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

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Abstract

The distribution of gold 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/BD 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/BD 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 gold coral *Kulamanamana haumeaae* (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 coralligenous assemblage. 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 Tyrrhenian 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; Barrajón *et al*., 2008; Coppo *et al*., 2009; Oceana, 2010b; Cossu *et al*., 2011; Pardo *et al*., 2011), Adriatic Sea (Kružić, 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; Salomidi *et al*., 2009) and Marmara Sea (Artüz *et al*., 1990; Öztürk & Bourguet, 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 macaronesicus (=Gerardia macaronesica)* (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

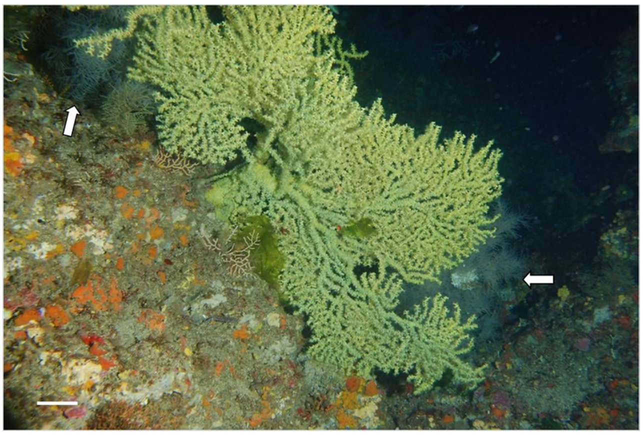

Fig. 1: *Savalia savaglia* with *Antipathella subpinnata* in the background (white arrows); scale bar: 10 cm.

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-

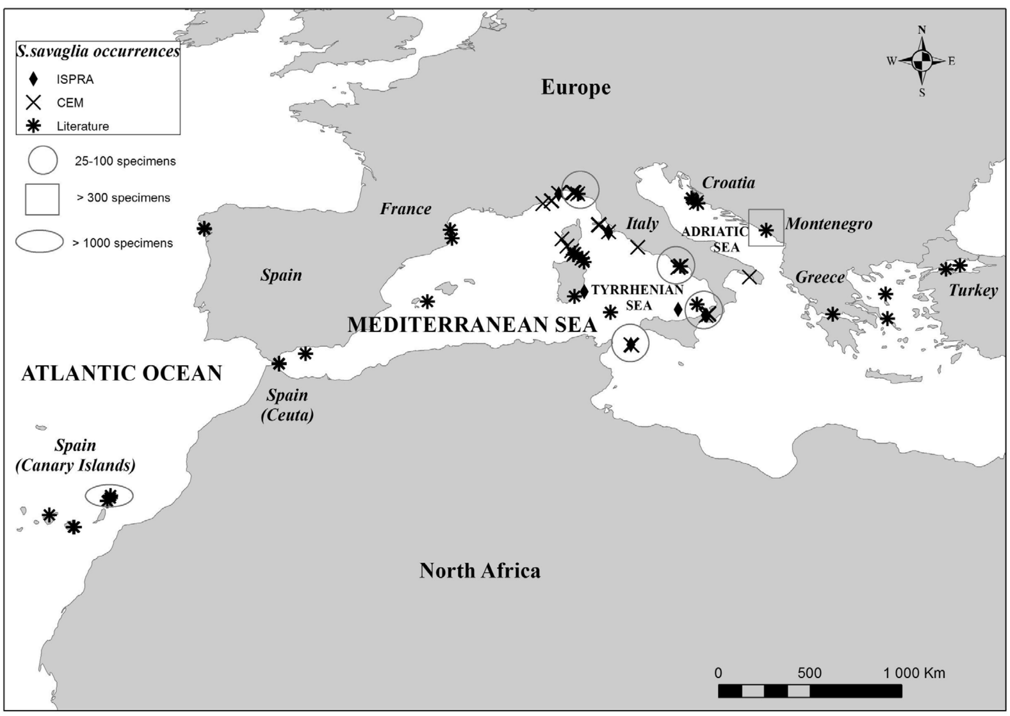

Fig. 2: Map of the geographical distribution of Savalia savaglia in the Mediterranean Sea and the Atlantic Ocean.

Table 1. Savalia *savaglia occurrences.*

lat.	long.	depth (m)	n. colonies	locality	sampling method	source
			Mediterranean sea			
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	76	> 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
43.91	8.13	41-45	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	Italy	SCUBA	CEM
44.30	9.22	30	1	Italy	SCUBA	CEM
44.24	9.40	45	10	Italy	SCUBA	CEM, Rossi, 1958
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; Bussotti *et al*., 1999
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)

Table 1 *(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		Artüz *et al.*, 1990
40.53	27.48	32-52	16	Turkey	SCUBA, Cross of Saint Andrew, dredge	Öztürk & Bourguet, 1990
41.33	9.25	25	1	France	SCUBA	Meinesz, 1990
41.24	9.20		> 15	Italy	ROV, SCUBA	Cossu *at 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	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	fishing trawl	Arena & Li Greci, 1973
42.50	18.67	10-20	> 300	Montenegro	SCUBA	Mačič V.(pers.comm.); Eusebio *et al.*,2007
38.95	2.00	500-900		Spain	ROV	Oceana, 2010b

(continued)

Table 1 *(continued)*

lat.	long.	depth (m)	n. colonies	locality	sampling method	source
			Atlantic Ocean			
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		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	Ocaña *et al*., 2007
28.46	-16.56	35	1	Spain	SCUBA	Ocaña *et al*., 2007
29.14	-13.72	230-600		Spain	ROV	Oceana, 2010a

tween 25 and 100 specimens from four different sites: 25 specimens live in Capo Peloro (Sicily, Italy) (Giusti *et al*., 2014), 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 (Mačič 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 cavolinii* (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 Tyrrhenian 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; Barrajón *at 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 reproduc-

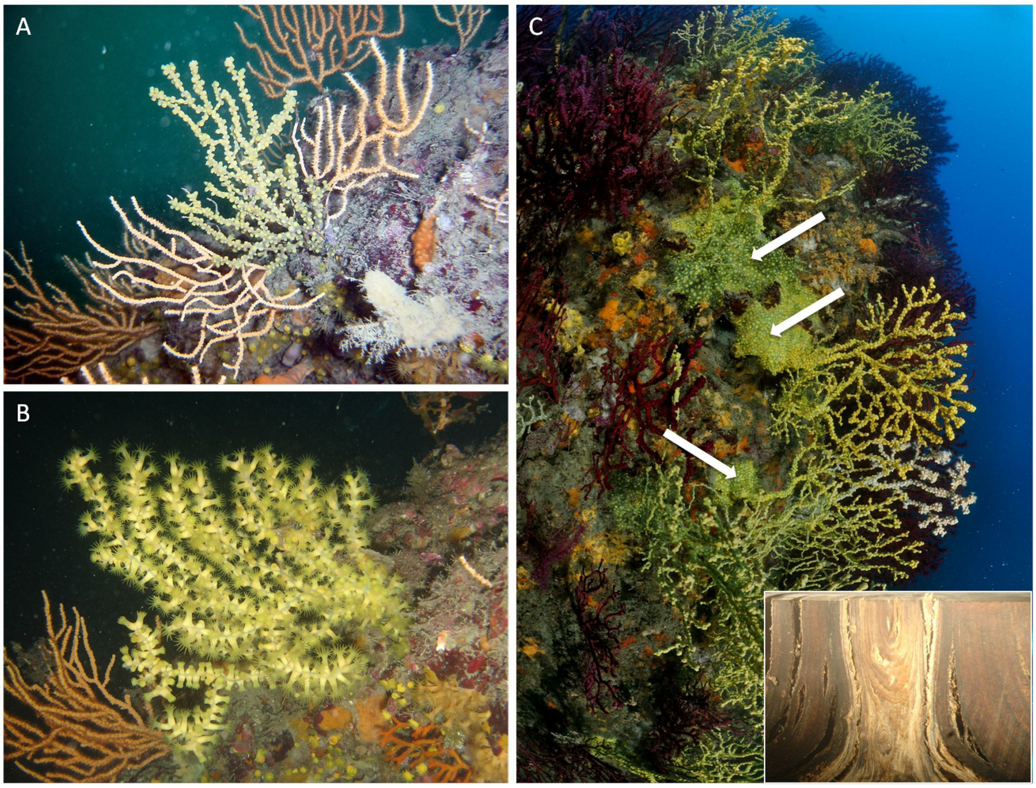

Fig. 3: (A-B) *Savalia savaglia* growing on a *Eunicella cavolinii* colony at Portofino Promontory; the same in 2004 and 2008. (C) A high density *facies* of *Savalia savaglia* with both evident basal plates (white arrows) and branching colonies at Punta Manara (Ligurian Sea, Italy) (photocredits Portofino Divers). In the inset a cross section of the base of one of the colonies showing the holdfast of *P. clavata* in the middle and the *S. savaglia* skeleton secreted around.

tion on the surrounding gorgonians. In this case, there is continuous physical contact between colonies (Previati *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. savalia* 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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