch was 3.03, underlying that catches were mostly composed of organisms feeding on zooplankton, e.g. small pelagics. Comparing the trophic levels of the fleets with the trophic levels of the functional groups it was seen that fisheries functioned as top predators.

The trawling fleet had the widest impact on the different functional groups of the ecosystem and also the deepest impact on some of the target and non-target functional groups of the ecosystem. The longline fleet had some deep negative impact on biomass of marine turtles, sea birds and dolphins and slightly positive impacts, mainly on small pelagics and mackerel. The purse seine fleet and troll bait fleet had lower impacts on the diversity of groups; however important negative impacts were recorded on their main target species.

References

1 - Örek H., 2000. An application of Mass Balance Ecopath Model to the trophic structure in the Black sea "after anchovy collapse". Ms. In Marine Science. Middle East Technical University. 119 p.

2 - Pinnegar J.K., 2000. Planktivorous fishes: links between the Mediterranean littoral and pelagic. PhD Thesis, University of Newcastle upon Tyne, UK. 213 p.

3 - Pranovi F., Libralato S., Raicevich S., Granzotto A., Pastres R. and Giovanardi O., 2003. Mechanical clam dredging in Venice lagoon: ecosystem effects evaluated with trophic mass-balance model. *Mar. Biol.*, 143: 393-403.

4 - Christensen V., 1995. Ecosystem maturity – towards quantification. *Ecol. Model.*, 77: 3-32.

5 - Christensen V., Walters C. and Pauly D., 2000. Ecopath with Ecosim: a User's guide. Fisheries Centre of University of British Columbia, Canada / International Center for Living Aquatic Resources Management, Malaysia. 130 p.

6 - Pauly D., Christensen V. and Walters C., 2000. Ecopath, Ecosim and Ecospace as tools for evaluating ecosystem impact of fisheries. *ICES J. Mar. Sci.*, 57: 697-706.

7 - Abelló P., Arcos J.M and Gil De Sola L., 2003. Geographical patterns of seabird attendance to a research trawler along the Iberian Mediterranean coast. *Sci. Mar.*, 67 (Suppl.2): 69-75.

8 - Kavanagh P., 2002. Automatic Mass Balance Procedure for Ecopath Ecosystem Models User's Guide. Fisheries Center. University of British Columbia. 28 p.

9 - Coll M., 2002. Construcción de un modelo de equilibrio de masas Ecopath en el ecosistema marino explotado asociado al Delta del Ebro, Mediterráneo noroccidental. Recogida y análisis de los datos básicos. M.Sc. thesis. Autonomous University of Barcelona, Spain. 241 p.

10 - Odum E. P., 1971. Fundamentals of Ecology. Saunders Publ., Philadelphia. 574 p.

11 - Tudela S., 2000. Assesment of the ecological footprint of fishing in the Catalan central coast (NE Spain). *In*: Briand F. (ed.). Fishing down the Mediterranean Food Webs? *CIESM Workshop Series*, 12: 79-81.