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## Demersal fish assemblages off the Seine and Sedlo seamounts (northeast Atlantic)

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### ABSTRACT

Seamounts are thought to support special biological communities, and often maintain high standing stocks of demersal and benthopelagic fishes. Seamount fish fauna have been described in several studies but few works have included species taken below 600 m. The demersal fish assemblages of the Seine and Sedlo seamounts (northeast Atlantic) from the summits to 2000 m depth were investigated based on longline survey catch data, conducted as part of the OASIS project. A total of 41 fish species from 24 families were caught at Seine near Madeira, and 30 species from 19 families were caught at Sedlo north of the Azores. Both fish faunas have high affinities with the neighbouring areas of the Azores, Madeira and with the eastern North Atlantic and the Mediterranean Sea. Overall abundances and mean body weights were slightly higher at Sedlo seamount, appearing in conformity with the latitudinal effect of increasing species abundance and productivity from south to north. The differential influence of the Mediterranean Water at each seamount may contribute to explain (a) the differences found in vertical distribution of common species, which tend to distribute deeper at Seine, and (b) the observed changes in the species composition and dominance in deeper waters. Multivariate analysis revealed a vertical structure that is approximately coincident with the expected zonation of water masses at each seamount. Physiological tolerance to the prevailing vertical hydrological conditions may explain the species distribution and the large-scale vertical assemblage structure found. However, further ecological factors like productivity patterns affecting the amount and quality of the available food appear to shape the abundance, diversity or dominance patterns of functional groups within those main assemblages. At Seine, the species *Trachurus picturatus* dominated the catches, mainly at the shallower edge of the plateau, appearing consistent with the sound-scattering layer interception hypothesis [Isaacs, J.D., Schwartzlose, R.A., 1965. Migrant sound scatterers: interaction with the sea floor. *Science* 150, 1810–1813]. At both seamounts mesopelagic feeders (e.g., *Beryx splendens*) dominate the upper-slope assemblages (<800 m), while the mid-slope assemblages (800–1200/1300 m) and the lower-slope assemblages (>1300 m) were dominated by squaliform species (e.g., *Centrophorus squamosus*, *Centroscymnus coelolepis*, *Etmopterus princeps*) along with *Mora moro* or the *Antimora rostrata*. The lower abundance of *C. squamosus* observed at Seine may be a result of the fishing activities in the area, since the species is an important by-catch of the black-scabbard fish fishery in the Madeira archipelago. The slightly higher predominance of scavenger species at Seine in deeper assemblages may be the result of an ecological response favouring this functional group in lower productivity regimes. Especially relevant was the record of large reproductive aggregations of *B. splendens* and *Epigonus telescopus* found at the edge of the Sedlo plateau.

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### 1. Introduction

Seamounts, in general, are thought to support high biodiversity and special biological communities (Rogers, 1994). On a global scale, the role of seamounts in the biogeography, biodiversity, productivity and evolution of marine organisms has been hypothesized but is still poorly understood and controversial. It

is estimated that there are potentially up to 100,000 seamounts with summits higher than 1 km above the surrounding seabed and many more of lesser relief. However, few seamounts have been studied biologically, only about 350 have been sampled, and less than 100 in any detail (Clark et al., 2004).

Seamounts are highly variable landscapes, acting as a habitat for numerous benthic organisms and feeding grounds for fishes and other marine fauna (Morato et al., 2008). Seamounts often maintain high standing stocks of demersal and benthopelagic fishes (Boehlert and Genin, 1987; Rogers, 1994) despite the impoverished nutritional conditions in oceanic regions (e.g., Fock

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et al., 2002b). Instead of an autochthonous-derived energy, some evidences suggest that these stocks are mainly supported by an advected energy supply of zooplankton and micronekton (Dower and Mackas, 1996; Fock et al., 2002a; Pusch et al., 2004). Studies on the diets of demersal fish species at Great Meteor Seamount found that their interaction with vertically migrating mesopelagic fauna plays a significant role in the maintenance of these stocks (Fock et al., 2002b), in agreement with the sound-scattering layer (SSL) interception hypothesis (Isaacs and Schwartzlose, 1965).

In recent years, seamount fish fauna and invertebrate communities have received increasing research interest for scientific, conservation and economic reasons. They are important fishing grounds for both demersal and pelagic fisheries, but also areas of increased biodiversity and greater densities of filter feeders with high conservation importance, such as deep-water corals and sponges. Seamounts have been targeted by commercial fishing due to the occurrence of large aggregations of some fish species in mid- and deep-water. For instance, orange roughy (*Hoplostethus atlanticus*) and other economically valuable fish species (e.g., *Beryx splendens*, *Epigonus telescopus*) have been found to form dense reproductive and feeding aggregations at seamounts and have been heavily exploited in several oceans (Rogers, 1994; Vinnichenko, 1997b; Clark et al., 2004; Tracey et al., 2004).

Increasing fishing activities at seamounts and the complexity of biological and ecological traits of their exploited fish populations (e.g., recruitment mechanisms, resilience, longevity) have raised concerns on the human impacts on this biota (Rogers, 1994; Koslow, 1997). A number of seamount fish populations have already been depleted, and the long-term impacts of such activities on the seamount habitats and benthic organisms remain unquantifiable (Vinnichenko, 1997b; Clark et al., 2004).

The Azores and Madeira archipelagos, like most of the oceanic islands, are surrounded by oligotrophic waters, and have steep slopes and narrow shelves. In general, exploitable fishing resources are therefore smaller, deeper, more vulnerable to overfishing, and most of the fishing is done on seamount-like features. Seamounts are common topographic features in the Azores area. Recently Morato et al. (2008) mapped and described 63 large, and 332 small seamount-like features in the whole EEZ of the Azores. In Madeira, seamounts are less numerous, comprising only about five large features.

Over the period 1979–1982, several scientific longline surveys were carried out in the Madeira archipelago, including Seine seamount, by the former National Institute for Fisheries Research (INIP) using the R/V “*Noruega*” (INIP, 1980; Leite, 1983). These surveys aimed to evaluate and support the development of the fishery for black-scabbard fish (*Aphanopus carbo*), and also to study the oceanographic conditions of the region.

In the 1980s, Seine seamount was already exploited by longliners targeting demersal fishes and also by traditional pole-and-line tuna fleets. In general, fishing activities at Sedlo and Seine are almost unknown. Sedlo seamount has not been a common demersal fishing ground for the Azorean fishing fleets probably because it is relatively deep, limiting the occurrence of most traditional target species. The few records of fishing near Sedlo seamount refer to surface-longliners targeting swordfish (Santos et al., 2009). In 2002, exploratory trawl fishing, targeting orange roughy (*H. atlanticus*), took place at Sedlo seamount and 15 fish species were recorded for the first time in the Azores area (Menezes et al., in prep.). This was the first time a bottom trawl was used in the Azores, and most of the new species recorded are not catchable by baited fishing gears (the gears used in commercial fishing and fish sampling surveys in region). Trawling on island slopes and seamount features is difficult due to the steep slopes and rough nature of the seabed; therefore, longlines have been used in most studies of demersal and deep-water fish

assemblages in the Atlantic archipelagos and at their neighbouring seamounts (Uiblein et al., 1996, 1999; Menezes, 2003; Menezes et al., 2006).

Seamount fish fauna have been described in several studies, but few works have included species taken below 600 m (Tracey et al., 2004). Comparisons of fish assemblages between seamounts, or between seamounts and neighbouring areas (islands and continental slopes), are still scarce.

In this study, we characterize and compare the structure and spatial distribution of the demersal fish fauna of Seine (Seine) and Sedlo (Sedlo) seamounts down to 2000 m water depth, based on longline fishing surveys carried out under the OASIS project. Patterns of abundance and distribution of the fish fauna of the Sedlo and Seine seamounts, over such a wide depth range, are important to infer the spatial dynamics of these species and may have implications for conservation and management, or for planning future monitoring survey programs in similar areas. Results are discussed at a regional scale and compared with previous studies made in the Azores and Madeira archipelagos.

### 1.1. Study areas

The two investigated seamounts are located in the North Atlantic near the Portuguese archipelagos of the Azores and Madeira (Figs. 1 and 2). Sedlo seamount rises from a depth of about 2000 m. The depth of the eastern and shallowest summit is about 750 m below the winter mixed-depth layer (Bashmachnikov et al., 2009), with an approximate planar area of about 43 km<sup>2</sup> at the 800-m depth contour. Seine seamount rises from a depth of about 4000 m. The shallowest depth is about 160 m, and the approximate area at the 200-m depth contour is about 20 km<sup>2</sup>.

At Sedlo and Seine seamounts, the North Atlantic Central Water (NACW) forms the shallower water mass down to 600–700 m. Below, the Mediterranean Water (MW) occupies a layer from 700 to 1100–1400 m. The Labrador Sea Water (LSW) predominates below 1500 m, and the North Atlantic Deep Water (NADW) distributes lower than 2500 m. At Sedlo (from 700 to 1000–1200 m), traces of other water masses can also be identified: the SubArctic Intermediate Water (SAIW), the Labrador Sea Water (found below the NACW) and the Antarctic Intermediate Water (AAIW). Slow currents dominate the LSW and the NADW and spread to the south and east, while the MW outflow spreads to the west at around 1000 m depth, and should distribute deeper and have a strong influence at Seine seamount (Bashmachnikov et al., 2009).

Both seamounts are located in an area of some oceanographic complexity, influenced by the Azores current (AzC) or the North Azores Flow (NAzF), with this probably having a great influence at Sedlo. These flows are linked to the Gulf Stream and are subject to high seasonal changes in their dynamics.

## 2. Material and methods

### 2.1. Fish surveys

The longline investigations at both seamounts were carried out by the R/V “*Arquipélago*” (25 m long). The Seine seamount survey took place in July 2003, while the cruise survey to Sedlo seamount was made in two missions, the first in October 2003 and the second in September 2004.

Fish populations were sampled through several longline stations in a depth-stratified sampling design by intervals of 50 m. In all surveys we used a transect strategy where a continuous length of gear was deployed in a single fishing

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