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Research Article

Recovery of the commercial sponges in the central and southeastern Aegean Sea (NE Mediterranean) after an outbreak of sponge disease

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Abstract

The distribution and biometry of commercial sponges (Porifera) in coastal areas of the central and southeastern Aegean Sea was investigated to estimate the recovery progress of the populations eight years after the first appearance of sponge disease. Signs of the disease were detected only in 1.6% of the harvested sponges. Multivariate analysis on the percentage abundance of sponges showed two distinct groups among the sixteen fishing grounds studied: the eight deep (50-110 m) and the eight shallow ones (<40 m). The group from the deep depths consisted of *Spongia officinalis adriatica, S. agaricina* and *S. zimocca.* The infralittoral zone was characterized by the presence of *Hippospongia communis, S. officinalis adriatica* and *S. officinalis mollissima.* These bath sponges showed an enhanced abundance in the eastern Cretan Sea (S. Aegean Sea). In addition, their dimensions, particularly height, increased with increasing depth. It is indicated that the hydrographic conditions prevailing in the eastern Cretan Sea affected the repopulating processes of sponge banks. In each species, the biometric characteristics of the experimental specimens were similar to those of the sponges found in the market and harvested at respective depths prior to the appearance of sponge disease.

Keywords: Commercial sponges; Sponge disease; Biometry; Aegean Sea; Eastern Mediterranean.

Introduction

Porifera is mainly, but not exclusively, a marine phylum including over 8500 valid species (VAN SOEST, 2007), which make up an ecologically important and highly abundant and diverse component of marine benthic communities. Commercial sponges were (and still are) a natural resource for most of the Mediterranean countries.

The Mediterranean commercial sponges are (common English names; Greek names): (a) *Hippospongia communis* (honeycomb; kapadiko), (b) *Spongia agaricina* (elephant's ear; lagophyto, psathouri, laphina), (c) *Spongia zimocca* (leather sponge; tsimoucha, chimousse), (d) *Spongia officinalis adriatica* (Greek bathing sponge; fino; fino-matapas; matapas) and (e) *Spongia officinalis mollissima* (Turkey cap, fine sponge of Syrie; psilo, melati) (FAO, 1990, CASTRITSI-CATHARIOS, 1998). The taxonomy of these sponges has recently been changed by VAN SOEST *et al.* (2008): (a) *Hippospongia communis* (Lamarck, 1814), (b) *Spongia (Spongia) agaricina* Pallas, 1766, (c) *Spongia (Spongia) zimocca* Schmidt, 1862 and (d) *Spongia (Spongia) officinalis* Linnaeus, 1759. PRONZATO & MANCONI (2008) claimed that the taxonomic status of some sponge species is under revision or debate, and must therefore be considered with caution. In this study, the commercial sponges are presented according to FAO (1990) in order to compare the results to previous studies in the Aegean Sea (eg. KEFALAS *et al.,* 2003a; VOULTSIADOU *et al.,* 2008). In addition, *S. officinalis mollissima* differs totally from *S. officinalis adriatica* due to its form (even in young sponges), which is generally a reversed cone, to its texture and to other taxonomic characteristics (eg. conules, mesh of primary and secondary fibers). In general, *S. officinalis mollissima* is considered to be the finest bath sponge in the Mediterranean, but is hardly exploited (FAO, 1990).

Data on the fishery and the merchandising of commercial sponges are limited and not absolutely accurate (MILANESE *et al.,* 2008). PRONZATO & MANCONI (2008) mentioned that few data are available regarding general trends in sponge fishing, while a worldwide increase in the sponge trade was reported for 1980-1985 (190 tons in 1980, up to 200 tons in 1985).

In August 1986, the so-called 'sponge disease' appeared and caused mass mortality of bath sponges in most of the fishing grounds, resulting in a real disaster for the sponge fishery in Greece. More than 50 tons of sponges per year were imported, mainly from the Gulf of Mexico (Florida and Cuba). These sponges are of considerably lower quality than those harvested in the Mediterranean (CASTRITSI-CATHARIOS *et al.,* 2007; LOUDEN *et al.,* 2007).

The sponge fishery used to constitute a basic part of the fishery sector in Greece The export of sponges, before the appearance of sponge disease, contributed greatly the inflow of exchange into Greece, which was considered one of the main centers for sponge harvesting and commercialization. Before1970, over 80% of the fishing and over the 90% of the commercial activities were concentrated at Kalymnos Island, while in 1995 the above figures reached almost 100%.

In 1868, Kalymnos had 300 sponge fishing boats with free divers, 70 gagavas and 70 spear fishermen. The value of the sponges fished yearly by the Kalymnians in those days amounted to 2,000,000 gold francs. The industrial revolution in Western Europe brought about an increased demand for sponges with the result that the Kalymnian commercial houses prospered, while annual production exceeded 100 tons. World War II destroyed the entire sponge fishing fleet. New vessels were built from 1945 onwards, and their number soon exceeded 150. Until 1962, Greek production was between 150-200 tons per annum. In 1962, the Arabian countries nationalized marine resources and the Kalymnian divers now fish only in Greek and international Mediterranean waters and production has considerably decreased. This was the main reason for the negative trend in Greek exports of sponges from 1964 to 1978, with a decrease of 50 tons over a period of 15 years (VERDENAL & VACELET, 1985).

During the 20th century sponge disease destroyed the populations of both commercial sponges and that of non-commercial species belonging to the order Dictyoceratida (VACELET, 1994; PRONZATO, 1999; PEREZ *et al.,* 2000). WEBSTER (2007) summarizes the gross pathological symptoms, the species affected, the aetiological agent, the related reference, as well as the location and the year.

MILANESE *et al.* (2008) reported that Greece harvested approximately 56 tons/year of bath sponges in the period 1969–1986, but 9 tons/year in the period 1987-2004. GAINO and PRONZATO (1992) mentioned that in Greece the production of commercial sponges dropped after 1985 from around 30–35 tons per annum to 10 tons afterwards. According to PRONZATO (1999), around 1990 the decline in sponge stock was dramatic. In Greece, Turkey, Cyprus, Syria, Egypt and Tunisia sponge harvesting stopped, resulting in significant economic losses for the above- mentioned countries (ECONOMOU & KONTEATIS, 1988; PRONZATO & GAINO 1991; VACELET, 1994). From 1989-1990, only bottom gears at depths of 60-100 m fished commercial sponges in the Aegean Sea (CASTRITSI-CATHARIOS, 1995). In 1991-1994 the Kalymnian fishing fleet remained almost inactive, as a result of the disease (CASTRITSI-CATHARIOS, 1995, PRONZATO, 1999, 2003). The first signs of the sponge banks' recovery appeared in 1991 (CASTRITSI-CATHARIOS, 1995). Following recovery, growth is a critical factor in developing successful fishing activities and commercialization of bath sponges. Many sea and land-based studies have shown that sponges grow quickly, often doubling in size every few months.

The aim of the present study was the investigation of the bath sponge fauna in the central and southeastern Aegean Sea (1994) after the first appearance of sponge disease in 1986. In addition, the distribution of the commercial sponges at different depths in known fishing grounds was studied. Special attention was given to the biometric characteristics of the specimens harvested during experimental trips and comparison was made to other sponges of the same species taken from the market. The Kalymnian fleet had not fished the fishing grounds under study since 1990.

Materials and Methods

Sampling Area

Experimental surveys were conducted in 1994 along the coasts of the islands in the central and southern Aegean Sea (Table 1) during late summer–early autumn. Sixteen fishing grounds were investigated in the central and southeastern Aegean Sea (Fig. 1),

Sampling Methods

In the infralittoral zone (<40 m), sponges were collected by divers using the 'nargile' (this is a Greek common name for scuba diving) method introduced in 1970, as described by CASTRITSI-CATHARIOS *et al.* (2005), PRONZATO (1999) and VOULTSIADOU *et al.* (2008).

At the deep depths (50-110 m), commercial sponges were collected with a dragged sponge-fishing gear type called a 'gagava' (Fig. 2). More details about this type of gear are given in KEFALAS *et al.* (2003a) and CASTRITSI-CATHARIOS *et al.* (2010).

The divers did not sample young sponges

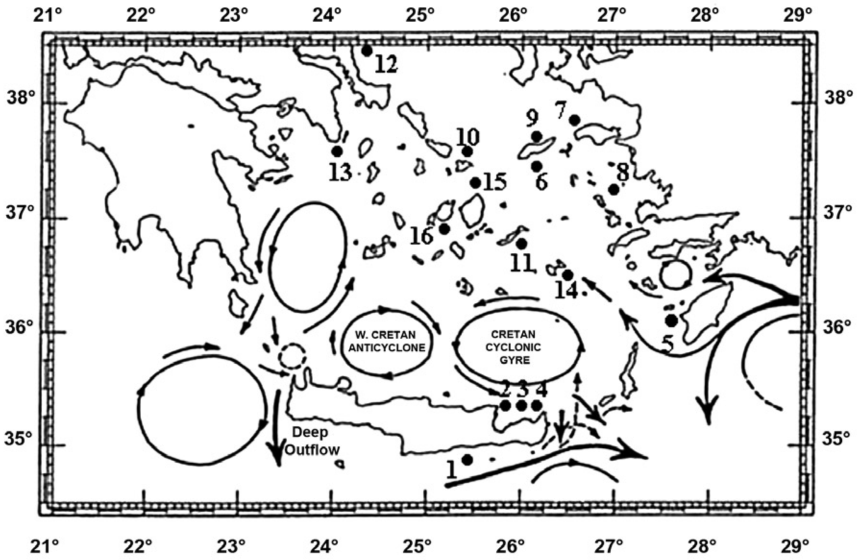

Fig. 1: Sampling stations in the Aegean Sea (basic map from SOUVERMEZOGLOU *et al.,* 1999).

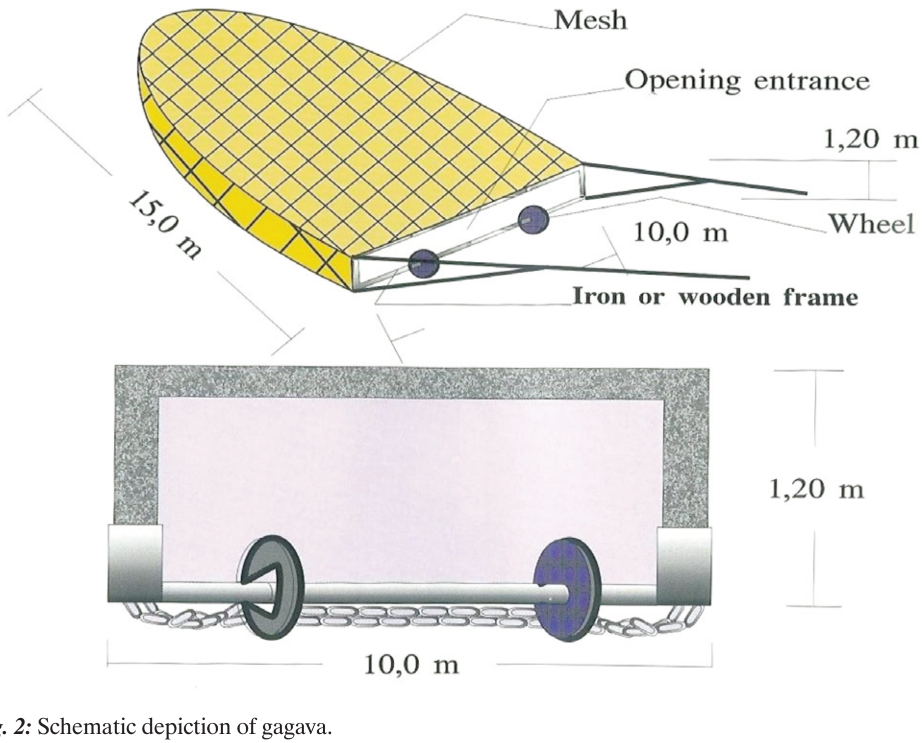

Fig. 2: Schematic depiction of gagava.

Table 1
Location, date, coordinates and mean depth of the sampling stations on the islands (prefectures) of the Aegean Sea. Temperature (T) and salinity (S) recorded at the bottom of the water column.

No	Location	Date	Longitude (E)	Latitude (N)	Depth (m)	T (°C)	S (psu)
1	Gaidouronisi (Lasithi)	10/1994	25° 35'46"	34° 59' 56"	70	22	40
2	West Sitia, Kriti (Lasithi)	08/1994	25° 46' 59"	35° 20' 14"	33.5	24.2	38
3	Central Sitia, Kriti (Lasithi)	08/1994	25° 59' 22"	35° 12' 44"	37.5	24.6	36
4	East Sitia, Kriti (Lasithi)	08/1994	26° 15' 26"	35° 17' 58"	12	25.2	39
5	Rhodos (Dodekanisos Islands)	10/1994	27° 33' 17"	36° 12' 14"	20	23.9	41
6	Furni (Dodekanisos Islands)	10/1994	26° 70' 90"	37° 32' 43"	80	22	40
7	Samos (Samos)	10/1994	26° 37' 58"	37° 46' 26"	87.5	22	40
8	Lipsi (Dodekanisos Islands)	10/1994	26° 45' 58"	37° 24' 11"	67.5	22	40
9	Ikaria (Samos)	10/1994	26° 60' 53"	37° 38' 17"	100	22	39
10	Mykonos (Kyklades)	09/1994	25° 22' 15"	37° 29' 49"	20	22.5	40
11	Amorgos (Kyklades)	09/1994	25° 56' 12"	36° 50' 48"	95	22	41
12	Kimi (Evvoia)	08/1994	24° 11' 55"	38° 29' 39"	20	24.5	39
13	Cavo d'oro (Evvoia)	08/1994	24° 20' 57"	37° 39' 24"	20	24	38
14	Kalymnos (Dodekanisos Islands)	10/1994	26° 26' 34"	36° 33' 48"	55	21.5	39
15	Naxos (Kyklades)	09/1994	25° 27' 70"	37° 10' 23"	55	22	39
16	Paros (Kyklades)	09/1994	25° 11' 40"	36° 57' 39"	32.5	22.5	39

(length <10 cm), in order to protect the populations of the commercial sponge species. In addition, the gagava used was modified for the same reason (usage of wheels 40 cm in diameter, mesh opening 12 – 15 cm, chain at the bottom to avoid harming *Posidonia* beds). Each diver could investigate 300 m^2 per dive. In each dive, two divers explored the area simultaneously, covering 600 m^2. At each station, ten dives were performed (two divers per dive) and the commercial sponges over an area of 6,000 m^2 were collected. The gagava moved with a speed of 600 mh^{-1} and the dredge had an opening of 10 m. Each draw lasted for 1 hour and the gagava covered 6,000 m^2.

Biometry

Biometrical measurements were performed *in situ* on specimens immediately after harvesting. Length was considered as the longest axis parallel to the substratum, width was the greatest axis perpendicular to the long axis, and height was the distance between the base (point of attachment onto the substratum) and the highest point of the sponge. The circumference (it makes a sense in case of individuals with a more or less irregular shape) was measured with a cord along the bigger dimension.

Biometry was also performed on specimens taken from the market (the oldest and most reliable shop in Kalymnos was selected, one which sold exclusively Mediterranean sponges). The specimens were carefully examined to assure their origin and the shop's owner also provided information for each individual sponge, regarding the area or the specific fishing ground and the depth at which the sponge was collected.

Statistical analysis

The Primer statistical software package was used to perform multivariate analysis on the abundance data (CLARKE & WARWICK, 1994). A hierarchical Cluster analysis based on the Bray-Curtis similarity index was calculated, after log transformation of data. The dendrograms were formed with the grouping average method, and Anosim was used for testing the significance of grouping. In order to determine discriminating species, the Simper analysis was performed.

One way analysis of variance was performed on biometry data (Statgraphics Plus). Comparison of means was conducted with a Duncan test. Normal distribution (Kolmogorov) and homogeneity of variance (Cochran's C, Bartlett' and Hartley' tests) were assessed before analysis. When necessary, data were log transformed prior to ANOVA or were subjected to non parametric analysis (Kruskal-Wallis test). Differences were considered significant at $P<0.05$.

Results

A total of 1053 commercial sponges were harvested by the 'nargile' method (93.67%) in the shallow fishing grounds (<40 m depth) and 71 by the 'gagava' method (6.32%) in the deep ones (50-110 m) (Tables 1 and 2). Overall, 1124 sponges from 14 islands of the Aegean Sea were distributed in five prefectures of Greece, in terms of the location of the fishing ground, as follows: Lasithi on Kriti Island 1023 (91.01%), Samos 34 (3.02%), Kyklades 34 (3.02%), Dodekanisos Islands 19 (1.69 %) and Evvoia 14 (1.26%). *Hippospongia communis* (250 individuals) or 22.24%) and *Spongia officinalis mollissima* (433 ind. or 38.52%) were found only in shallow waters, while *S. agaricina* (10 ind. or 0.89%) and *S. zimocca* (7 ind. or 0.62%) only in deep waters. *S. officinalis adriatica* (424 ind. or 37.72%) was collected at both shallow and deep sampling stations. The substratum at the deep stations was mainly coralligenous, while at the shallow ones consisted in the majority of *Posidonia oceanica* meadows or/and sand with a few rocks sometimes. Only two of the shallow fishing grounds were characterized by hard substratum (large rocks with stones or plaques).

Eighteen sponges (1.6%) showed external corruption, deterioration and in general signs of sponge disease (Table 2). Thirteen of them were collected at Mykonos Island (Kyklades) and were *H. communis.* Four other were detected at Cavo d'Oro (Evvoia) and belonged to both *H. communis* and *S. officinalis adriatica.* The last one was found at Rodos Island (Dodekanisos Islands) and was *S. officinalis adriatica.*

Multivariate analysis on the percentage abundance of sponges separated the stations (Fig. 3) into two distinct groups (average dissimilarity = 72.15); the shallow (<40 m) and the deep (50-110 m). The Anosim test proved that the stations in the two data sets differed significantly with respect to sponge species composition ($R = 0.825$, $p = 0.1\%$). The Simper analysis (Table 3) showed that the shallow stations were characterized by the presence of *H. communis, S. officinalis adriatica* and *S. officinalis mollissima.* The latter was found only at stations 2, 3 and 4 located on the

Table 2
Sample size of the commercial sponges harvested in an area of 6,000 m^2 (number of individuals with signs of the sponge disease) and type of substratum at each sampling station.

No	*H. communis*	*S. officinalis adriatica*	*S. officinalis mollissima*	*S. agaricina*	*S. zimocca*	Type of substratum
1				2	3	coralligenous, sand
2	94	12	20			*Posidonia*
3	103	37	88			*Posidonia,* rocks
4	23	316	325			sand, rocks
5	1	1 (1)				sand, *Posidonia*
6		7		2		coralligenous
7		8		3	1	coralligenous
8		4				coralligenous
9		21		1		coralligenous
10	13 (13)					large rocks, stones
11		7		2		coralligenous, sand
12	8	2				*Posidonia*
13	2 (2)	2 (2)				large rocks, plaques
14		3			1	coralligenous, algae
15		4			2	coralligenous, sand
16	6					*Posidonia*, sand

Table 3
Average percentage abundance of commercial sponges collected in the central and SE Aegean Sea. Simper analysis showing discrimination of the fishing grounds between shallow and deep. Av. abund.: average abundance, Av. diss.: average dissimilarity between all pairs of inter-group samples, Diss/SD: dissimilarity/standard deviation of contribution, Contrib%: percentage contribution, Cum%: cumulative percentage.

Sponges	Shallow Av.Abund	Deep Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%1
H. communis	31.25	0.00	27.13	2.82	37.60	37.60
S. officinalis adriatica	46.25	6.75	14.46	1.05	20.04	57.64
S. agaricina	0.00	1.25	12.26	1.19	16.99	74.62
S. zimocca	0.00	0.88	10.63	0.92	14.73	89.35
S. officinalis mollissima	54.13	0.00	7.68	0.75	10.65	100.00

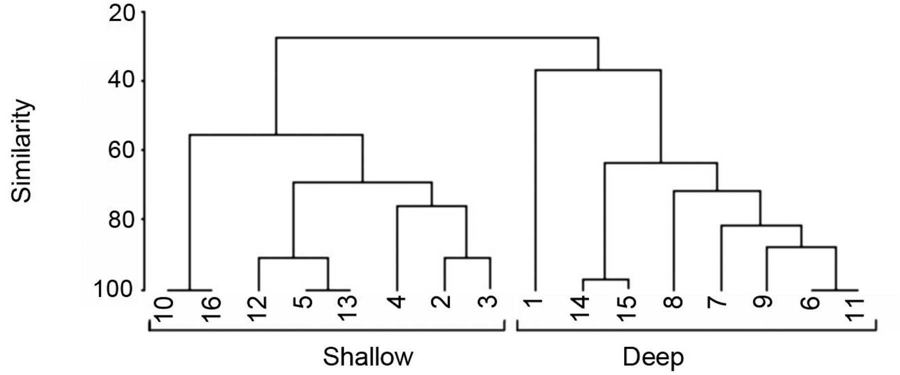

Fig. 3: Bray-Curtis similarity indexes of percentage abundance of commercial sponges at 16 shallow and deep stations in the Aegean Sea. Dendrogram using group averaged clustering.

shelf of the eastern Cretan Sea (Sitia Bay), where all these three commercial sponges exhibited an enhanced abundance (Table 2). The sponges from the deep stations consisted of *S. officinalis adriatica, S. agaricina* and *S. zimocca,* with the latter being less prevalent.

The biometry data on certain specimens (240) from Sitia Bay (Table 4) revealed that the sponges tended to be larger with increasing depth in the infralittoral zone (<40 m). This was more obvious concerning the height of all the sponge species examined. Specifically, the height of *H. communis, S. officinalis adriatica* and *S. officinalis mollissima* was significantly higher at 37.5 m than at a 12 m depth. At 33.5 m depth, height was similar for *H. communis* or significantly lower for *S. officinalis adriatica* compared to 37.5 m depth, but higher than that at 12 m depth for both species. In addition at 33.5 m depth, the width and the circumference of *S. officinalis adriatica* were significantly greater than those at 12 m depth, but similar to those at 37.5 m depth.

In total, biometrical measurements were performed on 346 specimens from all the experimental surveys and on 115 sponges from the market (Table 5). The dimensions of *S. officinalis adriatica* were significantly lower at the shallow than at the deep stations. *S. agaricina* was the largest commercial sponge, and the experimental samples showed an increased standard deviation. The dimensions of *H. communis* and *S. officinalis adriatica* from the shallow stations of this study were at levels measured on sponges of these species from the market harvester prior to the outbreak of sponge disease at similar depths. This was also true for *S. agaricina* and *S. zimocca* concerning the deep stations. However, two sponges of *S. officinalis mollissima,* found in the market and derived from deep depths, were much larger than the specimens from the experimental surveys.

Discussion

The distribution of the commercial sponge species depends mainly on the slope of the substrate and partially on the depth (VOULTSIADOU *et al.,* 2008). *Hippospongia communis* was found in different types of substrate (i.e. *Posidonia,* sand or large rocks), but only in shallow waters (<40 m), showing a photophilic behavior. In earlier studies a similar range of depth has been reported for the occurrence of *H. communis* in the Mediterranean; 10-50 m on the coasts of Italy (PRONZATO, 1999) and 16-35.5 m on the coasts of Egypt (CASTRITSI-CATHARIOS *et al.,* 2005). In addition, it was the most prevalent sponge species and showed a relatively increased abundance in most of the shallow grounds investigated. *H. communis* was also the most abundant commercial sponge species in the infralittoral zone of Egypt during recovery (1995) from sponge disease (CASTRITSI-CATHARIOS *et al.,* 2005). *H. communis* also constituted most of the Tunisian sponge production before the outbreak of sponge disease (FAO, 1990).

Spongia officinalis adriatica is the most common commercial sponge in the Aegean Sea, as has been previously reported (KEFALAS *et al.,* 2003a). Generally, it is considered as an excellent bath sponge, mainly harvested in Greek waters (FAO, 1990). In this study, it was collected in several types of substratum (from sandy to coralligenous) and over a wide range of depths (up to 110 m). According to PRONZATO (1999), *S. officinalis* occurs from 5-10 m down to 100 m depth. A num-

Table 4
Dimensions of commercial sponges harvested at three stations (east, west and central) of different depths (12, 33.5 and 37.5 m, respectively) in Sitia Bay, Kriti Island.

Depth (m)	Length (cm)	Width (cm)	Height (cm)	Circumference (cm)	N
H. communis					
12	16.5 ± 2.1	12.8 ± 3.6	6.6 ± 2.9 a	43.2 ± 6.0	5
33.5	20.4 ± 5.3	15.0 ±4.3	10.9 ± 2.8 b	54.4 ± 14.4	34
37.5	18.4 ± 5.5	14.6 ± 4.4	10.4 ±2.9 b	48.6 ±1 4.3	59
P	*NS*	*NS*	**	*NS*	
S. officinalis adriatica					
12	14.3 ± 4.0 a	10.3 ± 3.7 a	5.1 ± 2.2 a	37.1 ± 10.9 a	64
33.5	15.2 ± 5.5 ab	12.8 ± 4.7 b	9.5 ± 3.4 b	46.1 ± 15.4 b	12
37.5	17.3 ± 5.1 b	13.4 ± 4.5 b	12.3 ± 3.7 c	47.3 ± 15.3 b	28
P	*	*	***	*	
S. officinalis mollissima					
12	15.4 ± 2.9	11.8 ± 3.7	8.7 ± 1.43 a	42.3 ± 8.44 a	23
37.5	17.4 ± 3.7	13.3 ± 3.0	11.5 ± 2.21 b	49.9 ± 9.60 b	15
	NS	*NS*	***	*	

Means with different letter in superscript differ significantly.
*:P<0.05, **:P<0.01, ***:P<0.0001.
NS: no significant differences (P>0.05).
N: sample size.

Table 5
Dimensions of bath sponges harvested at shallow (<40 m depth) or deep fishing grounds during the surveys of the present study (A) or prior to sponge disease (B).

	A		B	
	Shallow	**Deep**	**Shallow**	**Deep**
H. communis				
Length (cm)	18.4 ± 5.2		19.4 ± 6.8	
Width (cm)	14.6 ± 4.2		15.6 ± 6.0	
Height (cm)	10.0 ± 3.3		8.8 ± 4.1	
Circumference (cm)	49.1 ± 14.2		48.3 ± 15.4	
	N=128		N=46	
S. officinalis adriatica				
Length (cm)	15.5 ± 5.2	22.4 ± 10.4	13.6 ± 3.1	
Width (cm)	11.4 ± 4.1	16.9 ± 7.5	10.2 ± 2.6	
Height (cm)	7.4 ± 4.7	14.0 ± 5.5	5.3 ± 2.0	
Circumference (cm)	40.8 ± 14.0	61.8 ± 31.5	34.7 ± 8.0	
	N=109	N=54	N=52	
S. officinalis molissima				
Length (cm)	16.2 ± 3.31		39.0	
Width (cm)	12.3 ± 3.43		23.0	
Height (cm)	9.6 ± 2.13		20.0	
Circumference (cm)	45.3 ± 9.57		91.0	
	N=38		N=2	
S. agaricina				
Length (cm)		29.4 ± 25.5		25.4 ± 6.9
Width (cm)		36.8 ± 67.7		21.7 ± 6.8
Height (cm)		2.7 ± 0.4		14.0 ± 3.0
Circumference (cm)		86.9 ± 74.9		68.2 ± 17.3
		N=10		N=13
S. zimocca				
Length (cm)		20.9 ± 15.0		20.5
Width (cm)		19.4 ± 16.9		15.0
Height (cm)		11.7 ± 5.0		10.5
Circumference (cm)		56.5 ± 39.3		49.5
		N=7		N=2

ber of species considered as sciaphilous in the western Mediterranean, like *S. officinalis,* are rather photophilic in the eastern Mediterranean (VACELET, 1964; KEFALAS *et al.,* 2003a). In addition, a remarkable extension of the semi-sciaphilous zone was observed in the Aegean, characterized by the survival of sciaphilous species at depths of up to 110 m (KEFALAS *et al.,* 2003a). *S. agaricina* was found only at deep grounds on coralligenous substratum. KEFALAS *et al.* (2003a) also reported that this species occurs from 50 up to 110 m in the Aegean Sea. These findings corroborate present results concerning the bathymetric distribution of *S. officinalis adriatica* and *S. agaricina,* which were the most prevalent commercial sponges in the deeper waters (50-110 m).

S. officinalis mollissima was found at depths of up to 40 m in this study and at depths of up to 130 m in the Aegean Sea by KEFALAS *et al.* (2003a). The substratum was mainly sandy carrying a few big rocks or *Posidonia* meadows. *S. zimocca* was fished at depths of 50-80 m, mainly on coralligenous substratum. KEFALAS *et al.* (2003a) reported that this sponge species occurred at depths of up to 90 m in the Aegean Sea. In addition, it was collected in the infralittoral zone of Egypt (17 m depth), indicating an adaptation to light penetration (CASTRITSI-CATHARIOS *et al.,* 2005). However, in all previous studies both *S. officinalis mollissima* and *S. zimocca* were scarcely detected. This probably explains the absence of the former from the deep stations and of the second from the shallow ones in this study.

H. communis, S. officinalis adriatica and *S. officinalis mollissima,* particularly the latter, appeared to be benefited from the conditions prevailing in the infralittoral zone of the eastern Cretan Sea. On the other hand, *H. communis* was one of the first commercial species that repopulated the fishing grounds on the oligotrophic coasts of Egypt in 1995, while *S. officinalis* was absent (CASTRITSI-CATHARIOS, 1995). CASTRITSI-CATHARIOS *et al.* (2005) noticed a similar absence of this species from the coasts of Libya in 1993. According to VAN SOEST *et al.* (2008), in the Mediterranean *S. officinalis* is distributed in the Adriatic Sea, which is more eurotrophic than the Aegean Sea. It seems that feeding demands of the commercial sponge species play an important role in their distribution and abundance, apart from light conditions. The increased abundance of *S. officinalis* on the shelf of the eastern Cretan Sea may be influenced by the nutrient supply, the increased diatom/dinoflagellate ratio and the abundance of benthic living diatoms throughout the year (PSARRA *et al.,* 2000; DUINEVELD *et al.,* 2000). The bathymetrical distribution of *S. officinalis* seems to be associated with the Deep Chlorophyll Maximum (DCM) and the relative increase in importance of diatoms at the lowest layers of the euphotic zone during stratification, as dinoflagellates show the opposite pattern and picoplankton does not display any vertical differentiation related to DCM in the Aegean Sea (GOTSIS-SKRETAS *et al.,* 1999; IGNATIADES *et al.,* 2002).

The upwelling conditions, the SE direction of the mesoscale jet and the eddy in the eastern Cretan Sea (TSELEPIDES *et al.,* 2000) may also contribute to the enhanced abundance of the three aforementioned sponge species by promoting the transportation of their larvae before settlement from deeper to shallow waters. The lecithotrophic sponge larvae have a very short life, which lasts from a few hours to a few days for free-swimming larvae (MALDONADO & BERGQUIST, 2002), and behave essentially as passive particles. Oceanographic processes can play a major role in the large-scale dispersal of sponge larvae (SPONAUGLE *et al.,* 2002), due to the overriding viscous force, which dictates the motion of a small larva. It should be noticed that many fishing grounds on other coasts of Kriti (Psira Island, Hersonissos, Ierapetra, Theophilos) and the nearby islands of the Dodekanisos Islands (Kos and Simi Islands), that used to be rich in sponges before the appearance of sponge disease, were found to be fully desertified in 1994 (CASTRITSI-CATHARIOS, 1995).

It has been observed that the populations of commercial sponge species located deeper than 40 m depth in the Aegean and Ionian Seas were less affected or non-affected by the disease of 1986–1987 (CASTRITSI-CATHARIOS, 1998), probably due to the lower temperatures prevailing at greater depths (VACELET, 1991). The phenomenon of a severe epidemic of the disease has also been observed (in 1999) in the northwestern Mediterranean, where extensive damage to all the sessile filter-feeder invertebrates, including sponges, occurred up to 40 m depth (PEREZ *et al.,* 2000). These corroborate present results, since signs of the disease appeared in some sponges collected in shallow grounds and most of these specimens belonged to the photophilic species *H. communis.*

In their natural environment, commercial sponges can sometimes show symptoms like those of the early stages of the disease. For instance, breaks (like small holes) on the surface membrane of *S. officinalis* have been observed. As divers have pointed out, however, these are caused by the bites of a small red crab. In other cases, various kinds of commercial sponges show white spots on their surface caused by fishing gear. In both these cases, these wounds heal comparatively quickly. On the contrary, the disease, which appears in the form of white spots on the surface, spreads quickly into the interior on the main body, damages the live tissues and affects the structure of spongin fibers (CASTRITSI-CATHARIOS 1998, MALDONADO *et al.* 2010). In addition, the skeleton becomes brittle and the sponge loses its market value, while the surrounding area exudes a strong smell of hydrogen sulphide. Although the causes of the sponge disease have not yet clarified, it should be noticed that most of the infected sponges in this study were collected at Mykonos Island, in an area that is lee, without strong currents and which carries a high microbial load (KEFALAS *et al.,* 2003b).

An exponential increase in the dimensions of adult specimens of *H. communis* with the increasing of the depth of fishing grounds was observed in the infralittoral zone of Egypt in May 1995, indicating that most of the individuals at the deeper depths were older (CASTRITSI-CATHARIOS *et al.,* 2005). A similar tendency of increasing size with depth was observed in this study for *H. communis, S. officinalis adriatica* and *S. officinalis mollissima,* confirming that the repopulation of commercial sponges in the infralittoral zone showed a gradient from deeper to shallower waters. Furthermore, at the deeper depths, the increase in height of these species seems to be promoted rather than that of length or width as the sponge matures. Specifically, the dimensions of *H. communis* on the Aegean Sea coasts (present study) were similar to those on the coasts of Egypt (CASTRITSI-CATHARIOS *et al.,* 2005) at the respective depth.

S. officinalis adriatica showed a larger size, as well as a relatively increased standard deviation of all the measured dimensions, in the deep compared to shallow stations. In addition, in the infralittoral zone, the differentiation of size with depth was more important in *S. officinalis adriatica* than in *S. officinalis mollissima* or *H. communis,* particularly as far as height is concerned. It should be mentioned that experienced divers recognise three different phenotypes for *S. officinalis adriatica.* The first type, 'matapas', is flat and met in shallow waters (5-15m), where the waves and light are relatively strong, and seasonal fluctuations in temperature are relatively intense. The second type is found in deep waters and looks similar to 'matapas' but is of different texture. The third , 'fino', is also found in deep waters, but without strong currents, and has an almost spherical shape.

The least uniform sponge species was *S. agaricina* collected by 'gagava'. It should be noted that one huge individual was collected with a circumference of 300 cm. However, the majority of the specimens had dimensions at the levels estimated for the sponges of this species from the market, as it was observed for the specimens of *S. zimocca* that were also harvested from the deep fishing grounds with the same gear. In addition, *S. officinalis adriatica* and *H. communis* that were sampled by 'nargile' in the infralittoral zone were similar in size to the sponges of the respective species from the market, which had also been collected by the same method, but prior to the appearance of sponge disease. Taking into consideration that, in both cases, adult bath sponges were harvested by professional Kalymnian divers, a recovery of the sponge populations in the shallow grounds could be indicated in terms of their size distribution within the time period of eight years from the onset of sponge disease. However, larger individuals of *S. officinalis* were detected in the experimental surveys or in the market (after or before the disease, respectively), deriving from deep sponge banks that were probably less affected by fishing activity. Recently, Milanese *et al.* (2008) stated that bath sponges larger than 20 cm are rare in the market, particularly pieces belonging to *S. officinalis,* as these may not be easily found in the field.

RIZZELLO *et al.* (1997) reported that the restoration of the fishing grounds by new specimens of *S. officinalis* was achieved 5 years after the disease had moved out, while full restoration of the population was achieved after 8 years. In Greece, the progress of recovery from sponge disease on most of the sponge banks in the infralittoral zone seems to have been slower than that estimated in Egypt (CASTRITSI-CATHARIOS *et al.,* 2005), in terms of the abundance of bath sponges and the presence of unhealthy ones. This is probably due to overfishing with several bottom gears or/and pollution in the former. CASTRITSI-CATHARIOS (1998) noted that almost a decade was required for the total recovery of commercial sponges from sponge disease in 1986. In 1996 and 2000, sponge disease appeared again but to a lesser extent, mainly in Kriti, and caused new damage to sponges up to 40 m depth. In 2008, in the Aegean Sea including the Cretan Sea, a new recovery of the bath sponges was observed, with an obvious reduction in the number and the abundance of the sponge species (CASTRITSI-CATHARIOS *et al.,* 2010). Nowadays (2009-2010), according to the few sponge fishermen who are still active, the fishing grounds of SE Kriti (mainly) and the remaining Aegean Sea have totally recovered, but the production has amounted to over 6 tons.

Further investigation is required concerning the factors affecting the distribution and abundance of commercial sponges with important implications for fisheries and aquaculture. Cultivation of sponges is a promising solution to relieve the impact of harvesting (PRONZATO, 1999; CORRIERO *et al.,* 2004). OSINGA *et al.* (1999) suggested that food organisms can be selected by determining the natural diet of the sponge to be cultured under controlled conditions, while for *in situ* cultivation of sponges the selection of the appropriate environmental conditions is very important.

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