

Spatial differences and temporal trends in cephalopod populations along the Mediterranean

Stefanie Keller^{*1}, Valerio Bartolino², Manuel Hidalgo¹, Isabella Bitetto³, Loredana Casciaro³, Antonio Esteban⁴, Maria Cristina Follesa⁵, Cristina Garcia⁶, Germana Garofala⁷, Marios Iosifides⁸, Angelique Jadaud⁹, Evgenia Lefkaditou¹⁰, Porzia Maiorano¹¹, Chiara Manfredi¹², Bojan Marceta¹³, Enric Massutí¹, Reno Micallef¹⁴, Panagiota Peristeraki¹⁵, Giulio Relini¹⁶, Paolo Sartor¹⁷, Maria Teresa Spedicato³, George Tserpes¹⁵, Antoni Quetglas¹

¹ Instituto Español de Oceanografía, Centre Oceanogràfic de les Balears, Moll de Ponent s/n, 07015 Palma de Mallorca, Spain; Tel: +34971133742; fax: +34971404945; e-mail: stefanie.keller@ba.ieo.es

² SLU Swedish University of Agricultural Sciences, Department of Aquatic Resources

³ COISPA-Tecnologia & Ricerca

⁴ IEO Centro Oceanográfico de Murcia

⁵ Dipartimento di Scienze della Vita e dell'Ambiente, Università di Cagliari

⁶ IEO, Centro Oceanográfico de Malaga

⁷ IAMC – Coastal Marine Environment Institute – CNR

⁸ DFMR – Department of Fisheries and Marine Research, Ministry of Agriculture, Natural Resources and Environment

⁹ Ifremer, Sete

¹⁰ HCMR, Hellenic Centre of Marine Research, Athens

¹¹ University of Bari - Department of Biology

¹² Laboratorio Biologia Marina e Pesca, Università di Bologna

¹³ Fishery Research Institute of Slovenia

¹⁴ Ministry for Sustainable Development, Department of Fisheries and Aquaculture

¹⁵ HCMR, Hellenic Centre of Marine Research, Crete

¹⁶ SIBM, Società Italiana di Biologia Marina, Genova

¹⁷ CIBM – Centro Interuniversitario di Biologia Marina ed Ecologia Applicata (Livorno)

Summary

In this work we present spatio-temporal trends of cephalopod diversity across the entire Mediterranean Sea during the last 20 years, analyzing data from the annual MEDITS surveys conducted by 5 different Mediterranean countries using standardized gears and sampling protocols. Species diversity patterns will be presented encompassing both the shelf and slope grounds. The influence of local and regional environmental variability in different Mediterranean regions are analyzed using general additive models.

Introduction

Species diversity is an important measure for conservation issues and has strong implications for the functioning of ecosystems. Especially in the Mediterranean Sea, an area with substantial anthropogenic influences, understanding and monitoring species diversity is a crucial issue. Until today, few diversity studies that cover the whole longitudinal gradient of this sea exist, and long-time data series obtained from cruises using standardized protocols and covering shelf as well as slope areas are rather rare.

In this study, cephalopod diversity is analyzed within space and over a time series of 6 years. Cephalopods are important marine keystone species, which can respond rapidly to changes in climate regimes. Temporal changes in their distribution and community structure can therefore supply important information about ecosystem alterations.

Material and methods

The analyzed data were obtained for the Mediterranean bottom trawl survey MEDITS, which is performed throughout the Mediterranean Sea since 1994. Research cruises take place every year in spring (May-August) and cover depths from 50 m down to 800m. The data used in this study came from 15 areas (GSAs) belonging to five different countries and comprised 6261 hauls. The survey uses a standardized sampling procedure including the use of the same gear and the same sampling strategy during all conducted expeditions. We used generalized additive models (GAMs) to model the spatial distribution of cephalopod diversity including the influence of monthly mean sea surface temperature (SST) and chlorophyll a concentration (Chla) on species diversity. All Chla and SST seasonal means were obtained from satellite-derived products and calculated per area. Diversity was measured by the Shannon Wiener index (H') and the species richness (S). For the analysis, the Mediterranean was divided into 6 biogeographical zones similar to Gaertner et al. (2013) in order to see if the bathymetric pattern varies between the different regions.

Results and Discussion

A total of 28 different cephalopod species or species complexes were included in the analysis over the entire time series. The number of species per sample ranged between 1 and 12, with a mean of 4 species. Shannon Diversity and species richness were lowest in the Adriatic and Ionian Sea, and high but very variable in the Aegean Sea (Fig. 1). In this area, the diversity increased markedly from 2003 onwards. Diversity showed a clear pattern with depth, being highest between about 200-400 m and slowly decreasing over slope grounds. Bathymetric patterns were similar but still distinct in each of the 6 bioregions analyzed. Chla concentration and SST of the winter preceding the sampling season significantly influenced diversity, although the explained deviance only increased marginally. The spatial analysis revealed a complex pattern (Fig. 2) with no clearly marked longitudinal or latitudinal gradients as found in some benthic diversity studies in this sea. In contrast, our results are similar to Gaertner et al. (2007, 2013), who found similar bathymetric trends and patterns for groundfish communities on the Mediterranean shelf and slope.

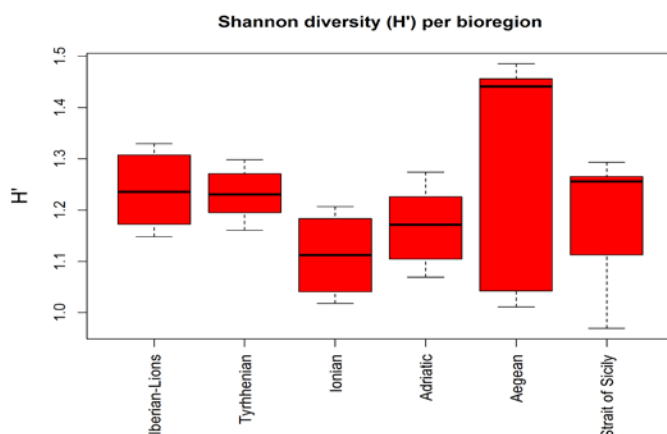


Fig 1. Shannon diversity per bioregion, data from 2003-2008

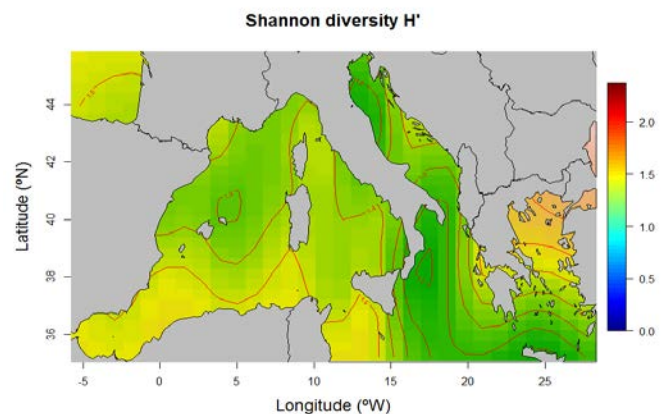


Fig 2. Spatial pattern of cephalopod diversity (H') in the Mediterranean Sea (result of the GAM model)

References : Gaertner, J., Bertrand, J., Relini, G., Papaconstantinou, C., Mazouni, N., de Sola, L. et al. 2007. Spatial pattern in species richness of demersal fish assemblages on the continental shelf of the northern Mediterranean Sea: a multiscale analysis. *Marine Ecology Progress Series*, 341, 191–203. doi:10.3354/meps341191

Gaertner, J.-C., Maiorano, P., Mérigot, B., Colloca, F., Politou, C.Y. et al. 2013. Large-scale diversity of slope fishes: pattern inconsistency between multiple diversity indices. *PloS One*, 8(7), DOI 10.1371/journal.pone.0066753