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An updated overview of the geographic and bathymetric distribution of Savalia savaglia

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Abstract

The distribution of golden coral Savalia savaglia is modified on the basis of bibliographic information and recent occurrence data collected by ROV (Remotely Operated Vehicle) and SCUBA divers. The species is long-lived, rare and has been exploited in the past by divers for collection purposes. S. savaglia is listed in Annex II of the SPA/BDA Protocol of the Barcelona Convention and has a wider distribution than previously thought, including both the Mediterranean Sea and the Atlantic Ocean. Our results highlighted that specimens mainly live at a depth range of 15-90 m, but may reach as deep as 900 m in the Mediterranean Sea. This species can form monospecific facies of hundreds of colonies, as observed in Montenegro (Adriatic Sea), between 10 and 20 m, and in the Canary Islands, at a depth range of 27-70 m. Recent data highlighted numerous cases of specimens that were endangered by lost fishing gear, which exposed this species to further threats. Considering its longevity and structural role, it is urgent to develop an effective protection measure for S. savaglia, thereby increasing research efforts and implementing protection areas for this species.

Keywords: Savalia savaglia, distribution, ROV, SCUBA divers, bibliographic records.

Introduction

The species Savalia (=Gerardia) savaglia (Bertoloni, 1819) (Fig. 1) is a zoanthid belonging to the family Savaliidae (Häussermann, 2003). Living colonies show a golden colour that can vary from pale to bright. Considered rare and endangered, it is listed in Annex II of the SPA/BDA Protocol of the Barcelona Convention and in Annex II of the Bern Convention for the conservation of European wildlife and natural habitats.

This species is unique in that it grows on its own skeleton (e.g. Ocaña et al., 2007) or it can generate a hard-layered proteinaceous skeleton, which grows on the stem of gorgonians for several hundreds of years (e.g. Paramuricea clavata, Eunicella spp.) (Sinniger et al., 2005; Cerrano et al., 2006; Sinniger et al., 2009), resembling the long-living Hawaiian coral Kulamanana haumeaeae (Sinniger et al., 2013).

S. savaglia creates elevated and complex tertiary structures, which can play the role of an important structural component of the twilight or mesophotic zone of the Mediterranean coraline assemblages. Colonies form an important three-dimensional habitat and increase the deposition of bioavailable substrata, thereby enhancing biodiversity (Cerrano et al., 2010).

The distribution of this species includes the western Mediterranean Sea (Strait of Gibraltar, Catalonian coast, Balearic Islands, Algerian coast, Ligurian and Tyrhenian Sea) (Schmidt, 1972; Arena & Li Greci, 1973; Zibrowius, 1985a, b; Gili et al., 1987; Pais et al., 1992; Cristo & Pais, 1997; Bussotti et al., 1999; Cristo, 2003; Ocaña & Brito, 2004; Cerrano et al., 2007; Barraquín et al., 2008; Coppo et al., 2009; Oceana, 2010b; Cossu et al., 2011; Pardo et al., 2011), Adriatic Sea (Kružič, 2007) and Ionian Sea (Salomidi et al., 2010), as well as the eastern Mediterranean basin, where it has been found in the Aegean Sea (Bell, 1891; Vafidis & Koukouras, 1998; Salomidou et al., 2009) and Marmara Sea (Artüz et al., 1990; Öztürk & Bourgue, 1990).

Recently, a new record of S. savaglia was reported in north-western Spain (Altuna et al., 2010). This occurrence, with further sampling from the Canary Islands, re-examination of the morphological characteristics (Ocaña et al., 2007) and new observations collected from Oceana cruises (Oceana, 2010a), demonstrated that S. savaglia exhibited a wider distribution than previously thought, including the Atlantic Ocean. Regarding the taxonomic difference between S. savaglia and Antipathozoanthus macaronensis (=Gerardia macaronensis) (Ocaña & Brito, 2004) from the Macaronesian Islands, the issue is complex and has recently been clarified by Swain & Swain (2014).

Recent studies and monitoring programs of the Italian National Institute for Environmental Protection and
Research (ISPRA) and of the participation of volunteers in the Coastal Environment Monitoring Protocol (CEM; http://www.progettomac.it) provided new data on the distribution of *S. savaglia* in several Mediterranean locations.

The aim of the present study is to provide an overview of the distribution of this important species, using recent Italian records (by ISPRA and CEM) and all the data available to date that are published in scientific journals.

Material and Methods

Three different datasets were analysed in this study to update the distribution map of *S. savaglia*. The first dataset included observations and records of the species collected directly by the authors using underwater video surveys. These data were obtained from 680 ROV transects performed by the ISPRA within the past five years (2009-2013) on board the R/V Astrea, near the Italian coasts at a depth range between 20 and 500 meters. The second dataset consists of visual observations performed by trained SCUBA divers in the Mediterranean Sea, who voluntarily participated in the Coastal Environmental Monitoring (CEM) project. These data were stored in an online database. They were periodically confirmed and subsequently integrated into web-GIS to create species distribution maps that are freely available (http://www.progettomac.it). Data are validated and can also be confirmed by contacting the single volunteer who provided the information.

The third dataset consists of information regarding the presence of the species found in the literature. Both scientific papers and reports from field surveys were examined.

Results

Analysis of *S. savaglia* occurrences showed that approximately 1793 colonies were recorded: 784 in the Mediterranean Sea and 1009 in the Atlantic Ocean. Of these data, 50 occurrences were quantified from ROV video and photo analysis, 357 of which were computed from CEM project data analysis and 1386 were estimated from the literature dataset (Table 1). The species dwells at a depth range of 15-900 m.

Specimens were generally found between 15 and 700 m in the Mediterranean Sea and at a depth range of 26-415 m in the Atlantic Ocean.

In the Mediterranean Sea, colonies are mainly reported from the west side of the Italian peninsula (Tyrrhenian Sea) (Fig. 2).

The range of depth for this species in the Tyrrhenian Sea was usually between 15-90 m. Here, we recorded be-
| lat. | long. | depth (m) | n. colonies | locality | sampling method | source |
|------|-------|-----------|-------------|----------|-----------------|--------|
| 38.27 | 15.66 | 30-45     | 25          | Italy    | ROV ISPRA       |        |
| 38.26 | 15.74 | 67-72     | 9           | Italy    | ROV ISPRA       |        |
| 38.54 | 14.33 | 35        | 1           | Italy    | ROV ISPRA       |        |
| 36.83 | 12.01 | 76-83     | 3           | Italy    | ROV ISPRA       |        |
| 36.83 | 12.01 | 75-86     | 4           | Italy    | ROV ISPRA       |        |
| 42.31 | 10.92 | 90        | 1           | Italy    | ROV ISPRA       |        |
| 42.39 | 10.90 | 45        | 1           | Italy    | ROV ISPRA       |        |
| 44.23 | 8.46  | > 5       | > 5         | Italy    | ROV ISPRA       |        |
| 39.43 | 9.72  | 90        | 1           | Italy    | ROV ISPRA       |        |
| 43.77 | 7.69  | 31        | 2           | Italy    | SCUBA CEM       |        |
| 43.90 | 8.10  | 40        | 1           | Italy    | SCUBA CEM       |        |
| 44.26 | 8.47  | 35-38     | 1           | Italy    | SCUBA CEM       |        |
| 44.26 | 8.47  | 34-36     | 2           | Italy    | SCUBA CEM       |        |
| 44.26 | 8.47  | 37        | 2           | Italy    | SCUBA CEM       |        |
| 44.27 | 8.46  | 34-38     | 1           | Italy    | SCUBA CEM       |        |
| 44.32 | 9.14  | 30-50     | 5           | Italy    | SCUBA CEM       |        |
| 44.32 | 9.14  | 20-45     | 5           | Italy    | SCUBA CEM       |        |
| 44.31 | 9.18  | 42        | 1           | Italy    | SCUBA CEM       |        |
| 44.31 | 9.18  | 30-40     | 10          | Italy    | SCUBA CEM       |        |
| 44.31 | 9.18  | 20-27     | 50          | Italy    | SCUBA CEM       |        |
| 44.31 | 9.18  | 20-25     | 10          | Italy    | SCUBA CEM       |        |
| 44.31 | 9.19  | 50        | 2           | Italy    | SCUBA CEM       |        |
| 44.31 | 9.21  | 15-20     | 2           | Italy    | SCUBA CEM       |        |
| 44.30 | 9.22  | 30-50     | 2           | Italy    | SCUBA CEM       |        |
| 44.30 | 9.22  | 1         | 1           | Italy    | SCUBA CEM       |        |
| 44.30 | 9.22  | 30        | 1           | Italy    | SCUBA CEM       |        |
| 44.24 | 9.40  | 45        | 10          | Italy    | SCUBA CEM       |        |
| 42.71 | 10.41 | 47-50     | 1           | Italy    | SCUBA CEM       |        |
| 42.71 | 10.42 | 35        | 1           | Italy    | SCUBA CEM       |        |
| 42.71 | 10.42 | 35        | 1           | Italy    | SCUBA CEM       |        |
| 42.70 | 10.44 | 40-45     | 1           | Italy    | SCUBA CEM       |        |
| 42.74 | 10.43 | 28        | 1           | Italy    | SCUBA CEM       |        |
| 42.74 | 10.43 | 30-32     | 2           | Italy    | SCUBA CEM       |        |
| 42.74 | 10.43 | 28        | 1           | Italy    | SCUBA CEM       |        |
| 42.74 | 10.43 | 31-33     | 2           | Italy    | SCUBA CEM       |        |
| 42.73 | 10.43 | 35-42     | 5           | Italy    | SCUBA CEM       |        |
| 42.37 | 10.92 | 37        | 1           | Italy    | SCUBA CEM       |        |
| 41.61 | 12.34 | 37        | 1           | Italy    | SCUBA CEM       |        |
| 41.61 | 12.34 | 37        | 1           | Italy    | SCUBA CEM       |        |
| 40.70 | 14.47 | 30-40     | 2           | Italy    | SCUBA CEM       |        |
| 40.70 | 14.47 | 40-50     | 2           | Italy    | SCUBA CEM       |        |
| 40.68 | 14.43 | 34-36     | 10          | Italy    | SCUBA CEM       |        |
| 40.68 | 14.43 | 30-45     | 10          | Italy    | SCUBA CEM       |        |
| 40.64 | 14.35 | 15-30     | 50          | Italy    | SCUBA CEM       |        |
| 40.62 | 14.32 | 28-30     | 10          | Italy    | SCUBA CEM       |        |

(continued)
| lat. | long. | depth (m) | n. colonies | locality | sampling method | source |
|------|-------|-----------|-------------|----------|----------------|--------|
| 38.36 | 15.83 | 40 | 2 | Italy | SCUBA | CEM |
| 38.34 | 15.83 | 30-44 | 5 | Italy | SCUBA | CEM |
| 38.32 | 15.82 | 38-40 | 2 | Italy | SCUBA | CEM |
| 38.26 | 15.71 | 42 | 1 | Italy | SCUBA | CEM |
| 40.15 | 17.83 | 49-53 | 5 | Italy | SCUBA | CEM |
| 43.82 | 15.23 | 44-46 | 5 | Croatia | SCUBA | CEM |
| 36.80 | 12.05 | 50-88 | 10 | Italy | SCUBA | CEM |
| 36.80 | 12.05 | 60-87 | 50 | Italy | SCUBA | CEM |
| 36.83 | 12.01 | 50-80 | 50 | Italy | SCUBA | CEM |
| 41.08 | 9.61 | 38 | 1 | Italy | SCUBA | CEM |
| 41.26 | 9.20 | 33-38 | 10 | Italy | SCUBA | CEM |
| 41.44 | 9.10 | 27 | 2 | France | SCUBA | CEM |
| 41.67 | 8.87 | 45 | 1 | France | SCUBA | CEM |
| 42.02 | 8.62 | 40 | 2 | France | SCUBA | CEM |
| 41.08 | 9.61 | 20-36 | 4 | Italy | SCUBA | Cristo & Pais, 1997; Cristo, 2003 |
| 41.25 | 9.18 | 34-36 | > 15 | Italy | SCUBA | Cristo & Pais, 1997; Cristo, 2003 |
| 39.21 | 9.23 | 27 | 1 | Italy | SCUBA | Cristo & Pais, 1997; Cristo, 2003 |
| 42.05 | 3.22 | 45 | 1 | Spain | SCUBA | Gili et al., 1987 |
| 35.90 | -5.28 | 30 | 1 | Spain | SCUBA | Ocaña & Brito, 2004 |
| 35.88 | -5.28 | 30-35 | 1 | Spain | SCUBA | Ocaña & Brito, 2004 |
| 42.48 | 3.13 | 40 | 1 | France | SCUBA | Ocaña & Brito, 2004 |
| 36.39 | -3.97 | 340* | | Alboran Sea | ROV | Pardo et al., 2011 |
| 44.25 | 9.40 | 53-83 | | Italy | ROV | Coppo et al., 2009 |
| 40.73 | 28.17 | 40 | | Turkey | SCUBA, Cross of Saint Andrew, dredge | Artüz et al., 1990 |
| 40.53 | 27.48 | 32-52 | 16 | Turkey | SCUBA, Agassiz trawl, fishing trawl | Öztürk & Bourguet, 1990 |
| 41.33 | 9.25 | 25 | 1 | France | ROV, SCUBA | Meinesz, 1990 |
| 41.24 | 9.20 | > 15 | | Italy | ROV, SCUBA | Cossu et al., 2011 |
| 38.33 | 21.93 | 40-45 | | Greece | SCUBA | Salomidi et al., 2009; Salomidi et al., 2010 |
| 39.32 | 24.53 | 35-90 | 11 | Greece | SCUBA, Agassiz trawl, fishing trawl | Vafidis & Koukouras, 1998 |
| 40.89 | 9.70 | 51 | 4 | Italy | SCUBA | Pais et al., 1992 |
| 38.12 | 24.61 | 37 | 1 | Greece | SCUBA, spongefishers | Bell, 1891 |
| 38.82 | 15.25 | 58 | 1 | Italy | SCUBA | Schmidt, 1972 |
| 44.04 | 14.99 | 65 | 1 | Croatia | SCUBA | Kružić, 2007 |
| 43.95 | 15.06 | 51 | 1 | Croatia | SCUBA | Kružić, 2007 |
| 43.77 | 15.30 | 47 | 1 | Croatia | SCUBA | Kružić, 2007 |
| 38.41 | 11.00 | 505-650 | 1 | Italy | SCUBA | Arena & Li Greci, 1973 |
| 42.50 | 18.67 | 10-20 | > 300 | Montenegro | SCUBA | Mačić V. (pers.comm.); Eusebio et al., 2007 |
| 38.95 | 2.00 | 500-900 | | Spain | ROV | Oceana, 2010b |
between 25 and 100 specimens from four different sites: 25 specimens live in Capo Peloro (Sicily, Italy) (Giusti et al., 2013), 50 in the Marine Protected Area (MPA) of Portofino (Liguria, Italy), 50 in the MPA of Punta Campanella (Campania, Italy) and 100 at two different sites near Pantelleria Island (Sicily, Italy) (Fig. 2).

Regarding the Mediterranean Sea, three deep records of the species were reported from the literature data: Arena & Li Greci (1973) found a colony in a fishing net that was located between 505 and 650 m; Oceana (2010b) found the species between 500 and 900 m on the Seco de los Olivos seamount (Alboran sea); Pardo et al. (2011) recorded the species at 340 m on the Bank of Djibuti (Alboran Sea).

In the Mediterranean Sea, the maximum abundance documented in the bay of Kotor (Montenegro) was more than 300 colonies (Maciç V. & Trainito E. personal communication; Eusebio et al., 2007).

In the Atlantic Ocean, the deepest occurrence was reported between 230-600 m depth near Lanzarote (Canary Islands) (Oceana, 2010a), and until recently, the highest abundance was documented at “El Bajo de las Gerardias” (Canary Islands) inside the Marine Reserve of La Graciosa Island and islets north of Lanzarote with more than 1000 colonies of S. Savaglia (Ocaña et al., 2007; Rivera, 2010; Van den Berg, 2010).

The documented organic substrates that S. savaglia can exploit are Paramuricea clavata, Eunicella cavoilini (Fig. 3A-B), E. singularis and Leptogorgia sarmentosa.

### Discussion

Analysis of the three datasets provided an updated overview of the geographic and bathymetric distribution of the species, adding more Mediterranean records to the literature data. Most of the occurrence data was obtained from the analysis of the CEM dataset, which highlighted that the involvement of trained volunteers in monitoring species was a practice that contributed to the collection of important datasets on many species, as confirmed by several studies performed in recent years (e.g. Tidball & Krasny, 2011; Tulloch et al., 2013).

In addition, bibliographic data highlighted that the species has a wider distribution than previously thought, including the Atlantic Ocean (Fig. 2). Our results indicated that in the Mediterranean Sea, the species was mainly reported in the Tyrrenhan Sea (Fig. 2); however, it presented a higher density in the Adriatic Sea, where it forms a dense monospecific facies of hundreds of colonies between 10 and 20 m in Montenegro (Adriatic Sea) and several colonies reported from Croatian waters. In the Atlantic Ocean and the Canary Islands, the species formed a monospecific facies too, at a depth range of 27-70 m, but usually with a lower density.

These observations indicate that S. savaglia could form monospecific facies with higher densities in the Mediterranean compared to the Atlantic Ocean, resulting in the hypothesis that in the past, it was present in dense forests, which are no longer living, most likely due to the three-dimensional rigid structure of the colonies. This type of morphology facilitates the entanglement of nets and fishing lines in their branches (Bavestrello et al., 1997; Maldonado et al., 2013; Bo et al., 2014), and rigidity increases its potential fragmentation and destruction. Other arborescent species (e.g. A. subpinnata, P. clavata, Ellisella paraplexauroides) are specifically threatened by fishing activities (i.e. trawling) and ghost nets, but their flexibility may limit the detachment of the entire colony with respect to the rigid S. savaglia.

Moreover, divers represent another potential threat for this species because, particularly in the past, a large number of sites where the species was identified were at depths accessible by SCUBA divers, who collected the beautiful skeletons of S. savaglia as souvenirs (Cristo, 2003; Ocaña & Brito, 2004; Oceana, 2007; Barrajon et al., 2008). From the cut bases left in situ, basal plates may develop and new colonies may grow (Fig. 3C).}

Table 1

| lat. | long. | depth (m) | n. colonies | locality | sampling method | source |
|------|-------|-----------|-------------|----------|-----------------|--------|
| 29.30 | -13.54 | 27-70 | > 1000 | Spain | ROV, SCUBA | Ocaña et al., 2007; Oceana, 2010a; Rivera, 2010; Van den Berg, 2010 |
| 27.86 | -15.38 | 30 | 1 | Spain | ROV | Oceana, 2010a |
| 42.55 | -8.96 | 29 | 3 | Spain | SCUBA | Altuna et al., 2010 |
| 42.51 | -8.94 | 26 | 1 | Spain | SCUBA | Altuna et al., 2010 |
| 27.86 | -15.34 | 30 | 1 | Spain | SCUBA | Ocaña et al., 2007 |
| 29.41 | -13.56 | 40 | 1 | Spain | SCUBA | Oceana et al., 2007 |
| 28.46 | -16.56 | 35 | 1 | Spain | SCUBA | Oceana et al., 2007 |
| 29.14 | -13.72 | 230-600 | | Spain | ROV | Oceana, 2010a |

In the Atlantic Ocean, the deepest occurrence was reported between 230-600 m depth near Lanzarote (Canary Islands) (Oceana, 2010a), and until recently, the highest abundance was documented at “El Bajo de las Gerardias” (Canary Islands) inside the Marine Reserve of La Graciosa Island and islets north of Lanzarote with more than 1000 colonies of S. Savaglia (Ocaña et al., 2007; Rivera, 2010; Van den Berg, 2010).

The documented organic substrates that S. savaglia can exploit are Paramuricea clavata, Eunicella cavoilini (Fig. 3A-B), E. singularis and Leptogorgia sarmentosa.

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In addition, bibliographic data highlighted that the species has a wider distribution than previously thought, including the Atlantic Ocean (Fig. 2). Our results indicated that in the Mediterranean Sea, the species was mainly reported in the Tyrrenhan Sea (Fig. 2); however, it presented a higher density in the Adriatic Sea, where it forms a dense monospecific facies of hundreds of colonies between 10 and 20 m in Montenegro (Adriatic Sea) and several colonies reported from Croatian waters. In the Atlantic Ocean and the Canary Islands, the species formed a monospecific facies too, at a depth range of 27-70 m, but usually with a lower density.

These observations indicate that S. savaglia could form monospecific facies with higher densities in the Mediterranean compared to the Atlantic Ocean, resulting in the hypothesis that in the past, it was present in dense forests, which are no longer living, most likely due to the three-dimensional rigid structure of the colonies. This type of morphology facilitates the entanglement of nets and fishing lines in their branches (Bavestrello et al., 1997; Maldonado et al., 2013; Bo et al., 2014), and rigidity increases its potential fragmentation and destruction. Other arborescent species (e.g. A. subpinnata, P. clavata, Ellisella paraplexauroides) are specifically threatened by fishing activities (i.e. trawling) and ghost nets, but their flexibility may limit the detachment of the entire colony with respect to the rigid S. savaglia.

Moreover, divers represent another potential threat for this species because, particularly in the past, a large number of sites where the species was identified were at depths accessible by SCUBA divers, who collected the beautiful skeletons of S. savaglia as souvenirs (Cristo, 2003; Ocaña & Brito, 2004; Oceana, 2007; Barrajon et al., 2008). From the cut bases left in situ, basal plates may develop and new colonies may grow (Fig. 3C). Regarding the Mediterranean Sea, there are hot spot areas with high densities, as reported in the Portofino Promontory and Punta Manara in the Ligurian Sea (Fig. 3C), and in Kotor in Montenegro. These areas are characterised by high densities of gorgonians, where S. savaglia can settle and its growth is enhanced by its fast asexual reproduci-
tion on the surrounding gorgonians. In this case, there is continuous physical contact between colonies (Previti et al., 2010). Only two of the five sites at which we found the major number of specimens were in MPAs, which confirmed the importance of increasing the number of these areas to preserve this long-lived species. In the Atlantic Ocean, the species was present with a rich forest in the Marine Reserve of La Graciosa Island and islets north of Lanzarote, but the population structure was more scattered, which mirrored the structure of the surrounding gorgonians. Depth occurrences for the species, both in the Mediterranean Sea and Atlantic Ocean, have been reported in the literature. In this case also, the presence of *S. savaglia* could indicate the occurrence of a previous living substratum, such as deep-living gorgonians.

Our results, which were derived from the literature and collected by SCUBA divers and ROV that studied the seafloor until a depth of nearly 500 m, confirm that the species in the Tyrrhenian Sea prefers the upper circalittoral hard bottoms within a range of depth that makes the species vulnerable to illegal collection by SCUBA divers, to nets and to the improper use of artisanal fishing tools. For these reasons and because *S. savaglia* is an endangered species able to create an important three-dimensional habitat enhancing biodiversity (Cerrano et al., 2010), it is fundamental to develop specific protection measures, starting in the areas where the presence of the species has been confirmed.

To achieve this protection, new efforts must be made to increase knowledge about the habitat requirement of this species and its actual distribution.

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