BLUEMED

Activity 4.2
Preparatory activities in pilot sites

Deliverable 4.2.5
Preliminary marine biodiversity and abundance study of MPA/UM/DP marine areas

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I. INTRODUCTION

The aim of this deliverable is to record the marine biodiversity (macrophytes, invertebrates, fish fauna) of the pilot areas of BLUEMED. Within the framework of this deliverable actions were implemented in the regions of Capo Rizzuto and Baiae bay in Italy, in Cavtat in Croatia and in the western Pagasitikos bay and Sporades in Greece. The Oceanography Centre, University of Cyprus (OC-UCY) was the responsible partner for recording the marine biodiversity found at the pilot sites.

The works at Baiae (Italy) was carried out between 13^{th} and 16^{th} May 2018, while the same team also carried out works in Capo Rizzuto, (Italy) between 16^{th} and 19^{th} May 2018. The work in Italy was carried in collaboration with the DIMEG - University of Calabria, the local diving centers, 'entro Sub Campi Flegrei' in Baiae and 'Made in Sub' in Capo Rizzuto, and with the support of the 'Parco Archeologico dei Campi Flegrei', responsible public local authority for the Baiae UCH site, and of the Regione Calabria, responsible authority for the 'MPA Capo Rizzuto'. Both the above-mentioned authorities have signed a letter of intent authorizing all the described pilot activities.

The Cavtat Underwater Archaeological Sites in Croatia, managed by Croatian Ministry of Culture, has 3 main underwater archeological sites protected as cultural heritage with diving restrictions. OC-UCY's team, carried out field work in the pilot site of Cavtat, Croatia between 6-10 June 2018. The work in Croatia was carried out in collaboration with the University of Calabria and the University of Zagreb - Faculty of Electrical Engineering and Computing, and with the support of Epidaurum Diving Centre, Dubrovnik Neretva Regional Development Agency DUNEA, and the University of Zadar, Dept. of Archaeology.

The Underwater Cultural Heritage (UCH) sites and UCH diving parks in Cavtat, are of the most attractive and biologically rich areas in Croatia for advanced level divers to dive. These amphorae, pithoi and old pots sites harbouring many of the world's plant and animal species and providing important ecological services. The high biodiversity and abundance of marine species found in these areas is often one of the factors that constitutes them very attractive to tourists, as well as snorkellers and divers.

The pilot areas of BLUEMED in Greece are the wreck on the island of Peristera near Alonissos (5th century BC); the Byzantine wreck on the islet of Kikinthos (dating back to the 9th - 13th century); the shipwreck at Akra Glaros (Byzantine period) and the wreck at Telegraphos (4th century AD).

Peristera is an islet near Alonissos in the North Sporades, a cluster of islands in Greece on the central Aegean Sea. The shipwreck is located at the north of Kokkalia bay near the west rocky coast of Peristera. Peristera which is considered the largest and most important Classic Age shipwreck and at the same time evidence of the importance of trade in the classical period, that is legally recognized as Underwater Museum since January 2015. It is estimated that it was able to carry three to four thousand amphorae, which were one of the main trade products in antiquity. The cargo was mainly composed of transport amphorae (ceramic vessels used for the transportation and storage of foodstuffs), mostly the so called "Mendean" type transport amphorae, as well as the "Peparithian" type [probably produced in ancient Peparithos, now Skopelos]. Wine and oil probably constituted the main cargo of the ship.

Between 28 September and 1 October 2018, OC-UCY's team, carried out fieldwork in Alonnisos in Peristera shipwreck. The mission in Greece was carried out with the collaboration of Ephorate of Underwater Antiquities and ATLANTIS CONSULTING SA and with the support of Alonnisos diving centre IKION and other local diving centres. The team also carried out the fieldwork in Kikinthos, Glaros and Telegraphos shipwrecks in Amaliapolis in the western Pagasitikos bay, Greece between 1 and 3 of October 2018.

The islet of Kikinthos is a natural breakwater, lying at the east of Amaliapolis bay, on the west side of the Pagasetic gulf. The remnants of a Byzantine shipwreck cargo of mainly pithoi (large storage containers) are located at around 3 to 11 metres from the seabed. An area of around 8 x 6 metres is covered by big pithos shards that can be attributed to at least three different types according to marine archaeologist Elias Spondylis. Among the pithoi there are also shards of two types of amphorae, dating to the 12th – 13th centuries AD. The pithoi types are attributed to the 8th – 9th centuries AD, but it seems that they coexist with the later amphorae due to the fact that storage vessels were usually used for long periods of time.

Akra Glaros Cape is located in an area opposite of Nies, a coastal village in the prefecture of Magnesia and close to the city of Amaliapolis. Amaliapolis or Mitzela (local name, which means Small Mountain in the woods) is located near Almiros and 54 kilometers from Volos, on the western coast of the Pagasetic Gulf.

According to the Hellenic Institute of Marine Archaeology that investigates the area from 2000 to the present under the direction of marine archaeologist Elias Spondylis, at least four shipwrecks were recognized: a Hellenistic one (3rd – 2nd century BC), an Early Roman one (1st – 2nd century AD) and two of Middle and Late Byzantine (12th – 13th century AD) where Late Roman pottery is also present. The finds related to the aforementioned shipwrecks are so dispersed and mixed that the description of the different shipwrecks is a really difficult and not yet concluded task. On the other hand, it is really worth visiting the site and diving among the plentiful and varying objects indicative of ancient cargoes and dangerous journeys.

Telegrafos Bay is located in the prefecture of Magnesia and close to the city of Amaliapolis. Nowadays the town has turned into a holiday centre attracting many tourists, local and foreign. Visitors can admire the picturesque stores, visit the castle and walk the lovely paths.

The initial picture was of an intact shipwreck caused possibly by the ship's crushing against the rocky coast and capsizing. Unfortunately, the site was looted before the excavation. Despite that, the excavation brought to light the rest of the cargo and a thorough study led to the recognition of three main types of Late Roman (4th century AD) amphorae for the main cargo that could be attributed northern Peloponnesian (Corinth) and Eastern Aegean (Samos) origin. Facts indicate a ship travelling along the sea routes of the Late Roman - newly established Byzantine Empire across and along the sides of the Aegean Sea. Moreover, together with the main cargo smaller amounts of amphorae of six different types point to probable stops at minor ports along the route connecting the western side of the Aegean or even different products from secondary landing points.

II. METHODOLOGY

A. Frame

During the field work at the pilot sites, the OC-UCY team dove over the designated areas and recorded marine life using photo-quadrats and video. The photo-quadrat was constructed with dimensions of the base 40cm X 40cm (1.600 cm^2) while the top frame with dimensions of 30cm X 30cm. The camera was placed on the top frame at a constant height of 50cm above the base. The video was used to record mainly fish species swimming in the general area.

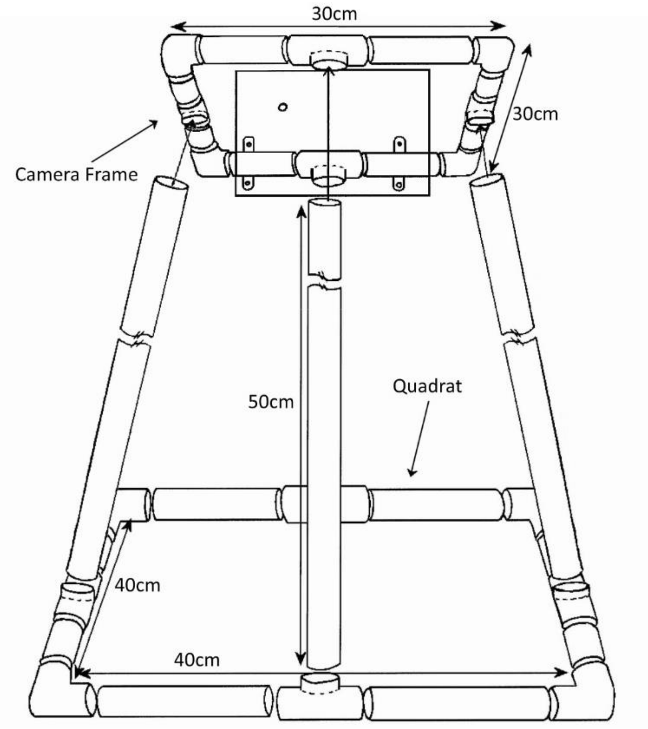

Figure. 1. Photoquadrat framer (modified from Preskit et al, 2004).

B. Transects

A metered tape was laid over the seafloor across each pilot site. Photographs were taken using a GoPro Hero 6 camera over the seabed every 1m interval next to the metered tape with a photo-quadrat for a continuous 25m long distance (figure 2). For pilot sites longer than 25m, a 5m blank zone where no photographs were taken was included after the first series of 25 photos, before resuming again with the photo-quadrat sampling every 1m.

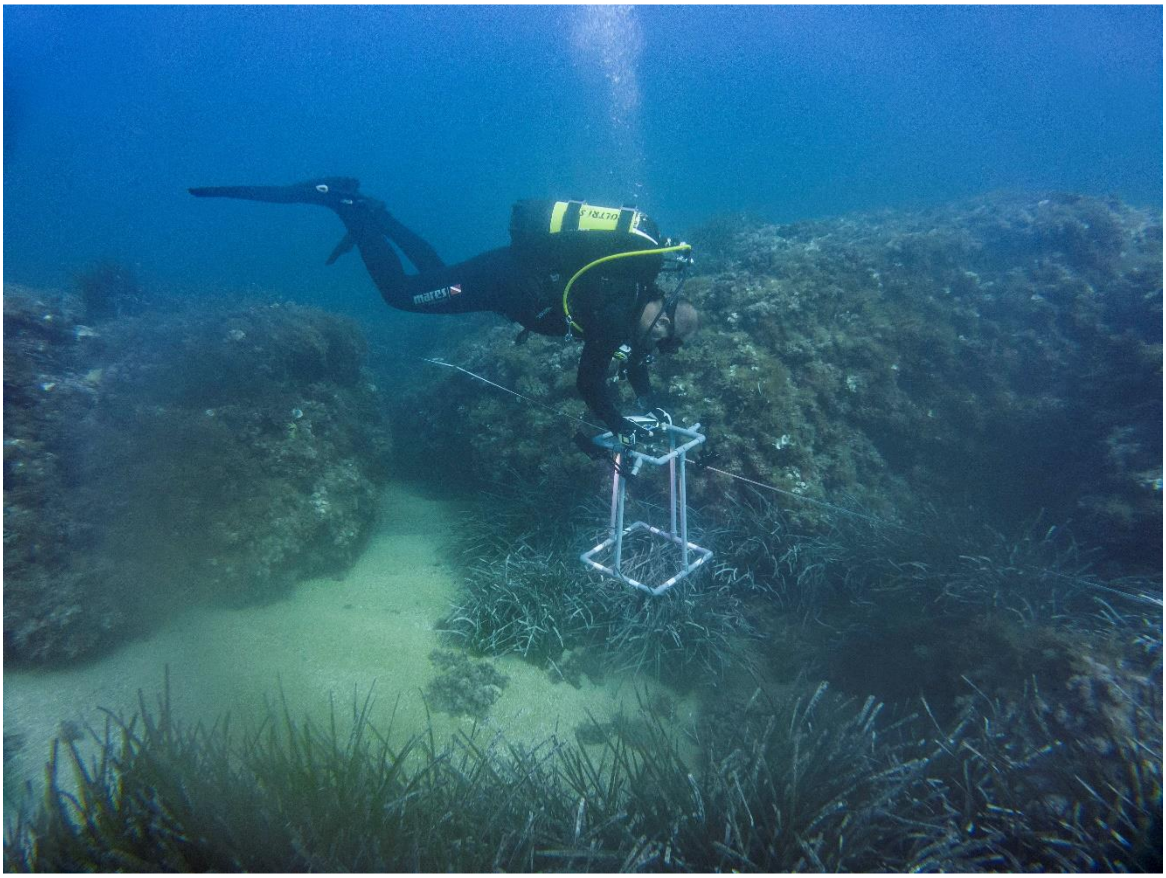

Figure 2. Transects laid out over the study site.

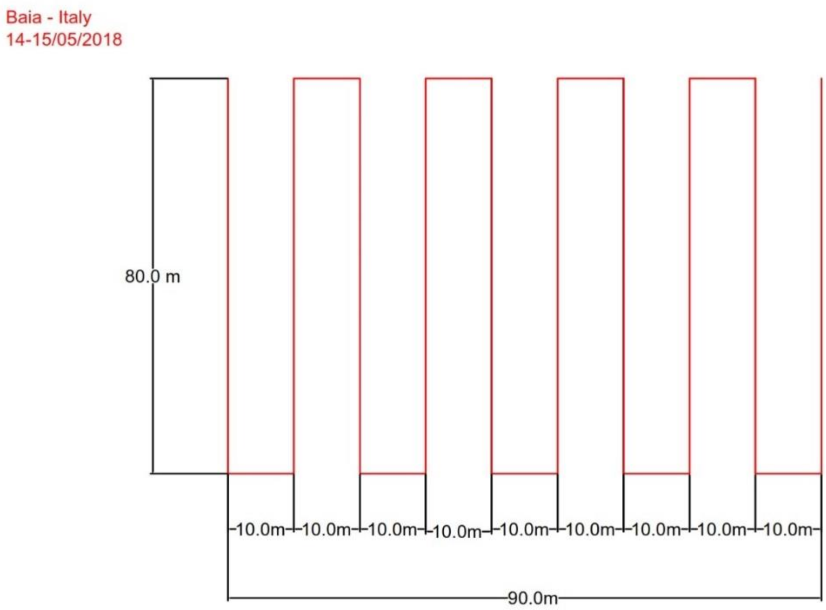

Fig. 3. Transects (in red colour) carried out in the area of Baia

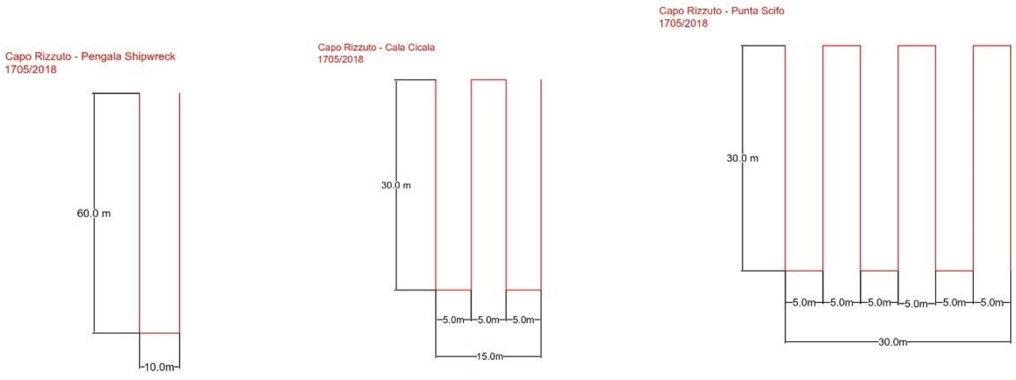

Fig. 4. Transects (in red colour) carried out in the area of Capo Rizzuto.

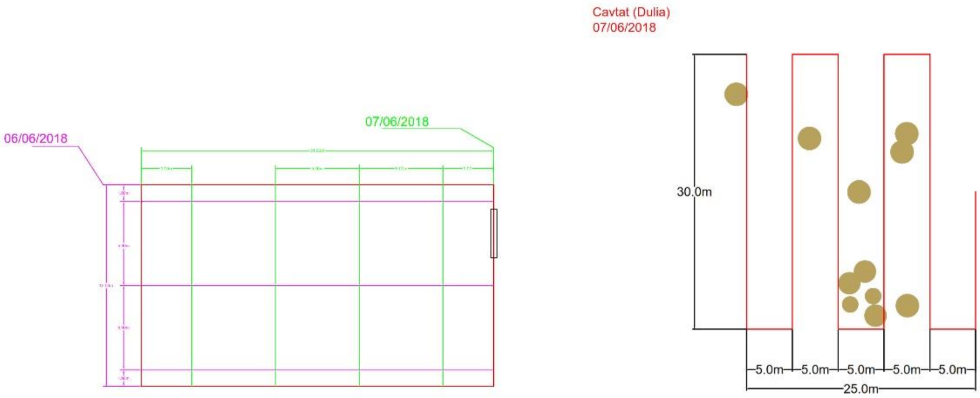

Fig. 5. Transects (in red and green colour) carried out in the area Cavtat.

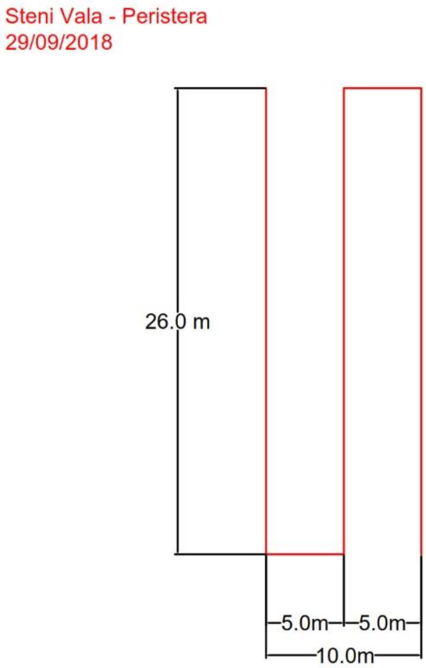

Fig. 6. Transects (in red colour) carried out in the area of Alonnisos (Peristera Shipwreck).

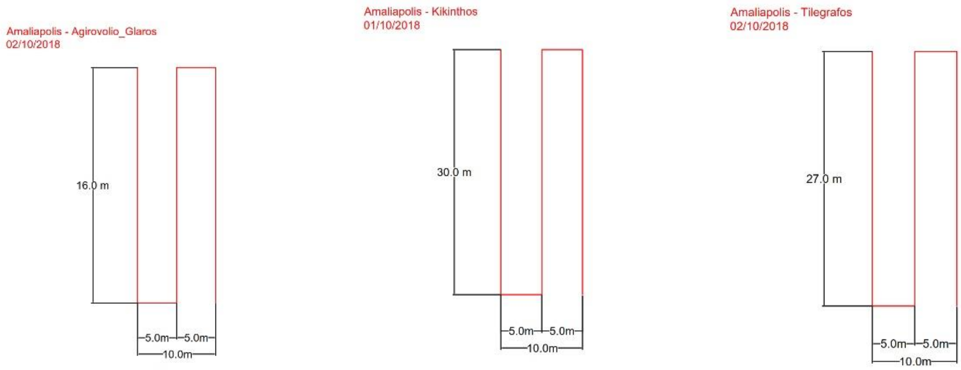

Fig. 7. Transects (in red colour) carried out in the area of Amaliapolis.

C. Photoquadrat analysis

Photographic quadrat sampling is commonly used for the study of sessile benthic communities. However, photo-quadrat data handling is fragmented into several processing methods, and there is a scarcity of dedicated software tools that integrate all major analysis options. PhotoQuad is a software system for advanced image processing of photographic samples, dedicated to ecological applications (Fig. 8). The software integrates a series of methods for the extraction of species area, percentage coverage, or presence/absence information, including random point counts (RP), grid cell counts (CL), freehand regions (FH), and image segmentation-based regions (SG). These are simultaneously functional in a layer-based environment, further supported by a variety of tools for image calibration, image enhancement, multi-scale image segmentation, management of user-specific species libraries, random point counts, species counts, grid cell counts, estimation of absolute or relative-to-quadrat area and coverage, extraction of advanced 2D morphometric descriptors such as centroid or perimeter roughness, as well as several annotation, measurement or image metadata tools (Trygonis and Sini, 2012).

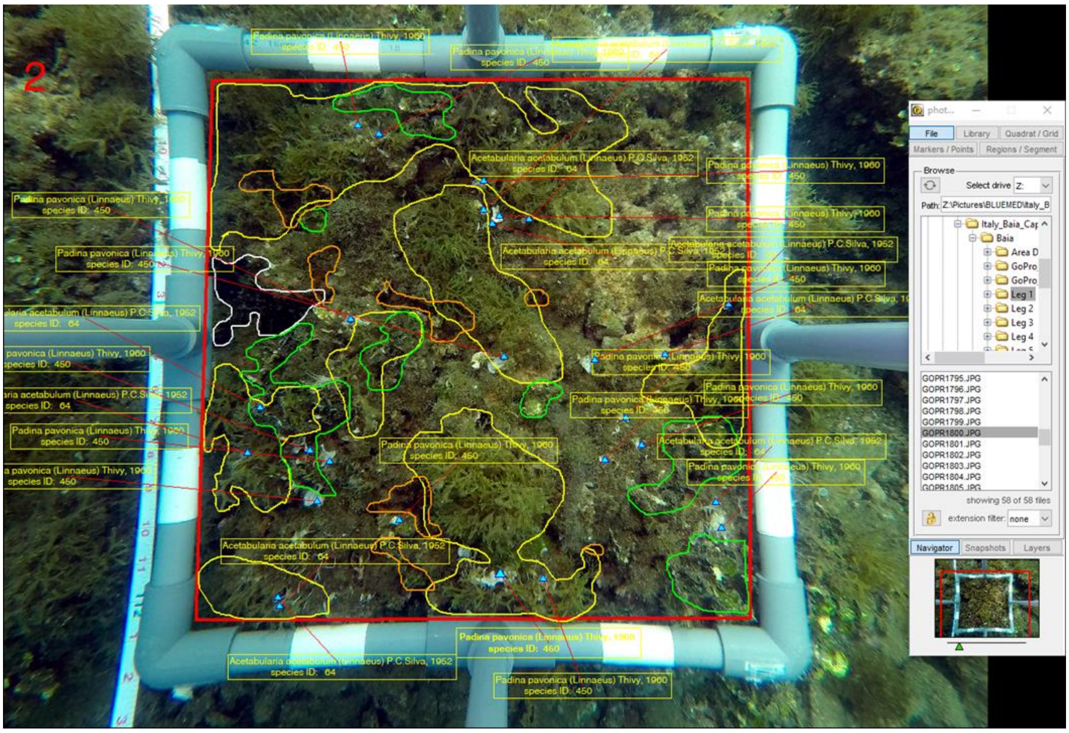

Fig. 8. Identification of species in PhotoQuad.

For the analyses and identification of the marine species at the BLUEMED pilot sites, one thousand three hundred and thirty-one (1331) photos in total have been used. Analytically, for the pilot sites in Greece a) Alonissos: Peristera, b) Amaliapolis: Glaros, Kikinthos and Tilegrafos, two hundred and seventy (270) photos, in Italy a) Baiaeand b) Capo Rizzuto eight hundred and forty-four (844) photos and in Croatia a) Cavtat: Amphorae and Pithos diving sites, two hundred and seventy-seven (217) photos. The photographs were used to identify the marine species, but also to estimate species abundance (N) and percentage of the coverage area in the photographed areas.

D. VIDEO ANALYSIS

Video footage taken of the surrounding area while swimming along the predefined transect lines at each pilot site was analysed to identify mainly species of fish at each location.

III. RESULTS

A. ITALY

1. Baiae

The University of Cyprus, Oceanography Centre, covered an area of about 100mX100m in total, recording marine life and biodiversity. A total of 49 species were recorded in the Baiae underwater area (Table 1). The majority of marine life recorded in the area were invertebrates (44%) while a wide range of algae (24%) and fish (32%) was also recorded (Table 2, Fig. 9). Using the photoquadrat camera, a total area of 1.118.400 cm^2 was photographed (699 frames X 1.600 cm^2).

Sponges and molluscs were the most common invertebrate found in the Villa. Other invertebrates included sea worms, anemones, sea urchins, barnacles, molluscs, crabs, sea cucumbers, and bryozoans. Green, Red, and Brown algae were recorded. All of them very common for the area. Among the brown algae, ***Dictyota dichotoma var intricata*** was the most common species in the Villa. Another species of brown algae, ***Colpomenia sinuosa*** is used in human diet, as a raw salad vegetable. It is also used as a fertilizer and as an indicator of metal pollution in the water (Fig. 10).

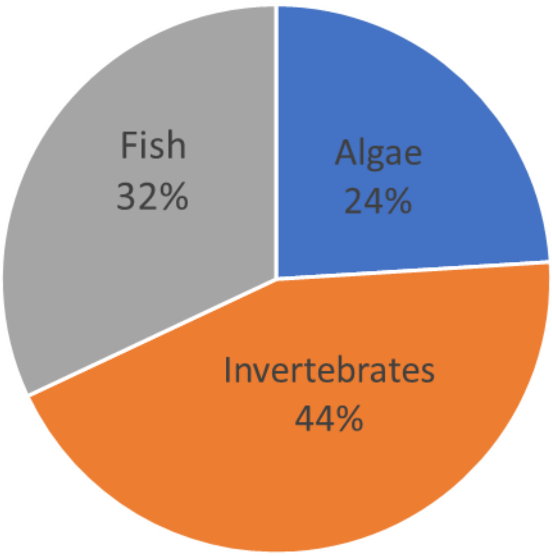

Fig. 9. Marine biodiversity abundance of the macrophytes/algae, invertebrates and fish in the Baiae dive site.

Table. 1. Marine species recorded in Baiae.

A/A	Macrophytes - Macroalgae	Invertebrates	Fish
1	*Acetabularia acetabulum*	*Acanthocardia tuberculata*	*Apogon imberbis*
2	*Anadyomene stellata*	*Aphrodita aculeata*	*Chromis chromis*

3	*Cladophora prolifera*	*Aptyxis syracusana*	*Coris julis*
4	*Colpomenia sinuosa*	*Ascandra contorta*	*Diplodus annularis*
5	*Dictyota dichotoma (Hudson)*	*Barbatia barbata*	*Diplodus puntazzo*
6	*Dictyota dichotoma var intricata*	*Cerithium scabridum*	*Diplodus sargus*
7	*Flabellia petiolata*	*Chondrilla nucula*	*Diplodus vulgaris*
8	*Hildenbrandia rubra*	*Condylactis aurantiaca*	*Gobius spp.*
9	*Hydrolithon cruciatum*	*Hexaplex trunculus*	*Lithognathus mormyrus*
10	*Padina pavonica*	Holothuria (Panningothuria) forskali	*Oblada melanura*
11	*Palmophyllum crassum*	Holothuria (Holothuria) tubulosa	*Sarpa salpa*
12		*Maja squinado*	*Scorpaena notata*
13		*Perforatus perforatus*	*Serranus scriba*
14		*Petrosia (Petrosia) ficiformis*	*Solea solea*
15		*Sarcotragus foetidus*	*Thalassoma pavo*
16		*Sarcotragus spinosulus*	*Trachinus araneus*
17		*Schizomavella (Schizomavella) mamillata*	
18		*Tarantinaea lignaria*	
19		*Thylacodes arenarius*	
20		*Venus verrucose*	
21		*Zonaria toumefortii*	

Table 2. Marine species abundance (N) and covered percentage recorded by the quadrat camera in Baiae for the most common species abundance (N) over 10.

Italy_Baia site			
A/A	**Species names**	**Abundance (N)**	**Covered Area %**
1	*Tarantinaea lignaria*	11	0,216
2	*Colpomenia sinuosa*	12	0,465
3	*Hildenbrandia rubra*	19	0,722
4	*Sarcotragus spinosulus*	19	0,533
5	*Petrosia ficiformis*	30	0,901
6	*Perforatus perforatus*	34	1,114
7	*Venus verrucosa*	52	1,150
8	*Flabellia petiolata*	53	1,546
9	*Hydrolithon cruciatum*	53	1,851
10	*Chondrilla nucula*	172	5,841
11	*Anadyomene stellata*	181	6,245

12	*Dictyota dichotoma*	260	8,274
13	*Padina pavonica*	299	2,765
14	*Acetabularia acetabulum*	380	3,688
15	*Dictyota dichotoma var intricata*	1680	53,090

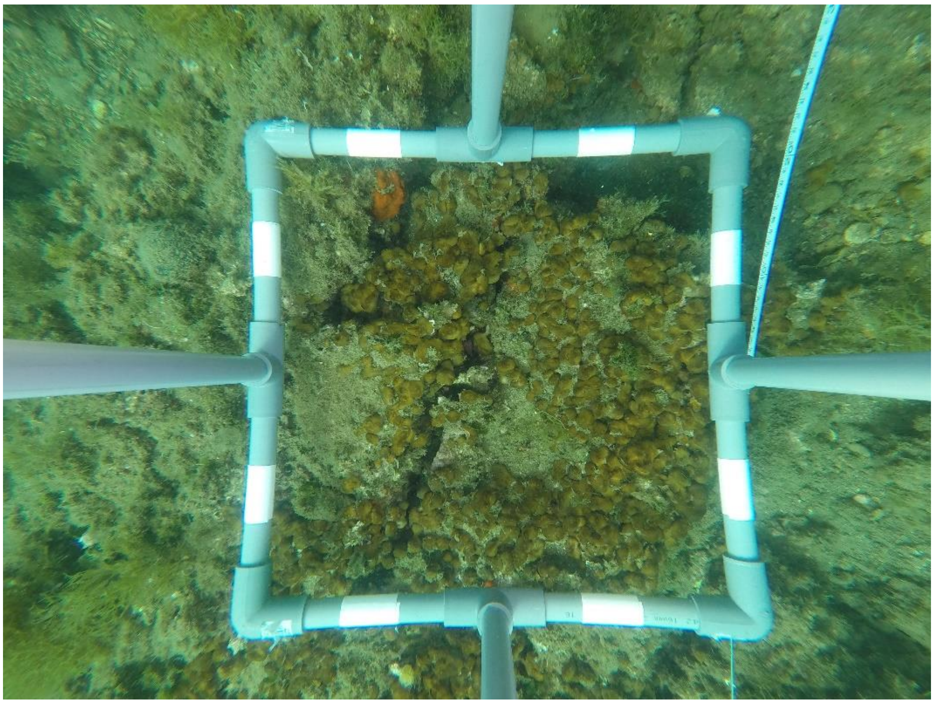

Fig. 10. *Colpomenia sinuosa* as photographed in Baia.

2. Capo Rizzuto

The University of Cyprus, Oceanography Centre, covered a total underwater distance of about 1.2km in total, recording marine life and biodiversity. In the water, more than 22 different species of fish and invertebrates are finding shelter in the extended meadows of the seagrass *Posidonia oceanica* (Fig. 11, Table 3). A variety of at least 11 Red, Green, and Brown algae are also occurring in the area, forming the bottom of a varied food web. Using the photoquadrat camera, a total area of 232.000 cm^2 was photographed (145 frames X 1.600 cm^2).

The majority of marine life recorded in the area were algae (33%) and fish (36%) while a wide range of invertebrates (28%) was also recorded (Table 4). Sponges were the most common invertebrate found in the marine park of Capo Rizzuto. Green, Red, and Brown algae were recorded, with brown algae being the most coming (6 different species present). The Angiosperm ***Posidonia oceanica*** (Neptune grass) covered the area extensively. The most common species recorded was the brown algae ***Padina pavonica*** (Peacock's tail) and the red algae ***Peyssonnelia orientalis*** (Leather rock), which is used by the Marine Strategy Framework Directive (MSFD) as one of the indicator species for monitoring habitat distributional range. Another species of brown algae, ***Zanardinia typus*** (Penny weed) is considered a "characteristic species", reflecting the good ecological status of the environment. Penny weed has a relatively high antimicrobial activity, which allows it to fight against microbial attacks. The extracts of this algae also have antifungal, antiviral, cytotoxic and antimitotic properties.

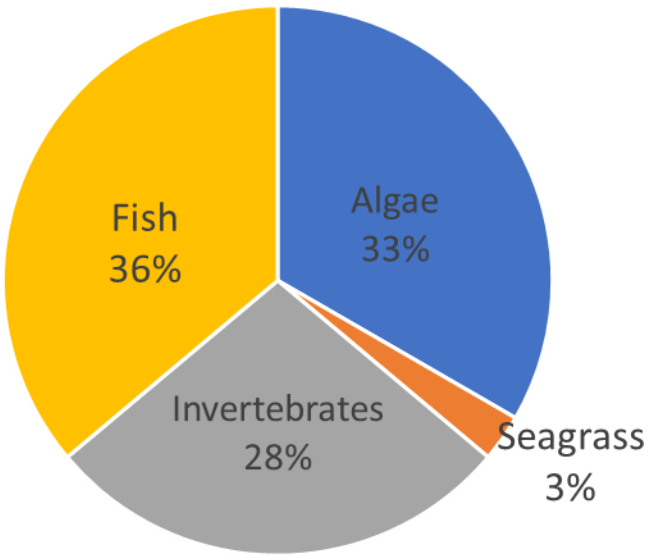

Fig. 11. Marine biodiversity abundance of the macrophytes/algae, invertebrates and fish in the Capo Rizzuto area.

Table. 3. Marine species recorded in Capo Rizzuto.

A/A	Macrophytes - Macroalgae	Invertebrates	Fish
1	*Codium bursa*	*Agelas oroides*	*Atherina spp.*
2	*Cystoseira zosteroides*	*Aplysilla rosea*	*Chromis chromis*
3	*Dictyopteris polypodioides*	*Ascandra contorta*	*Coris julis*
4	*Dictyota dichotoma (Hudson)*	*Axinella damicornis*	*Diplodus annularis*
5	*Dictyota dichotoma var intricata*	*Axinella verrucosa*	*Diplodus vulgaris*
6	*Halimeda tuna*	*Chondrilla nucula*	*Halocynthia papillosa*
7	*Mesophyllum alternans*	*Crambe crambe*	*Oblada melanura*
8	*Padina pavonica*	*Petrosia (Petrosia) ficiformis*	*Sarpa salpa*
9	*Peyssonnelia orientalis*	*Sarcotragus foetidus*	*Serranus cabrilla*

10	*Peyssonnelia squamarina*	*Sarcotragus spinosulus*	*Serranus scriba*
11	*Posidonia oceanica*		*Scorpaena maderensis*
	Sphaerococcus coronopifolius		*Sparisoma cretense*
12	*Zanardinia typus*		*Thalassoma pavo*

Table 4. Marine species abundance (N) and covered percentage recorded by the quadrat camera for the most common species abundance (N) over 10 in Capo Rizzuto.

Italy_Capo Rizzuto site			
A/A	**Species names**	**Abundance (N)**	**Covered Area %**
1	*Halimeda tuna*	13	1,751
2	*Petrosia ficiformis*	14	2,002
3	*Sphaerococcus coronopifolius*	15	2,515
4	*Aplysilla rosea*	17	2,070
5	*Dictyota dichotoma var intricata*	20	4,483
6	*Posidonia oceanica*	21	1,249
7	*Sarcotragus spinosulus*	21	3,148
8	*Dictyota dichotoma*	30	4,790
9	*Mesophyllum alternans*	43	6,257
10	*Cystoseira zosteroides*	60	7,296
11	*Peyssonnelia orientalis*	89	16,315
12	*Padina pavonica*	244	5,032

B. Croatia

1. Cavtat - Amphorae

Using the photoquadrat camera, a total area of 132.800 cm^2 was photographed (83 frames X 1.600 cm^2) in the amphorae site in Cavtat within the cage. Twenty-three (23) marine species in total were recorded in the amphorae diving site in Cavtat (Fig. 12, Table 5). Specifically, 12 species of macrophytes (1 species: *Posidonia oceanica*) and macroalgae (11 species) together were recorded, whereas another 8 species of invertebrates were identified as well. Moreover, 3 fish were recorded from the video. Macroalgae - Rhodophyta (*Peyssonellia rosa-marina*, *Mesophyllum alternans*, *Peyssonellia squamaria* and *Hydrolithon cruciatum*) were found to be more abundant 73% in the dive site, specifically on and between the amphorae. Tracheophyta (*Posidonia oceanica*) were found the second most abundant species between and next of the amphorae inside the cage (Table 6).

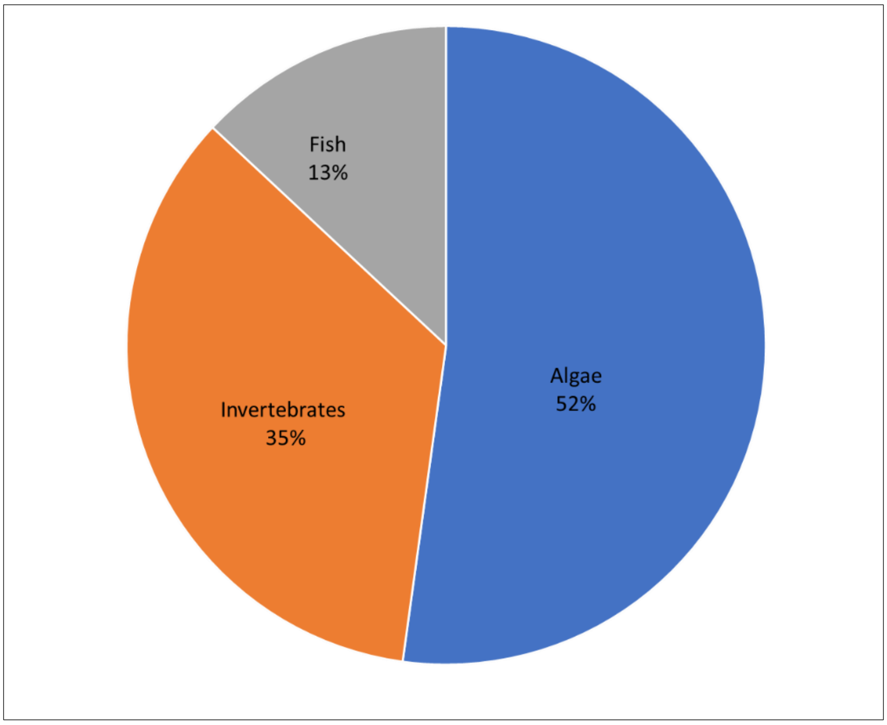

Fig.12: Marine biodiversity abundance of the macrophytes, invertebrates and fish in the amphorae dive site.

Table. 5. Marine species recorded in Cavtat – Amphorae dive site.

A/A	Macrophytes - Macroalgae	Invertebrates	Fish
1	*Posidonia oceanica*	*Axinella verrucosa*	*Diplodus sargus*
2	*Acetabularia acetabulum*	*Cacospongia mollior*	*Serranus cabrilla*
3	*Halimeda tuna*	*Cliona celata*	*Muraena helena*
4	*Hildenbrandia rubra*	*Halocynthia papillosa*	
5	*Hydrolithon cruciatum*	*Reteporella grimaldii*	
6	*Lithothamnion valens*	*Schizomavella mamillata*	
7	*Mesophyllum alternans*	*Spongia officinalis*	
8	*Penicillus capitatus*	*Hacelia attenuata*	
9	*Peyssonnelia rosa-marina*		
10	*Peyssonnelia squamaria*		
11	*Sporochnus pedunculatus*		
12	*Zanardinia typus*		

Table 6. Marine species abundance (N) and covered percentage recorded by the quadrat camera for the most common species abundance (N) over 10 in Cavtat, Amphorae site.

	Cavtat_Amphorae site		
A/A	**Species names**	**Abundance (N)**	**Covered Area %**
1	*Zanardinia typus*	12	2,350
2	*Posidonia oceanica*	15	11,750
3	*Peyssonnelia squamaria*	23	8,730
4	*Hydrolithon cruciatum*	29	8,130
5	*Mesophyllum alternans*	32	11,170
6	*Peyssonnelia rosa-marina*	50	22,370

2. Cavtat - Pithos

Thirty-two (32) marine species in total were recorded in the Dulia - Pithos dive site in Cavtat (Fig. 13, Table 4). Using the photoquadrat camera, a total area of 214.400 cm^2 was photographed (134 frames X 1.600 cm^2). Specifically, 16 species of macrophytes (1 species: Posidonia oceanica) and macroalgae (15 species) together were recorded, whereas another 14 species of invertebrates were identified as well. Moreover, 2 fish (*Chromis chromis* and *Coris julis*) were recorded from the video (table 7).

Seagrass meadows (Posidonia oceanica) were found to be more abundant 26% in the dive site between the pithoi and the Rhodophyta (*Lithophyllum racemus*, *Lithothamnion valens*, *Peyssonnelia squamaria*, *Mesophyllum alternans* and *Hydrolithon cruciatum* were found the second most abundant species between, on and under the pithoi. *Pinna nobilis* was also found alive in the dulia site (Fig. 14, Table 8).

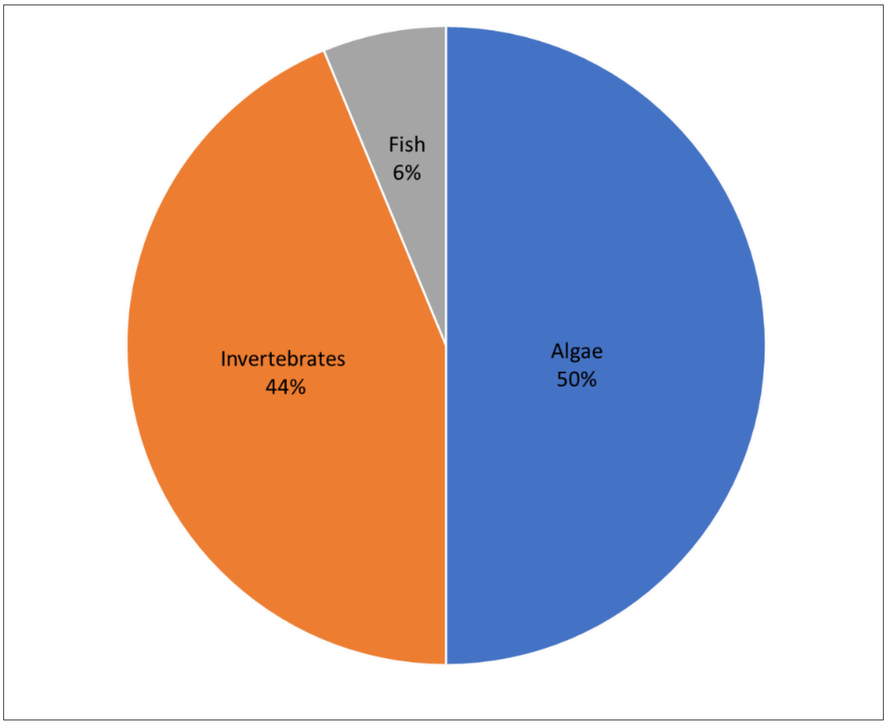

Fig. 13: Marine biodiversity abundance of the macrophytes, invertebrates and fish in the Pithos dive site.

Table 7. Marine species recorded in Cavtat – Pithos dive site.

A/A	Macrophytes - Macroalgae	Invertebrates	Fish
1	*Posidonia oceanica*	*Aglaophenia harpago*	*Chromis chromis*
2	*Bangia atropurpurea*	*Aglaophenia pluma*	*Coris Julis*
3	*Cystoseira amentacea*	*Aphrodita aculeata*	
4	*Cystoseira foeniculacea f. latiramosa*	*Aplysilla rosea*	
5	*Flabellia petiolata*	*Axinella verrucosa*	
6	*Halimeda tuna*	*Cacospongia mollior*	
7	*Hildenbrandia rubra*	*Cliona celata*	
8	*Hydrolithon cruciatum*	*Ircinia variabilis*	
9	*Lithophyllum racemus*	*Petrosia ficiformis*	
10	*Lithothamnion valens*	*Pinna nobilis*	
11	*Mesophyllum alternans*	*Sabella pavonina*	
12	*Peyssonnelia rosa-marina*	*Sarcotragus spinosulus*	
13	*Peyssonnelia squamaria*	*Antedon mediterranea*	
14	*Pseudochlorodesmis furcellata*	*Echinaster sepositus*	
15	*Sporochnus pedunculatus*		
16	*Zanardinia typus*		

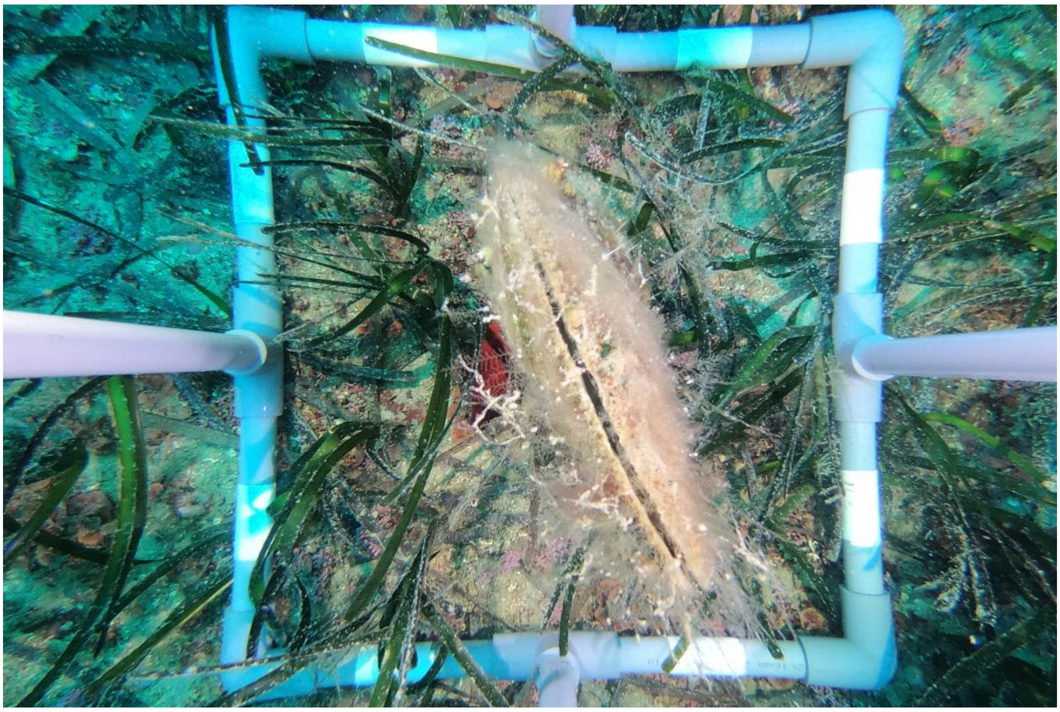

Fig. 14. *Pinna nobilis* as photographed in the Dulia site of Cavtat.

Table 8. Marine species abundance (N) and covered percentage recorded by the quadrat camera for the most common species abundance (N) over 10 in Cavtat – Pithos dive site.

	Cavtat_Pithos site		
A/A	**Species names**	**Abundance (N)**	**Covered Area %**
1	*Sarcotragus spinosulus*	11	1,987
2	*Cliona celata*	13	1,624
3	*Zanardinia typus*	17	0,583
4	*Hydrolithon cruciatum*	20	2,114
5	*Cacospongia mollior*	21	1,491
6	*Mesophyllum alternans*	27	2,608
7	*Peyssonnelia squamaria*	50	5,629
8	*Lithothamnion valens*	55	5,708
9	*Lithophyllum racemus*	83	6,914
10	*Posidonia oceanica*	121	77,733

C. Greece

1. Alonnisos

Thirty-one (31) marine species in total were recorded in Peristera shipwreck (Fig. 15, Table 9). Specifically, 11 species of macrophytes (1 species – *Posidonia oceanica*) and macroalgae (10 species) together were recorded, whereas another 9 species of invertebrates were identified as well. Using the photoquadrat camera, a total area of 108.800 cm^2 was photographed (68 frames X 1.600 cm^2). Moreover, 11 species of fish were recorded from the video (Table 9).

The species from macroalgae that was found in the most quadrats is *Padina pavonica* at 22%, whereas the invertebrate that presented the highest numbers was *Agelas oroides* at 4%, in the photo-quadrats (Table 10). The videos showed that *Chromis chromis* was one of the most abundant fish in the shipwreck. Many individuals of *Muraena helena* were also observed in the amphorae of the shipwreck.

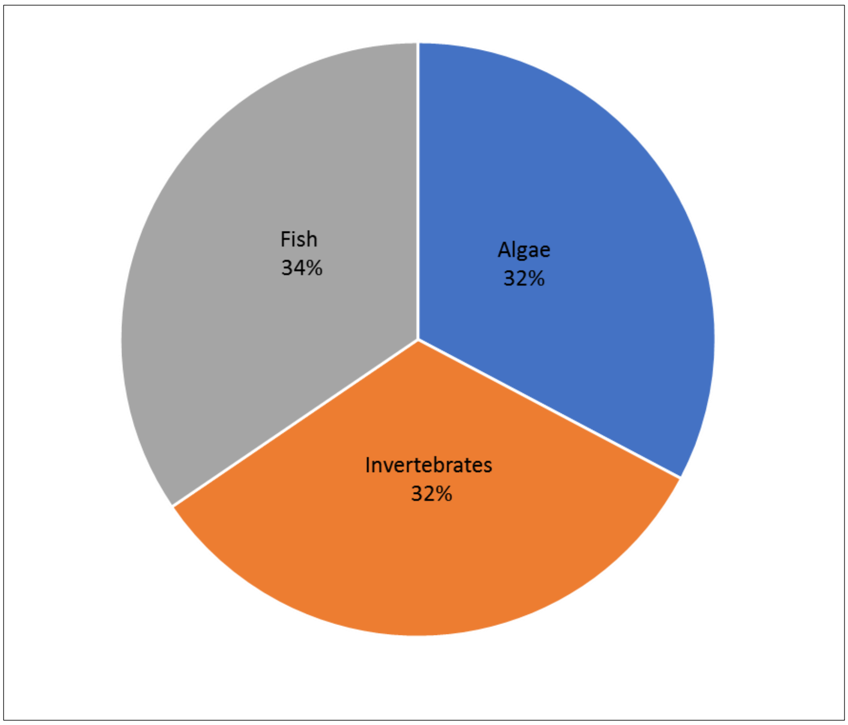

Fig. 15: Count of algae, invertebrates and fish in Peristera dive site.

Table 9. Marine species recorded in Peristera shipwreck.

A/A	Macrophytes - Macroalgae	Invertebrates	Fish
1	*Anadyomene stellata*	*Agelas oroides*	*Apogon imberbis*
2	*Arthrocladia villosa*	*Aplysina cavernicola*	*Chromis chromis*
3	*Dictyota dichotoma*	*Chondrilla nucula*	*Coris julis*
4	*Flabellia petiolata*	*Geodia cydonium*	*Diplodus vulgaris*
5	*Halimeda tuna*	*Hermodice carunculata*	*Muraena helena*
6	*Hydrolithon cruciatum*	*Petrosia (Petrosia) ficiformis*	*Sarpa salpa*
7	*Mesophyllum alternans*	*Pinna nobilis*	*Sciaena umbra*
8	*Lithophyllum racemus*	*Sarcotragus spinosulus*	*Serranus cabrilla*
9	*Padina pavonica*	*Sphaerechinus granularis*	*Serranus scriba*
10	*Posidonia oceanica*		*Sparisona cretense*
11	*Pseudochlorodesmis furcellata*		*Symphodus tinca*

Table 10. Marine species abundance (N) and covered percentage recorded by the quadrat camera for the most common species abundance (N) over 10 in Alonnisos.

Greece_Alonisos site			
A/A	**Species names**	**Abundance (N)**	**Covered Area %**
1	*Pseudochlorodesmis furcellata*	16	6,757
2	*Flabellia petiolata*	21	7,149
3	*Halimeda tuna*	35	13,464
4	*Posidonia oceanica*	36	10,513
5	*Padina pavonica*	60	19,871

2. Cape Glaros

In total, 33 species of marine organisms were recorded during the fieldwork in Glaros shipwreck (Fig. 16, Table 11). Using the photoquadrat camera, a total area of 99.200 cm^2 was photographed (63 frames X 1.600 cm^2). Specifically, 11 macroalgae, 16 invertebrates and 6 species of fish were recorded in the shipwreck of Glaros (Table 11). *Halimeda tuna* presented the highest numbers among the macroalgae at 31% within the quadrats, while *Chondrosia reniformis* among the invertebrates, reaching 14% (Table 12).

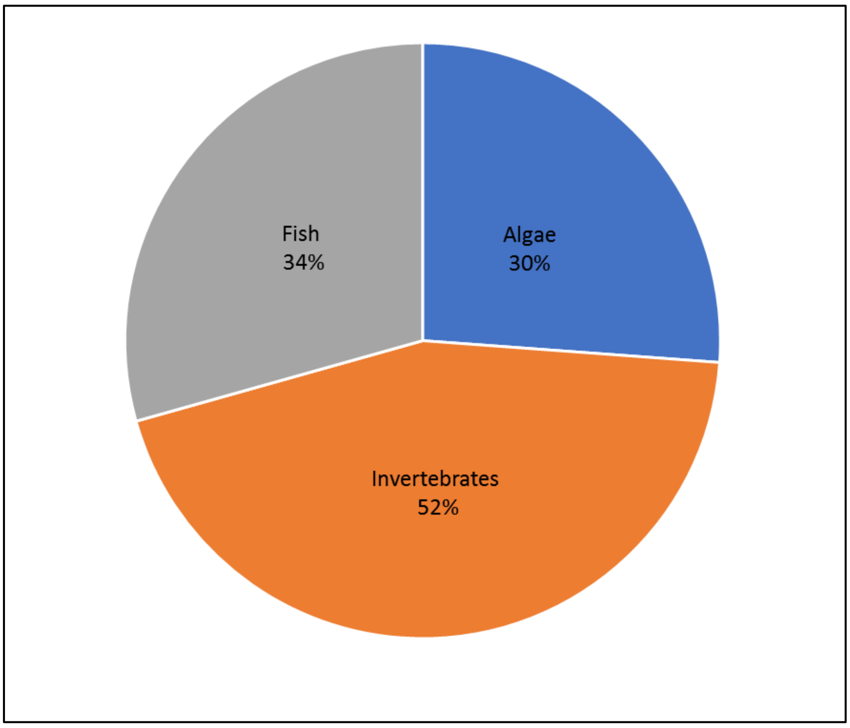

Fig. 16: Count of algae, invertebrates and fish in Cape Glaros dive site.

Table 11. Marine species recorded in Cape Glaros.

A/A	Macrophytes - Macroalgae	Invertebrates	Fish
1	*Codium bursa*	*Agelas oroides*	*Chromis chromis*
2	*Dictyota dichotoma var intricata*	*Aplysina cavernicola*	*Coris julis*
3	*Flabellia petiolata*	*Ascandra contorta*	*Diplodus vulgaris*
4	*Halimeda tuna*	*Axinella cannabina*	*Muraena helena*
5	*Mesophyllum alternans*	*Axinella verrucosa*	*Sciaena umbra*
6	*Lithothamnion valens*		
7	*Padina pavonica*	*Chondrilla nucula*	*Serranus scriba*
8	*Peyssonnelia squamaria*	*Chondrosia reniformis*	
9	*Pseudochlorodesmis furcellata*	*Cladocora caespitosa*	
10	*Sporochnus pedunculatus*	*Cliona celata*	
11	*Terpios gelatinosus*	*Crambe crambe*	
12		*Echinaster sepositus*	
13		*Halocynthia papillosa*	
14		*Marthasterias glacialis*	
15		*Pinna nobilis*	
16		*Protula tubularia*	
17		*Sarcotragus spinosulus*	

Table 12. Marine species abundance (N) and covered percentage recorded by the quadrat camera for the most common species abundance (N) over 10 in Cape- Glaros dive site.

Greece_Glaros Agkirovolio site			
A/A	**Species names**	**Abundance (N)**	**Covered Area %**
1	*Crambe crambe*	10	4,469
2	*Chondrilla nucula*	22	8,333
3	*Codium bursa*	23	10,112
4	*Chondrosia reniformis*	44	16,040
5	*Flabellia petiolata*	61	24,720
6	*Halimeda tuna*	96	14,115

3. Kikinthos

At the shipwreck of Kikinthos one macrophyte (*Cymodocea nodosa*), 5 macroalgae, 9 invertebrates and 5 species of fish were recorded (Fig. 17, Table 13). Using the photoquadrat camera, a total area of 80.000 cm^2 was photographed (50 frames X 1.600 cm^2). The most abundant macroalgae was *Flabellia petiolata* at 22%, whereas the most abundant invertebrate was *Aplysina cavernicola* at 20% in the sampling area (Table 14).

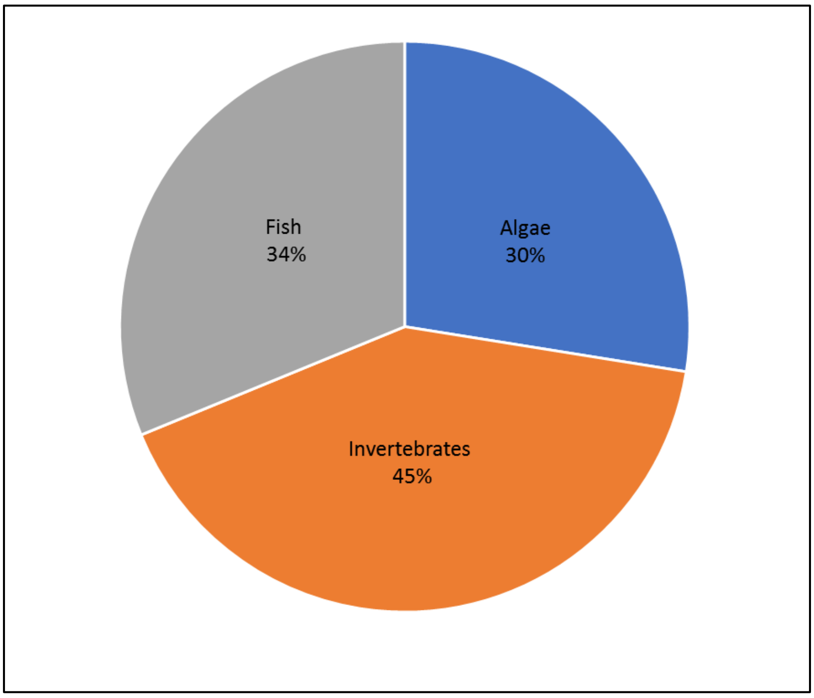

Fig. 17: Count of algae, invertebrates and fish in Kikinthos dive site.

Table 13. Marine species recorded in Kikinthos shipwreck.

A/A	Macrophytes - Macroalgae	Invertebrates	Fish
1	Codium bursa	Agelas oroides	Chromis chromis
2	Cymodocea nodosa	Aphrodita aculeata	Diplodus vulgaris
3	Flabellia petiolata	Aplysina aerophoba	Sarpa salpa
4	Halimeda tuna	Aplysina cavernicola	Seriola dumerili
5	Pseudochlorodesmis furcellata	Arbacia lixula	Serranus scriba
6	Zonaria tournefortii	Chondrilla nucula	
7		Chondrosia reniformis	
8		Condylactis aurantiaca	
9		Sarcotragus spinosulus	

Table 14. Marine species abundance (N) and covered percentage recorded by the quadrat camera for the most common species abundance (N) over 10 in Kikinthos dive site.

Greece_Kikinthos site			
A/A	**Species names**	**Abundance (N)**	**Covered Area %**
1	*Chondrosia reniformis*	10	4,999
2	*Sarcotragus spinosulus*	13	5,132
3	*Chondrilla nucula*	23	12,333
4	*Aplysina cavernicola*	25	13,062
5	*Flabellia petiolata*	27	15,393

4. Tilegrafos

In total, 27 species of marine organisms were recorded in Tilegrafos shipwreck (Fig. 18, Table 15). Using the photoquadrat camera, a total area of 144.000 cm^2 was photographed (90 frames X 1.600 cm^2). Specifically, 8 macroalgae, 15 invertebrates and 4 species of fish were recorded in the shipwreck of Tilegrafos. *Halimeda tuna* and *Codium bursa* were the most abundant macroalgae in the shipwreck of Tilegrafos at 25% both. *Agelas oroides* and *Chondrilla nucula* were the most abundant among the invertebrates with a total of 10% and 9%, respectively.

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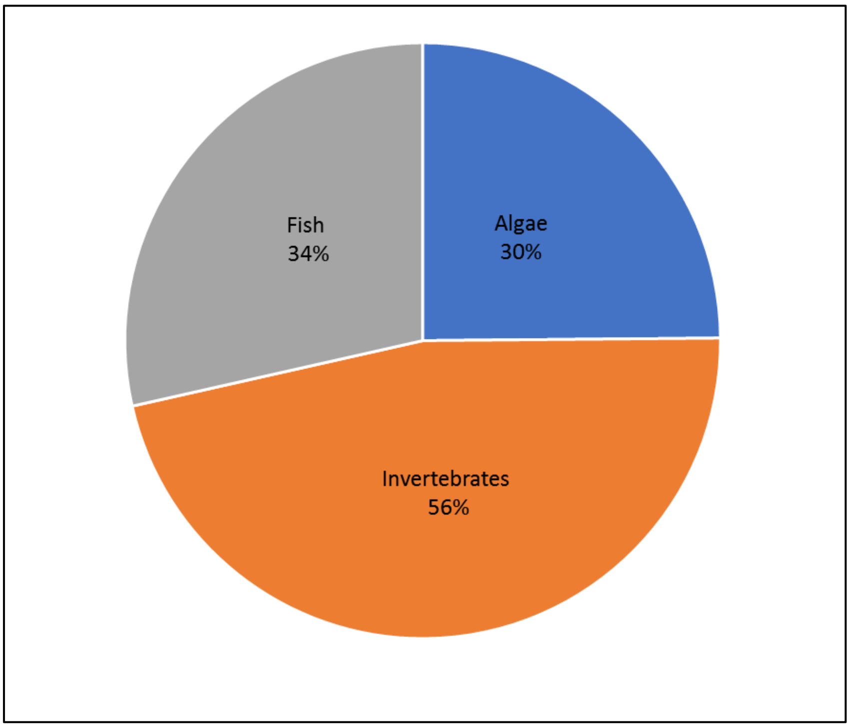

Fig. 18: Count of algae, invertebrates and fish in Tilegrafos dive site.

Table 15. Marine species recorded in Tilegrafos shipwreck.

A/A	Macrophytes - Macroalgae	Invertebrates	Fish
1	*Codium bursa*	*Agelas oroides*	*Chromis chromis*
2	*Dictyota dichotoma var intricata*	*Aplysina cavernicola*	*Coris julis*
3	*Flabellia petiolata*	*Axinella cannabina*	*Diplodus vulgaris*
4	*Halimeda tuna*	*Axinella polypoides*	*Serranus scriba*
5	*Lithophyllum racemus*	*Axinella verrucosa*	
6	*Mesophyllum alternans*	*Chondrilla nucula*	
7	*Padina pavonica*	*Chondrosia reniformis*	
8	*Peyssonnelia squamaria*	*Cliona celata*	
9		*Crambe crambe*	
10		*Halocynthia papillosa*	
11		*Ircinia variabilis*	
12		*Oscarella lobularis*	
13		*Pecten jacobaeus*	
14		*Sarcotragus foetidus*	
15		*Sarcotragus spinosulus*	

Table 16. Marine species abundance (N) and covered percentage recorded by the quadrat camera for the most common species abundance (N) over 10 in Tilegrafos dive site.

Greece Tilegrafos site			
A/A	**Species names**	**Abundance (N)**	**Covered Area %**
1	*Mesophyllum alternans*	10	3,257
2	*Crambe crambe*	19	3,516
3	*Chondrilla nucula*	47	13,505
4	*Agelas oroides*	48	11,182
5	*Flabellia petiolata*	63	17,294
6	*Codium bursa*	124	33,962
7	*Halimeda tuna*	125	33,317

IV. DISCUSSION

A. ITALY

1. Baiae

The marine area of Baiae, as well as the extended area of the Gulf of Naples, is characterized by an immense biodiversity and beauty of volcanology, biology, and archaeology. The Gulf of Naples has a wide range of underwater caves, marine itineraries, and submerged Roman ruins. The water currents of the Gulf of Naples, bring lots of nutrients to the Gulf of Pozzuoli and especially the marine environment of Baiae, constituting Baiae as an area of high marine biodiversity and abundance. Furthermore, the mussel farms located within the Bay of Pozzuoli contribute to increase the nutrients in the water, making them eutrophic. Underwater visibility can sometimes be limited (less than 5m) due to the presence of suspended sediments. However, the high biodiversity of marine life in combination with underwater Roman ruins is very attractive to divers. In addition to this, the shallow waters and the close proximity of the marina to the archaeological marine park of Baiae is further contributing to the attractiveness of the site to divers.

2. Capo Rizzuto

The Marine Protected Area (MPA) of Capo Rizzuto, extends about 15,000 ha. The area includes the shipwrecks and archaeological sites of Cala Cicala, Bengala, Punta Scifo D, and Relittone. The Torre Vecchia Cave is of interest to divers as well. The MPA of Capo Rizzuto is characterized by a mainly rocky bottom with sandy patches. The seagrass Posidonia oceanica is common in the area, stabilizing the seabed, breaking swells and waves, and encouraging the deposit of sedimentary particles. Posidonia is considered to be an indicator species of the overall quality of coastal waters since it is very sensitive to pollution and can only grow in clean unpolluted waters. It supports a wide variety of animal species that use these habitats for breeding, feeding and shelter. Due to the presence of Posidonia, underwater visibility is excellent, making the area very attractive to divers. Further, the wrecks and archaeological sites proved a wide range of depths (from 6m down to 25m) for the divers.

B. Croatia

The Underwater Cultural Heritage (UCH) sites and UCH diving parks in Cavtat, are of the most attractive and biologically rich areas in Croatia for advanced level divers to dive. These amphorae, pithoi and old pots sites harbouring many of the world's plant and animal species and providing important ecological services. The high biodiversity and abundance of marine species found in these areas is often one of the factors that constitutes them very attractive to tourists, as well as snorkellers and divers.

1. Cavtat Cage

From Cavtat in Croatia it is possible to dive one of the biggest amphorae and pithoi sites under water which lie there for 2000 years ago.

Amphorae dive site characterized by high biodiversity and abundance of marine species like sponges, sea anemones, moray eels, starfish, fish, molluscs, seagrass meadows on the seabed and green algae, red algae and brown algae, between, on and under the amphorae. Rhodophyta (*Peyssonellia rosa-marina, Mesophyllum alternans, Peyssonellia squamaria* and *Hydrolithon cruciatum*) were found to be more abundant 73% in the dive site, specifically on and between the amphorae. Important species were recorded in amphorae dive site e.g. *Posidonia oceanica* which is endemic to the Mediterranean Sea and forms large underwater meadows that are an important part of the ecosystem. Tracheophyta (*Posidonia oceanica*) were found the second most abundant species between and next of the amphorae, inside the cage. However, another species *Muraena helena* which recorded from a video is an important fish and is listed in the Red list of Europe and IUCN.

Due to the fact, that the Archeology Department of Cavtat performs periodic maintenance for the conservation of the amphorae and to keep those in an attractive condition for the visitors, more species could have been found.

2. Cavtat Dulia

At another dive site (Pithos) close to the amphorae several huge pithoi can be found. These are huge storage containers which were most probably used to transport water on the ships

Pithos diving site, as the Cage diving site, characterized by high biodiversity and abundance of marine species like sponges, sea anemones, moray eels, starfish, fish, molluscs, seagrass meadows on the seabed and green algae, red algae and brown algae, between, on and under the pithoi. Seagrass meadows (*Posidonia oceanica*) were found to be more abundant 26% in the dive site. *Posidonia oceanica* is an important habitat-forming species and provides habitat for many species. Nursery grounds for the juveniles of many commercially important fishes and vertebrates. The Rhodophyta (*Lithophyllum racemus*, *Lithothamnion valens*, *Peyssonnelia squamaria*, *Mesophyllum alternans* and *Hydrolithon cruciatum* were the second most abundant species between, on and under the pithoi.

C. Greece

1. Alonnisos

Peristera is the largest and most important Classic Age shipwreck that is legally recognized as Underwater Museum in Greece but is also an important habitat and refugee for many marine organisms. Important species were recorded in Peristera shipwreck e.g. *Posidonia oceanica* which is endemic to the Mediterranean Sea and forms large underwater meadows that are an important part of the ecosystem. It is a priority habitat *1120 in the Habitats Directive (92/43/EEC) and it is included in Annex II of the Bern Convention as species of flora strictly protected. *Muraena helena* is also an important fish and is listed in the Red list of Europe and IUCN. *Sciaena umbra* that was recorded in the shipwreck is categorized as Near Threatened (NT) in the list of IUCN. Hence, Peristera shipwreck is a significant underwater museum, important habitat for marine life and a beautiful diving site.

2. Cape Glaros

Glaros Cape is located in an area opposite of Nies, a coastal village in the prefecture of Magnesia and close to the city of Amaliapolis. Amaliapolis is located near Almiros and 54 kilometers from Volos, on the western coast of the Pagasetic Gulf. Glaros found to be one of the most abundant areas in the Pagasetic Gulf hosting 33 species of 10 macroalgae, 17 invertebrates and 6 different fish species. It is really worth visiting the site and diving among the plentiful and varying objects indicative of ancient cargoes and get close to the beautiful marine species that call this area home such as the *Muraena helena* and the *Sciaena umbra* which are listed in the Red list of Europe and IUCN.

3. Kikinthos

The islet of Kikinthos is a natural breakwater, lying at the east of Amaliapolis bay, on the west side of the Pagasetic gulf. The remnants of a Byzantine shipwreck cargo of mainly pithoi (large storage containers) are located at around 3 to 11 metres from the seabed hosting a diversity of marine life. Diving in Kikinthos the visitor will have the chance to get close to important marine species such as the *Cymodocea nodosa* which is protected by the Bern Convention and Barcelona Convention and if lucky to encounter the fast-swimming *Seriola dumerili*.

4. Tilegrafos

Tilegrafos Bay is located in the prefecture of Magnesia and close to the city of Amaliapolis. Hosting 27 different species Tilegrafos constitutes an important habitat for marine life where the diver will not only dive into history but also enjoy the diverse and beautiful marine environment the area has to offer.

V. CONSERVING THE MARINE ENVIRONMENT

Coastal-marine environments are some of the most biologically diverse areas on Earth, harbouring many of the world's plant and animal species and providing important ecological services. They are also destinations to hundreds of millions of people who either live near or visiting coastal-marine areas, and the pressure they put on these ecosystems, is intense. Many activities taking place such as diving, snorkelling, recreational fishing, and cruising may have a negative impact and cause extensive damage to important near-shore marine ecosystems.

Responsible marine activities, especially in protected UCH sites, are critical to both preservation unique ecosystems and the continued economic health of the local communities. Adopting good practices can help protect the integrity of the unique landscapes, habitats and species that attract visitors in the first place and sustain the high-quality visitor experiences that will ensure the ongoing financial viability of local businesses.

Best practices for the use of the marine protected UCH sites include: boating practices (proper anchoring, boat operation and maintenance, boat sewage and garbage disposal), snorkelling/diving/scuba diving, as well as recreational fishing. Analytical guidelines for promoting these best practices, are provided in Deliverable 4.3.5 – Training methodology for pilot training courses aimed at target groups (PAs, UMs, MPAs, DPs, tourism and diving industry, etc.) of the project.

Indices for monitoring the marine environment, as specified by the European Union, can be applied by the authorities at the pilot sites as a tool for monitoring change. Two main legislative tools are proposed by the EU for the monitoring of marine environment: the Water Framework

Directive (2000/60/EC) and the Marine Strategy Framework Directive (2008/56/EC). Specifically, the Water Framework Directive (2000/60/EC) proposes specific quality elements for the classification of ecological status of coastal waters, while ANNEX I of Marine Strategy Framework Directive (2008/56/EC) lists the Qualitative descriptors for determining good environmental status. Analytical guidelines for monitoring, are provided in Deliverable 4.4.3 – "Impact checklists developed (incl. climate change) and report on measured environmental impact to marine ecosystem after completion of pilot activities" of the project.

A consideration should be given to both directives, in order to establish a monitoring protocol for each area. Since the publication of these directives a lot of biological indices have been produced. A biological element that is abundant in most of the pilot areas and could be used as biological index is Posidonia oceanica. Two examples of biological indices that use Posidonia oceanica for the evaluation of the ecological status of water are POMI (Romero et al., 2007) and BiPo (Lopez y Royo et al. 2010).

VI. REFERENCES

Font T., Lloret J., Piante C. 2012. Recreational fishing within Marine Protected Areas in the Mediterranean. MedPAN North Project. WWF-France. 168 pages

Office of Ocean and Coastal Resource Management, NOAA Ocean Service. 2011. Marine Protected Areas and Recreational Fishing. Available at: https://nmsmarineprotectedareas.blob.core.windows.net/marineprotectedareas-prod/media/archive/pdf/helpful-resources/mpas_rec_fish.pdf [Accessed 12 Feb. 2019].

Preskitt, L.B., P.S. Vroom, and C.M. Smith. 2004. A rapid ecological assessment (REA) quantitative survey method for benthic algae using photoquadrats with scuba. Pacific Science 58(2): 201-209.

United Nations Environment Programme, Conservation International, Rainforest Alliance. 2015. Guide to Good Practices for Sustainable Tourism in Marine-Coastal Ecosystems. Available at: https://ra-training-library.s3.amazonaws.com/galapagos_guide.pdf [Accessed 12 Feb. 2019].

WWF-Germany. 2007. Coastal Conservation and Tourism. Available at: https://mobil.wwf.de/fileadmin/fm-wwf/Publikationen-PDF/Coastal_Conservation_and_Tourism_-_WWF_Marine_Tourism_Benchmarks.pdf [Accessed 12 Feb. 2019].

Greek News Agenda © 2015 http://www.greeknewsagenda.gr/index.php/topics/culture-society/6964-underwater-museums [31 May 2019].

Trygonis, V., Sini, M., 2012. photoQuad: a dedicated seabed image processing software, and a comparative error analysis of four photoquadrat methods. Journal of Experimental Marine Biology and Ecology 424-425, 99-108. doi:10.1016/j.jembe.2012.04.018

EUROPEAN UNION, (2000), European Commission Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for community action in the field of water policy, Off. J. Eur. Union, 2000; L327: 1-72.

EUROPEAN UNION, (2008), Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008, establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive). Off. J. Eur. Union, 2008: L164: 19-40.

LOPEZ Y ROYO C, CASAZZA G, PERGENT-MARTINI C, Pergent G (2010) A biotic index using the seagrass *Posidonia oceanica* (BiPo), to evaluate ecological status of coastal waters. Ecol Indic 10: 380–389.

ROMERO J., MARTINEZ-CREGO B., ALCOVERRO T., PEREZ M. (2007) - A multivariate index based on the seagrass *Posidonia oceanica* (POMI) to assess ecological status of coastal water under the Water Framework Directive (WFD). Mar. Pollut. Bull., 55: 196 -204.