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Titel der Diplomarbeit / Title of the Diploma Thesis

„Evaluation of the state of conservation of the coastal detritic bottom within the Port-Cros National Park (Northwestern Mediterranean Sea, France)“

verfasst von / submitted by

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Content

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2. Introduction

The Port-Cros National park created in 1963 is one of the oldest National parks of France. In 2012 the National park has been reconfigured and includes now all the area between the peninsula Giens to the cape Lardier including the three islands Port-Cros, Porquerolles and Le Levant, containing 150 000 ha including more than 120 000 ha of marine surface (Parc National de Port-Cros 2014).

This extension of the park is one of the reasons for commissioning a new research that helps to better understand this new territory. The last actualization of the map and description of the different marine habitats was made in 2011 with a focus on the communal habitats (European Framework 92/43/CEE) such as the coralligenous, posidonia meadows, infralittoral rocks with photophilous algae and mediolittoral and supralittoral rocks. The coastal detritic assemblages were as well included in this study but as they are not a communal habitat they weren´t considered further (Bonhomme *et al*. 2011; Bensettiti *et al*. 2004). But the detritic zone situated around the island of Port-Cros is particularly interesting because no bottom-trawling was allowed since 1963.

The coastal detritic bottoms are a habitat that concern soft bottoms and are located in the circalittoral, immediately after the lower infralittoral and reaches until the deep sea. That's also the reason why the substrate is composed of debris from the infralittoral and the neighboring habitats of the circalittoral such as fragments of rock, shells or bryozoans (Peres and Picard 1964).

According to Peres and Picard (1964) it is composed of eight different associations such as associations of maerl or *Osmundaria volubilis.*

This habitat can be very diverse and its diversity can inform about physical-chemical disturbances and as well of biological disturbances such as invasive species (Bonhomme *et al*. 2011).

Its characteristic species are primarily algae especially calcareous algae from the order Corallinales and the genus Peyssonnelia. (Peres and Picard 1964).

Another very abundant alga is the invasive species *Caulerpa cylindracea*, which was introduced in 1990 from south-western Australia and can nowadays be considered as one of the most harmful invasive macrophyte species in the Mediterranean Sea (Klein and Verlaque, 2008).

The SYMBIOSIS project was commissioned by the Port-Cros National park and is realized by the GIS Posidonie. The goal of this project is to define the state of conservation of the coastal detritic assemblages within the National park.

In context of this project a new method has been invented due to high costs of a Remote Operated Vehicle (ROV) investigation method. This much cheaper BioCube permits as well the examinations of deeper depths of the coastal detritic bottoms.

The whole project is a project for two years finishing in October 2016, for this reason, only the goals of this work will be treated.

The aim of this study is the characterization of the state of conservation of the coastal detritic bottoms within the Port-Cros National park with specific attention to the invasive species *Caulerpa cylindracea* and a critical analysis of the practicability of the methods of characterization, given that these methods are used for the first time.

3. Materials and methods

3.1. Study area and efficacy of sampling

Within the Port-Cros National park 5 sites have been examined: the three islands Porquerolles, Port-Cros and Le Levant as well as the cape Lardier and the Giens peninsula (Figure 1).

In these five sites 13 radials have been chosen and distributed as good as possible with the aid of bathymetric data and maps of existing marine habitats. As the island Le Levant is a military zone a forecasted 14th station at the south of the island could not be realized as it was positioned in a prohibited area. Finally two stations at Giens, three at Porquerolles, four at Port-Cros, three at the Levant and two at the cape Lardier could be sampled.

For each site two to five radials were realized. A radial is composed of three stations at different depths. The chosen profundities are 40 m, 60 m and 80 m depth due to its positioning between the inferior limit of Posidonia meadows and the deep-sea.

Before the BioCube was used for SYMBIOSIS it was tested in the bay of Marseille the 8th of September 2015. Tests were made at 40 and 60 meters depth. Two divers accompanied the BioCube to verify its position. This permitted to make some improvements before its first scientific use.

The first missions of sampling were made between the 11th to the 26th of September 2015, with some breaks in between due to uncertainty of the weather. For the same reason the last samples (Porquerolles) were collected not till the 22th and 23th of October.

The position of the stations was adjusted on-site with the aid of a hand sensor, depending on the bathymetry of the ground. Eventually some stations at 80 m depth couldn’t be carried out because 80 m depth were untraceable because of the low slope of the continental shelf. At some stations it wasn’t even possible to find 60 m depth therefore some stations were sampled at 40 m and 50 m depth. Finally 39 dives with the BioCube and 14 scuba dives have been realized (Figure 1, Table 1 and Table 2).

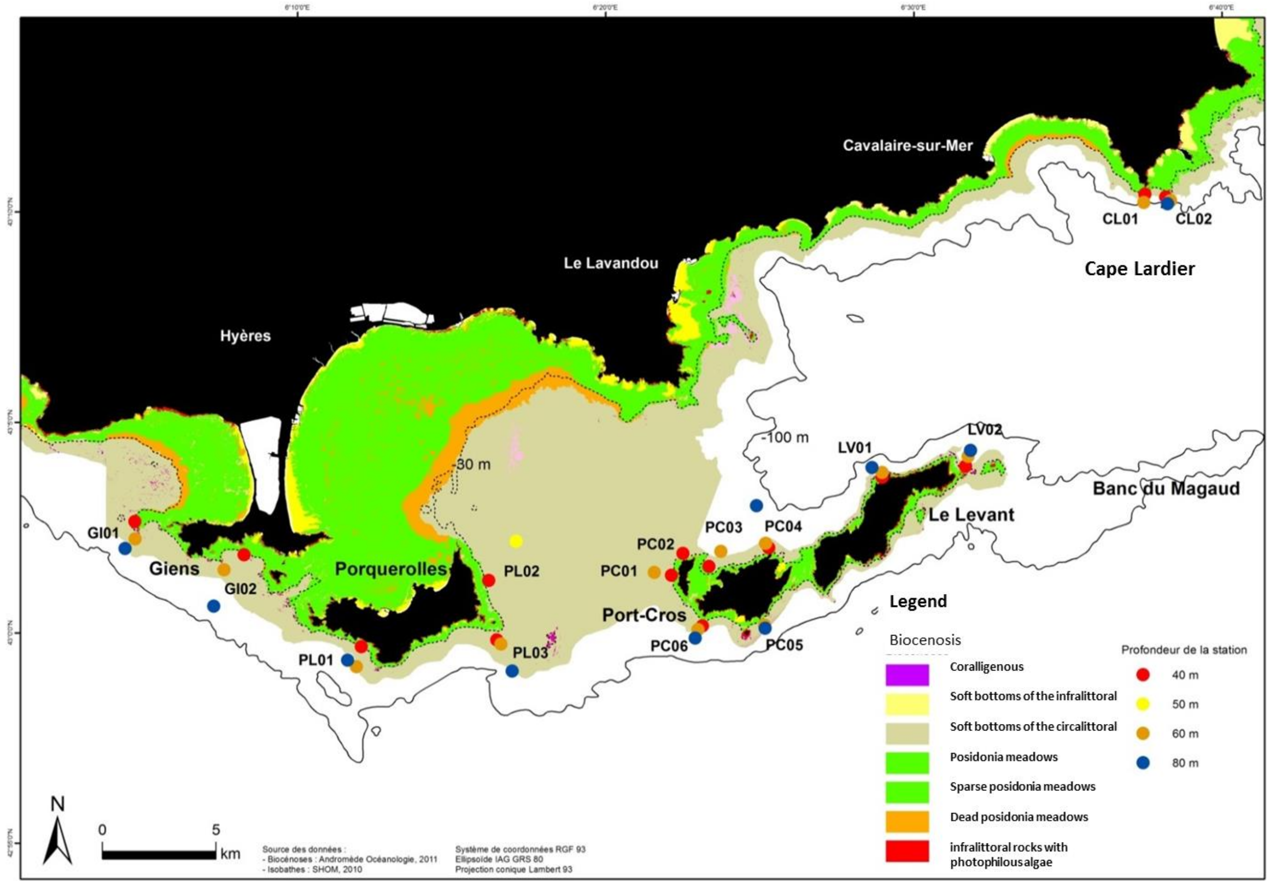

Figure 1. Location of data collections at 40, 60 and 80m depth within the 5 different sites of investigation

These missions allowed us to get almost 16 hours of videos material, 1191 workable pictures plus 136 extra pictures (cannot be used for statistics as the cube is not placed correctly but give some extra information of the station)(Table 1).

Table 1. Synthesis of BioCube dives with the number of selected pictures

Site	N° of the radial	Depth (en m)	Code of the station	Date	Number of the picture-quadrats	Latitude (WGS84)	Longitude (WGS84)
Giens	01	40	GI01_40	11/09/2015	30	43,0423	6,0679833
		60	GI01_60	11/09/2015	39	43,0354833	6,06775
		80	GI01_80	11/09/2015	25	43,0317833	6,062033
	02	40	GI02_40	11/09/2015	33	43,0275167	6,12611667
		60	GI02_60	11/09/2015	29	43,02185	6,115
		80	GI02_80	11/09/2015	30	43,0275333	6,1333
Porquerolles	01	40	PL01_40	23/10/2015	33	42,98975	6,26046
		50	PL01_50	23/10/2015	33	42,98802	6,26264
		80	PL01_80	23/10/2015	26	42,97707	6,26799
	02	40	PL02_40	22/10/2015	29	43,01336	6,25738
		60	PL02_60	22/10/2015	30	43,0285	6,27304
	03	40	PL03_40	22/10/2015	33	42,98926	6,1873
		60	PL03_60	22/10/2015	26	42,98136	6,18416
		80	PL03_80	22/10/2015	34	42,98408	6,17962
Port-Cros	01	40	PC01_40	16/09/2015	31	43,0124	6,35614
		60	PC01_60	16/09/2015	30	43,01383	6,34692
	02	40	PC02_40	16/09/2015	10	43,0209	6,3627
	03	40	PC03_40	15/09/2015	32	43,01525	6,3764
		60	PC03_60	15/09/2015	31	43,02103	6,38332
		80	PC03_80	15/09/2015	30	43,03855	6,40357
	04	40	PC04_40	16/09/2015	31	43,02168	6,40907
		60	PC04_60	16/09/2015	29	43,02346	6,40753
	05	40	PC05_40	24/09/2015	31	42,99312	6040517
		60	PC05_60	24/09/2015	30	42,99105	6,40507
		80	PC05_80	24/09/2015	33	42,98983	6,40522
	06	40	PC06_40	24/09/2015	31	42,99186	6,37163
		60	PC06_60	24/09/2015	30	42,99045	6,36915
		80	PC06_80	24/09/2015	30	42,98716	6,36734
Le Levant	01	40	LV01_40	25/09/2015	30	43,0477	6,47188
		60	LV01_60	25/09/2015	30	43,0495	6,47202
		80	LV01_80	25/09/2015	34	43,05171	6,46666
	02	40	LV02_40	26/09/2015	32	43,05054	6,51724
		60	LV02_60	26/09/2015	33	43,05437	6,51887
		80	LV02_80	26/09/2015	31	43,05669	6,52029
Cape Lardier	01	40	CL01_40	22/09/2015	29	43,15508	6,62068
		60	CL01_60	22/09/2015	37	43,15187	6,61983
	02	40	CL02_40	21/09/2015	32	43,15361	6,63179
		60	CL02_60	21/09/2015	31	43,15207	6,63442
		80	CL02_80	21/09/2015	33	43,15088	6,63268

All the stations could be sampled by scuba diving except the station PC02_40 because of too high currents. The station GI02_40 was sampled but almost uninhabited so that only two samples could be collected. This leads us to 41 samples by a 20 cm x 20 cm frame in order to determinate flora and epi-fauna diversity in species level with a taxonomist help (binocular observations). Nineteen extra samples were collected corresponding to the additional specimen outside of the frame not identifiable on *insitu* (Table 2).

Table 2. Synthesis of scuba dives and samples

Site	Code of the station	Date	Latitude (WGS84)	Longitude (WGS84)	Divers	Samples via square	Extra samples
Giens	GI01_40	31/08/2015	43,0423	6,0679833	ER, JGH	3	1
Giens	GI02_40	31/08/2015	43,0275167	6,12611667	AG, PA	2	0
Porquerolles	PL01_40	23/10/2015	42,98975	6,26046	AG, PA	3	2
Porquerolles	PL02_40	02/08/2015	43,01336	6,25738	JGH, PA	3	2
Porquerolles	PL03_40	22/10/2015	42,98926	6,1873	AG, PA	3	1
Port-Cros	PC01_40	01/09/2015	43,0124	6,35614	JGH, PA	3	2
Port-Cros	PC03_40	01/09/2015	43,01525	6,3764	AG, ER	3	0
Port-Cros	PC04_40	16/09/2015	43,02168	6,40907	ER, PA	3	2
Port-Cros	PC05_40	15/09/2015	42,99312	6,40517	AG, ER	3	1
Port-Cros	PC06_40	15/09/2015	42,99186	6,37163	ER, PA	3	2
Le Levant	LV01_40	25/09/2015	43,0477	6,47188	AG, ER	3	2
Le Levant	LV02_40	26/09/2015	43,05054	6,51724	AG, ER	3	2
Cape Lardier	CL01_40	22/09/2015	43,15508	6,62068	AG, ER	3	1
Cape Lardier	CL02_40	21/09/2015	43,15361	6,63179	AG, ER	3	1

3.2. Data collection

3.2.1. Sample drawing and description of the sites by scuba diving

Material

The Materials used during the scuba dive to realize the sampling and the description of the station are:

- Shovel
- Lockable net
- 20 cm x 20 cm frame
- Freezer bags
- Underwater camera
- Clipboard and pencil
- Spreadsheet on waterproof paper

Method

One dive each was realized at the stations at 40 m depth. A 20 cm x 20 cm frame was randomly thrown on the sea bottom and its content was collected (until 2 cm deep), using the shovel and stored in a freezer bag. Three replicates per station were sampled. Thanks to the special spreadsheet a description of each site and its species (sessile and mobile benthic epimega fauna and flora) could be made directly on site by a second observer. For identifying less abundant species not consisted in the frame an extra collection of these species were made to identify these later in the laboratory.

A camera was used as well to make a picture documentation of the seen species.

After the dive the water in the freezer bags was removed and the samples were labeled and frozen for the present, to conserve them for analysis in laboratory.

The other depths haven't been sampled by scuba-diving because it's too deep for divers.

3.2.2.Examination of the coastal detritic bottom with the BioCube

With the aid of the so called 'BioCube' pictures and videos of the coastal detritic bottom can be realized in depths where diving is no longer feasible. These pictures, thanks to a standardized size can be used to identify species and to determine the percentage of covering of vegetation.

The BioCube

The BioCube is an 80 cm x 80 cm x 100 cm big cube consisting only of the cube edges made of synthetic material. The four lateral faces are strengthened by two crossed metal bars each. The ground area of the cube is open, so that the pictures of the ground can be made unimpaired. To have a better scale on the pictures the ground edges are market every 5 cm with a colored adhesive tape. On the opposite face to the open ground face several parallel metal bars are fixed to attach all the technical equipment.

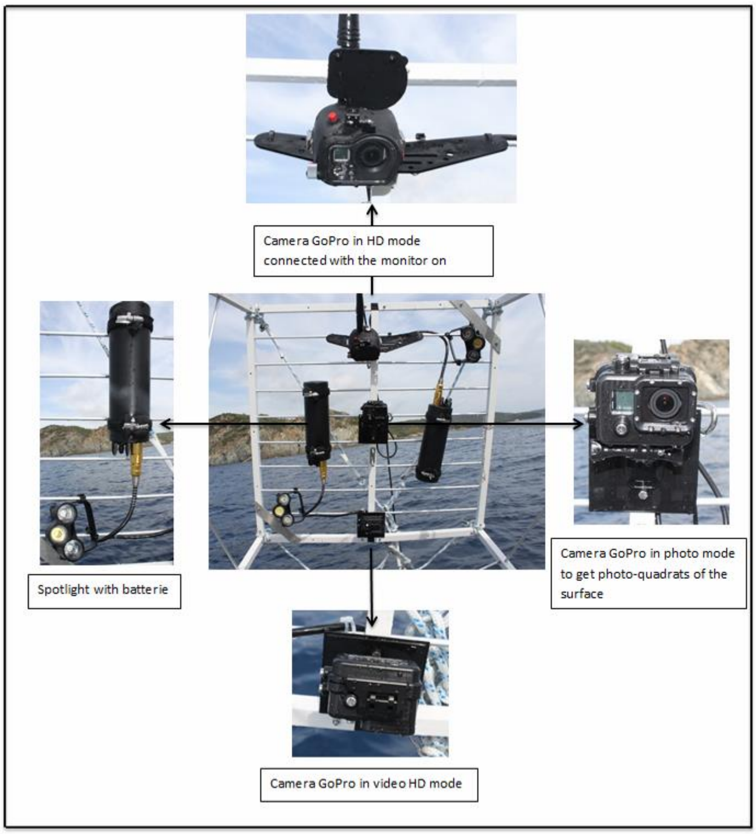

Figure 2. Equipment of the BioCube

The technical equipment consists of two water-resistant spotlights with each an extern battery, a depth gauge, three cameras GoPro with a waterproof case and a monitor connected with one of the cameras (Figure 2).

The depth gauge is located on one of the edges of the ground area, the spotlights and their batteries are located on the top face in two diagonal vertices. One camera is located in the middle of the top face, one on the middle of one edge and the third in the middle of the opposite edge. The camera in the middle is programmed to make a picture every ten seconds. It is angled downwards, so that the whole ground area is visible on the pictures. The other camera is so oriented and programmed, that it films the surroundings without having the cube on its images. The last camera in its specific case is connected with the monitor via a waterproof cable and films a part of the cubes bottom. With the pictures from this camera, the cube can be controlled in real time over the monitor located on the boat.

Four weights of 1kg each are fixed on the bottom of the four lateral edges, favoring the right positioning of the cube.

The whole cube is fixed on a 200 m long rope, on a spool, facilitating to let the cube down in deeper waters.

Method

In each of our three depths (40 m, 60 m, and 80 m depth) 30 pictures have been made if the conditions allowed it, making 90 pictures per radial.

Before putting the cube into the water a hand sonar was used to verify the depth. When the right depth was found the two filming cameras were activated and the camera for taking pictures was activated in accordance with a ten seconds interval (as it is programmed to take a picture every 10 seconds) to control the number of taken pictures. After that the cube was put in the water. By hand, with the aid of the rope it was sunk slowly until the ground was visible on the monitor on board, controlled by another observer. With the instructions of the controlling person the cube was sunk completely. Once a clear and stable image of the ground was visible the time was counted and after at least ten seconds the cube was lifted up several meters. Depending on the currents of the water, the cube derived self-dependent and could be sunk again after several seconds. When the current was too weak it was moved by moving the boat. This procedure had to be repeated until 30 bottom pictures were made.

Then the cube was lifted up completely and the whole procedure started again at the next depth. Of course the time, date and coordinates of each depth were noted as well.

3.3. Treatment of data

3.3.1.Processing of the samples

Identification of algae

The samples were one by one unfrozen with seawater and for the present separated in four categories: fauna, calcareous algae, fleshy algae (all the algae which are not considered as calcareous algae) and *Caulerpa cylindracea* (Figure 3). The fauna was conserved per sample in a mix of seawater and formalin in same proportions. The calcareous algae were dried and then sorted according to visible characteristics (stations not separated, one general list). Some of theme where decalcified with HCl and then identified with the help of Thierry Thibaut a phycologist from the university "Aix-Marseille Université".

Figure 3. Example of aseparated sample, left: fleshy algae on the top and calcareous algae on the bottom, right *Caulerpa cylindracea* on the top and fauna on the bottom

The fleshy algae were immediately sorted as far as possible and then identified (per sample) in collaboration with Marc Verlaque a specialist in macrophytes of the Mediterranean Sea.

Determination of the biomass

Once all *Caulerpa cylindracea* of a sample was isolated it was rinsed with fresh water to remove the salt of the sea water, which could influence the weight of the dried algae. After washing them an aluminum pot was weighed empty and then with the Caulerpa. Then it was dried for at least 48 hours at 60°C before it was weighed again. The same procedure was made for the already identified fleshy algae.

3.3.2.Processing of the pictures

Before the pictures were used they have been sorted out so that only the good placed pictures were used. This is necessary as there are automatically taken pictures in between the right placement of the cube and also to avoid two pictures of the same frame. The selected pictures were cut with Adobe Photoshop CS5.1 and edited with Adobe Lightroom (Figure 4).

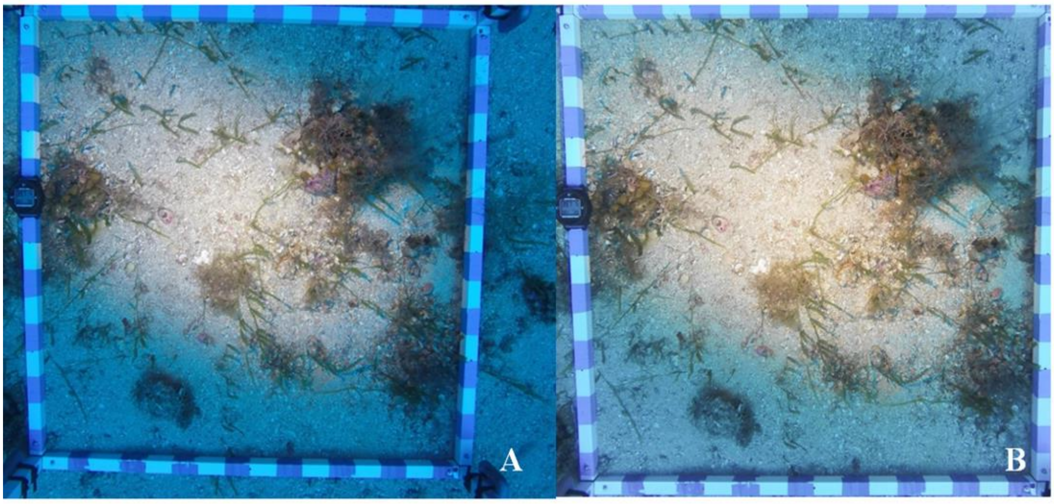

Figure 4. An original picture (A) and after treatment process (B)

Then they were integrated in a database (Figure 5) where they were characterized. Two sections compose the base, one applicable for the whole BioCube-dive and another one only valid for each single picture.

The general section includes the name of the dive, the name of the site, the sighted depth, the geographic coordinates, and the time of the beginning and the end of the dive. There is also a category for a general description of the dive.

For each picture the typology, the substrate, the actual depth and the occurrence of waste and regular and irregular urchin tests was determined. The typology was determined according to the criteria of Peres and Picard (1964). Then the maximum of algae was identified as far as possible using guides (Cabioc'h *et al*. 2014; Conxi *et al*. 2013) and given a percentage of recovery by means of diagrams of frequency according to Baccelle and Bosellini (Charollais and Davaud 1976). The fauna was identified as well but instead of a percentage the number of individuals was given. There is also a space for commentaries.

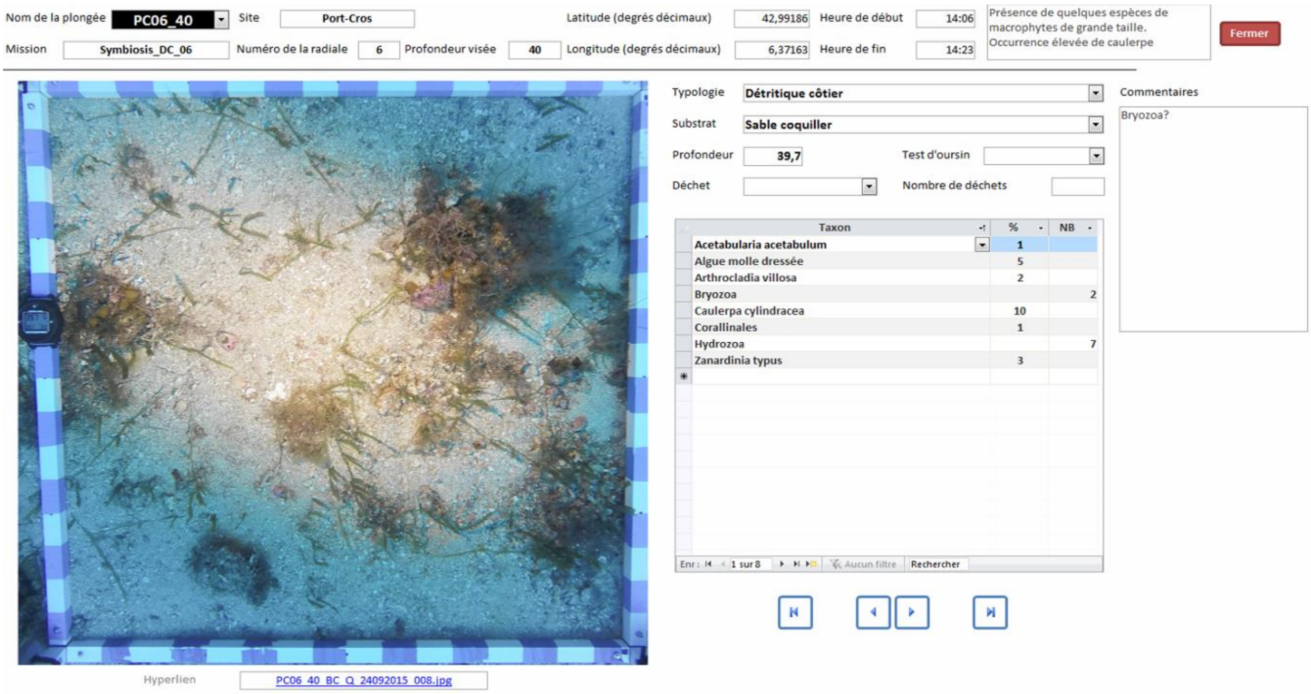

Figure 5. Database used for picture treatment

3.3.3.Calculations and graphs

All the calculations and graphs considering distribution of fauna and flora, the percentage of the organic and inorganic parts, the recovery rate of the Caulerpa and its Biomass and the amount of new species per site were done with Excel. The XYGraphs to compare the correlation between two factors (substrate and recovery rate) and the heatmap to compare all the sites among several categories were made with the language R. To calculate the chao index the lqnguqge R was used as well.

4. Results

4.1. Algae of the coastal detritic bottom samples

All samples have been separated and the biomass of the *Caulerpa cylindracea* has been determinate. For the time being, the flora could be identified on only 17 samples (including GI02 which is not part of the coastal detritic bottom (Table 3). Similarly, not all the calcareous algae been identified, due to its big effort because of the need to decalcifying them.

Table 3. Treatment of the samples

Station	Sample	flora identified	Biommasse Caulerpa	Station	Sample	flora identified	Biommasse Caulerpa	Station	Sample	flora identified	Biommasse Caulerpa
GI01	1		x	PC01	1	x	x	PC06	1		x
GI01	2		x	PC01	2		no caulerpa	PC06	2		x
GI01	3	x	x	PC01	3	x	x	PC06	3	x	x
GI02	1	no fauna	no caulerpa	PC02	1	--------------	--------------	LV01	1	x	x
GI02	2	x	no caulerpa	PC02	2	--------------	--------------	LV01	2	x	x
GI02	3	--------------	--------------	PC02	3	--------------	--------------	LV01	3	x	x
PL01	1	x	x	PC03	1		x	LV02	1	x	x
PL01	2		x	PC03	2		x	LV02	2	x	x
PL01	3		x	PC03	3			LV02	3	x	x
PL02	1		no caulerpa	PC04	1		x	CL01	1		no caulerpa
PL02	2		no caulerpa	PC04	2		x	CL01	2		x
PL02	3	x	no caulerpa	PC04	3		x	CL01	3	x	no caulerpa
PL03	1		x	PC05	1	x	no caulerpa	CL02	1	x	x
PL03	2		x	PC05	2		x	CL02	2		x
PL03	3		x	PC05	3		x	CL02	3	x	x

On the whole 98 species of fleshy algae have been identified. As visible in the Table 4the most abundant group is Rhodophyta (59%), mostly Florideophyceae (98%), followed by Ochrophyta (34%) mostly Phaeophyceae (97%). The smallest group is Chlorophyta (7%) represented by two groups: Chlorophyceae (57%) and Ulvophyceae (43%) (Table 4).

With 17 different species Rhodomelaceae is the most abundant family including six species from the genus *Polysiphonia* and three from the genus *Chondria*. The next abundant family is Chordariaceae with eleven species four of them from the genus *Myriactula* and two from the genus *Elachista*. The family Ceramiaceae includes six species same as the family Dictyotaceae with three species from the genus *Dictyopteris* and two from the genus *Dictyota*. They are followed by the Dasyaceae (5) with three species from the genus *Dasya*. The family Sphaceláriaceaehas has three species of the genus *Sphacelaria*. There are also the families Callithamniaceae, Cutleriaceae and Peyssonneliaceae with three different species each.

Table 4. Register of identified species (only coastal detritic bottom)

Phylum	Class	Order	Taxa	Giens	Porque-rolles	Port-Cros	Le Levant	Cape Lardier
Chlorophyta	Chlorophyceae	Dasycladales	*Acetabularia acetabulum*				x	
		Cladophorales	*Chaetomorpha ligustica*	x				
			Cladophora lehmanniana			x	x	
		Siphonocladales	*Valonia macrophysa*		x	x		x
	Ulvophyceae	Bryopsidales	*Caulerpa cylindracea*	x	x	x	x	x
			Blastophysa rhizopus			x		
		Ulvales	*Entocladia majus*			x		
Ochrophyta	Dictyochophyceae	Sarcinochrysidales	*Chrysonephos lewisii*			x	x	x
	Phaeophyceae	Cutleriales	*Aglaozonia chilosa*	x	x	x	x	
			Cuteria chilosa				x	x
			Zanardinia typus			x	x	x
		Desmarestiales	*Arthrocladia villosa*			x	x	
		Dictyotales	*Dictyopteris lucida*					x
			Dictyopteris polypodioides			x		x
			Dictyopteris sp.			x		
			Dictyota dichotoma	x	x	x	x	x
			Dictyota implexa	x	x	x	x	x
			Taonia atomaria		x			x
		Ectocarpales	*Elachista intermedia*	x			x	
			Elachista stellaris			x	x	
			Feldmannia paradoxoides			x		

Phylum	Class	Order	Taxa	Giens	Porque-rolles	Port-Cros	Le Levant	Cape Lardier
			Kuckuckia spinosa			x	x	
			Myriactula elongata					x
			Myriactula microscopica			x	x	
			Myriactula rivulariae			x		
			Myriactula stellulata		x	x	x	x
			Nemacystus flexuosus			x		
			Spermatochnus paradoxus				x	x
			Zosterocarpus oedogonium		x	x		
			Asperococcus bullosus				x	
			Stictyosiphon adriaticus			x	x	
		Fucales	*Cystoseira spinosa*			x		
			Cystoseira zosteroides				x	
		Sphacelariales	*Choristocarpus tenellus*				x	
			Halopteris filicina		x	x	x	x
			Sphacelaria cf. *rigidula*	x			x	x
			Sphacelaria cirrosa		x	x	x	x
			Sphacelaria plumula	x	x	x	x	x
		Sporochnales	*Nereia filiformis*		x	x	x	
			Sporochnus pedunculatus			x	x	x

Phylum	Class	Order	Taxa	Giens	Porque-rolles	Port-Cros	Le Levant	Cape Lardier
Rhodophyta	Florideophyceae	Acrochaetiales	*Acrochaetium subtilissimum*			x		
		Ceramiales	*Acrothamnion preissii*		x	x	x	x
			Antithamnion cruciatum			x	x	
			Brongniartella byssoides		x	x	x	x
			Callithamnion sp.			x		
			Ceramium codii		x	x	x	
			Ceramium diaphanum				x	
			Chondria capillaris					x
			Chondria mairei		x	x		
			Chondria sp.		x	x		
			Crouania attenuata	x				
			Dasya baillouviana		x			
			Dasya corymbifera		x	x		
			Dasya rigescens			x		
			Eupogodon planus		x	x	x	x
			Halopithys incurva		x		x	x
			Herposiphonia secunda				x	
			Heterosiphonia crispella				x	
			Laurencia sp.		x	x	x	x
			Monosporus pedicellatus			x		
			Myriogramme tristromatica			x		
			Osmundaria volubilis		x	x	x	

Phylum	Class	Order	Taxa	Giens	Porque-rolles	Port-Cros	Le Levant	Cape Lardier
			Osmundea pelagosae		x	x	x	x
			Polysiphonia sp.				x	x
			Polysiphonia biformis	x		x		
			Polysiphonia denudata			x		
			Polysiphonia elongata	x	x			x
			Polysiphonia furcellata				x	x
			Polysiphonia subulifera	x	x	x	x	x
			Pterothamnion crispum	x	x	x		
			Radicilingua reptans	x				
			Rytiphlaea tinctoria		x			
			Seirospora interrupta			x		
			Spyridia filamentosa	x	x		x	
			Womersleyella setacea		x	x	x	x
			Wrangelia penicillata		x	x	x	
		Champiaceae	*Champia parvula*	x				
			Chylocladia verticillata			x		
		Cryptonemiales	*Cryptonemia lomation*	x	x	x	x	x
			Dudresnaya verticillata			x		
			Halymenia floresii		x			
			Jania adhaerens	x	x	x	x	x
			Jania rubens var. *corniculata*					x
			Kallymenia patens		x	x		

Phylum	Class	Order	Taxa	Giens	Porque-rolles	Port-Cros	Le Levant	Cape Lardier
			Kallymenia requienii		x	x		
		Faucheaceae	*Leptofauchea* cf. *coralligena*	x	x	x	x	x
		Gelidiales	*Gelidium* sp.				x	
			Gelidium spinosum				x	
		Gigartinales	*Chondracanthus acicularis*		x		x	
			Contarinia squamariae	x	x	x		
			Feldmannophycus rayssiae		x	x		
			Gracilaria dura		x	x	x	x
			Phyllophora crispa				x	
			Rhodophyllis divaricata			x		
			Sebdenia dichotoma			x		
		Nemastomatales	*Nemastoma dumontioides*		x	x		
		Rhodymeniales	*Lomentaria chylocladiella*			x		
	Stylonematophyceae	**Stylonematales**	*Stylonema alsidii*			x		
Total number of identified species		**98**	**Number of different species per site**	20	65	44	52	35
			Number of samples	1	2	4	6	3
			Average of different species per sample	20	27,25	29,5	15,16	16,33

The identified calcareous algae belong all to the phylum Rhodophyta and the class Florideophyceaeas as most of the algae from the coastal detritic bottom. We can separate them in three orders although the two bigger orders are Corallinales and Peyssoneliales (Table 5).

Table 5. Register of identified calcareous algae

Order	Taxon
Corallinales	*Lithophyllum stictaeforme*
	Spongites fruticulosa
	Lithothamnion corallioides
	Lithothamnion minervae
Peyssonneliales	*Peyssonnelia harveyana*
	Peyssonnelia rubra
	Peyssonnelia squamaria
	Peyssonnelia sp.
	Peyssonnelia rosa-marina
Nemaliales	*Tricleocarpa fragilis*

The species with the highest occurrence (in parentheses) are the followings:

- *Dictyota implexa*(13)
- *Caulerpa cylindracea* (12)
- *Polysiphonia subulifera*(12)
- *Dictyota dichotoma*(11)
- *Leptofauchea* cf. *coralligena*(9)
- *Acrothamnion preissii*(9)
- *Womersleyella setacea (9)*
- *Brongniartella byssoides*(8)
- *Cryptonemia lomation*(8)
- *Halopteris filicina*(8)
- *Laurencia* sp.(8)
- *Osmundea pelagosae*(8)
- *Sphacelaria plumula*(8)
- *Ceramium codii*(6)
- *Eupogodon planus*(6)
- *Jania adhaerens*(6)
- *Pterothamnion crispum*(6)
- *Sphacelaria cirrosa*(6)
- *Aglaozonia chilosa*(5)
- *Arthocladia villosa*(5)
- *Gracilia dura* (5)
- *Myriactula stellulata*(5)
- *Peysonnelia rubra*(5)
- *Sporochnus pedunculatus*(5)
- *Valonia macrophysa*(5)

Species richness

The Figure 6 Figure 6shows us a rarefaction curve presenting the gain of new species with each additional sample. The highest rise we have at the first five samples, with up to 21 new species (third sample). From ten samples the richness in species is stabilized so the curve seems to have an asymptote, almost parallel to the x-axis which permits us to estimate the assyptoyic richness with the aid of the chao index 1. (Figure 6).

According to the calculation: $S_{est\ chao1} = S_{obs} + (f_1(f_1\text{-}1))/(2(f_2+1))$ the estimated richness is 16 (Chao et al. 2013 and Colwell et al. 2011).

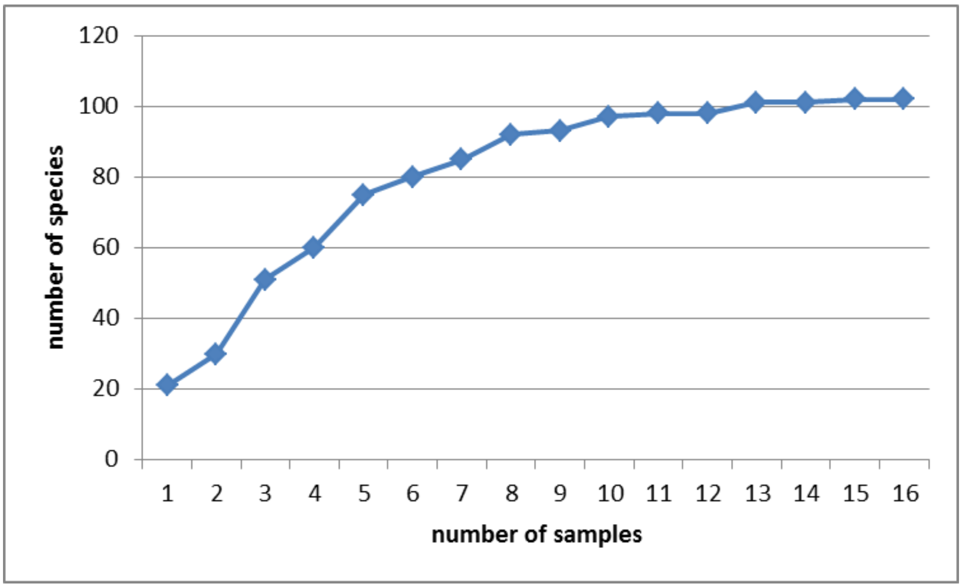

Figure 6. Rarefaction curve according to the number of new identified species with respect to the number of samples

4.2. Invasive species

In the studied coastal detritic assemblages we could trace three invasive species. The Chlorophyta *Caulerpa cylindracea* and the two Rhodophyta *Womersleyella setacea* and *Acrothamnion preissii*, all of them are part of the species with the highest occurrence. As the recovery rate of *Womersleyella setacea* and *Acrothamnion preissii* do not exceed 1% they are not further considered.

Regarding the Caulerpa on the picture quadrates, we can immediately see that there is no Caulerpa at 80 m depth and 60 m depth with the only exception of a small abundance at the stations PC01_60 and PC05_60 (60 m depth). Therefore these two depths are not considered further.

The highest abundance we have at the stations PC03, CL01 PC06, LV02, PL02, PC05 and CL02.No Caulerpa we have at the stations GI02 and PL01 (Figure 8).If we compare this results with the obtained biomass we can see no relation (Figure 7).

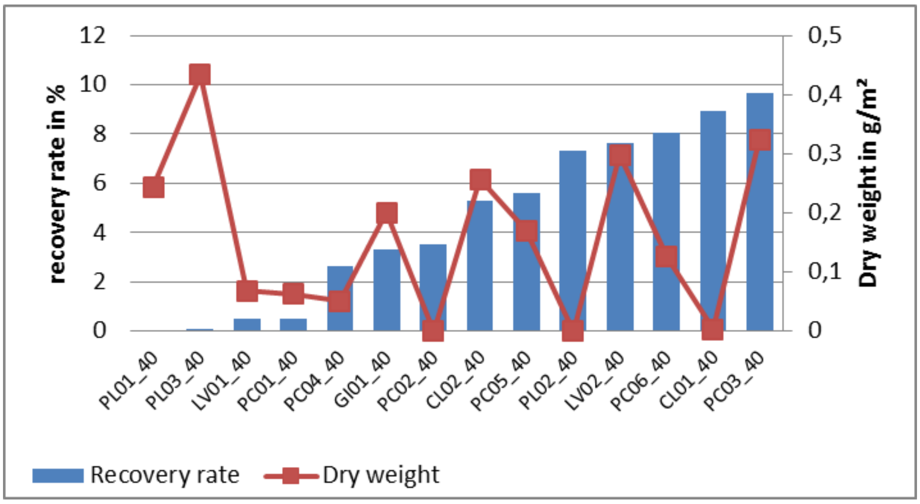

Figure 7. Comparison of the recovery rate (in %) and the dry weight (in g/m²) of Caulerpa cylindracea, respectively with the two techniques picture quadrates and samples

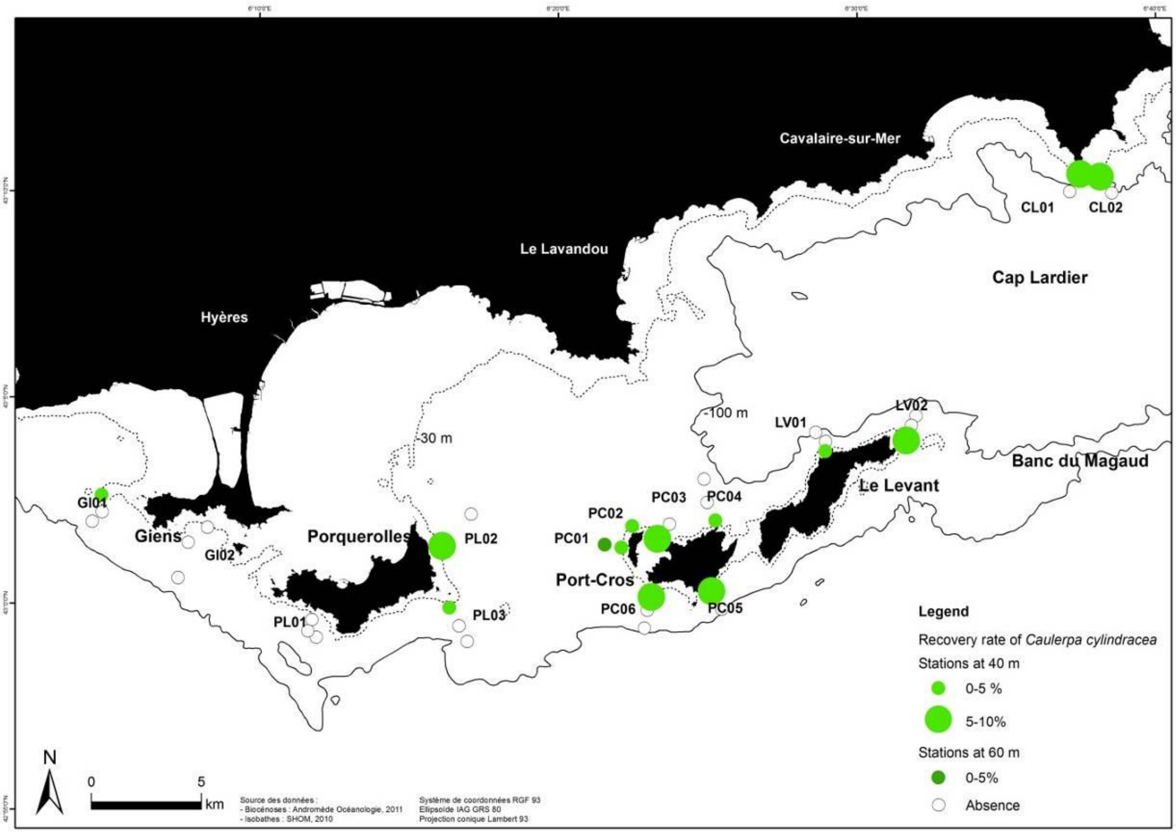

Figure 8. Map of the abundance of the *Caulerpa cylindracea*

4.3. Picture-quadrates

Typology and substrate

The first thing we can observe looking at the map (Figure 9) is that although we tried to sample the coastal detritic bottom that was not always the case. Five stations at 80 m depth and even a whole radial station (40 m, 60 m and 80 m depth) are not part of the coastal detritic bottoms. At most of the stations at 80 m depth we find the shelf-edge detritic bottom. Most of the other stations at 80 m depth considered as coastal detritic bottoms are marginal. Therefore they are not always considered in the following study. Three of our stations are part of the muddy detritic (Peres and Picard, 1964) so that also some stations in smaller depths are not part of the coastal detritic bottom.

Regarding the different substrates, we can find seven categories: sand, shell sand, silty sand, silt, coarse sand and silty sand with shells. There is no visible factor telling us where we find which substrate. The only conspicuity is that almost all the stations are very homogenous considering the substrate. By contrast there is no commonality between the stations of one radial.

The stations not considered as the coastal detritic stations contain all a variety of silt. The same also applies for all the other stations at 80 m depth with the exception of the station PL03_80 (green on the Figure 9).

In Giens shell silt is predominant but apart from this no further conspicuity is visible.

As the characteristic of coastal detritic bottoms are debris, calcareous algae should also be considered as a type of substrate. But as they are also part of the organic recovery in the rest of this study the stations containing more than five % of calcareous algae are only marked with a circle to indicate them as part of the substrate as well.

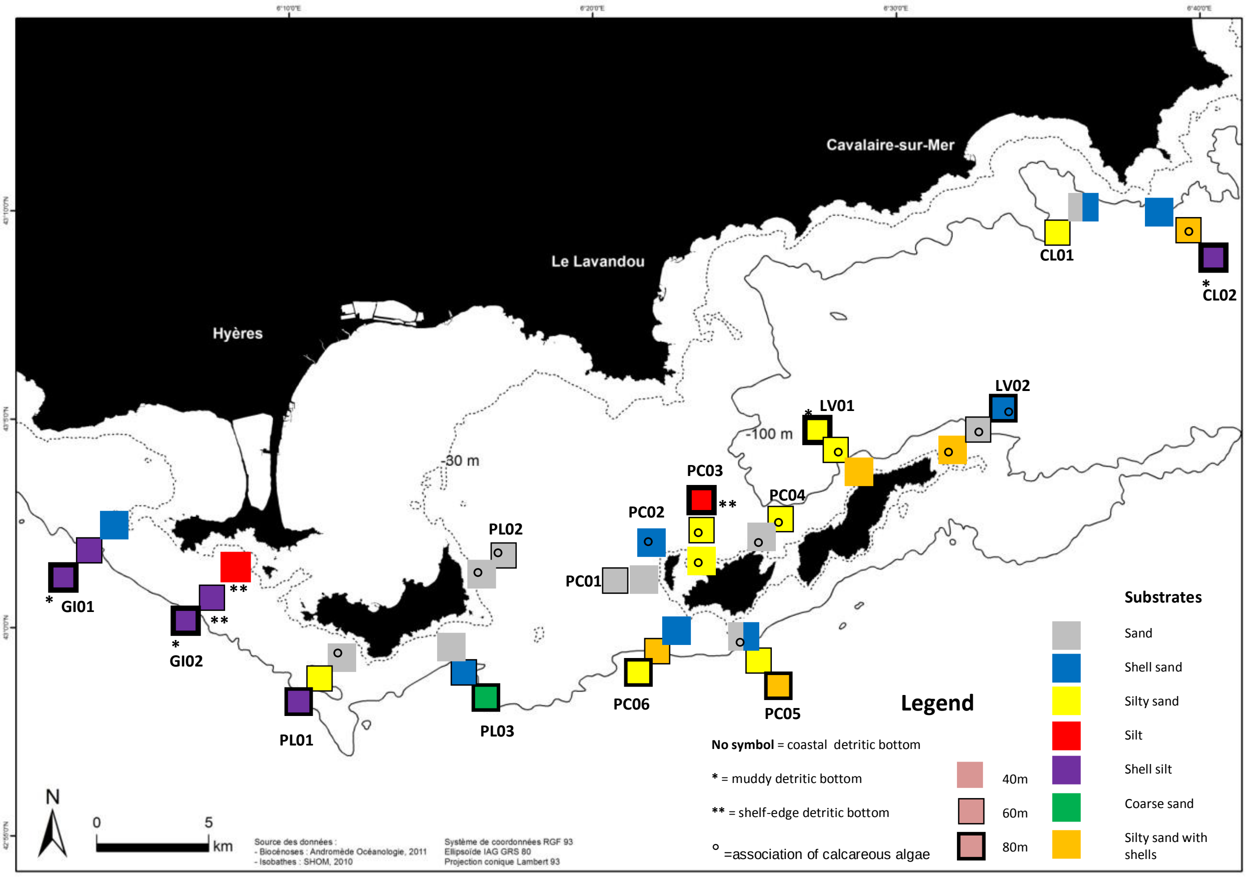

Figure 9. Typology and substrates of the bottom at the sampled stations

The recovery of organic and inorganic fractions of the stations

Like with the different substrates it is hard to find similarities according to the percentage of organic and inorganic fraction recovery between the different stations (Figure 10).

Essentially, the stations at 40 m depth contain a higher organic fraction as the stations at 60 m depth from the same radial station. The huge exception is the station PC05 where the organic fraction at 60 m depth is 48% higher than at the station at 40 m depth. At the stations CL02 (13%), PL02 (11%), PL03 (2%) and PC01 (2%) we can also find a higher percentage of organic recovery at the stations at 60 m depth.

The stations with the biggest part of organic recovery are PC05_60 (71%), PC03_40 (67%), PC02_40 (41%), and LV02_40 (38%). There is a very high amount of organic substances at Port-Cros with the exception of the radial station PC01, which is almost the poorest station at

40 m at all. This station is very similar to the eastern station of Porquerolles (PL03). Giens and the cape Lardier are also not especially high covered with organic matter.

The recovery of dead Posidonia leaves is neither considered as organic nor as inorganic. The two stations PL01_40 (17%) and LV 01_40 (42%) have a protruding high recovery of dead Posidonia leaves.

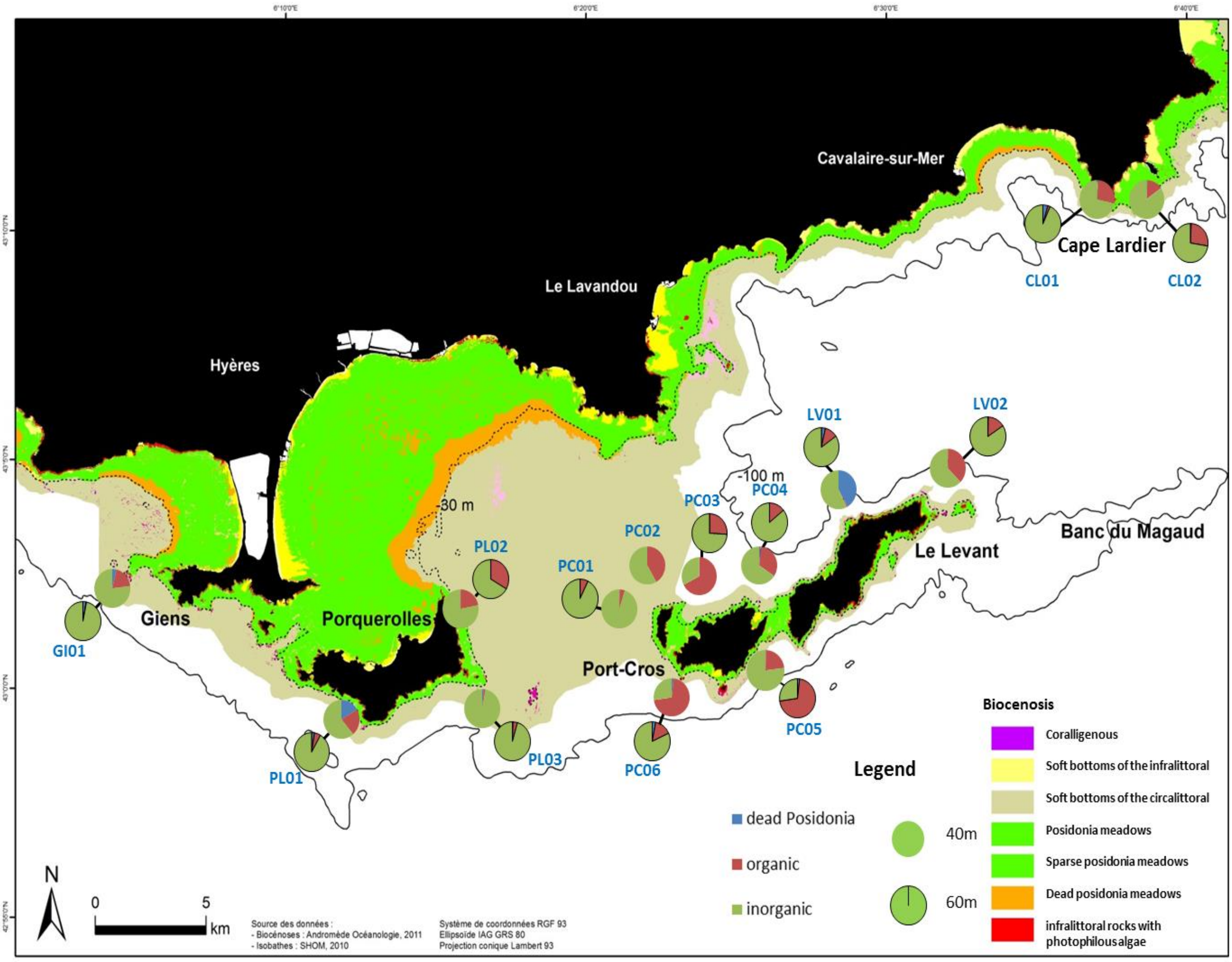

Figure 10. Recovery of organic and inorganic fractions at the stations at 40 m depth and 60m depth

The composition of the organic fractions considering the percentage of the whole picture-quadrate

Regarding the average of the organic composition at 40 m depth for every site as depicted in the Figure 11, Port-Cros (30%) is by far the site with the highest percentage of organic recovery (Posidonia is not included). Giens (19%), Le Levant (19%) and cape Lardier (21%) are very close to each other. The site with the lowest recovery rate is Porquerolles (15%). The occurrence of dead Posidonia is highest at Le Levant (21%). The amount of calcareous algae is highest at Port-Cros (16%) followed by Porquerolles (10%). The amount of fleshy algae is relatively balanced (Giens 14%, Port-Cros 10%, Le Levant 7%, and cape Lardier 11%). The only exception is Porquerolles with only 3%. The recovery of the Caulerpa in between the different sites is also quite balanced (Figure 11).

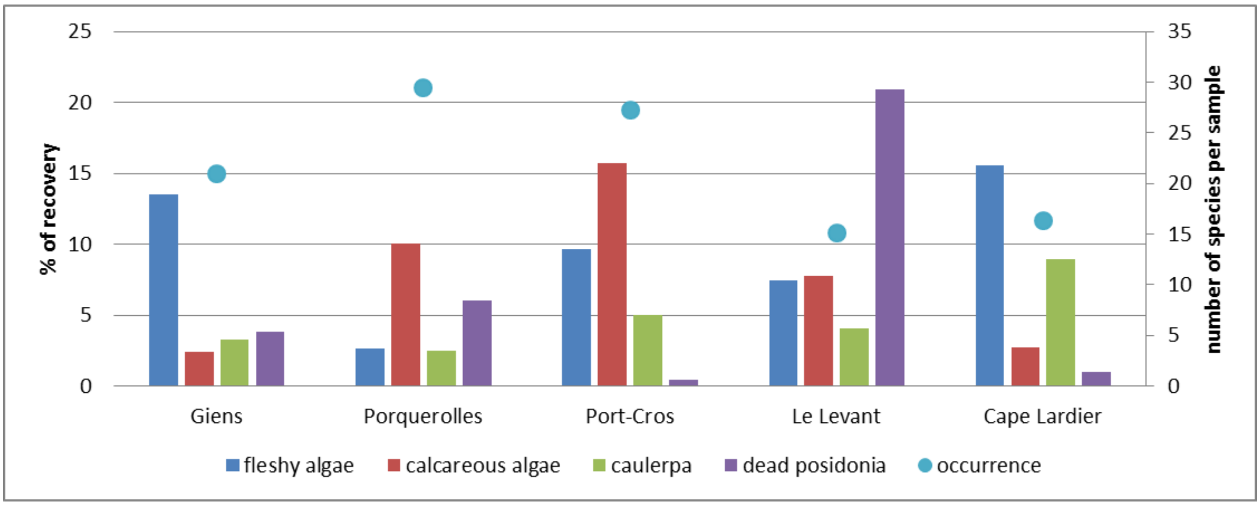

Figure 11. Recovery rate of the coastal detritic bottom via picture quadrates at 40 m depth, guarding the real percentage and occurrence via samples

Although Porquerolles seems to be the poorest station it has the highest amount of species per sample (average of 29,5 species, only fleshy algae). Giens has with 21 also a surprisingly high number of species per sample, Le Levant 15 and the cape Lardier 16. Port-Cros has as expected quite a high number of different species per sample (27).Conspicuous is that it seems to be a relation between the amount of calcareous algae and the occurrence of fleshy algae as we can see at the sites Porquerolles and Port-Cros.

At 60 m depth (Figure 12) Port-Cros is also characterized by the highest percentage of organic recovery (27%). In contrast to its station at 40 m depth the occurrence of fleshy algae (20%) is more important than its occurrence of calcareous algae (6%). Porquerolles, Le Levant and the cape Lardier are with maximum 1% of difference very balanced (between 14 and 15%). These three sites plus Port-Cros are also very balanced in the percentage of calcareous algae (5-7%). Le Levant and the cape Lardier have fleshy algae and calcareous algae nearly in the same amount. Porquerolles is a little richer in fleshy algae (10%). Different than at 40 m depth Giens is by far the poorest site (<1%).

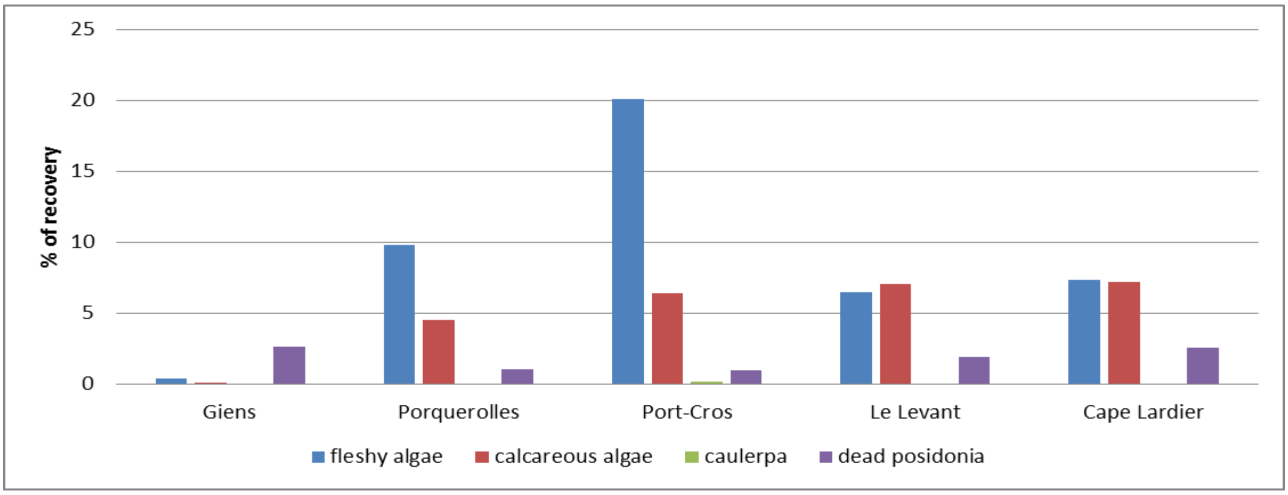

Figure 12. Recovery rate of the coastal detritic bottom at 60m depth, guarding the real percentage

If we take a look at the commonalities of all the stations (also the stations not considered as coastal detritic bottoms) without separating the different depths demonstrated with the help of an heatmap (Figure 13) we note that there are two stations which are very different from the rest of the stations, PC03_40 with 57% of calcareous algae and PC05_60 with 68% of fleshy algae. Excluding these two stations from the comparison we can see that there are basically three big groups. The first group (from bottom to top) is quite a rich group in organic parts and contains two smaller subgroups. One of it contains the stations PC04_40, CL02_60, LV02_40, PC02_40 and PL02_40. They are rich in fleshy algae (13-26%) and as well in calcareous algae (9-15%). The other subgroup only contains the stations PC05_40, GI01_40 and CL01_40. They differ in the amount of calcareous algae which is significantly smaller (2-3%). Both subgroups are rich in *Caulerpa cylindracea* except of the two stations at 60 m CL02_60 and PL02_60 not containing the Caulerpa at all. Almost all the stations are stations at 40 m depth. A correlation of the sites cannot be seen.

The second group is the biggest group and can be separated in three subgroups. The first subgroup (PC06_60, PC04_60, LV02_60 and PC05_80) is very similar to the second subgroup of the first group and contains even a little bit more of calcareous algae (1-7%). The difference is tough that it contains no Caulerpa at all. Noticeable is here, that all these stations are at 60 m depth with one exception (PC05_80).

The next subgroup is the biggest and the poorest subgroup at the same time. It is separable in two big groups. The only difference, between these groups, is that the first group is a little richer in fleshy algae (2-5% to 0-1%). Interesting is, that all of the station not considered as the coastal detritic form part of its second group. In general a lot of the stations of this group are at 80 m depth.

The third subgroup (CL02_40, PC06_40, LV02_80, LV01_60, PC03_60 and PL01_40) is again a little richer in all three categories; especially in calcareous algae (3-11%).

The last group is the smallest group only containing PC03_60 and PL01_40. It is similar than the third subgroup of the second group rich in algae especially in calcareous algae (20%). But in contrast it contains no Caulerpa.

Summing up there is no correlation between the different sites in evidence. It's also not easy comparing the different depths although it shows us, that the percentage of algae is highest at 40 m and 60 m. A clear difference between these two depths is not visible.

The most protruding observation is however, the stations not considered as coastal detritic bottoms although some other stations such as LV01_40 are as well in this same subgroup.

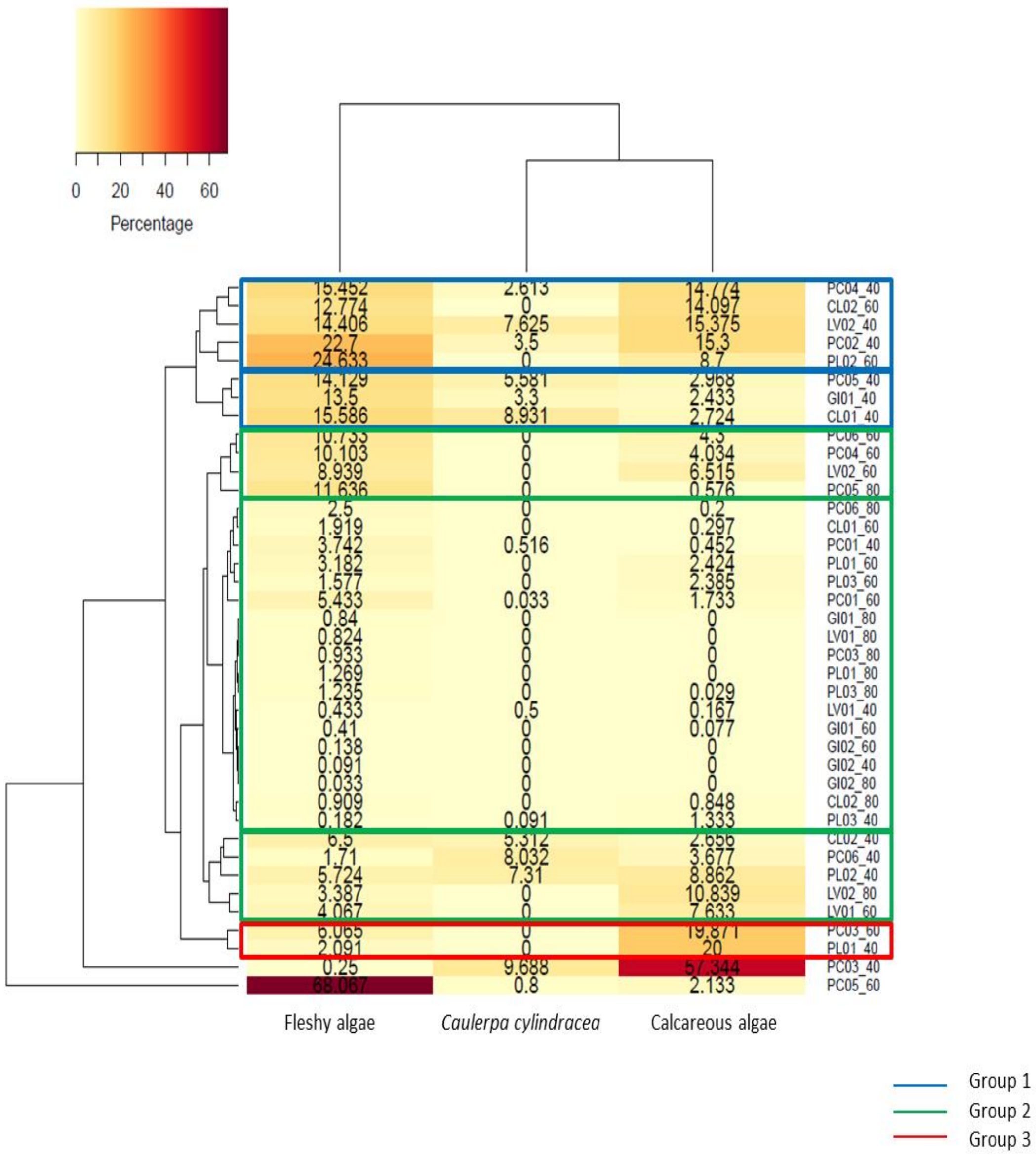

Figure 13. Heat map comparing the different stations and it organic part

Correlation between the substrate and the organic part

As we can see in the figure 14 there is no relation between the substrate and the percentage of the visible organic part. The silty sand has the highest percentage of organic substances. All the others are very widespread from each other (Figure 14).

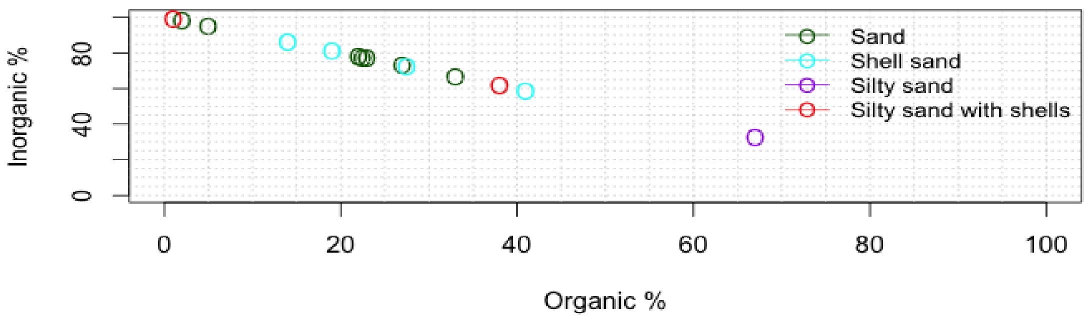

Figure 14. Correlation between the substrate and the organic recovery at 40m

Correlation between the described associations and the organic part

In contrast to the substrate there seems to be a link between the different associations and the percentage of organic recovery (Figure 15). The percentage of the associations of Corallinales are very close, also the association of a mixture of calcareous algae. The associations of *Peyssonnelia* in contrast are a little widespread, as well the stations without associations.

At 60 m depth the associations of *Peysonnelia* are very close. The associations of calcareous algae are also very close. There are no associations of Corallinales. The stations without associations in contrast are even more widespread than at 40 m (Figure 15 and Figure 16).

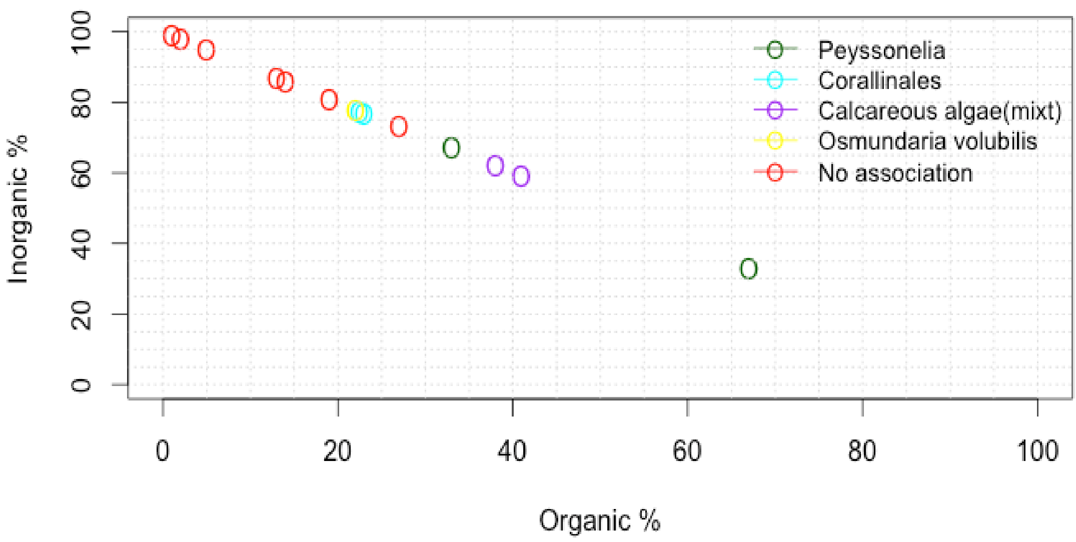

Figure 15. Correlation between the presence of different associations and the organic recovery at 40m

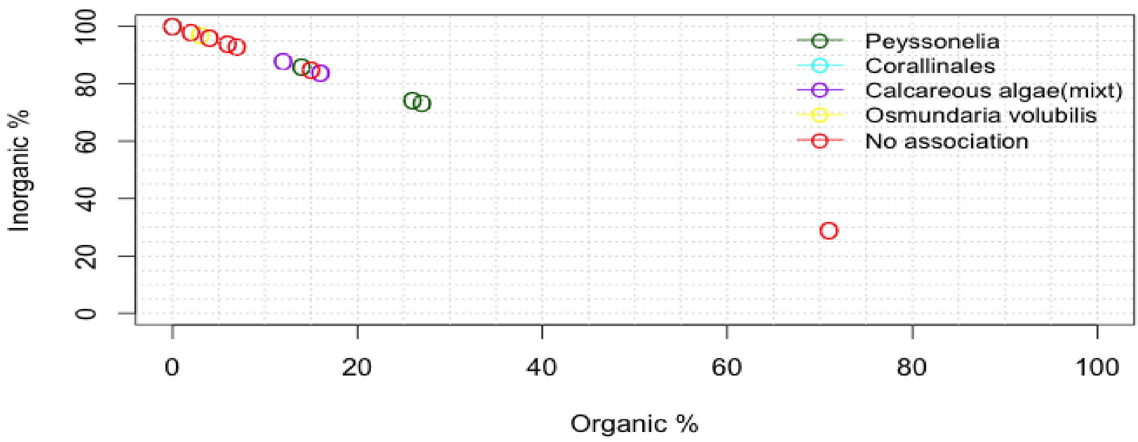

Figure 16. Correlation between the presence of different associations and the organic recovery at 60m

Fauna of the coastal detritic bottom

As the fauna was limited to a few individuals it was not considered for calculating the percentage of organic recovery. Nevertheless some stations shelter an elevated number of animals.

The most abundant phyla are the Porifera and Echinodermata followed by the Cnidarians and Bryozoans (Table 6). At PC03 (5), PC04 (4) and CL02 (3) several Spatangidae were identified. Most of them could be identified as *Spatangus purpureus.* At CL02_80, GI01_60, the whole radial station LV01 and all the stations around Port-Cros, several tests of Spatangidae could be identified. At LV02 eleven individuals of *Stylocidaris affinis* were found.

CL01 (6), CL02 (6), PC03 (3), PC05 (5) and PL02 (6) contain at least three individuals of Holothurians. Asteroidea were found at GI01 (3), LV02 (3), PC05 (5), PC06 (3) and PL02 (3).

The most populated stations of Porifera are PC05 (76), PC06 (22) LV02 (19) and CL02 (12). At PL03 there is also an elevated number of small Porifera difficult to count. The Bryozoans are not as abundant as the Sponges but we can still find some at PC05 (9) and PC06 (5).We have to add as well that they are difficult to see as they have often a very small size and are often incrusted.

Regarding the Cnidaria we could find ten at GI01, six of them Hydrozoans and four *Pennatula rubra*. At LV02 we could also find ten colonies, nine of them *Eunicella singularis*, at PC05 four colonies of *Eunicella singularis* and one Hydrozoa (Table 6).

Table 6. Register of identified fauna

Embranchement	Classe	Ordre	Smallest level of identification
Annelida	Polychaeta	Sabellida	*Sabella pavonina*
			Polychaeta
Arthropoda	Malacostraca	Decapoda	Paguridae
			Decapoda
Bryozoa	Gymnolaemata	Cheilostomatida	*Pentapora fascialis*
			Reteporella grimaldii
Chordata	Actinopteri	Perciformes	Blenniidae
			Coris julis
			Gobiidae
			Serranus cabrilla
		Scorpaeniformes	*Scorpaena porcus*
	Ascidiacea	Stolidobranchia	*Halocynthia papillosa*
		Phlebobranchia	*Phallusia mammillata*
			Phallusia sp.
Cnidaria	Anthozoa	Actiniaria	*Alicia mirabilis*
		Alcyonacea	*Eunicella singularis*
		Pennatulacea	*Pennatula rubra*
			Pteroeides spinosum
	Hydrozoa		Hydrozoa
Echinodermata	Asteroidea	Spinulosida	*Echinaster (Echinaster) sepositus*
		Valvatida	*Hacelia attenuata*
	Echinoidea	Cidaroida	*Stylocidaris affinis*
		Spatangoida	*Spatangus purpureus*
	Holothuroidea	Aspidochirotida	*Holothuria forskali*
			Holothuria (Holothuria) tubulosa
			Holothuria poli
	Ophiuroidea	Ophiurida	*Ophioderma longicauda*
Mollusca	Gastropoda	Nudibranchia	*Hypselodoris* sp.
			Facelinidae
Porifera	Demospongiae	Agelasida	*Agelas oroides*
		Dictyoceratida	*Dysidea avara*
		Hadromerida	*Cliona viridis*
		Halichondrida	*Axinella verrucosa*
			Axinella damicornis
			Dictyonella
		Haplosclerida	*Haliclona mediterranea*
		Poecilosclerida	*Phorbas tenacior*

5. Discussion

5.1. Identified species via samples

The biggest conspicuity of the identified algae is that by far the most identified species are Rhodophyta. This is not very surprisingly as the study area is with 40 m -80 m depth quite deep. Rhodophyta possess the phycobili protein. This protein intensifies the absorption of light, thus allows making the photosynthesis deeper (Cabioc'h et al. 2014).

In general in the coastal detritic bottom, the Rhodophyta are the most abundant and Chlorophytes and Ochrophytes are sparser. Typical species of the Rhodophyta are: *Aeodes marginata, Calliblepharis jubata, Cryptonemiat uniformis, Kallymenia spp., Osmundaria volubilis, Phyllophora crispa, Phyllophora heredia* and *Sphaerococcus rhizophylloides* (Alfonso-Carrillo et al. 2013).

In our samples we could find the species *Osmundaria volobilis* and *Phyllophora crispa*, species from the genus *Cryptonemia* (*Cryptonemia lomation*) and two of the genus *Kallymenia*. Other typical Rhodophyta we found are *Chondria* sp. and *Dudresnaya verticillata* mostly accompanied by its four epiphytes *Blastophysa rhizopus, Acrocheatium subtuilissimum, Entocladia majus* and *Dasya rigescens* (M.Verlaque pers. comm.).

Although the Rhodophyta are the embranchment with far the most species, the Ochrophyta seem to contain more characteristic species for the coastal detritic bottom. Just looking at the most abundant species 38% of them are Ochrophyta. Similar could apply to the distribution of mass.

According to a study made at detritic bottoms in the bay of Marseille, not very far from our own study area similar results were observed. They describe an Ochrophyta bloom especially in the warm period of June 2007. The most characteristic species are: *Arthrocladia villosa, Asperococcus bullosus, Carpomitra costata, Dictyopteris polypodioides, Dictyota dichotoma, Halopteris filicina, Sphacelaria spp., Sporochnus pedunculatus, Stypocaulon scoparium* and *Taonia atomaria*. (Klein and Verlaque 2009)

Although we made our samples two months later except of the two species *Stypocaulon scoparium* and *Carpomitra costata* we could find all of them.

Some of them (*Arthrocladia villosa, Asperococcus bullosus*, *Carpomitra costata* and *Sporochnus pedunculatus*) are even typical species of the coastal detritic bottom (Klein and Verlaque 2009).

Other characteristic species that we found are the *Cystoseira spinosa* and *Stictyosiphon adriaticus* (*M. Verlaque pers. comm.).*

Most of the identified species are nearly ubiquitous. Taking a look at the Table 4 we can see, that in general the appearance of different species in between the different sites does not vary a lot. This could be a note that the coastal detritic distinguishes more with the abundance of algae, not with the variety of different species (Table 4).

Regarding the Figure 6 we can see as well, that after ten samples the gain of new species is lower than one species per sample. That tells us, that taking two samples more to assure us about twelve samples are enough to detect most of the species in the coastal detritic in the area of the Port-Cros National park (Figure 6).

5.2. Invasive species

As already told in the results the best visible observation is that there is absolutely no Caulerpa at 80 m depth. At 60 m depth it is also very rare. The only two stations are PC01 and PC05 with a recovery of less than one percent. Both of them reached a maximum of 57 m depth. By contrast the station PC04_40 has its average depth at 46 m depth and we can still find a recovery of 3%.

Considering that *Caulerpa cylindracea* has the biggest occurrence between June and December with a maximum from September to November (Klein and Verlaque 2008, Ruitton *et al.* 2005) exactly the period of sampling, we can conclude that its limit of growth is around 50 m depth. At least for our study area this is the case.

Regarding only the stations at 40 m depth we can conclude that the Caulerpa is almost present at all the station determined as coastal detritic bottoms (except at PL02). But its recovery rate exceeds never 10% (average of about 30 picture quadrates with 0,64 m^2 each). As most of the other studies are made at lower depths it is hard to make comparisons.

Comparing the different stations there is no correlation recognizable. Same as, if one compares the results of the determinate recovery rate via the pictures and the obtained biomass where no correlation is found.

As the determination of the biomass of the Caulerpa is very precise per sample compared to the determination of the recovery via photo one could say that this is the better method. But the investigated surface via sampling is 0,12m^2 per station and the surface via pictures is around 19,2m^2 per station. As the surface of sampling via picture is a lot bigger we suppose that it is more exact to determinate its occurrence via photo and no sampling of the Caulerpa is necessary.

The limit of sampling is furthermore around 40 m depth because scuba diving limits in depth and time and is also not always a hundred percent aleatory. Another advantage is, that the chance that some fragments of the Caulerpa gets pulled out, attaches itself somewhere else and could spread out more and more is a lot smaller. Caulerpa fragments can survive several days and the attachment to the substratum is quick, it is a very effective mechanism of asexual multiplication (Klein and Verlaque 2008).

5.3. Picture-quadrates

The first conclusion we can make regarding the correlation between the substrate and the typology is, that the composition of the substrate tells us already a lot about the typology. As also described from Peres and Picard (1964), the circalittoral is first characterized by the substrate and the quantity of light. The second characteristic is the composition of the organic part.

Regarding the results from the Figure 9, we can say that for our study area the occurrence from silt tells us already a lot about the typology, Peres and Picard confirm this observation. If we find a substrate characterized as silt it is more likely that it is part of the muddy detritic bottoms. If we have shell silt bottoms we are more likely in the shelf-edge detritic assemblages (Figure 9). However, endofauna determination is the better but not easier way to identify the type of biocenosis (Peres and Picard, 1964).

We have observed a wide variety of substrate at different depths at different radials. So we can assume that the current flow pattern varies a lot at the different depths. Considering that silt containing stations are surely in areas with low currents due to its fine particles

(Murawski and Meyer 2004). We can assume that contrarily applies for all the substrate without silt. Thus silty sand would be somewhere in between. That also confirms the conduct of the BioCube. Currents caused a fast replacement and a difficulty of control of the cube whereas contrary was the case when there was no or little current. With the help of the Videos we could also see ripple marks at one of the stations (CL02_40), a sign for currents or waves (Murawski and Meyer 2004). But these observations aren't sufficient to really describe the current flow patterns.

In general the sites are influenced by the liguro-provencal current (a wind coming from the noth) accelerating between the two Islands Porquerolles and Port-Cros (Jeudy de Grissac 1982).

It is evident that the recovery of algae will reduce with the depth because of the decrease of light. The current flow patterns may help to explain why this is not always the case as in the big exception PC05 a station with a lot of current at 40 m depth (conduct of the BioCube). The same applies for the stations PL02 and PC01, the stations between the two islands Porquerolles and Port-Cros (Figure 10).

According to this we could think that these stronger currents are responsible that the organic recovery is lower at 40 m depth as it is harder for algae to fix themselves but we shouldn't forget that calcareous algae require high-energy environments. Currents are also responsible for their distribution and growth form (Wray 1977).

Another thing to consider is that most of the calcareous algae that we found are free living Rhodolithes that means that they can move with the current. They can therefore be carried until higher depths and this could also explain why we find a higher percentage of organic recovery at 60 m depth instead of at 40m depth as at the station PC05. Regarding the percentage of fleshy algae and calcareous algae at the mentioned stations we can see that only this does not explain its high percentage at 60 m depth as most of them have a much higher percentage of fleshy algae (PC05_60 86% recovery of fleshy algae) (Figure 13).

Conspicuousness are as well the stations PL01_40 and LV01_40 with its very high percentage of dead Posidonia. This as well could be explainable with the current flow patterns. The North current coming from the north-east enters between Le Levant and the mainland, but as the station LV01 is located behind a sea wall (not very visible at the map) it is protected from this current and so the dead Posidonia from the nearby meadows are stocked (Millot 1991). Same hypothesis seems consistent for PL01.

Overall we can note that the composition of the organic part is not always the same. Just comparing the different sites we can see that the distribution between fleshy algae and calcareous algae can change completely although it seems to be a relation between the richness in species of fleshy algae and the recovery of calcareous algae (Figure 11).

In the study realized on the coastal detritic bottom within the bay of Marseille, the authors describe a dominance of fleshy algae during their whole study period (Klein and Verlaque, 2009). This is definitely not true in our case.

But this could be relied to the season in which we made our sampling, because fleshy algae have their maximum in cover in the summer months and at the end of September most of them are already vanished. In contrast for the calcareous algae this is almost contrarily (Klein and Verlaque 2009). However the occurrence of species does not change that much, which explains why we still could identify a lot of fleshy algae.

To sum up we have to consider that our percentage of distribution between the two types of algae is not very presentative and could falsify the reality as the sampling was only made at one period. Still we can say that we had clearly a superior percentage of calcareous algae at sites like Port-Cros and Porquerolles.

But the most interesting fact is that the recovery of calcareous algae affects the occurrence (not the recovery) of fleshy algae (Figure 11). This fact tells us that assemblages of calcareous algae have definitely a good influence of the diversity of fleshy algae. They permit fleshy algae to fix themselves like many epiphytic algae as *Nereia filiformis* which one finds only on a Peyssonneliae (M.Verlaque pers. comm.).

At Port-Cros the percentage of calcareous algae is higher than fleshy algae but just here we have the highest occurrence of fleshy algae. Giens and the cape Lardier have quite a high percentage of fleshy algae due to its low percentage of calcareous algae the number of species per sample is not that big. Le Levant has a lower number of fleshy algae but because of its balanced amount of calcareous algae the occurrence of different species per sample is similar as at Giens and the cape Lardier.

Although we have to be careful with its interpretation as the recovery is the average of all the analyzed pictures, the occurrence however is the result of the identified species of the samples, but until now the samples have not all been analyzed yet. Nevertheless it is a good approach as after ten analyzed samples not a lot of new species were found (Figure 6).

Comparing the sites at 40 m and 60 m depth we can only sum up that there is no real correlation between the composition and the percentage of the organic part; it seems to depend from various factors (Figure 11 and Figure 12).

Matching all the different stations the fact that highlights the most is that not only the substrate but also the percentage of the organic part tells us if we are in the coastal detritic or not. The percentage of fleshy algae does not raise 1,3%. The only station in the same category considered as the coastal detritic are PL01_80, PL03_80, GI01_60 and LV01_40 (Figure 13). Looking again at the figure 9 we can see that the stations PL01_80 and GI01_60 are the only stations with shell sand considered as the coastal detritic although they are on the border to the shelf-edge detritic (Figure 9). But maybe they should not been considered as it as we find them in the same group of the heatmap analysis. The same applies for the station PL03_80 with coarse sand. The only exception is LV01_40, because of its high percentage of dead Posidonia. The first ten pictures of this station are wholly covered with dead Posidonia and raise the total percentage of its recovery a lot and degrades the percentage of algae. But regarding the following pictures we can see that it is still part of the coastal detritic bottoms.

The Figure 14 seems to confirm, that there is effectively no relation between the substrate and the percentage of the organic part. The substrate can therefore only be used as an indication of the typology of the bottom of a station (Figure 14).

The far more interesting observation is though the relation between the different associations and the organic part. Regarding the Figure 15 and Figure 16 we can even say that they have a positive influence of the recovery. The association of *Osmundaria volubilis* cannot be considered as we have only one station per depth. As all our comparable associations are with calcareous algae this could also confirm our assumption between the calcareous algae and the percentage of fleshy algae (Figure 15 and Figure 16).

Peres and Picard describe eight different associations or facies of the coastal detritic bottoms. The association of**:** *Kallymenia spathulata*, *Ophiura ophiura*, maerl (*Lithothamnion* *corallioides* and *Phymatholithon calcareum*), synascidies (colonial ascidiacea), *Lithothamnium fructiculosum*, *Lithothamnium valens*, *Osmundaria volubilis*, and squamariacé (calcareous algae with free thalles) (Peres and Picard 1964).

We could only find 4 of them. The associations of maerl, *Lithothamnium fructiculosum*, *Lithothamnium valens* and *Osmundaria volubilis*.

This could have several reasons. The association forming species *Ophiura ophiura* for example is usually living in the substrate coming to the surface only at night to feed on. For this reason we couldn't detect it neither with the pictures nor with the samples. Noticeable is that we could only detect a single one. In the Video GI02_40_BC_V_11092015_002 at the minute 00:01:45 we can see a molding of a starfish, an indication that there could though be more of them (Ziemski and Müller 2013).

Another association we could not make out is the association of *Kallymenia spathulata*. We did find some individuals from this genus but not forming associations. This could be because of the period we realized the samplings. As in this period there are less fleshy algae this could be the reason why we couldn't find them as an association.

Furthermore, the investigation method is totally different from Peres and Picard's one. They used a dragnet as a sampling method and we sampled only on the surface of the bottom and via images (Peres and Picard 1964).

Looking again at our figures we can see that the stations with no association are widespread and some even have a very high percentage of organic substances especially one station at 60 m which is even the station with the highest percentage of organic material. It is the station PC05_60, looking at its composition of fleshy algae we can see that the percentage of *Arthocladia villosa* is protruding (3%), same for the station GI01_40. As it is also an association forming species (UNEP 2006) we can assume that it should also be one of the typical associations of the costal detritic bottom. This would also explain why some of the stations without typical associations have a high percentage in organic recovery.

Regarding the number of animals we can also sum up that associations of Porifera could exist. The Porifera rich radial stations CL02, PC05 and PC06 have a high percentage of organic recovery although they are not part of an association. Associations of Sponges could explain this.

Taking a look at the two radial stations PC03 and PC04 we could say that, associations of *Peyssonnelia* also have a positive influence on the presence of Spatangidae not only at fleshy algae. According to Peres and Picard facies of *Lithothamnium fructiculosum* harbor the Spatangidae *Spatangus purpureus* (Peres and Picard 1964). We could not observe the same as all the stations of Spatangidae have only associations of *Peyssonnelia*, but in any case calcareous algae seem to have a positive influence on them.

Conspicuous is also the station LV02, the only station where *Stylocidaris affinis* could be found in an elevated number. Here we found associations of calcareous algae and at the same time a high percentage of organic recovery. Peres and Picard refers them with the species forming the maerl (Peres and Picard 1964). Although we couldn't make out which of the two species is present (probably only *Lithothaminion corallioides* as *Phymatolithon calcareum* is mainly an Atlantic species (M. Verlaque pers. comm.)) we can confirm that this station has an important number of individuals belonging to the maerl.

Regarding Holothurians and Asteroidea no special partiality could be discovered. Bryozoans are always found associated with Porifera as at the stations PC05 and PC06.

The state of conservation

The state of conservation could be defined as a combination of the structure and the functionality of the habitat and the restoration issues. Both could be described by the percentage of organic recovery and the richness in species. As the identification of species via the pictures is limited to a few big or very flashy species we cannot tell much about its diversity. The samples whereas are only made at 40 m depth and can therefore neither been taken as a good relative reference.

However, we know that there is a relation between calcareous algae and the diversity of fleshy algae and as well between the occurrence of associations and the flora and fauna. With these two observations we can assume that all the stations considering any type of association are as well in a good biological state. And the higher the recovery of this association is the higher is also its diversity and therefore the state of conservation.

Granulometry should also be a good indicator that can contribute to the evaluation of the state of conservation. Comparing the observed granulometry to the theoretical granulometry (regarding depth and known hydrodynamic) could inform about abnormal trends that should be linked to antropogenic activities.

Without doubt, the reference site is the island of Port-Cros except the radial in the west of the island (PC01). The radial station PL02 and the station PL01_40 in contrary are also in a very good state. An explanation for the poor recovery at the station PC01 could be the due to the still small scale of sampling so that the absence of organic recovery at one station of a site does not mean that the state of conservation is low. It also could be due to hydrodynamic situation at a local scale.

Le Levant is also in a very good state although the station LV01_40 seems to have a low percentage of organic recovery but as already explained this is because of the first pictures completely covered with dead Posidonia. The stations CL01_40 and CL02_60 are also in a good state of conservation. Giens and the stations CL01_60 and CL02_40 in contrast are in a lot poorer state.

Likewise mentionable is that the following list of identified species can be considered as remarkable species:

Table 7. Remarkable species

Species	Barcelona Convention	Bern Convention	IUCN red list 3.1	forming assoziation	indicator of good quality of the milieu	patrimonial species	La Directive Habitat-Faune-Flore, 1992
Arthrocladia villosa				x			
Cystoseira spinosa	x	x			x		
Cystoseira zosteroides	x	x			x		
Halymenia floresia				x	x	x	
Kallymenia patens				x	x	x	
Kallymenia requienii					x	x	
Nereia filiformis					x	x	
Osmundaria volubilis				x		x	

Species	Barcelona Convention	Bern Convention	IUCN red list 3.1	forming assoziation	indicator of good quality of the milieu	patrimonial species	La Directive Habitat-Faune-Flore, 1992
Sebdenia dichotoma					x	x	
Lithothamnion corallioides							x
Coris julis			x				
Holothuria tubulosa			x				
Scorpaena porcus			x				
Serranus cabrilla			x				
Holothuria forskali			x				
Posidonia oceánica	x		x				
Dictyopteris polypodioides					x		

The occurrence of quite a lot of remarkable species is also a indication of a good state of conservation.

Evaluation of the method

As already describe it is hard to tell something about the state of conservation only looking at the pictures as we don't know much about the diversity of the species. In contrast we can say that the method is quite relevant for the determination of the recovery rate what we could see of the comparison between the biomass and the recovery rate of the Caulerpa.

The advantage of direct sampling is that we can identify almost all species, but it is very time-consuming and not feasible in greater depths. Another disadvantage is, that the surface of this sampling is very small as already presented in context with the Caulerpa. Also is the choosing of the samples less randomly as a diver often tends to place its frame at a place with a high percentage of recovery. The placement of the BioCube on the contrary is not really controllable as it is conducted from the currents.

In contrast, the combination of both of them seems very additional. What could be improved is however the quality of the cameras and also the number of spotlights to create o homogenous lighting.

For a next series the samples at 80 m depth could be omitted as they never presented a very representative coastal detritic bottom. Here the videos would be sufficient to determine the typology if this is requested. As the pictures of same stations are mostly homogenous only 20 pictures would also be sufficient to determine the recovery rate. This protects especially the physical exertion. Though then it would be good to don’t place the samples to close to each other to still get a wide range.

To sum up the BioCube is thus a very good option to avoid the high cost of a robot and the square at the ground of it, visible at the pictures also permits to make more exact statistics.

6. Conclusions

We can say that the best coastal detritic bottom is between 40 m and 60 m depth. Port-Cros is the best conserved site but the other two islands Porquerolles and Le Levant seem to be in a very good state of conservation as well.

The substrate type and the percentage of recovery are decisive to determine the typology and describe the state of conservation. The focus has to be on the associations and facies.

One could criticize the period of sampling as most of the fleshy algae are already vanished and not fertile. But the advantage is that so the always present associations forming calcareous algae are better visible and so the state of conservation is better determinable. Anyhow a second round of sampling in the summer months would give a better view of its diversity.

Another thing missing is a site of comparison such as Toulon where human influence (pollution, etc.) is bigger and so the state of conservation is better evaluable and comparable.

At the end we can say that our methods were selected properly although there are improvable.

For the future it would also be interesting to use the same methods (BioCube and sampling) for another habitat such as the coralligenous for example.

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8. Annex

8.1. Abstract

Abstract in English

The coastal detritic bottom is a habitat between the lower infralittoral and the deep sea and consists of mobile grounds, characterized by the presence of calcareous algae. As it is a non-communal habitat is relatively little studied however the extension of the National park of Port-Cros (Northwestern Mediterranean Sea, France) and its special condition due to the prohibition of bottom-trawling, allowed us to describe its state of conservation.

The development of a new method, the so called BioCube (a photo-cage allowing to take samples in bigger depths with relatively low costs) revealed several interesting traits of the coastal detritic bottoms among five sites within the National park of Port-Cros (Giens, Porquerolles, Port-Cros, Le Levant and cape Lardier) at different depths (40 m, 60 m and 80 m depth).

According to our results the richness in species rises with the presence of association forming species, suggesting that the evaluation of the state of conservation should be focused on these species. We found associations of Corallinaceae, Peyssonneliaceae, *Osmundaria volubilis* and *Arthocladia villosa*.

Based on a high diversity and also a high percentage of organic recovery we suggest that the best state of conservation among the five sites is around the island Port-Cros itself.

Abstract in Deutsch

Die "*coastal detritic bottoms*" (küstennahe detritische Böden) bezeichnen ein Habitat zwischen dem tieferen Infralitoral und der Tiefsee und bestehen aus beweglichem Sediment, charakterisiert von Kalkalgen. Da es sich um einen nicht kommunalen Lebensraum handelt, ist er relativ wenig erforscht. Mit der Erweiterung des Nationalparks Port-Cros (nordwestliches Mittelmeer, Frankreich) und des besonderen Zustandes der „*coastal detritic bottoms*" aufgrund des Verbotes der Schleppnetzfischerei, wurde es ermöglicht, den Erhaltungszustand dieses Habitats zu beschreiben.

Die Entwicklung einer neuen Methode - den sogenannten BioCube – ermöglichte es uns, interessante Ergebnisse über den „*coastal detritic bottom*" an fünf Standorten innerhalb des Nationalparks (Giens, Porquerolles, Port-Cros, Le Levant und Kap Lardier) in verschiedenen Tiefen (40 m, 60 m und 80 m Tiefe) zu erzielen. Bei dem BioCube handelt es sich um einen „Fotokäfig" der es erlaubt; relativ kostengünstig Fotos und Videos aus größeren Tiefen aufzunehmen.

Den Ergebnissen nach, steigt die Artenvielfalt mit dem Vorkommen von Arten, welche Assoziationen bilden. Daher nehmen wir an, dass ein spezieller Fokus auf diese Arten gerichtet werden sollte, um den Erhaltungszustand des „*costal detritique bottom*" zu beschreiben. Wir fanden Assoziationen mit Corallinaceae, Peyssonneliaceae, *Osmundaria volubilis* und *Arthocladia villosa*.

Aufgrund einer hohen Diversität und gleichzeitig einem hohen Prozentsatz an organischem Bewuchs schließen wir, dass unter unseren fünf Standorten die Insel Port-Cros selbst den besten Erhaltungszustand aufweist.

8.2. List of abbreviations

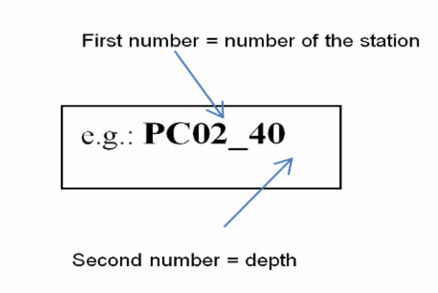
CL= Cap Lardier

GI= Giens

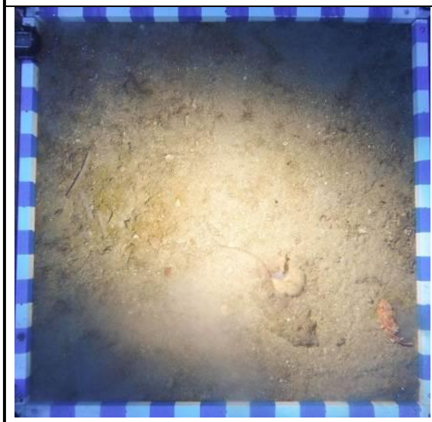
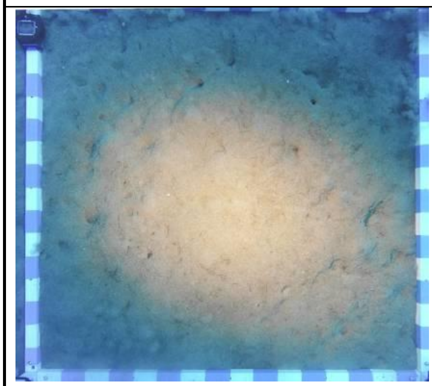
LV= Le Levant

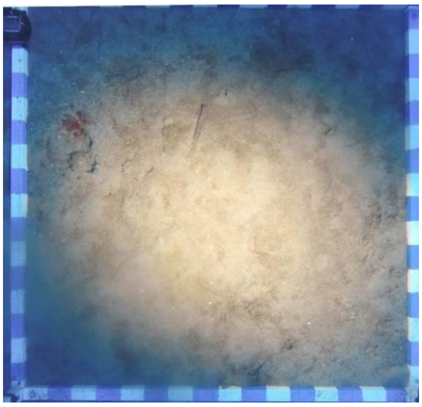
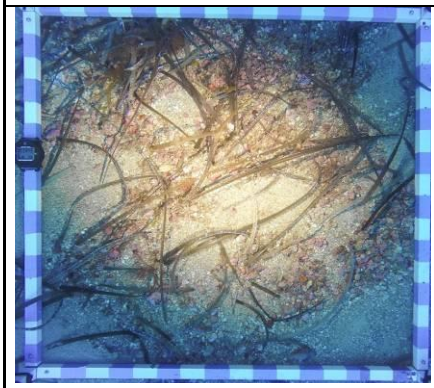
PL= Porquerolles

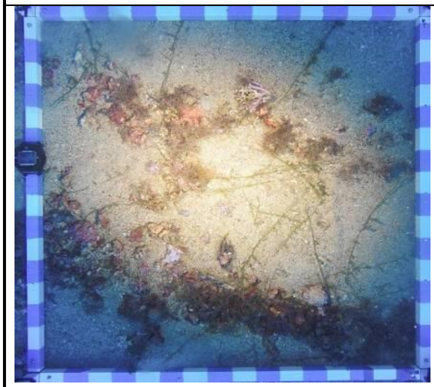
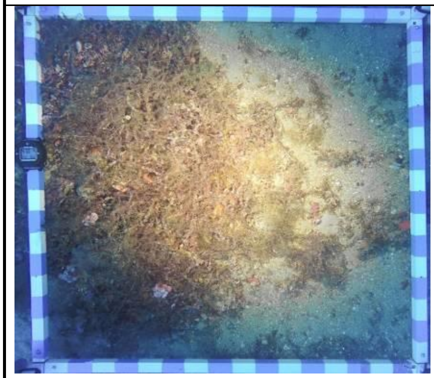
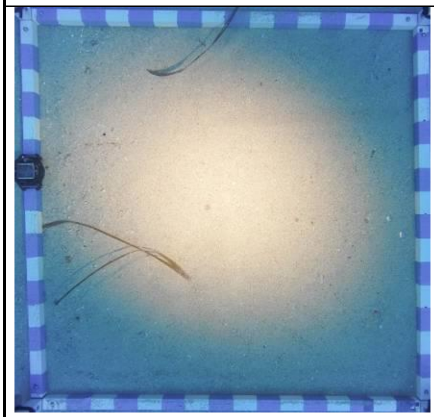
PC= Port-Cros

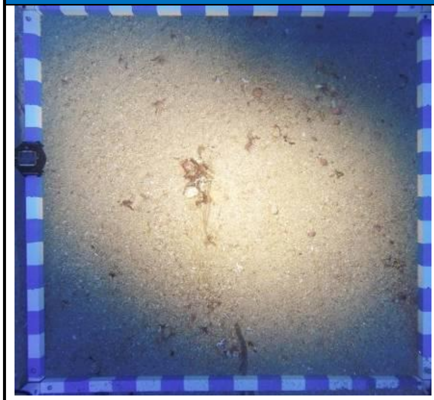
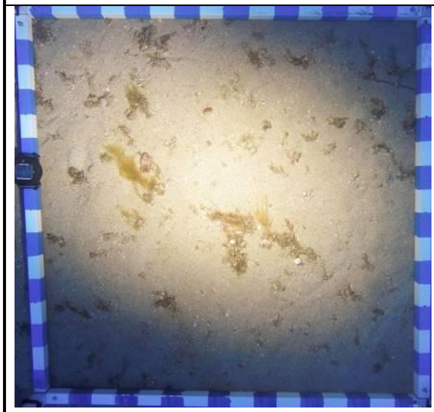


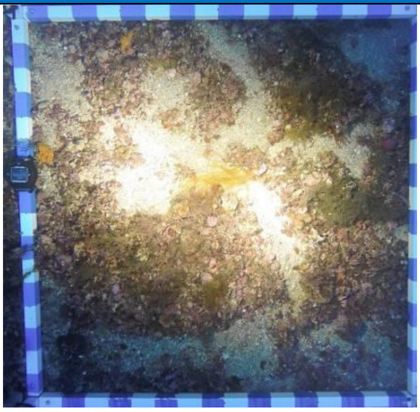
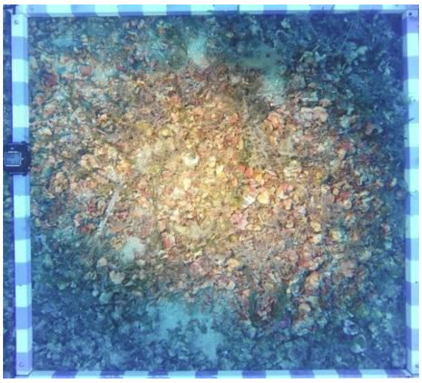
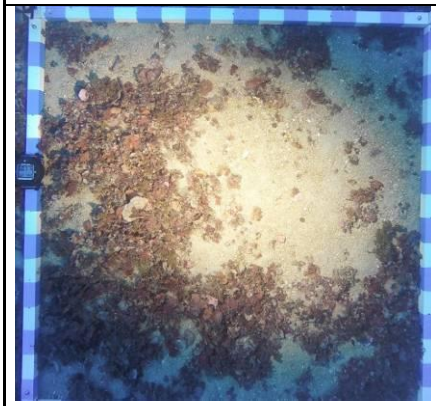
8.3. Description of the stations

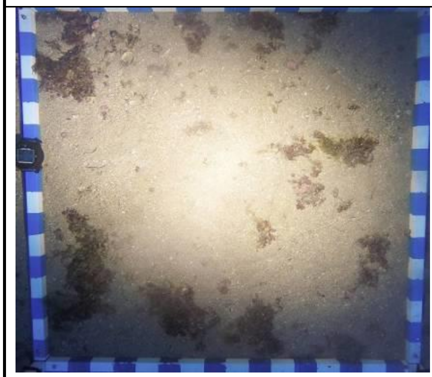
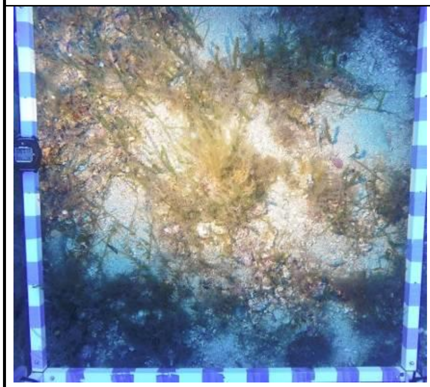
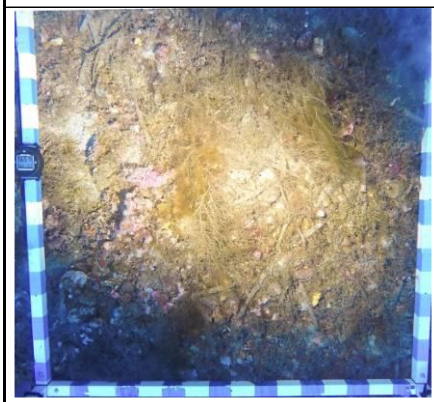
Picture	Station	Average depth (Standard aviation)	Substrate	Typo-logie	Description
	GI01_40	38,9 (1,7)	Shell sand	DC	Substrate homogeneous, presence of leafs from dead posidonia, low recovery of *Caulerpa cylindracea*
	GI01_60	63,3 (2,4)	Shell silt	DC	Substrate a few silted, recovery of macrophytes low; presence of leafs from dead posidonia; observation of Scorpaenaporcus;
	GI01_80		Shell silt	DL	Substrate very silted; absence of flora; presence of leafs of dead posidonia; depth not visible via pictures
	GI02_40	40,3 (0,4)	Silt	DE	Substrate silted very homogeneous and with a total absence of fauna and flora; depth constant

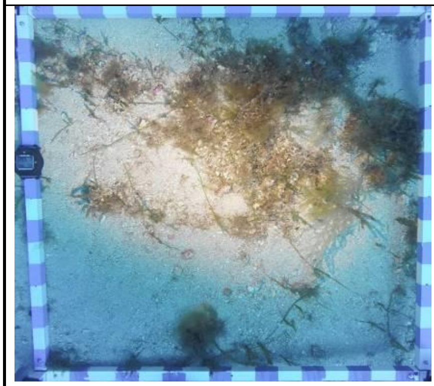
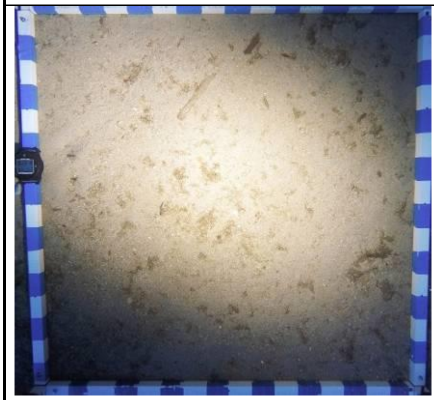
Picture	Station	Average depth (Standard aviation)	Substrate	Typo-logie	Description
	GI02_60	57,9 (0,4)	Shell silt	DE	Substrate a little silted with a lot of leafs and rhizomes of dead posidonia, macrophytes difficult to observe with exception of some Rhodophyta (low recovery)
	GI02_80	76,2 (0,5)	Shell silt	DL	Substrate little silted and homogeneous; presence of leafs of dead posidonia; depth not visible via pictures
	PL01_40	41,6 (0,5)	Sand	DC	Important recovery rate of dead posidonia leafs (fresh); very low recovery of fleshy algae; Corallinales with thallus of big size
	PL01_60	61,0 (0,7)	Silty sand	DC	Little recovery of macrophytes; film of bacteria (?)

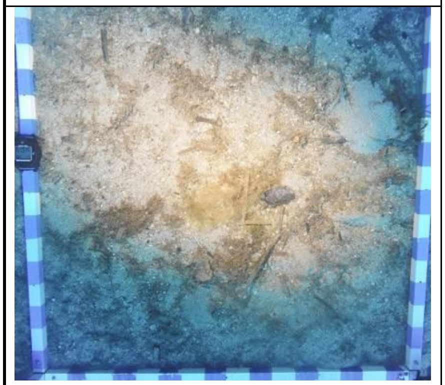
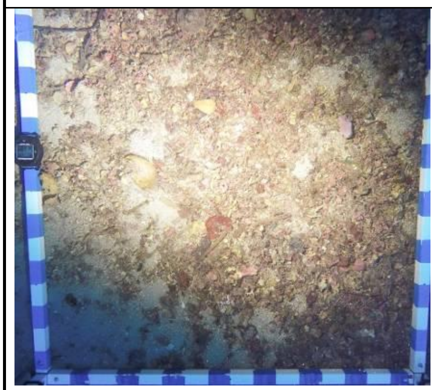
Picture	Station	Average depth (Standard aviation)	Substrate	Typo-logie	Description
	PL01_80	80,3 (3,6)	Shell silt	DC	Substrate homogenous, almost no macrophytes; observation and distinction between rhizomes and leafs of dead posidonia and macrophytes difficult
	PL02_40	38,3 (0,1)	Sand	DC	Some associations of peyssonnelia, corallinales and *Osmundaria volubilis*; important recovery of *Caulerpa cylindracea*
	PL02_60	47,0 (0)	Sand	DC	Important recovery of macrophytes; assotiations of *Osmundaria volubilis*; presence of maerl
	PL03_40	49,2 (3,8)	Sand	DC	Station sampled at 50 m; some leafs of dead posidonia (fresh);very low recovery of macrophytes

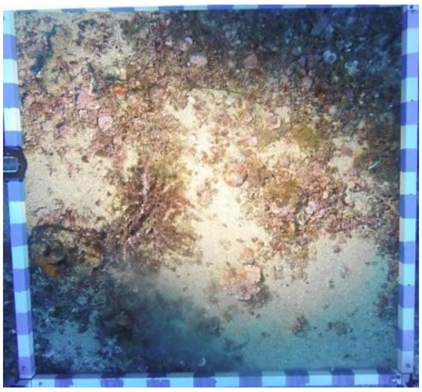
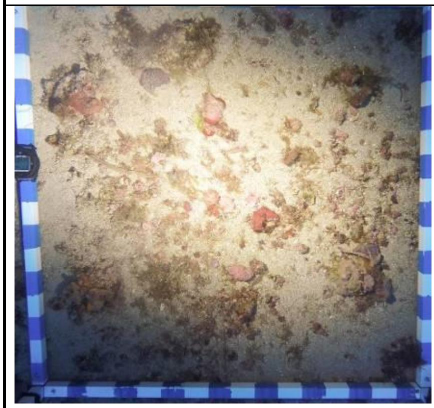
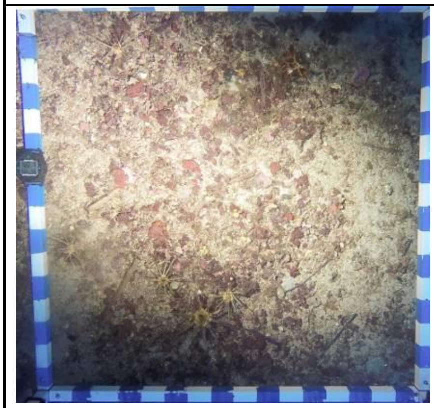
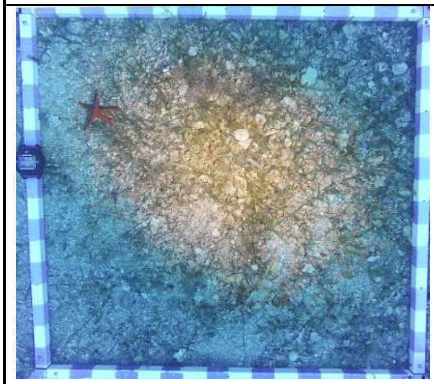
Picture	Station	Average depth (Standard aviation)	Substrate	Typo-logie	Description
	PL03_60	61,1 (1,5)	Shell sand	DC	Very low recovery of macrophytes; observation essentially of Rhodophyta
	PL03_80	90,9 (1,6)	Coarse sand	DC	Very little recovery of macrophytes; raised occurrence of small Porifera
	PC01_40	42,5 (1,2)	Sand	DC	Very little flora, some big individuals
	PC01_60	55,7 (0,5)	Sand	DC	Substrate and flora homogenous; low recovery (more than at 40 m)

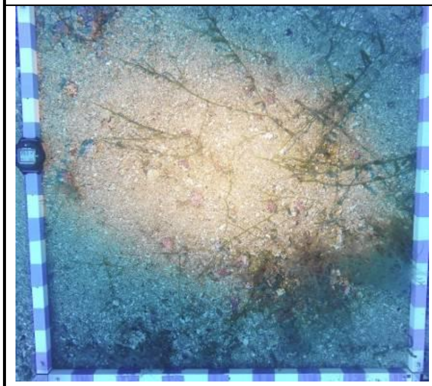
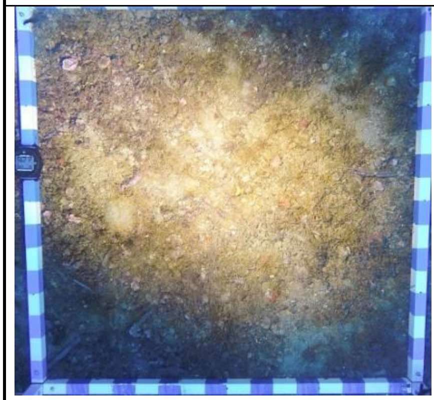
Picture	Station	Average depth (Standard aviation)	Substrate	Typo-logie	Description
	PC02_40	47,4 (1,2)	Shell sand	DC	Flora diverse with a average recovery of 40%, associations of peyssonnelia and corallinales, precence of maerl and Caulerpa cylindracea
	PC03_40	38,9 (0,1)	Silty sand	DC	Substrate and flora homogenous; very high recovery of marcophytes; up to 90% recovery of Peyssonnelia; presence of *Caulerpa cylindracea*
	PC03_60	60,4 (0,3)	Silty sand	DC	Substrate and flora homogenous; associations of peyssonnelia
	PC03_80	85,6 (0,7)	Si lt	DE	Substrate and flora homogenous; observations only of Rhodophyta (~2% recovery); depth not visible via the pictures

Picture	Station	Average depth (Standard aviation)	Substrate	Typo-logie	Description
	PC04_40	46,2 (4,4)	Sand	DC	Some associations of peyssonnelia, presence of some big macrophytes, important recovery of *Caulerpa cylindracea*, observations of several individuals of *Spatangus purpureus*
	PC04_60	60,4 (1,4)	Silty sand	DC	Substrate and flora homogenous; some associations of peyssonnelia
	PC05_40	38,9 (2,4)	Sable/shell sand	DC	Raised recovery of macrophytes and *Caulerpa cylindracea*; presence of Corallinales
	PC05_60	55,7 (1,8)	Silty sand	DC	Very rich in macrophytes and Porifera

Picture	Station	Average depth (Standard aviation)	Substrate	Typo-logie	Description
	PC05_80	72,2 (2)	Silty sand with shells	DC	Important recovery of Porifera and Bryozoa (up to 30%); very few macrophytes; some leafs of dead posidonia, films of bacteria (?)
	PC06_40	39,9 (0,4)	Shell sand	DC	Presence of some big macrophtes; raised occurrence of *Caulerpa cylindracea*
	PC06_60	60,4 (0,7)	Silty sand with shells	DC	Recovery of macrophytes about 20-30%; important recovery of Porifera and Beyozoa; film of bacteria (?)
	PC06_80	82,6 (1,1)	Silty sand	DC	Substrate and flora homogenous; low recovery of macrophytes; leafs of dead posidonia

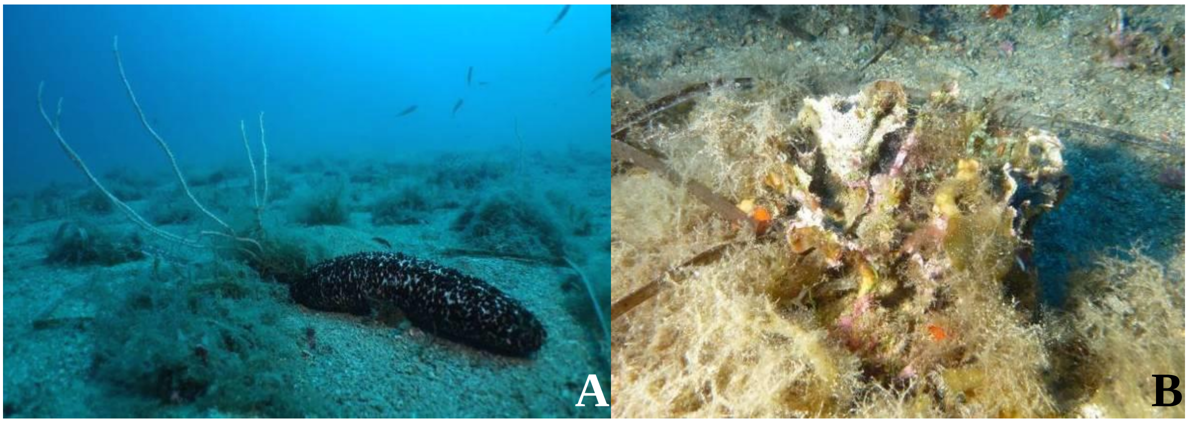
Picture	Station	Average depth (Standard aviation)	Substrate	Typo-logie	Description
 	LV01_40	43,9 (3)	Silty sand with shells	DC	Pictures heterogeneous: first ten nearly 100% recovery of dead posidonia, the following 20 pictures with a low recovery in macrophytes and *Caulerpa cylindracea*
	LV01_60	67,0 (1,8)	Silty sand	DC	Associations of peyssonnelia and corallinales
	LV01_80	85,1 (0,7)	Silty sand with shells	DL	Very low recovery of macrophytes, observation only of Rhodophyta

Picture	Station	Average depth (Standard aviation)	Substrate	Typo-logie	Description
	LV02_40	41,2 (2,8)	Sand	DC	Flora very divers; associations of peyssonnelia, corallinales and some of *Osmundaria volubilis*; maerl; important presence of *Caulerpa cylindracea*
	LV02_60	62,7 (0,7)	Shell sand	DC	Flora less riche than at 40m, associations of peyssonnelia and corallinales
	LV02_80	70,7 (0,9)	Silty sand	DC	Association of peyssonnelia, presence of several *Stylocidaris affinis*
	CL01_40	34,8 (1,3)	Sand/shell sand	DC	Important presence of *Caulerpa cylindracea*

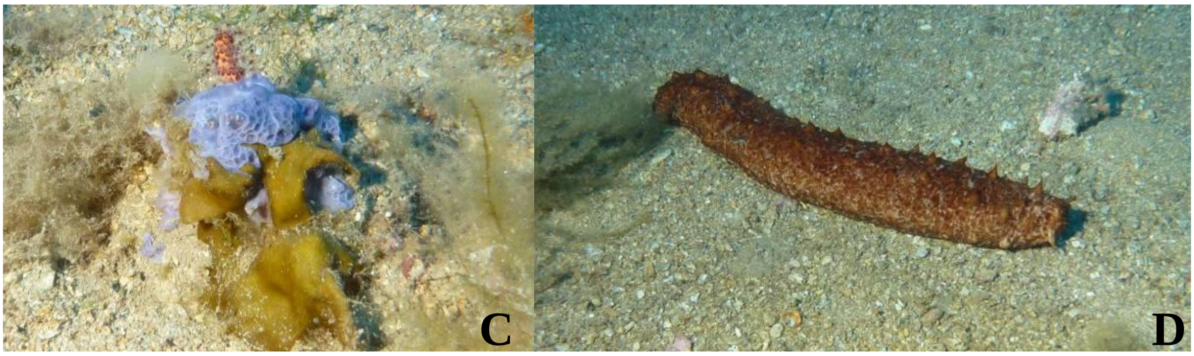
Picture	Station	Average depth (Standard aviation)	Substrate	Typo-logie	Description
	CL01_60	60,8 (6,1)	Silty sand	DC	Substrate and flora homogeneous, presence of leafs from dead posidonia, flora few present
	CL02_40	40,7 (2,3)	Shell sand	DC	Substrate and flora homogeneous, presence of some big macrophytes, important presence of *Caulerpa cylindracea*
	CL02_60	55,3 (0,8)	Silty sand with shells	DC	Substrate and flora homogeneous; some associations of peyssonnelia; presence of maerl; film of bacteria (?)
	CL02_80	87,2 (2)	Shell silt	DL	Substrate homogeneous; a little silted; diversity and recovery of marcophytes very low

8.4. List of photographed species by scuba-diving

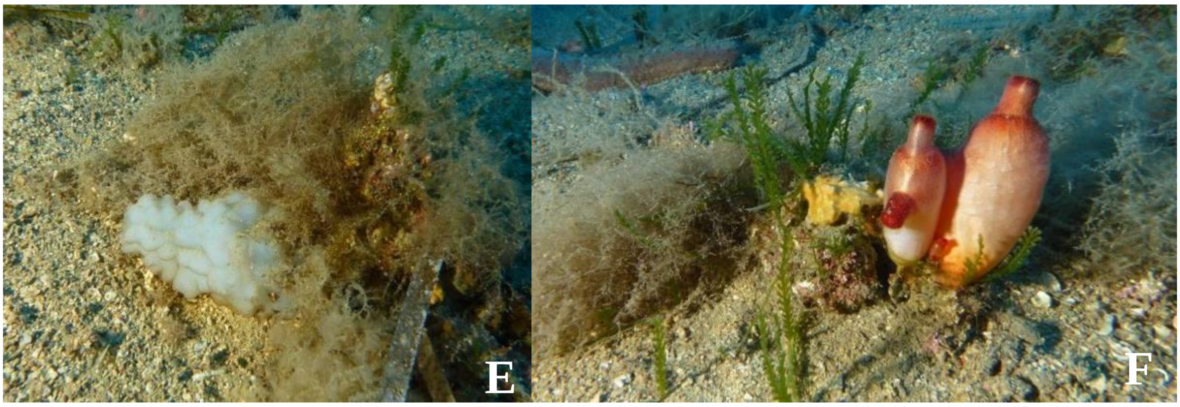
Giens GI01



A: *Holothuria polii*, *Eunicella singularis* **B:** Block of bioconstruction



C: *Zanardinia typus*, *Phorbas tenacior* **D:** *Holothuria tubulosa*

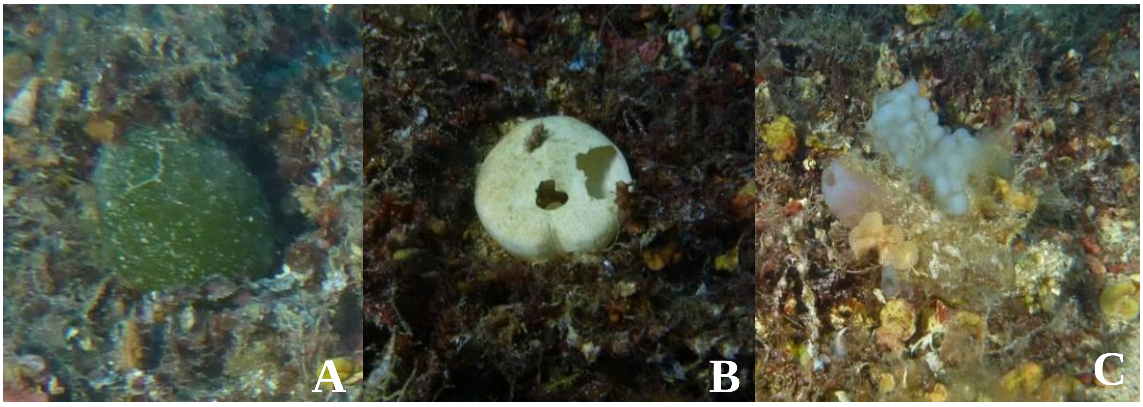


E: *Phallusia mamillata*, **F:** *Halocynthia papillosa*, *Caulerpa cylindracea*

GI02

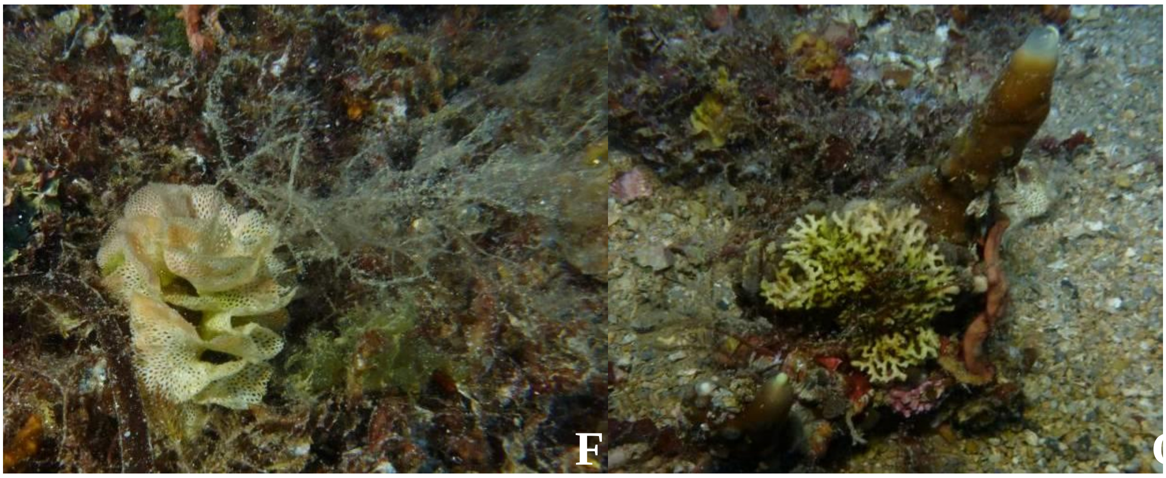
A: *Pteroides spinosum*

Porquerolles



A: *Codium bursa* **B:** *Spatangus* sp. (test) in association of *Osmundaria volubilis* **C:** *Phallusia mamillata*

D: Corallinales, *Acetabularia acetabulum*, *Laurencia* sp. **E:** *Osmundaria volubilis*, *Cliona viridis*, *Osmundaria volubilis*

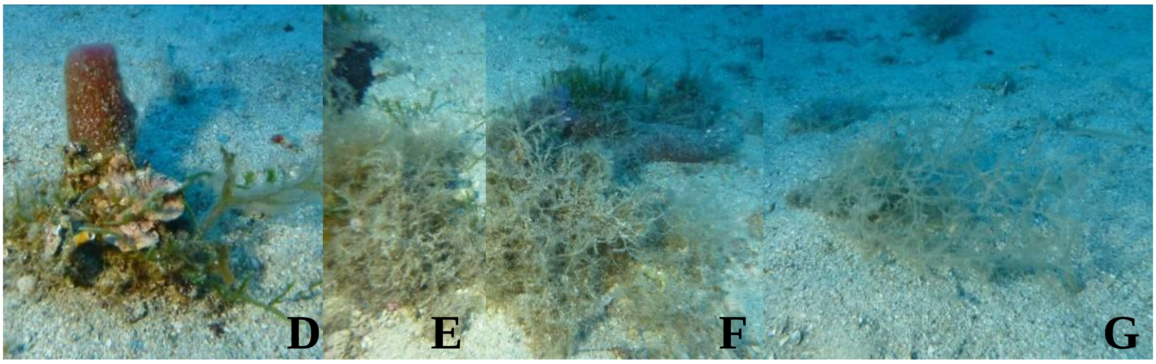


F: *Reteporella grimaldii, Arthocladia villosa* **G:** *Cliona viridis, Frondipora verrucosa*

Port- Cros

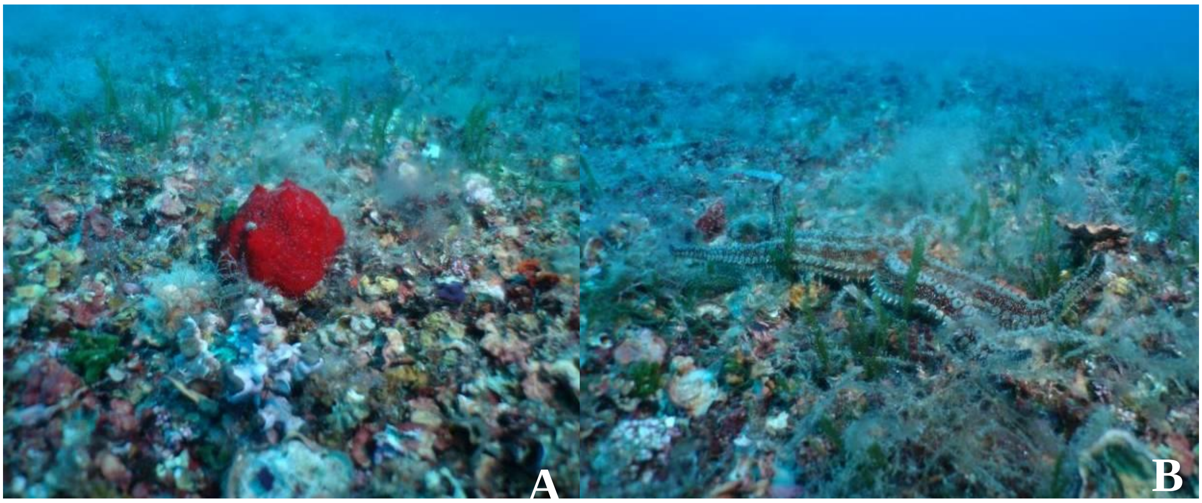
PC01

A: *Phallusia mamillata* **B:** *Zanardinia typus* **C:** *Pinna nobilis*



D: *Dictyopteris polypodioides,* Ascidiacea **E:** *Holothuria tubulosa* **F:** *Holothuria* sp. **G:** *Arthocladia villosa*

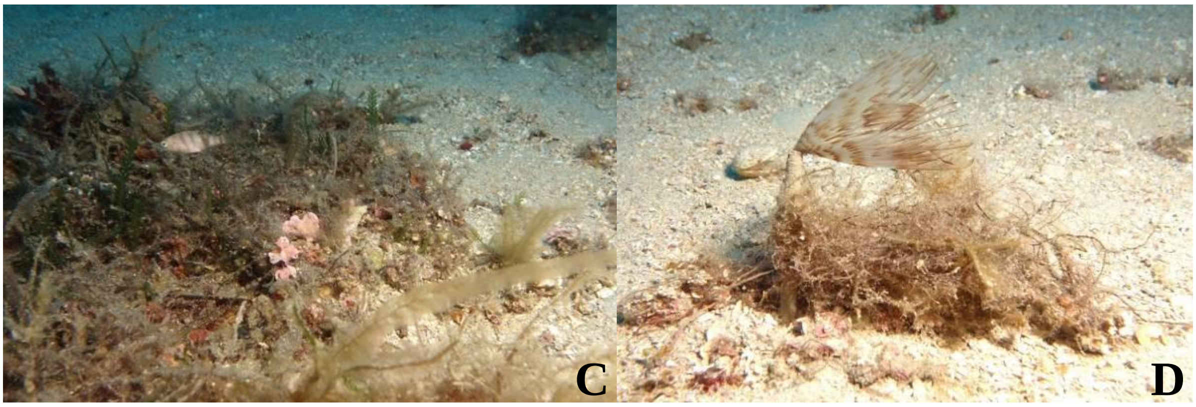
PC03



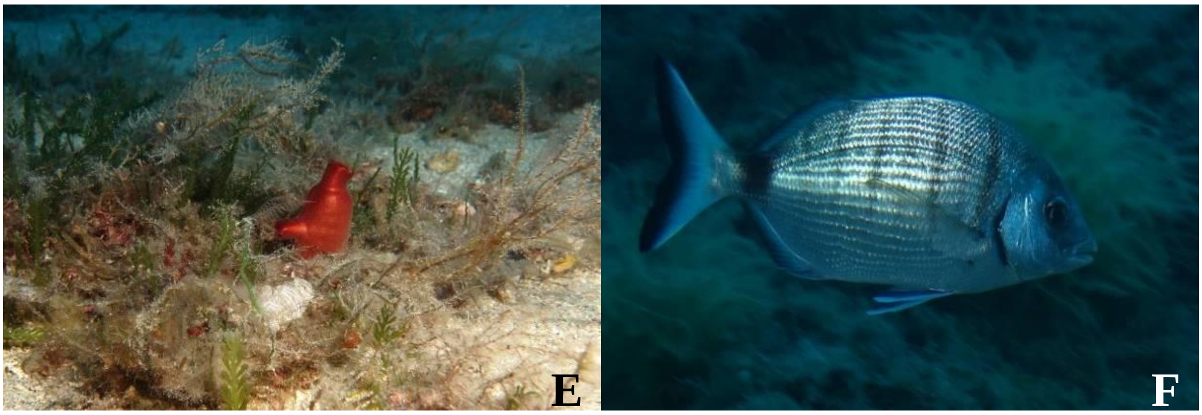
A: *Porifera* sp., *Caulerpa cylindracea* **B:** *Marthasterias glacialis*, *Caulerpa cylindracea*

PC04 (Not all species seen at the coastal detritic bottom but on the rock and in the Posidonia meadows)

A: *Pteroides spinosum* **B:** *Spatangus purpureus*



C: *Serranus hepatus* **D:** *Sabella pavonina*



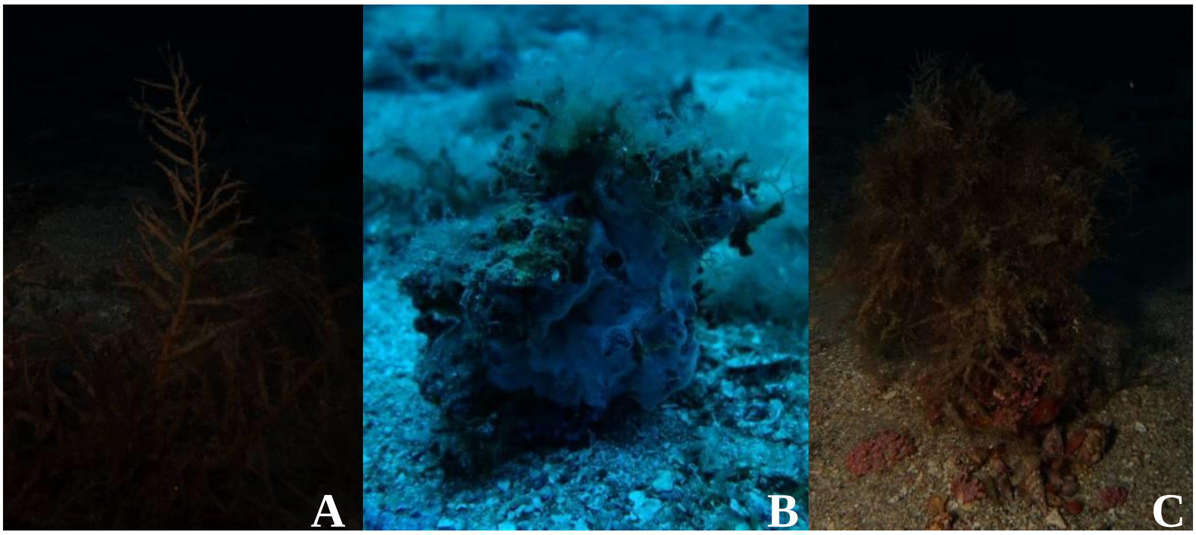
E: *Halocynthia papillosa***,** *Caulerpa cylindracea* **F:** *Diplodus sargus*

G: *Scorpaena scrofa* , *Posidonia oceanica* **H:** *Posidonia oceanica, Serranus scriba*

I: *Serranus scriba, Diplodus sargus, Sparus aurata* **J:** *Echinaster sepositus*

K: *Protula rubularia*, *Parablennius rouxi*, *Muraena helena* **L:** *Cladocora caespitosa*

PC05



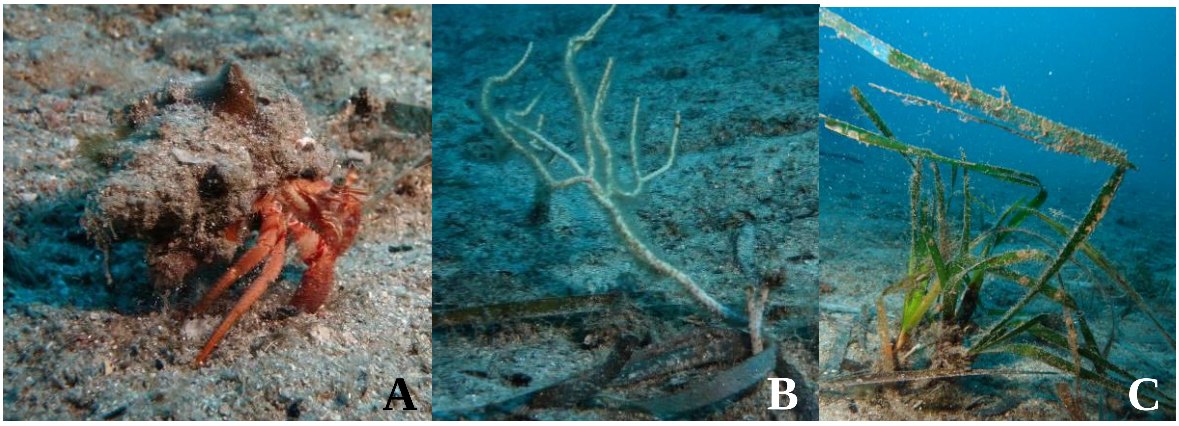
A: *Cystoseira* sp. **B:** *Phorbas tenacior* **C:** *Cystoseria* sp.

PC06

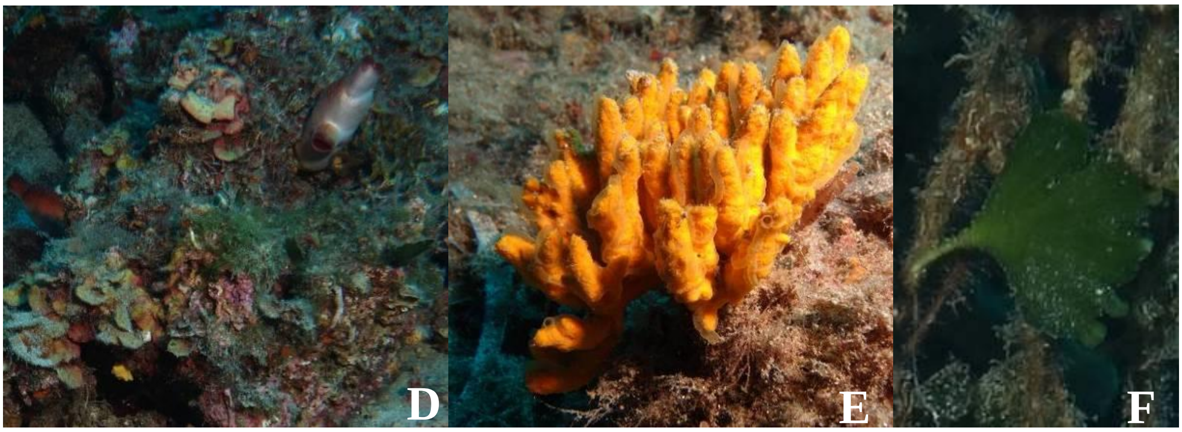
A: *Reteporella grimaldii*, *Valonia macrophysa*

Le Levant

LV01

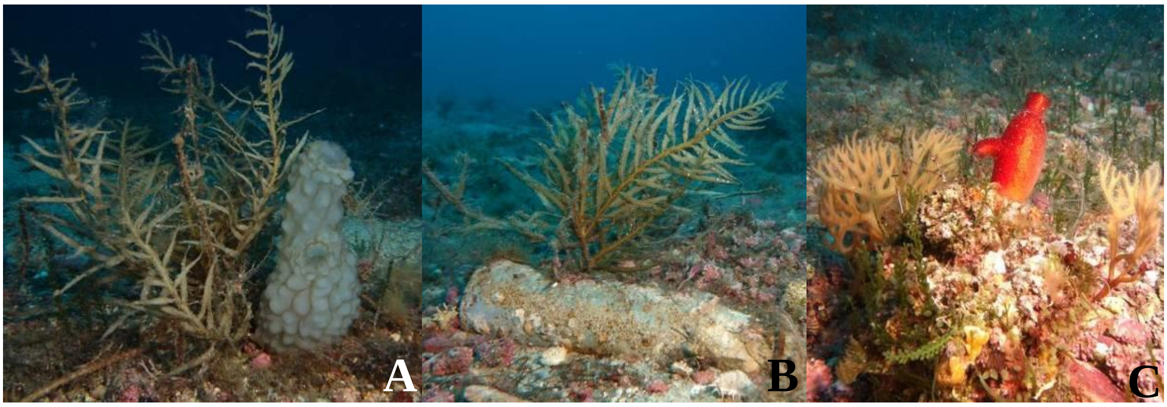


A: *Paguristes oculatus* **B:** *Eunicella singularis* **C:** *Posidonia oceanica*



D: Halocynthia papillosa**,** Peyssonneliacea **E:** Axinella verrucosa **F:** *Flabellia petiolata*

LV02



A: *Phallusia mamillata*, *Cystoseira* sp. **B:** *Cystoseira* sp. **C:** *Halocynthia papillosa*, *Sebdenia dichotoma*

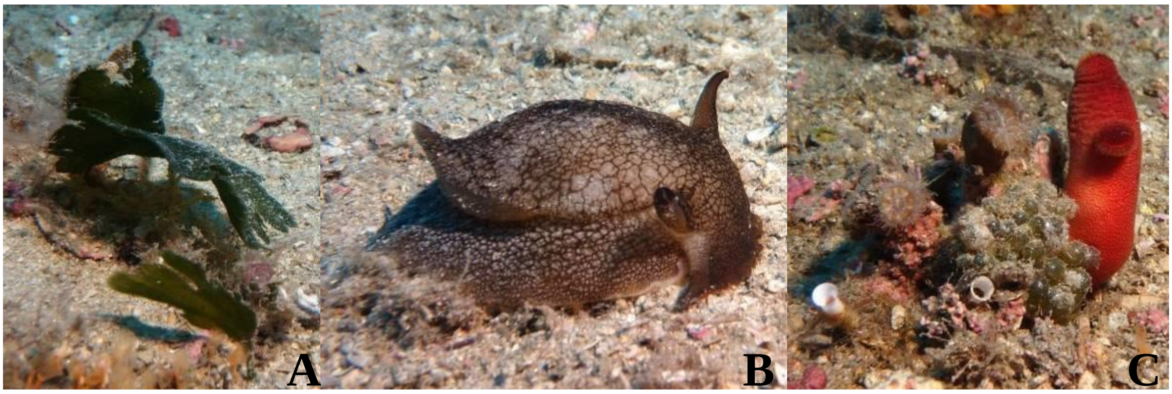
D: *Caulerpa cylindracea*, *Arthocladia villosa*, Bryozoa? **E:** Tyre, *Coris julis*, *Caulerpa cylindracea* **F:** Capsule, Rhodolithes

G: *Holothuria tubulosa*, Hydrozoa **H:** *Echinaster sepositus*

I: *Apomatus similis*, *Caulerpa cylindracea* **J:** *Astropecten aranciacus*

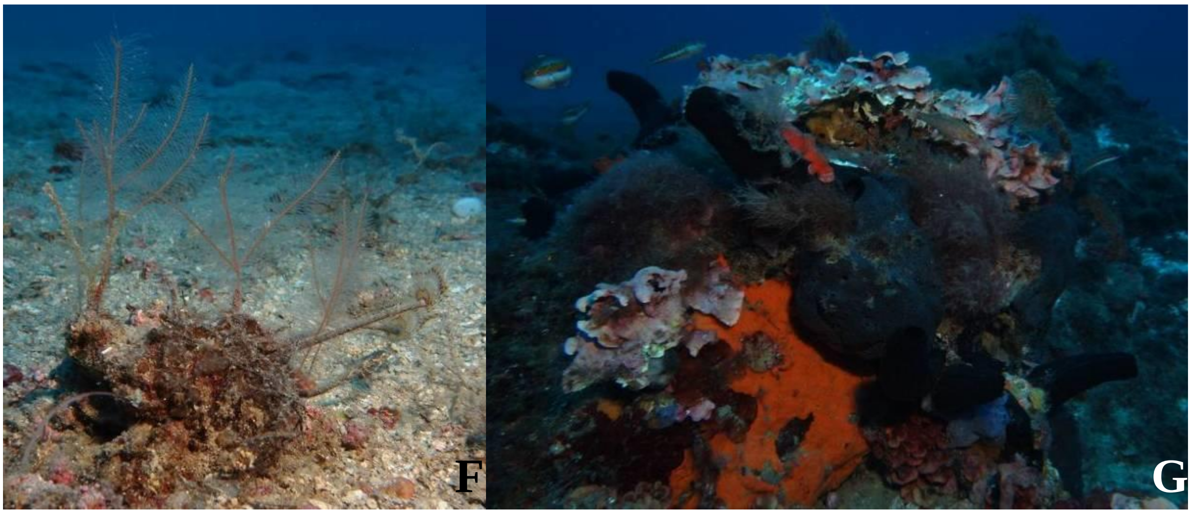
Cap Lardier

CL01



A: *Flabellia petiolata* **B:** *Pleurobranchaea meckeli* **C:** *Halocynthia papillosa*, *Valonia macrophysa*

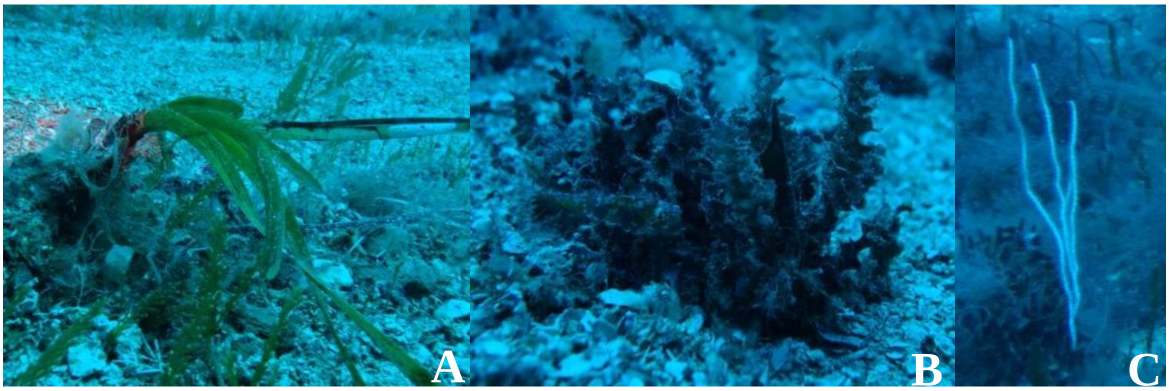
D: Sabella spallanzanii **E:** Halimeda tuna



F: Hydrozoa **G:** *Phallusia fumigata*, *Coris julis*, *Serranus cabrilla*, *Symphodus cinereus*, etc.

H: Crustacea **I:** *Holothuria tubulosa*

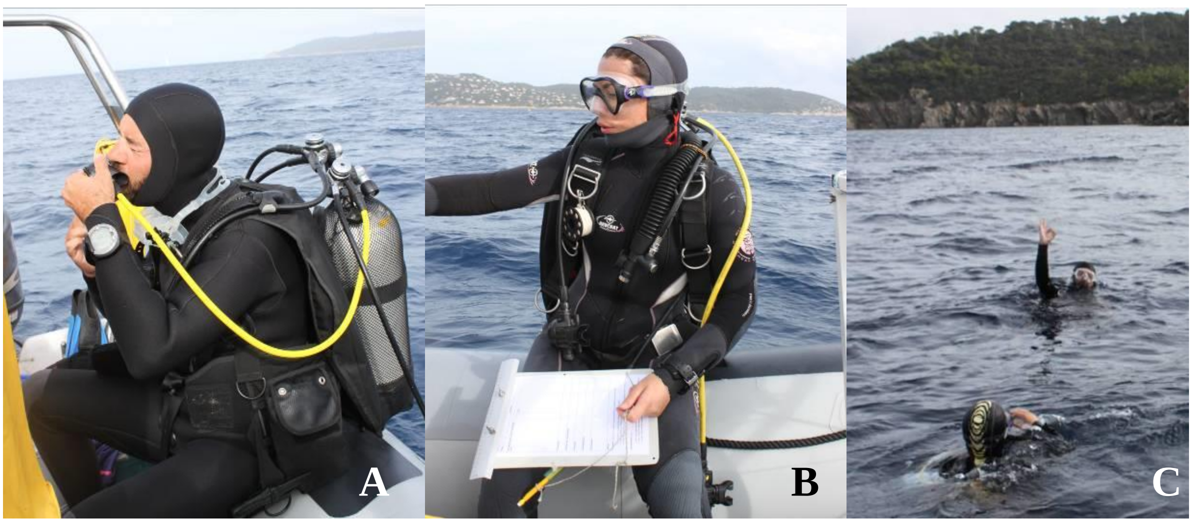
CL02



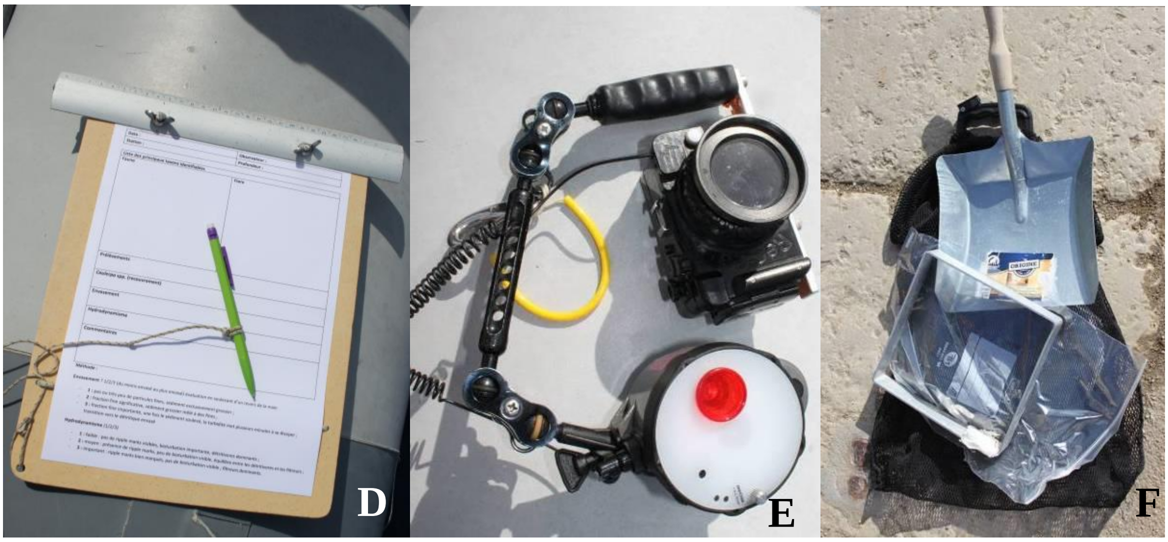
A: *Posidonia oceanica, Caulerpa cylindracea* **B:** *Osmundaria volubilis* **C:** *Eunicella singulari*

8.5. Pictures of the sampling and identifications

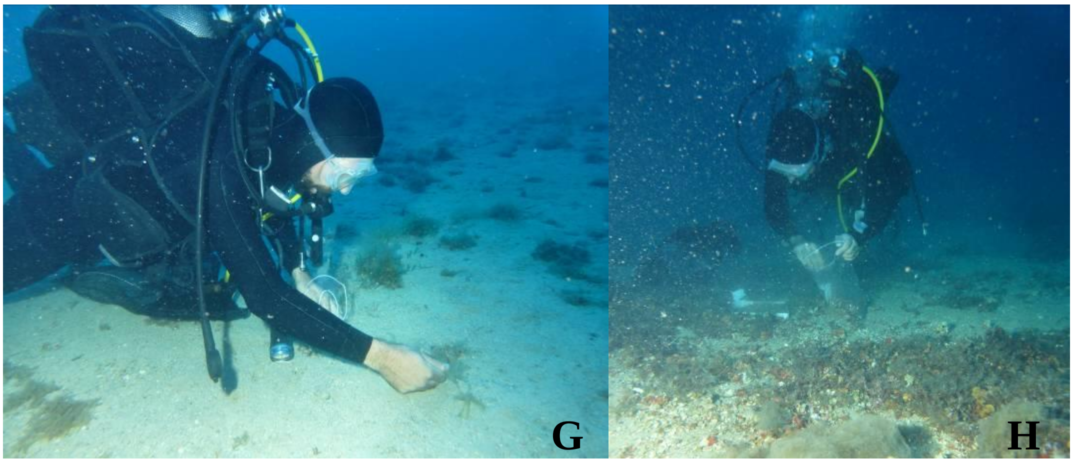
Scuba-diving:



A+B+C: Divers



D: Waterproof sheet for notices **E:** Underwater camera **F:** Material for collecting samples (Shovel, frame, plastic bag+ transportation bag)

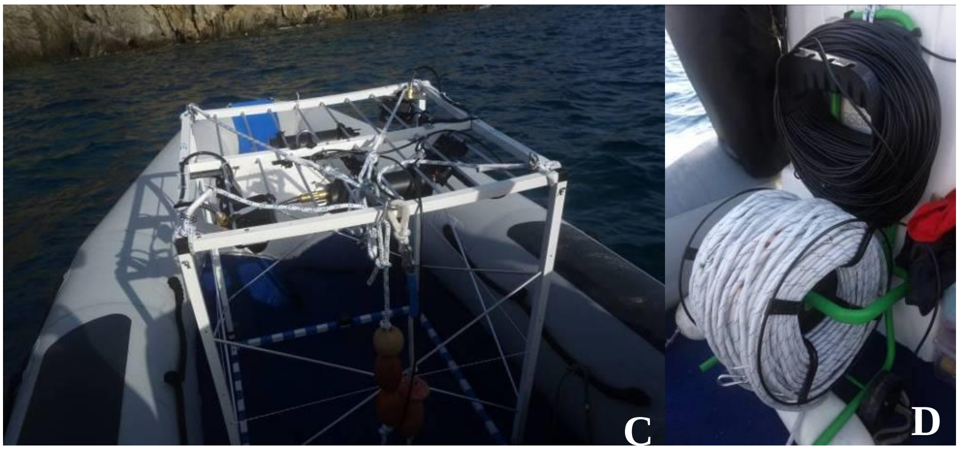


G+H: Sampling with the frame

Sampling with the BioCube:

Material:

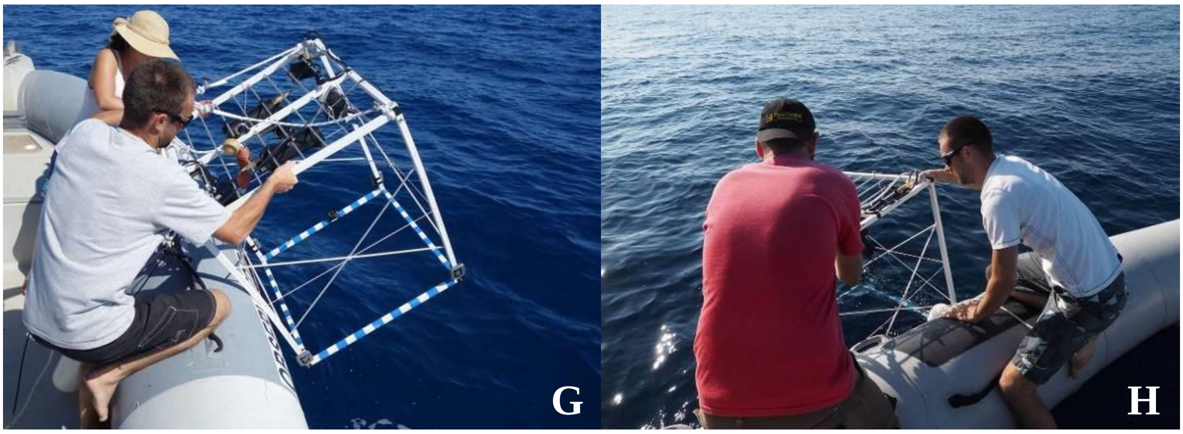
A: Boat with material **B:** BioCube and monitor on the boat



C: BioCube on the boat **D:** Robe and cable of the BioCube

Procedure:

E+F: Preparation of the BioCube

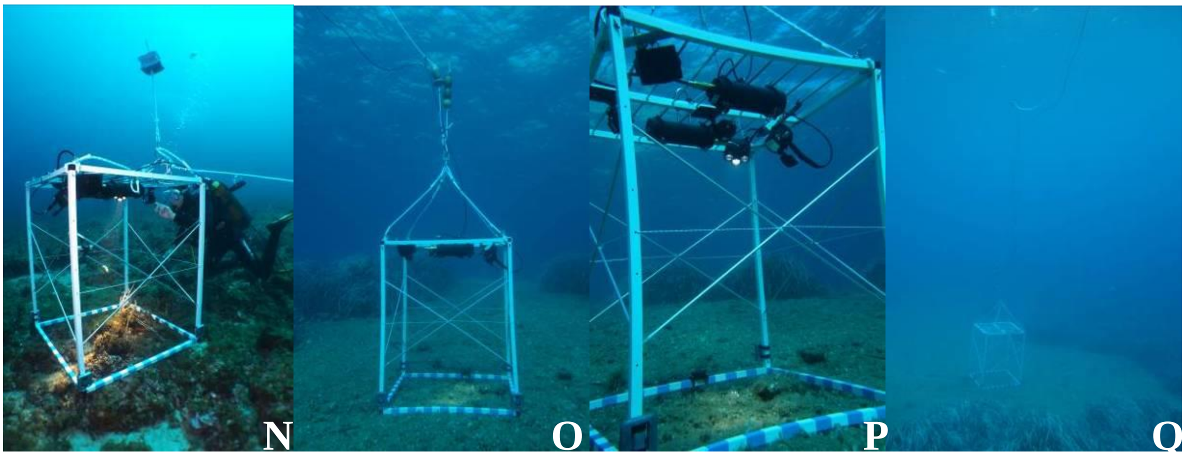


G+H: Putting the BioCube into the water

I+ J: Sinking the BioCube

K+L: Controlling the BioCube with help of the monitor **M:** Taking notes (depth, coordinates, etc.)

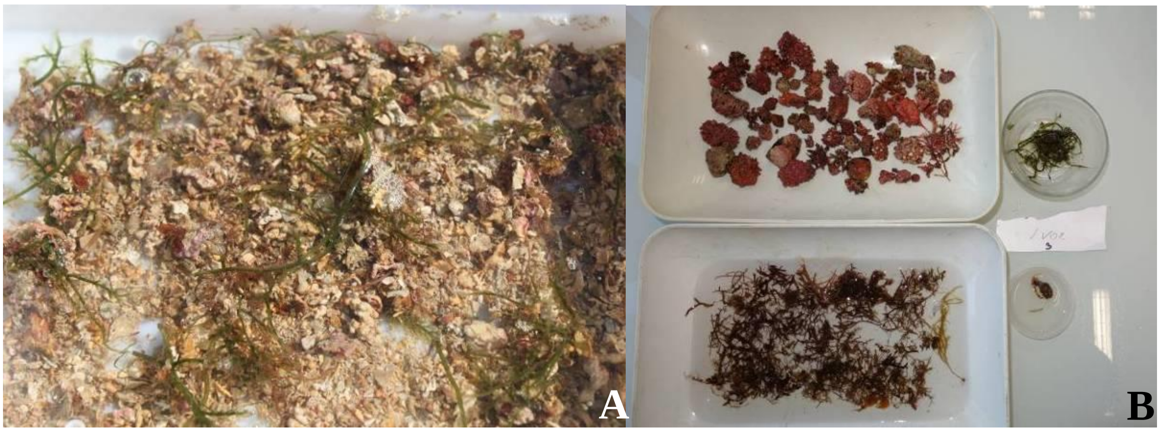
BioCube while sampling:



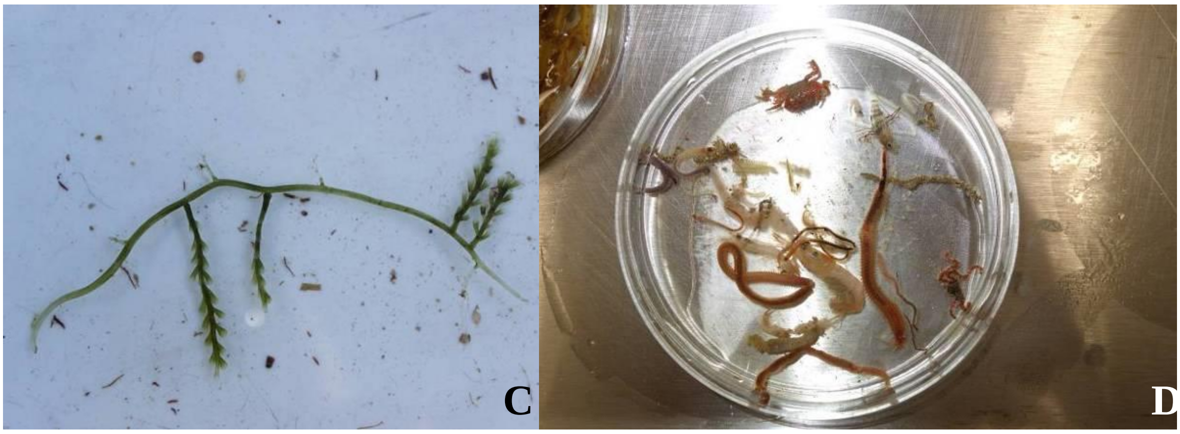
N+O+P+Q: BioCube in the water

R+S: BioCube in the water (R: Equipment of the BioCube)

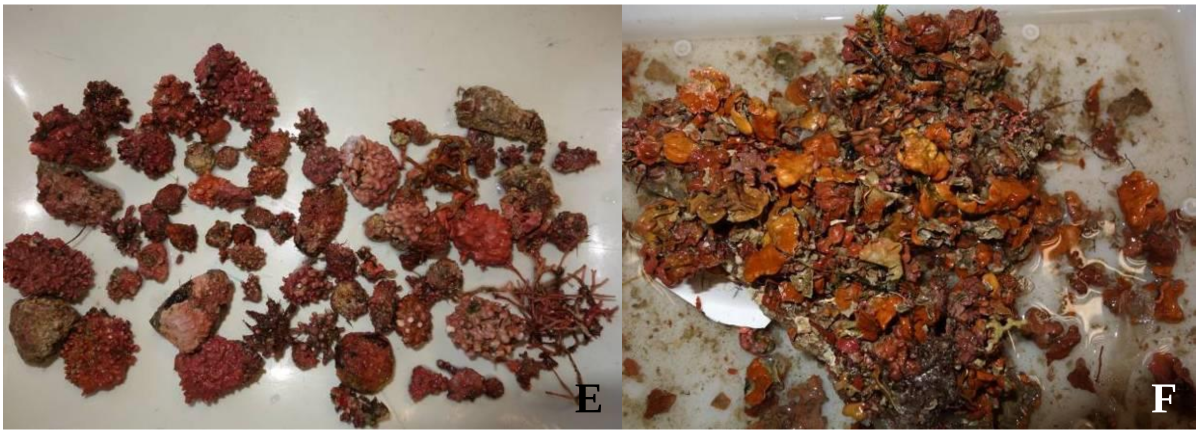
Identification of algae:



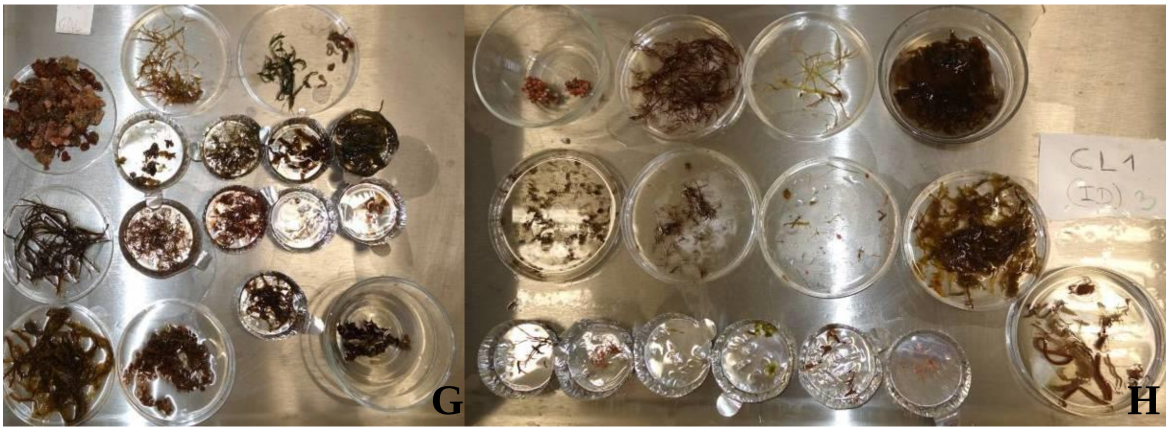
A: An unseparated sample **B:** Sample separated in the four categories calcareous algae (above left), fleshy algae (bottom left), *Caulerpa cylindracea* (above right) and fauna (bottom right)



C: *Caulerpa cylindracea* **D:** Fauna



E: Corallinales **F:** Peyssonneliales



G+H: Fist separation of fleshy algae

I+J: Identification of the fleshy algae

K: *Caulerpa cylindracea* (left: wet, right: dry)