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Deep-sea Ecosystem Model of the Condor Seamount

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ABSTRACT

Seamounts play an important role in the status of food webs and biodiversity in the open ocean. These habitats are now subject to an intensive exploitation and it is urgent to apply an ecosystem perspective towards the development of sustainable fisheries. Ecosystem models offer scope to understand the interactions between fisheries, exploited species and the ecosystem that supports them, enabling impact assessments of human activities on the marine environment. This study describes the construction and input data of an Ecopath with Ecosim model for the Condor seamount ecosystem, located in the Azorean archipelago (NE Atlantic). The model comprises 23 functional groups, including plankton, invertebrates, fishes, marine mammals and seabirds. The fisheries component consists on the regional fleet, with an emphasis on demersal fisheries. This model can serve as a basis for future Ecosim and Ecospace simulations of the effect of fishing on Condor seamount or on other seamounts around the Azorean islands.

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1. INTRODUCTION

Marine ecosystems are under threat for several reasons including degradation and loss of habitats, environmental pollution, climate change and constant pressure due to over-exploitation (Jackson *et al.*, 2001). The stocks of Atlantic cod (*Gadus morhua*), Peruvian anchoveta (*Engraulis ringens*) and southern bluefin tuna (*Thunnus maccoyii*) are examples of fish species, with different life cycles and habitats, which were decimated as a result of over-fishing (Reynolds *et al.*, 2002). The last estimates from the Food and Agriculture Organization of the United Nations (FAO) state that 57.4% of the world marine fish stocks are fully exploited, 29.9% are overexploited and only 12.7% are non-fully exploited (FAO, 2012). Global total catches are declining at a much faster rate than previously thought, indicating the crisis that the world fisheries are going through at the moment (Zeller & Pauly, 2005).

It is now recognized that traditional fisheries management measures, based on single-species assessments, have not always been appropriate, thus demonstrating the need to complement them with a wider knowledge of ecosystem dimensions (Pauly *et al*., 2002; Hughes *et al*., 2005). The 1995 FAO Code of Conduct for Responsible Fisheries stress the need for the adoption of management strategies that not only guarantee the conservation of target species, but also of species belonging to the same ecosystem or that somehow are related with the target species (FAO, 2011). At the end of 2002, the Common Fisheries Policy (CFP) review emphasized the importance of shifting from single-stock annual decisions to long-term management plans. Therefore, it is key to include environmental issues into policy, were an ecosystem based approach is the way forward in fisheries management (Penas, 2007).

The Ecosystem Approach to Fisheries (EAF) highlights the need to take an ecosystem perspective towards the development of sustainable fisheries. Through the implementation of management strategies that have little impact on the functioning and productivity of an ecosystem, the EAF aims at both human and ecosystem well-being to ensure a sustainable exploitation of stocks in the long-term (Garcia *et al.*, 2003).

For functioning responsible fisheries management it is essential to understand the interactions between fisheries, exploited species and the ecosystem that supports them. Trophic relationships offer scope to understand interspecific and environmental interactions. The diversity of links between predator and prey serves as a basis for a better understanding of the surroundings in which they inhabit. Ecosystem modelling allows the creation of food chains models, where fisheries can be considered as top predators. This enables impact assessments of human activities on the marine environment, providing a way to start using the EAF in management policies (Howell *et al.*, 2009).

There are many mathematical approaches that allows the construction of ecosystem models when considering all trophic levels, from primary producers to top predators, i.e. trophodynamic ecosystem models. Ecopath with Ecosim (EwE) has been the most widely used modelling approach in the EAF. It assists in describing how ecosystems react to changes and is considered excellent for its ecological sensitivity and conceptual simplicity (Plagányi, 2007). EwE is a food web model that enables the user to define the trophic flows that exist between the different elements of the ecosystem. It is used to deal with ecological questions, estimate the effect of fishing in the ecosystem, investigate management policy options, determine the location and the impact of marine protected areas and evaluate the consequences of climate change. EwE relies on relatively simple data to predict model outputs. Data can include biomass estimates, consumption rates, mortality estimates, diet composition and catches from fishing activities (Christensen *et al.*, 2008) EwE enables the investigation of past and future effects of fishing and ecological problems, which can lead to better fishing management policies (Christensen & Walters, 2004), and can be used in several types of marine habitats, with different human pressures and environmental disturbances (Coll & Libralato, 2011).

Seamount habitats have been intensively exploited by commercial fishing practices in the last 30 years, as a result of the improvement of fishing gear technology and depletion of other fishing grounds (Pitcher *et al.*, 2010). Seamounts attract rich biotic communities and play an important role in the status of food webs and biodiversity in the open ocean. They are essential areas of reproduction for some organisms and are used as reference points by many migratory species of cetaceans, turtles, fishes, cephalopods and seabirds (Pitcher *et al*., 2007). Despite their ecological and economic importance they still are one of the least known habitats on the planet and therefore, there is an urgent need to search for new strategies of management and conservation in these understudied habitats (Morato *et al*., 2010).

The tectonic and volcanic nature that characterizes the Azores seabed makes seamounts a common topographic feature. They represent an area of approximately 37% of the Exclusive Economic Zone (EEZ) from the Azorean archipelago (Morato *et al.,* 2008a). The bank encompassing the Formigas islets and the Dollabarat reef, located between São Miguel and Santa Maria islands, was the first offshore site in Europe to be awarded a marine reserve status in 1988 (Santos *et al.,* 1995). This demonstrates the importance the Azorean region applies to its marine habitats and the increase in awareness of protecting seafloor habitats. The Condor seamount, situated circa 10 nautical miles southwest of Faial island, was defined as a temporary protected area under the international project CONDOR. This allowed an opportunity for the installation of an innovative scientific underwater observatory aiming to integrate the study of the functioning and biodiversity of seamounts. This unique case study may serve as an example for future investigation on these fragile ecosystems (Morato *et al*., 2010).

This study intends to build a model of the Condor seamount ecosystem using EwE software. The main step is to develop and quantify the parameters for Condor seamount by gathering and incorporating all appropriate data on the physical, ecological, social and economic components of the system. The final step is to create a balanced model.