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Predicting suitable habitat for the gold coral *Savalia savaglia* (Bertoloni, 1819) (Cnidaria, Zoantharia) in the South Tyrrhenian Sea

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ABSTRACT

The gold coral *Savalia savaglia* (Cnidaria, Zoantharia) is a rare component of the mesophotic zone of the Mediterranean Sea and northeastern Atlantic Ocean.

During two field campaigns along the Italian coast in the South Tyrrhenian Sea, two populations of this species were discovered. The specimens were filmed and photographed by means of a Remotely Operated Vehicle (ROV).

To identify the role of local bathymetry and other derived variables on presence and distribution of *S. savaglia* we used a Habitat Suitability (HS) modeling technique based on Ecological Niche Factor Analysis (ENFA), utilizing high-resolution multibeam bathymetry and ROV data.

Among the set of environmental variables derived from multibeam data, slope, rugosity, eastness and distance to rocks, appear to be the main variables involved in *S. savaglia* distribution, pointing out that the habitat differs considerably from the mean environmental conditions over the study area, and that *S. savaglia* ecological niche is significantly narrower than the available habitat.

The HS map was developed to differentiate the sea floor into suitability classes. The comparison between suitability classes and presence data showed that the HS map is coherent with the observed spatial distribution of the species. The most suitable habitat for *S. savaglia* is characterized by a rough sea floor with rocks that is steeply sloped, oriented northeast, and within a water depth range of 34–77 m.

Our study suggests that predictive modeling is an approach that can be applied to other deep coral species to locate areas with a suitable habitat. Considering the difficulties to reach the habitats in which these species live, this approach could be essential to planning further studies that help define areas where the species may be present.

1. Introduction

Mesophotic, or twilight (30–150 m) coral reefs, are physically and biologically linked to adjacent shallow reef communities supporting a diverse abundance of habitat building taxa including algae, sponges, and corals (Hinderstein et al., 2010). However, they also host unique species not found in their shallow counterparts (Lesser et al., 2009).

Compared to shallow corals, little is known about the biology and ecology of most deep-sea corals because of the logistical difficulties of working in waters that cannot be safely accessed by researchers with conventional SCUBA technology (Pyle,1996; Menza et al., 2007).

Lately, an interest in the ecology and biology of deep-sea corals and the habitat they provide for other organisms has increased in response to growing concerns due to the threat of physical destruction caused by pelagic and benthic fisheries. Many deep-sea corals provide an important habitat for adult or juvenile recruitment of commercially important fish (Witherell and Coon, 2000, Witherell et al., 2000).

The gold coral *Savalia* (Gerardia) *savaglia* (Bertoloni, 1819) is a colonial hexacoral and an important component of the deeper section of the Mediterranean Sea's coralligenous assemblage (twilight or mesophotic zone). The distribution of this species includes the western Mediterranean Sea (Catalonian coast, Baleares, Algerian coast, Naples and Geneva Gulfs, and the Strait of Gibraltar) (e.g., Zibrowius, 1985a,b; Ocaña and Brito, 2004; Aguilar et al., 2010a,b), the Adriatic Sea (Kružić, 2007), the Levantine basin where it has been recorded in the Aegean Sea (e.g., Vafidis and Koukouras, 1998), the Ionian Sea (Salomidi et al., 2010), and the Marmara Sea (Artüz et al., 1990; Öztürk and Bourguet, 1990).

A new occurrence of *S. savaglia* was reported in northwestern Spain (Altuna et al., 2010). This occurrence shows that *S. savaglia* has a wider distribution than previously thought and has expanded its range to the northeastern Atlantic Ocean.

S. savaglia ia zoanthid belonging to the family Savaliidae (Häussermann, 2003). It is considered a rare species, and it is

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included in Annex II of Specially Protected Areas of Mediterranean Importance (SPAMI-Barcelona Convention) for the protection of threatened species and their habitats and in Appendix II of the Berne Convention on the Conservation of European Wildlife and Natural Habitats.

S. savalia is usually unable to create branch-like colonies on its own. Instead, the colony initially encrusts the stem of a gorgonian or antipatharian (Sinniger et al., 2005; Sinniger et al., 2009), forming a hard organic skeleton that covers it partially or entirely (Zibrowius, 1985b). In areas where gorgonians do not offer the appropriate support, colonies have been observed growing with their own skeleton; in this case, a basal plate is generated to erect a colony (Ocaña and Brito, 2004; Rossi, 1958).

A specimen collected from the Mediterranean Sea was 2 m high and more than 2 m wide with a main trunk circumference of 42.5 cm (Bell, 1891).

Species belonging to the genus *Savalia* are generally long-living organisms; radiocarbon datings conducted on some specimens from the Pacific Ocean, that are yet undescribed at a species level (Sinniger et al., 2013), are estimated to be 2700 years old (Roark et al., 2006).

Historically, the distribution of deep-water corals has only been speculated through fishermen's records, and mapping of the habitats where these organisms were present was uncertain. In recent years, advanced technologies have enabled us to directly observe features in the deep by employing different platforms with increasing levels of maneuverability, such as towed video cameras (Mortensen and Buhl-Mortensen, 2004), Remotely Operated Vehicles (ROVs, Grehan et al., 2005; Foubert et al., 2005) and Autonomous Underwater Vehicles (AUVs, Clarke et al., 2006). The progress of these technologies has gone in parallel with the development of multibeam echo sounders (MBES) that, now, are a standard tool for seafloor mapping. The combined availability of quantitative data on the presence and position of individuals, and digital maps of the seabed morphology led to renewed development of habitat models (Edwards et al., 2003; Orpin and Kostylev, 2006; Ryan et al., 2007). Integrated underwater surveys, using both high-resolution multibeam and video data, provide valuable information and a starting point for predicting the distribution of benthic species habitat (Wilson et al., 2007).

Nowadays, there are many methods for marine species habitat modeling, but the most used are the Ecological Niche Factor Analysis (ENFA), (e.g. Clark et al., 2006; Galparsoro et al., 2009; Tong et al., 2012), and, more recently, the Maximum Entropy Model (Maxent) (e.g. Howell et al., 2011; Yesson et al., 2012).

Here, we used the ENFA for modeling the habitat of *S.savaglia*. This method has its fundamentals in the niche concept described by Hutchinson's (1957) that consider the ecological niche of a species as a hypervolume in the multidimensional space defined by environmental variables within which a species can live. The Habitat Suitability (HS) models, based on the environmental envelope, describe the niche in terms of hyperspace, where individual EGVs (i.e., bathymetry and aspect) represent one dimension (Hirzel and Arlettaz, 2003). According to Hirzel and Le Lay (2008), HS models are operational applications of the ecological niche, where environmental variables, presumably reflecting some key factors of the niche, are used throughout a study area to predict how appropriate a habitat is for the viability of the species.

HS modeling can provide an initial estimate of the potential distribution of deep-water species, including corals. The ENFA computes a HS model by relating species presence data with EGVs (Hirzel et al., 2001; Hirzel et al., 2002; Dolan et al., 2008). This approach is useful, for example, when absence data are unobtainable (e.g., deep-water species) or are unreliable (e.g., cryptic or rare species) (Reutter et al., 2003). ENFA has its roots in terrestrial ecology (Hirzel et al., 2001) but has been applied with good results in several recent marine studies. For example, it was applied to model local distribution of cold-water corals (Dolan et al., 2008), to model gorgonian distribution on a regional scale (Leverette and Metaxas 2005; Bryan and Metaxas, 2007), to predict suitable habitat for stony corals on seamounts at a global scale (Clark et al., 2006) and to investigate the relationship between deep-water gorgonians and seabed topography on the Norwegian margin (Tong et al., 2012). In these studies, bathymetry data and its derivative terrain properties (e.g., slope, aspect, curvature and complexity) were important quantitative variables used to define (at least partially) the habitat that may be colonized by certain animals (Wilson et al., 2007). These parameters have the potential to predict variables in models of fauna distribution, and they are particularly useful in the absence of other local-scale data (Dolan et al., 2008).

Purposes of our study were to verify the possibility of using *S. savaglia* records growing on cnidarians collected by ROV, and bathymetry data acquired by MBES with its derived EGVs, to map the habitat of *S. savaglia* and predict new possible sites of occurrences through the use of ENFA (Hirzel et al. 2002).

2. Material and methods

2.1. Study areas

The two study areas are located on the Sicilian coast in front of Capo Peloro and on the Calabrian coast in front of the village of Favazzina. Both sites are located in the Tyrrhenian Sea at the northern border of the Messina Strait (Fig. 1). The northern border of the strait has a NE-SW orientation and is characterized by a geomorphological system formed by a group of exposed rocky pinnacles emerging from a seabed made of coarse sand and gravel (Santoro et al., 2002). The strait is also characterized by tidal displacements (Brandt et al., 1997). Although these phenomena are very small in the Mediterranean Sea, large gradients of tidal displacement are present in the Strait of Messina due to phase opposition of the predominantly semidiurnal tides. Because of the gradients and topographic constrictions, the current velocities in the Strait of Messina can reach 3.0 m/s in the sill region (Brandt et al., 1997). The area is also characterized by an upwelling phenomenon that creates water masses rich in nutrients and zooplankton and nekton populations (Guglielmo et al., 1991; Zagami et al., 1996).

The two study areas are located 3.7 nautical miles apart (Fig. 1) and were explored through ROV and multibeam. The first area is located 0.1 nautical miles from the Capo Peloro coast (38°16′23.678″N, 15°39′12.522″E, with a surface area of approximately 0.5 km^2). It is characterized by rocks of various sizes and a depth range of 20–90 m. The second area is located 0.4 nautical miles from the Favazzina coast (with a surface area of approximately 6 km^2) and is characterized by two pinnacles. Pinnacle 1 (38°15′45.44″N, 15°44′19.25″E, with a surface area of approximately 0.014 km^2) is characterized by a group of 3 minor peaks, the highest occurring at approximately 50 m and the lowest at approximately 70 m depth. The top of Pinnacle 2 (38°15′45.47″N, 15°44′5.43″E, with a surface area of approximately 0.018 km^2) occurs at 45 m depth; its eastern face gently declines towards the shore to a depth of 58 m, whereas the western rocky wall, facing towards the open sea, drops to depths of 100 m (Bo et al., 2009).

2.2. Data acquisition

The study areas were explored by RV '*Astrea*' of the Institute for Environmental Protection and Research (ISPRA) during summer 2007–2009.