A SPATIALLY ORIENTED ECOSYSTEM BASED MODEL TO EVALUATE ECOSYSTEM IMPACTS OF FISHERIES

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Abstract
The present study consists in the development of the first spatial model for the marine ecosystem of the Azores, situated in the mid North Atlantic Ocean. The main goal is to construct the spatially explicit version of the previous developed Ecopath with Ecosim (EwE) model to furthermore address fisheries-related management questions. The Ecospace model was built under the most recent EwE software capabilities.

Keywords: Fisheries, Models, Deep waters, Azores, North Atlantic

The implementation of ecosystem-based management (EBM) approaches via marine spatial planning (MSP) of human activities is widely recognized as an effective way to achieve sustainability of marine resources exploitation. Spatially oriented ecosystem based models, as Ecospace[1], are useful tools to support EBM, given its ability in assess temporal and spatial ecosystem dynamics and explore potential impacts of differential management scenarios at the ecosystem level. The present study aims to develop the first spatial model for the deep marine ecosystem of the Azores, located in the mid North Atlantic Ocean, to address fisheries related management questions. Therefore, we constructed the spatially explicit version of a previous built Ecopath with Ecosim model[2] for the same area to i) quantify the impact of foreign pelagic fleets fishing within 100nm of the Azores' Exclusive Economic Zone (EEZ), under a Common Fisheries Policy regulation (EC 1954/2003); ii) and evaluate the effect of the establishment of marine protected areas (MPA) for the main fishing fleet operating in the Azores, the bottom longline. Ecological statistics were derived from the Ecopath model to characterize the ecosystem of the Azores (Table 1).

Tab. 1. General ecosystem statistics calculated for the Ecopath model of the Azores exclusive economic zone

Sum of all consumption	354.05	t/km²/yr
Sum of all exports	1477.18	t/km²/yr
Sum of all respiratory flows	197.99	t/km²/yr
Sum of all flows into detritus	1558.16	t/km²/yr
Total system throughput	3587.37	t/km²/yr
Sum of all production	1760.42	t/km²/yr
Mean trophic level of the catch	3.95	
Calculated total net primary production	1675.17	t/km²/yr
Total primary production/total respiration	8.46	
Net system production	1477.18	t/km²/yr
Total primary production/total biomass	69.56	
Total biomass/total throughput	0.01	
Total biomass (excluding detritus)	24.08	t/km²
System Omnivory Index	0.22	
Ecopath pedigree index	0.53	

The Ecospace model was built under the most recent software capabilities (v6.5, beta), using the newly developed habitat foraging capacity model[3] and spatial-temporal data framework[4] that facilitates the direct input of environmental, human and legal spatial layers. The model entails 45 functional groups (a detritus group, two primary producer groups, eight invertebrate groups, 29 fish groups, three marine mammal groups, a turtle and a seabird group) and 12 fishing fleets (the deep bottom longline and handline, regional pelagic longline, Portuguese mainland pelagic longline, foreign pelagic longline, pole and line tuna - including the pole and line live bait fishery, small pelagic, drifting deep water longline, commercial coastal invertebrates, recreational fishing, bottom trawling and loligo). The area has approximately 1 million square kilometers and corresponds to the 200 nautical miles (nm) of Azores' EEZ. The first step in model development consisted of establishing the basemap, defining area boundaries and cells to include in the model and filling primary production and depth layers with geographic information system data available for the area. Since depth is identified as a potential factor influencing the spatial distribution of fish in the modeled area, four habitats were defined based on depth intervals (in meters): <350; <700; <1200; >1200, in which functional groups forage differently. Additionally, a marine protected area was designed to delineate the area wherein foreign fleets are not allowed to fish (100nm). Figure 1 shows the Ecospace depth map and the 100nm marine protected area designed for the foreign fishing fleets.

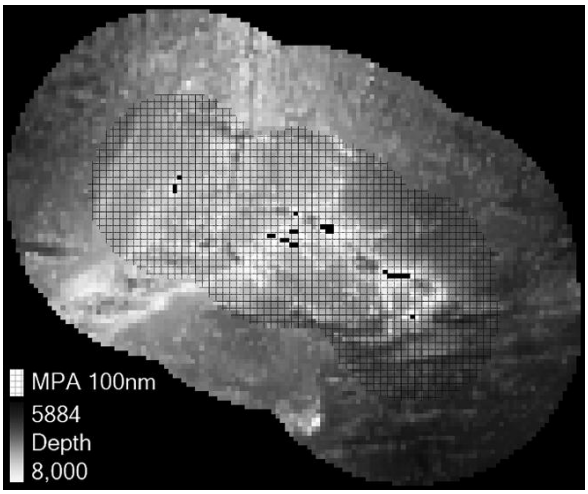

Fig. 1. Ecospace depth map of the modeled area (depth unit, meter), displaying the nine islands of the Archipelago (black cells) and the 100nm marine protected area for the foreign fishing fleets (grid)

The model was prepared to run after habitat parameterizations and the fishing fleets assigned to the created habitats. We believe the present study might constitute a step forward in the usage of spatially oriented ecosystem-based models to assist the implementation of EBM approaches in the Archipelago of the Azores, by exploring the outcomes of different management scenarios in the ecosystem dynamics.

References
1 - V. Christensen and C. J. Walters, "Ecopath with Ecosim: Methods, capabilities and limitations," Ecol. Modell., vol. 172, pp. 109–139, 2004.
2 - T. Morato, E. Lemey, G. Menezes, C. Pham, T. J. Pitcher, J. J. Heymans "Ecosystem model of the open-ocean and deep-sea of the Azores: what drives ecosystem dynamics?" (in preparation)
3 - V. Christensen, M. Coll, J. Steenbeek, J. Buszowski, D. Chagaris, and C. J. Walters, "Representing Variable Habitat Quality in a Spatial Food Web Model," Ecosystems, pp. 1397–1412, 2014.
4 - J. Steenbeek, M. Coll, L. Gurney, F. Mélin, N. Hoepffner, J. Buszowski, and V. Christensen, "Bridging the gap between ecosystem modeling tools and geographic information systems: Driving a food web model with external spatial-temporal data," Ecol. Modell., vol. 263, pp. 139–151, 2013.