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Spatial and temporal variability of demersal fishes at Condor seamount (Northeast Atlantic)

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ABSTRACT

Temporal and spatial patterns of variation of benthic and benthopelagic fish assemblages on the Condor Seamount of the Azores, Northeast Atlantic, were studied based on longline samples from the depth interval 200–1300 m depth. The seamount was used as a commercial fishing ground for decades but is currently closed to fishing as a temporary protected area for research. The protection regime offers an opportunity to monitor and analyze responses to harvesting and recovery from previous fishing impacts. Species number, catches per unit of effort, and zonation with depth corresponded in general with what was observed elsewhere for the Azorean demersal fish community. Total abundance, species richness and species composition significantly varied in time and space within the seamount, generally showing a North–South asymmetry. Abundance and species richness were higher in the Northern than in the Southern sector of the seamount, mainly due to higher abundances of the species *Helicolenus dactylopterus*, *Pagellus bogaraveo*, *Beryx splendens* and *Trachurus picturatus*. Analyses of abundance variation of the most frequent species showed an array of species-specific responses. The variability of fish assemblages is discussed in the light of oceanographic and anthropogenic factors, which may drive the observed patterns and trends.

1. Introduction

Seamounts occur in large numbers in all oceans (Kim and Wessel, 2011; Kitchingman et al., 2007; Morato et al., 2013; Wessel et al., 2010; Yesson et al., 2011) and many of them are significant areas for fisheries, biodiversity and conservation (Clark et al., 2012; Pitcher et al., 2007; Richer de Forges et al., 2000; Rogers, 1994; Rowden et al., 2010). Seamounts are heterogeneous features, comprising different habitat types and spanning a broad range of depths. They can be differentially influenced in space and time by variable oceanographic processes, and are subject to heterogeneous spatial exploitation by fisheries (Clark et al., 2010b, 2012). All these characteristics are expected to be important determinants of the variability of species occurrence, abundance and distribution between and within seamounts.

Several studies describe seamount demersal fish assemblages with respect to their abundance, species composition, diversity and distribution with depth (Christiansen et al., 2009; Geange et al., 2012; Lundsten et al., 2009; Magnussen, 2002; Menezes et al., 2006, 2009; Tracey et al., 2004). The few that study variation of composition between seamounts point to substantial variability between individual seamounts, even on a small spatial scale (Clark et al., 2010a, 2010b; Tracey et al., 2012). Moreover, some seamounts have been examined to assess changes in fish assemblages over time, and the few studies conducted showed that assemblage changes appear to be related to several factors, including productivity constraints, prey availability and trawling impacts (Fock et al., 2002a, 2002b; Niklitschek et al., 2010). In spite of the scientific interest in seamount demersal fishes, patterns of variation of fish assemblages at the scale of individual seamount still remain poorly described.

The characterization of fish assemblages and of their persistence over different spatial and temporal scales is important information for seamount fisheries management. Based on their life history characteristics and the specific environmental features of seamounts (e.g. their small sizes or degree of isolation), seamount fish species have been shown to be highly vulnerable to fisheries exploitation (Morato and Clark, 2007; Morato et al., 2006) and few seamount fisheries have proven sustainable (Clark et al., 2007). Large-scale trawl fisheries negatively affect both target and by-catch fish species (Anderson and Clark, 2003; Clark, 2001; Niklitschek et al., 2010), and once overexploited, it is uncertain if deep-sea fisheries on seamounts can recover (Clark et al., 2010b). In spite of being more sustainable than industrial fisheries, even small-scale artisanal fisheries may impact, in the long-term, species abundance levels (Menezes et al., 2013; Silva and Pinho, 2007), but to date only little attention has

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been given to their impacts on seamount species (Rowden et al., 2010).

Several initiatives for seamount conservation and management have been taken in the last decades, including fishing closures of some seamounts in the Atlantic and Pacific Ocean for conservation and research purposes (Giacomello et al., 2013; Morato et al., 2010; Probert et al., 2007). Although in some cases closures have been in force for over a decade, medium and long-term effects of fishing are still uncertain (Clark et al., 2012; Morato et al., 2010). For the generally slow-growing and long-lived seamount fishes (i.e. Morato et al., 2006) such a timespan may not be sufficient to produce significant changes in the assemblages. Even in assemblages of relatively fast-growing species rates of recovery are not well known and it is unclear how the assemblage composition changes over time after cessation of disturbance or how, why and which species recruit earlier.

Seamounts are common topographic features in the archipelago of the Azores, Northeast Atlantic (Morato et al., 2008). In the Azorean region, most of the deep-water and demersal fishing activities are conducted on seamount like features. Since the 1980s the demersal fisheries in the region have expanded from the island shelves to offshore seamount areas and deeper waters (Pham et al., 2013; Sedberry et al., 1999). Most of the local demersal fleet uses hook and line gears such as handlines and longlines to fish at or near the seabed (Pinho and Menezes, 2006), i.e. practices that have less negative impacts on bycatch and habitats than bottom trawls (Chuenpagdee et al., 2003; but see for example Sampaio et al., 2012). Despite this, recent signs of possible overfishing of several fish species or fishing grounds are of increasing concern (Menezes et al., 2013). To monitor fish abundances on the islands slopes and several seamounts a scientific longline survey was established in 1995 and is being conducted on an annual basis in the Azores. Based on data from the surveys, the main spatial and depth-related patterns of the deep-sea demersal fish assemblages have been described and discussed in relation to large- and small-scale environmental factors (Menezes et al., 2006). However, temporal and spatial variability of assemblages have not been investigated so far.

The Condor seamount, located approximately 17 km to the south-west of Faial Island is under a temporary fishing moratorium for scientific purposes, initiated in 2010 and ending in 2014 or later. The protection regime and the intense data collection in recent years (Giacomello et al., 2013) facilitates greatly studies of patterns of variation in fish assemblages in the absence of fishing pressure. This elongated seamount, with a West–East orientation, has depths ranging between the summit of 185 m to more than 1800 m near the base of the slope, and it has a flat and broad summit area (Fig. 1, Tempera et al., 2013). A characteristic is the presence of invertebrate assemblages of conservational importance such as deep-water coral gardens and deep-sea sponge aggregations (Braga-Henriques et al., 2011; Tempera et al., 2012). Harvesting of fisheries resources on Condor started in the 1960s and current abundances of demersal species appear significantly lower than those reported by the older fishermen active at that time (Menezes et al., 2013). Although this seamount was an important fishing ground for the local fleet, its demersal fish fauna has not been extensively described. The first scientific surveys of the demersal fish community were conducted in 1982–1983 when handline and longline sets were deployed on ;the seamount (Krug, personal communication; Dias et al., 1990); these studies were followed by another survey in 2003 and a more consistent annual longline surveys from 2009 onwards.

Here we analyze longline surveys catches from the depth range 200–1300 m to investigate the spatial and temporal variation of the deep-water demersal fish assemblages, at the scale of an individual seamount. More specifically, our first objective is to provide an inventory of species and characterize the demersal fish assemblage inhabiting the Condor seamount. Based on a subset of data we then analyze the spatial and temporal variability of species assemblage structure, diversity, abundance and the size structure of the most abundant species.

2. Materials and methods

2.1. Longline surveys and sampling design

A total of 28 longline sets were deployed in 2003 and in 2009–2012 onboard the R/V *Arquipélago*, following the standardized methodology used in the annual scientific surveys conducted to

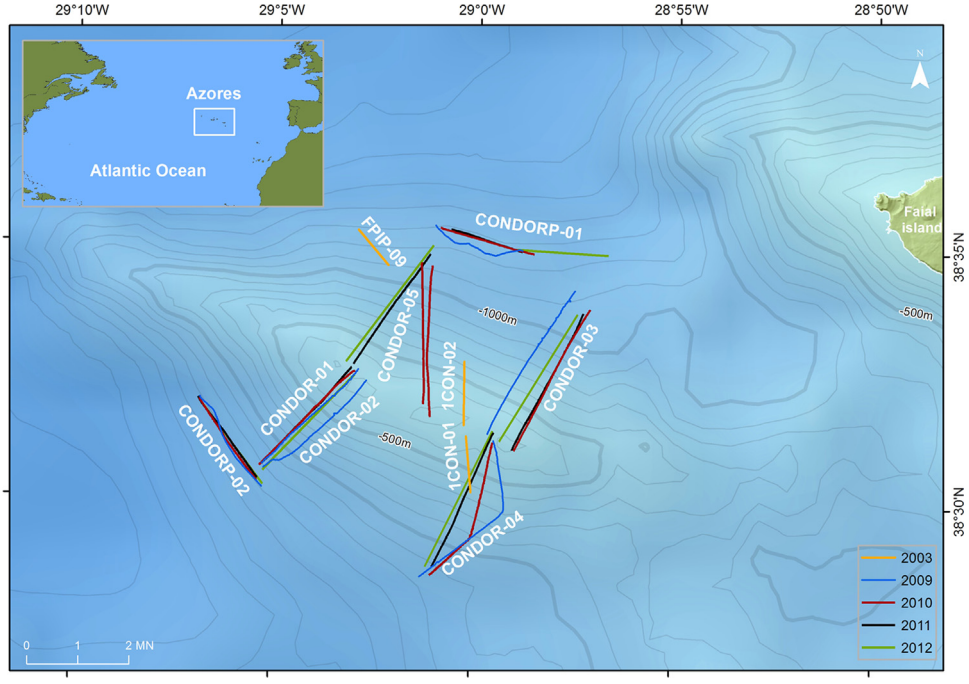

Fig. 1. Position of longline sets deployed at Condor seamount in 2003, 2009–2012. The codes indicate the longline sets as reported in Table 1.