REPUBLIC OF CROATIA
MINISTRY OF ENVIRONMENTAL AND NATURE PROTECTION

State Institute for Nature Protection

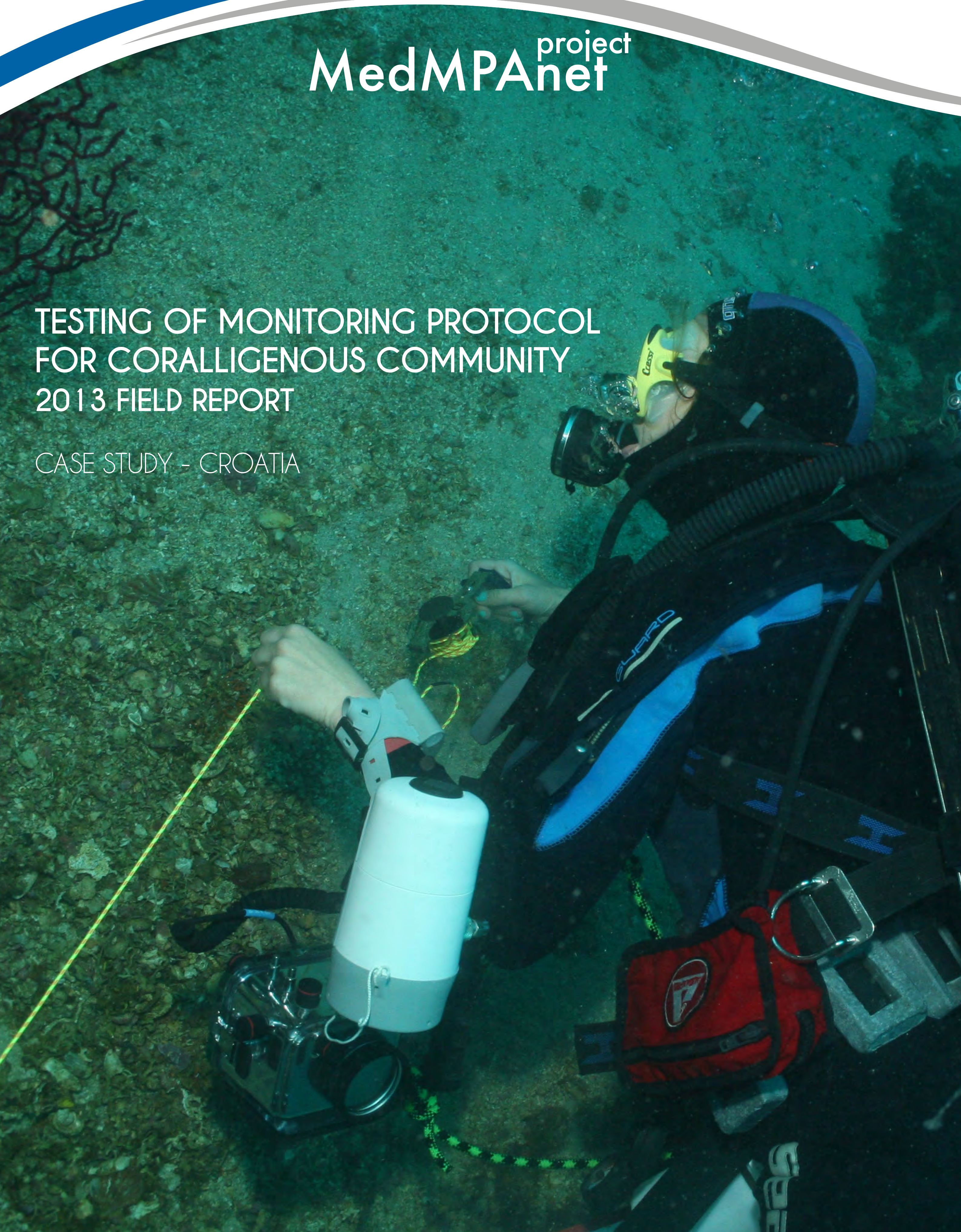
Priroda Public Institution

UNEP MAP RAC/SPA

MedMPAnet project

TESTING OF MONITORING PROTOCOL FOR CORALLIGENOUS COMMUNITY 2013 FIELD REPORT

CASE STUDY - CROATIA



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FOREWARD

Development and testing of the coralligenous monitoring protocol has been carried out in the framework of the "MedMPAnet Project – Pilot project Croatia".

The pilot project in Croatia is part of the Regional Project for the Development of a **Med**iterranean **M**arine and Coastal **P**rotected **A**reas (MPAs) **Net**work through the boosting of MPAs creation and management (MedMPAnet) that includes 12 Mediterranean riparian countries.

The objective of the regional project consists in 'enhancing the effective conservation of regionally important coastal and marine biodiversity features, through the creation of an ecologically coherent MPA network in the Mediterranean region', as required by the Barcelona Convention's Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/BD protocol).

Project objectives in Croatia are to improve MPA management at local level through filling gaps in ecological and fisheries knowledge and better enforcement and monitoring and to assist the Croatian Government in implementing the SPA/BD Protocol and developing marine part of Natura 2000 network through inventorying and mapping, as well as further development of national monitoring protocols.

Project partners in Croatia are the Ministry of Environmental and Nature Protection (MENP), the State Institute for Nature Protection (SINP) and the Public Institution "Priroda".

The project in Croatia is coordinated by the Ministry of Environmental and Nature Protection of the Republic of Croatia, whilst the regional project is coordinated by the Regional Activity Centre for Specially Protected Areas (RAC/SPA) based in Tunisia.

Project is funded by the European Commission, Spanish Agency for International Development Cooperation (AECID) and the French Global Environment Facility (FFEM). The MedMPAnet project is an integral part of the MedPartnership GEF full size project "Strategic Partnership for the Mediterranean Sea Large Ecosystem" lead by UNEP/MAP.

Contents

Executive summary

This document reports on the pilot study carried out from 13th until 25th of July 2013 within Primorje-Gorski Kotar County in order to test the protocol proposed by the MedMPAnet Working Group for the monitoring of coralligenous outcrops, a habitat endemic to the Mediterranean Sea and included in the priority habitat type “1170 Reefs“ by the EU Habitat Directive. According to the proposal, underwater work included photosampling and visual census to collect data for the characterization of the coralligenous structure and dynamics as well as on potential disturbances such as mass mortalities, mucilaginous algal aggregates, sedimentation and fishing impacts. In addition, at one site (Ćutin Mali) deployment of sensors to record seawater temperature (as one of the potential environmental parameters to monitor) was demonstrated.

In total, 11 sites have been studied, all of them being recently proclaimed as proposed Natura 2000 sites, except one (Cape Selzine at Cres Island). In addition, six studied sites where located within Prvić, Grgur and Goli Islands – the area that forms Prvić and Grgurov kanal Special Reserve. A total of 9 divers have participated in this field work, with affiliations at the University of Zagreb, University of Trieste, Center for Marine Research in Rovinj, Institute of Oceanography and Fisheries and State Institute for Nature Protection. Field work was conducted with support of the representative of the Public Institution "Priroda".

From photosampling surveys (424 images have been examined) a total of 101 macrobenthic taxa (i.e. categories of sessile organisms) were identified from photographs: 25 macroalgae, 42 sponges, 10 anthozoans, 1 hydrozoan, 3 polychaetes, 1 bivalve, 10 bryozoans and 9 tunicates. The highest number of taxa was recorded at the North coast of the Goli Island (68 taxa) and the lowest at the Cape Sokol at the Krk Island (40 taxa). The main algal builders were identified as encrusting calcareous red algae *Mesophyllum macroblastum*, *Lithophyllum stictaeforme,* unidentified encrusting Corallinacea, *Lithothamnion minervae, Neogoniolithon mamillosum* and calcareous *Peyssonnelia* species. The most common animal builders were bushy bryozoans *Myriapora truncata* and *Smittina cervicornis/Adeonella pallasii* as well as a group of orange encrusting bryozoans. Other frequent animal builders were serpulid polychaeta and scleractinian corals *Leptopsammia pruvoti, Caryophyllia smithii* and *C. inornata.*

Among agglomerative species, sponges *Fasciospongia cavernosa* and bryozoan *Beania* sp. were noted. Furthermore, the main bioeroders were boring sponges *Cliona* sp., and the endolithic bivalve *Gastrochaena dubia.* Species of structural importance were gorgonians *Paramuricea clavata* and *Eunicella cavolini* as well as sponges *Axinella cannabina*, *Axinella polypoides* and large specimens of *Aplysina cavernicola*. Collected species data will assist in compilation of typical/indicator species list, i.e. list of species that should be included in inventory/monitoring of coralligenous habitat.

Visual census was used to assess the habitat complexity, gorgonian health status as well as the abundance of macrobioeroders, mucilaginous incidence, sedimentation levels and fishing impacts. In order to test the applicability and replicability of the methods, visual surveys were carried out by different operators and at different sites. At two sites different operators made assessments along marked transects, while at 6 sites the assessments were made along random transects. Finally, at 1 site the assessments were carried out on 2 different dates. In total, visual census has been carried out along 28 transects, and 12 assessments of gorgonian health status have been made. The presence of discarded fishing gear has been recorded at 6 sites.

Overall, the comments during the debriefing and the comparison of data obtained from different assessments by different operators enabled us to determine the applicability and replicability of the proposed methods. Whereas no methodological modifications were envisaged for the assessment of gorgonian health status and fishing impact, the insights obtained during this field trip resulted in modification of the assessment of most other parameters. In summary, it was decided that:

- Macrobioeroders (except sea-urchins), cover of basal and intermediate layers and sediment cover should be assessed from photographs (instead of visual assessment along transects in the field)
- Photosampled area should be increased to accommodate the assessment of above mentioned parameters (in addition to the previous ones)

- Categories used for the estimation of cover of mucilaginous aggregates should be simplified

In view of these results a new monitoring protocol was developed and included in the Monitoring Program for Reefs – Coralligenous Community document. Developed monitoring protocol is intended to be used for the fulfilment of reporting and monitoring requirements of the Habitats Directive. This outcome is envisaged to significantly improve the implementation of the SPA/BD Protocol of the Barcelona Convention and contribute to implementation of the ecosystem approach in Croatia.

1. Introduction

1.1. Coralligenous habitat: value and threats

Coralligenous outcrops, which are hard bottoms of biogenic origin that thrive under dim light conditions, represent an endemic habitat for the Mediterranean Sea (Ballesteros 2006). They are common all around the Mediterranean coasts (UNEP/MAP-RAC/SPA, 2008). Coralligenous outcrops develop on rocky reefs and biodetritic bottoms from ~20 m down to 120 m depth, in relatively constant conditions of temperature, currents and salinity (Laborel 1987).

These outcrops are highly diverse (harboring approximately 20% of Mediterranean species), and exhibit great structural complexity (Ballesteros, 2006). A dynamic interplay between bioconstruction (mainly by encrusting red algae, but also bryozoans, serpulid polychaetes and scleractinian corals) and destruction processes (by borers and physical abrasion) is present within coralligenous outcrops (Ballesteros 2006). Besides species with bioconstruction/biodestruction roles, other organisms such as soft corals, sponges and tunicates dominate coralligenous seascapes, adding to its structural complexity (Fig. 1 a-d). This diversity promotes coralligenous outcrops as one of the most attractive seascapes in the Mediterranean for scuba diving (Harmelin & Marinopolous 1994). Moreover, coralligenous outcrops host some of the protected (e.g. Fig. 1 c) and commercially valued species (e.g. Fig. 1 d-f).

The coralligenous habitat is directly threatened by specific human activities, which strongly mortgage its future preservation. Major disturbances affecting coralligenous outcrops include mass mortality outbreaks related to global climate change, direct and indirect impacts of fishing activities (e.g. trawling, exploitation of the red coral, detachment and physical abrasion caused by various fishing gear), pollution, elevated sedimentation, mucilaginous algal aggregates and the colonization by invasive species (Ballesteros 2006, UNEP/MAP-RAC/SPA, 2008) (Fig. 2).

Due to their ecological, aesthetic and economic value, currently under threat, coralligenous outcrops were listed among the habitats needing rigorous protection by the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/BD

Protocol) to the Barcelona Convention[1] and recently the ''Action plan for the conservation of coralligenous and other calcareous bio-concretions in the Mediterranean Sea'' has been prepared (UNEP/MAP-RAC/SPA, 2008). Within the European Union, coralligenous outcrops are also recognized as a priority habitat type (EU Habitat Directive, under the code "1170 Reefs") that requires regular monitoring.

Although coralligenous habitat is widespread along the Croatian coast, it is insufficiently studied and there are no precise historical as well as recent data on its distribution, structure, dynamics and current status. Present scarcity of information on coralligenous habitat (in the Adriatic but also at the Mediterranean scale) partially stems from the complexity involved in studying these highly diverse systems with slow dynamics, coupled with general logistical constraints related to sampling within deep rocky habitats (Virgilio *et al.,* 2006, Kipson *et al.,* 2011). Further scientific research and extensive mapping efforts are urgently needed in the Adriatic Sea to make regular monitoring programme less challenging to implement.

[1] Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean

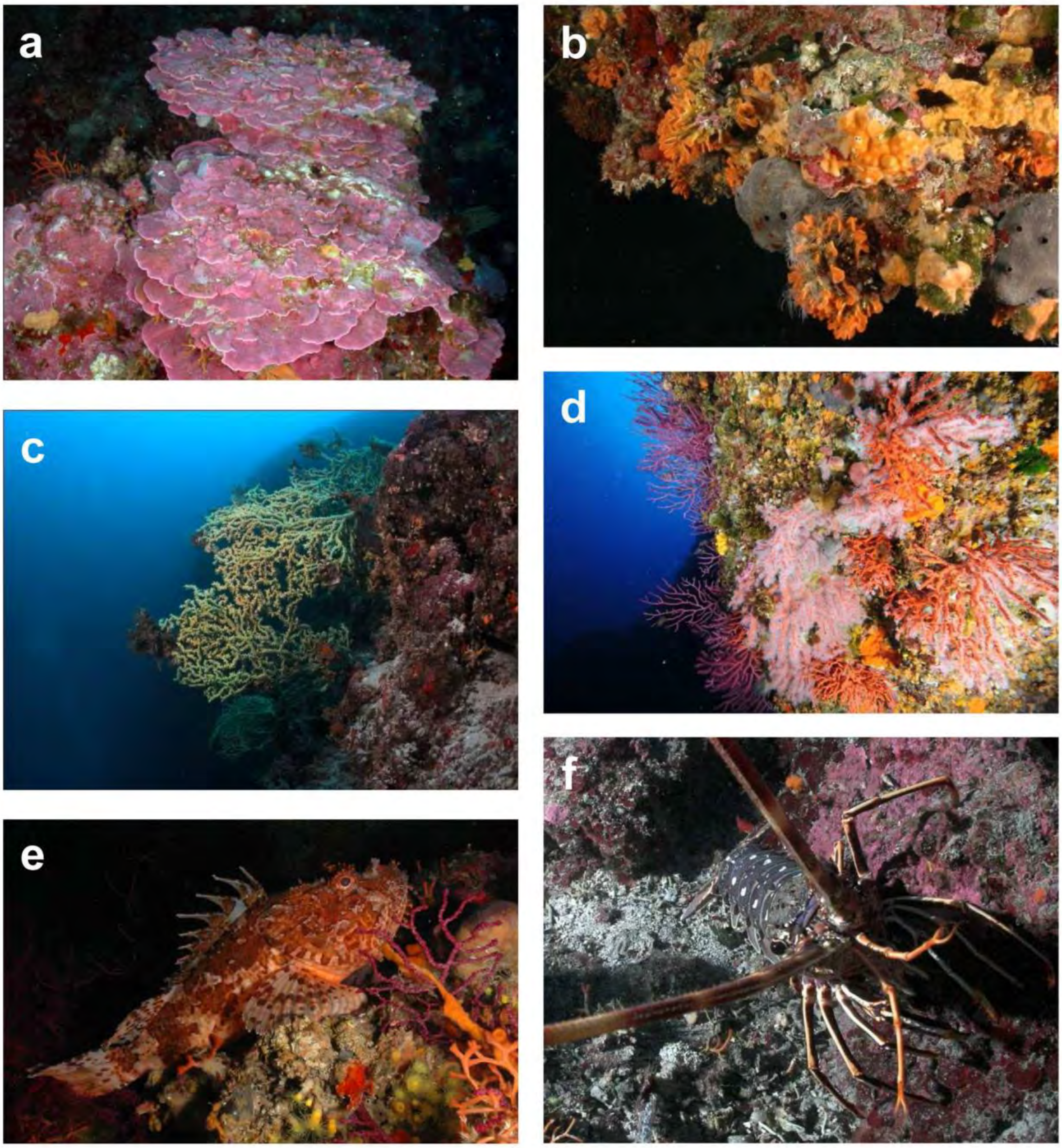

Figure. 1. Coralligenous seascapes and species. a) Calcareous red algae as the main algal builders; b) Bryozoans as one of the main animal builders; c) Protected species: hexacoral *Savalia savaglia*; d) Structurally complex facies with gorgonians *Paramuricea clavata* (left) and commercially exploited *Corallium rubrum* (right); Other commercially valuable species: e) red scorpionfish *Scorpaena scrofa* and f) spinny lobster *Palinurus elephas.* Photo credits: a, b, d, e) J. Garrabou; c, f) M. Kvarantan. Adopted from Kipson (2013).

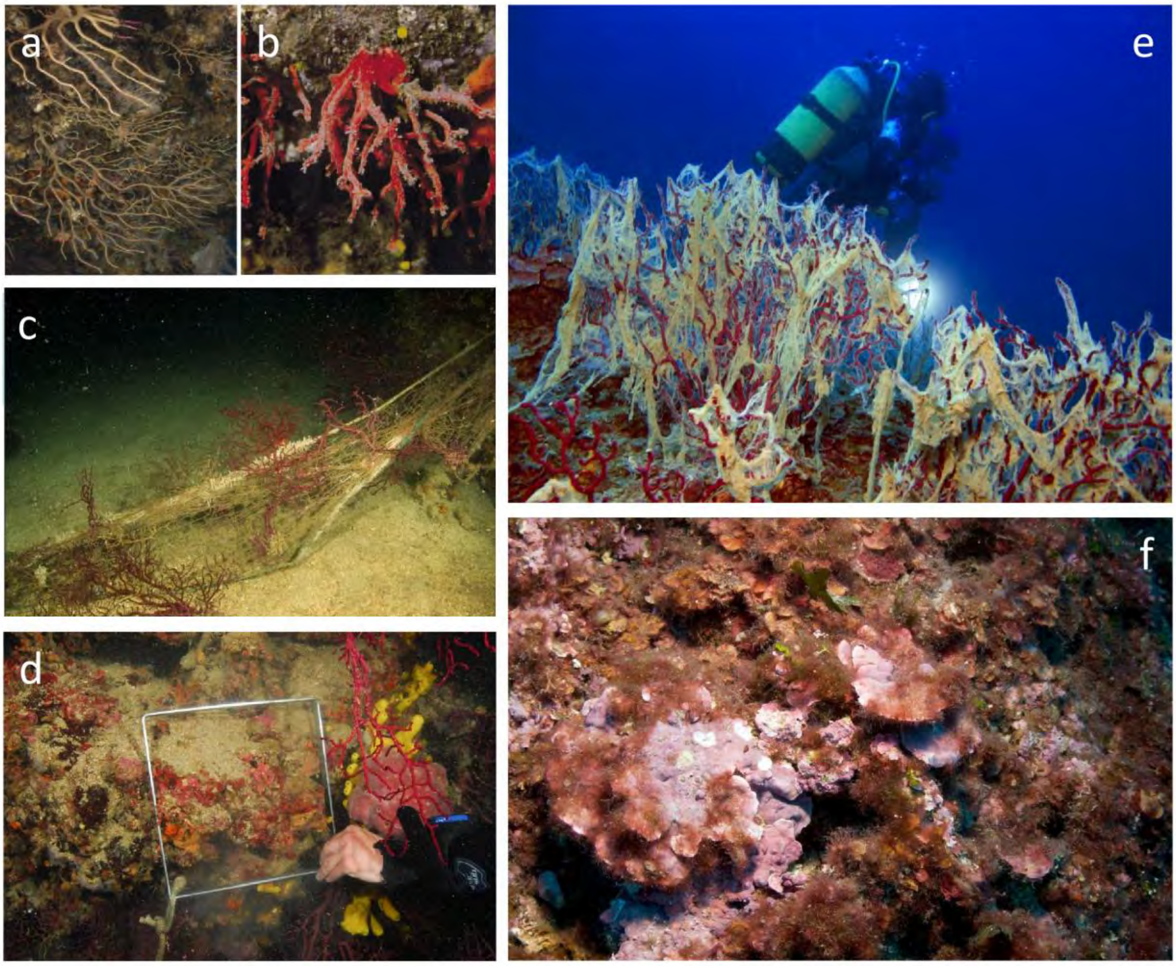

Figure. 2. Disturbances affecting coralligenous habitat. Mass mortality outbreaks related to global climate change: a) naked branches (devoid of tissue) of the red gorgonian *Paramuricea clavata* (adopted from Garrabou *et al.* 2009) and b) necrotic tissue (greyish in colour) of the precious red coral *Corallium rubrum* (adopted from Cerrano *et al.* 2000); c) destructive impact of fishing nets; d) sedimentation over coralligenous outcrops; e) mucilaginous algal aggregates over gorgonian branches; f) invasive red turf algae *Womersleyella setacea* overgrowing coralligenous main builders, calcareous red algae. Photo credits: c, d) P. Kružić; e) S. Kaleb; f) A. Žuljević.

1.2. The aim of this report

The main aim of this document is to report on the field activities carried out from 13th until 25th of July 2013 in order to test the protocol proposed by the MedMPAnet Working Group for the monitoring of coralligenous habitat. Taking into account current gaps in knowledge of the coralligenous habitat along the Croatian coast as well as lack of standardized methodology, the proposed protocol was envisaged as being robust enough to incorporate any future developments in that field. At the time of reporting (January 2014), the efforts to identify indicators of the coralligenous ecological status are being undertaken by several research groups in the Mediterranean but this work is still under development.

Therefore, the main field activities included the application of the monitoring scheme in order to validate the applicability of the proposed protocols and to update/modify the methods if necessary.

The main goals pursued by the proposed protocol were:

1. Gathering community and habitat data for the characterization of the structure and dynamics of coralligenous habitats;
2. Assessment of stressors affecting the coralligenous habitat such as mass mortalities, mucilaginous algal aggregates, sedimentation, fishing impacts;
3. Gathering of environmental data.

The monitoring envisaged the application of two methodological approaches by divers: photosampling and visual census. Photosampling was based on a validated method (Kipson *et al.* 2011), while some procedures during visual census were applied for the very first time in the field. In particular, visual census was used to assess the habitat complexity, gorgonian health status as well as the abundance of macrobioeroders, mucilaginous incidence, sedimentation levels and fishing impacts. The methods proposed were tested by most of national experts in order to obtain their opinion on the applicability and potential improvements of the methods. In order to test the applicability and replicability of the methods, visual surveys were carried out by different operators and at different sites. At two sites different operators made assessments along marked transects, while at 6 sites the assessments were made along random transects. Finally, at one site the assessments were carried out on two different dates. Overall, the comments during the debriefing and the comparison of data obtained from different assessments by different operators enabled us to determine the applicability (i.e. a degree of application difficulty) and replicability (i.e. to obtain the interoperator variability in the estimates of the different parameters) of the proposed methods (see Section 3). In view of these results a new monitoring scheme was developed and included in the Monitoring Program for Reefs – Coralligenous Community document.

2. Monitoring protocol applied

2.1. Gathering of community data for the characterization of the structure and dynamics of coralligenous habitat

As proposed by the first draft of the monitoring protocol for the coralligenous habitat, underwater work undertaken to gather community and habitat data included photosampling and visual census of habitat complexity and bioerosion.

2.1.1. Photosampling

Photosampling carried out during this field trip was envisaged to furnish data on:

(1) Community composition

(2) Impact of invasive species

At each studied site, two divers were engaged in photosampling: one diver was holding a frame (50 x 50 cm quadrat, divided in 4 subquadrats, each 25 x 25 cm in size) while the other one was taking photographs with Nikon D200 digital SLR camera fitted with a Nikkor 40 mm macro DX lens and housed in Sea & Sea housing (Fig. 3). Lighting was provided by two electronic strobes fitted with diffusers. Within the depth range of 30 to 37 m, 4-5 replicates were sampled. A replicate represented an area of 0,5 m^2 obtained by combining 8 contiguous images of 25 x 25 cm subquadrats to ensure species identification (Fig. 4).

Photos were further analysed in the laboratory and species at each study site were identified to the lowest possible taxonomic level. Visually similar taxa that could not be consistently identified from photographs were grouped in specific categories as indicated in Appendix 3.

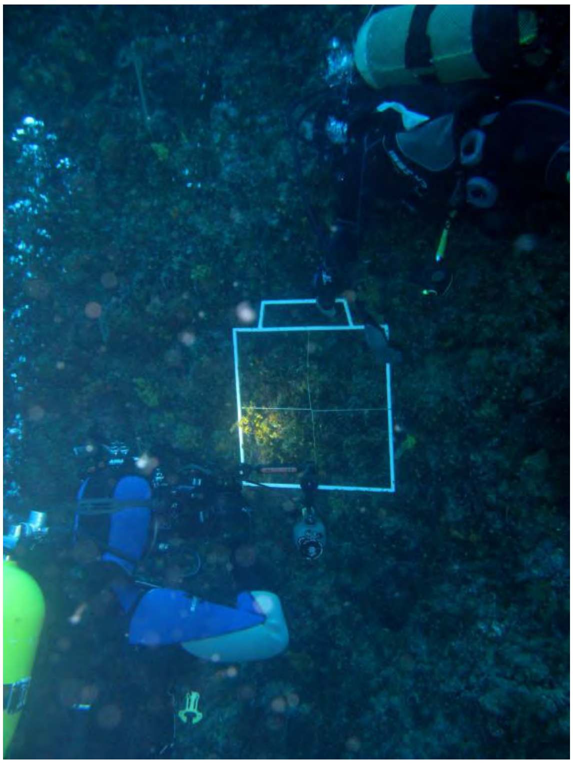

Figure. 3. Underwater photo sampling using 50 x 50 cm quadrat divided in four 25 x 25 cm subquadrats. Each subquadrat is photographed individually. After 4 subquadrats are photographed, quadrat is flipped horizontally (e.g. around the right vertical axis) and photographing procedure is repeated until images of 8 subquadrats in total (a replicate, see Fig. 4) has been acquired. Photo credit: D. Župan.

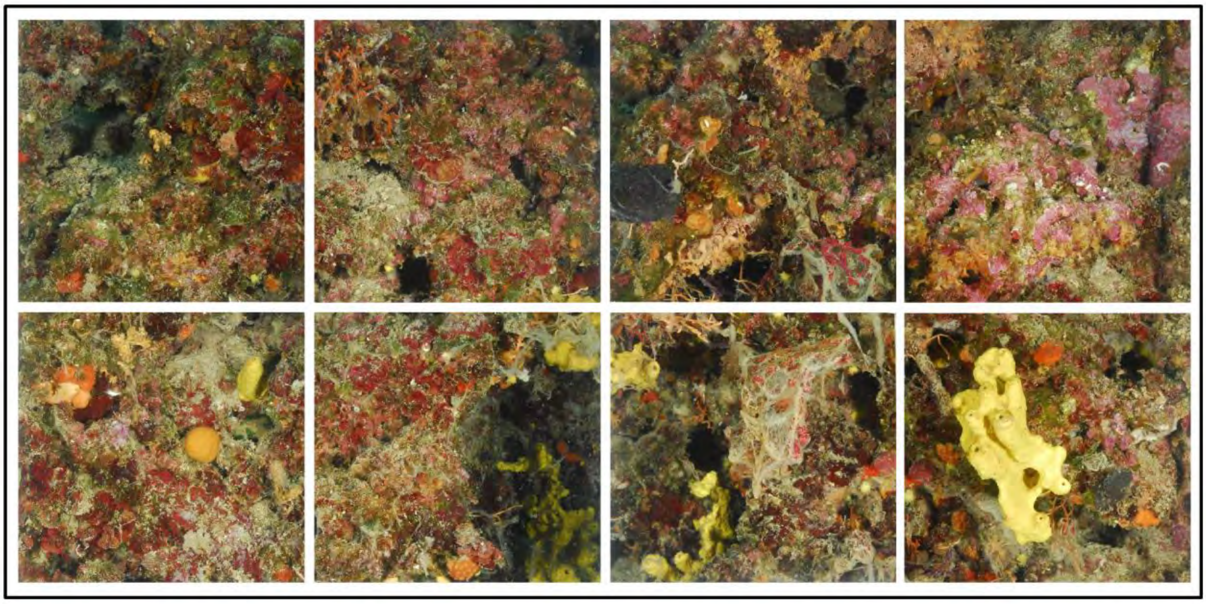

Figure. 4. A replicate used in photosampling: an area of 0,5 m^2 obtained by combining 8 contiguous photos of 25 x 25 cm subquadrats. At each study site 4 to 5 replicates were sampled. This example originates from Cape Šilo at the Prvić Island.

2.1.2. Visual census along transects

Visual census was carried out along horizontal transects that were 20 m long and 0,5 m wide. For each 5 m- portion of the transect (4 in total) a diver was estimating parameters related to the structure and dynamics of coralligenous habitat: parameters on habitat complexity (3) and bioerosion (4). As mentioned, at 8 sites different operators made the estimations of parameters either over marked (by a rope, see Fig. 5) or random transects in order to assess the replicability of the estimations.

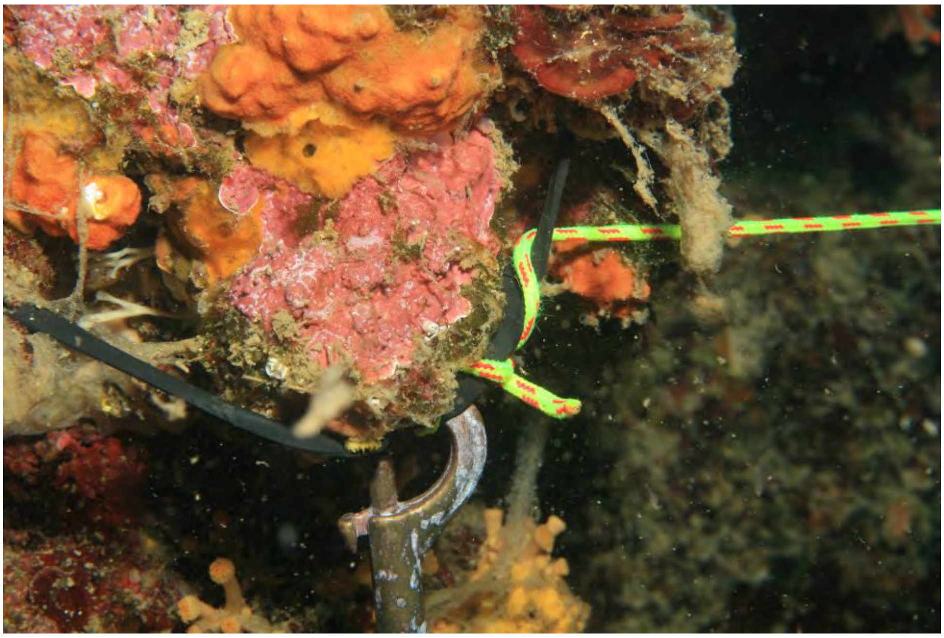

Figure. 5. Attachment of the rope used to mark 20 m long transect at two sites (Cape Markonj and Cape Sokol). In that way, the same transect could be assessed by different operators. Photo credit: A. Žuljević.

(3) Habitat complexity

The habitat complexity was assessed based on the estimation of coverage of the 3 basic coralligenous strata: basal (encrusting organisms), intermediate (bush-like organisms up to 15 cm height) and erect (large organisms). The illustration of different strata is provided in Fig. 6.

For the coverage estimates of the basal and intermediate strata the following categories were used:

Category 1: 1-5 % cover of the transect

Category 2: 5-25 % cover of the transect

Category 3: 25-50 % cover of the transect

Category 4: 50-75 % cover of the transect

Category 5: 75-100 % cover of the transect

For the coverage estimates of erect strata the following categories were used:

Category 1: Isolated colonies

Category 2: Some patches with colonies (few colonies per m^2)

Category 3: Continuous patches covering at least 25 % of the transect

Category 4: Continuous patches covering 25-50 % of the transect

Category 5: Continuous patches covering >50 % of the transect

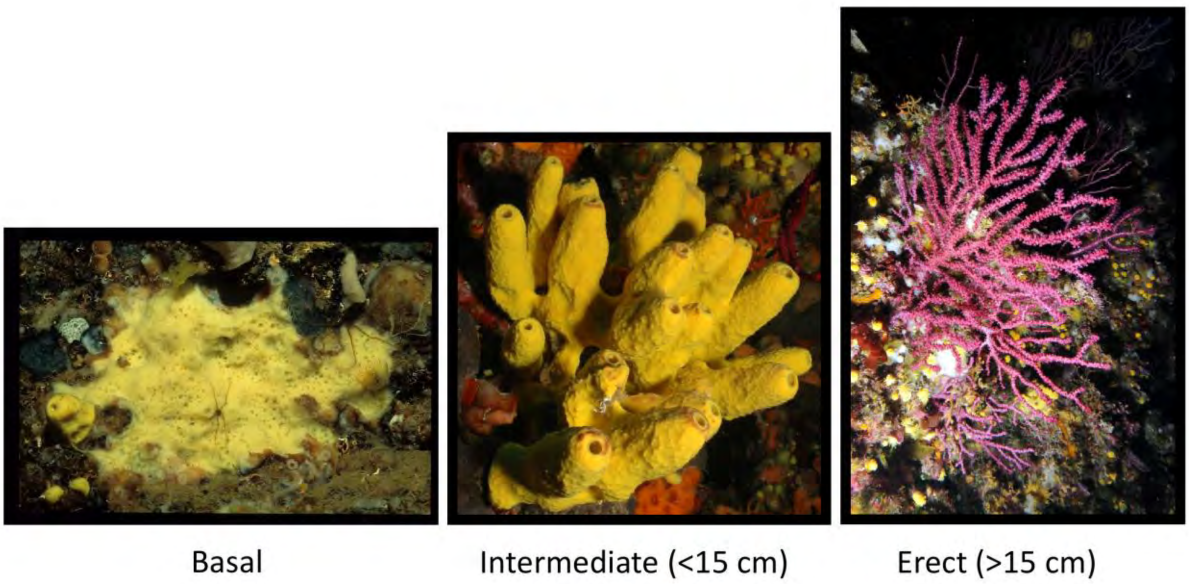

Figure 6. Illustration of three basic strata used to assess the degree of complexity of coralligenous habitat.

(4) Bioeroders abundance

Along the same horizontal transect used for the assessment of habitat complexity, a diver further estimated the abundance of the main macro-bioeroders (sponge *Cliona spp.*, sea-urchins such as *Sphaerechinus granularis*, *Echinus melo*). Depending on the abundance, quantitative or semi-quantitative estimates were used. Again, these estimations were done for each 5 m- section of the transect (4 in total for 20 m long transect).

2.2. Assessment of stressors affecting the coralligenous habitat

Assessment of impact of stressors affecting the coralligenous habitat was both associated to transects (the same ones as used for the assessment of habitat complexity and bioerosion, see section 2.1.2.) and not associated to transects.

2.2.1 Visual census along transects

Visual census along transects was used to assess parameters (5) and (6):

(5) Mucilaginous aggregates

To estimate the coverage of mucilaginous aggregates along the same horizontal transect used for the assessment of habitat complexity, the following categories were used:

Category 1: 1-5 % cover of the transect

Category 2: 5-25 % cover of the transect

Category 3: 25-50 % cover of the transect

Category 4: 50-75 % cover of the transect

Category 5: 75-100 % cover of the transect

(6) Sedimentation

To estimate the impact of sedimentation along the same horizontal transect used for the assessment of habitat complexity, the following categories were used:

Category 1: 1-5 % cover of the transect

Category 2: 5-25 % cover of the transect

Category 3: 25-50 % cover of the transect

Category 4: 50-75 % cover of the transect

Category 5: 75-100 % cover of the transect

2.2.2. Visual census not associated to transects

Visual census not associated to transects was used to assess parameters (7) and (8):

(7) Mass mortalities (assessment of gorgonian health status)

At each study site where gorgonians were present as well developed populations, between 1 and 3 divers were quantifying the percentage of affected colonies. A colony was considered as affected when the necrosis rate was above 10 % of its total surface (see Fig. 7 for estimation of affected surface). For affected colonies divers were also noting whether the necrosis is recent (presence of denuded axis or axis colonized by pioneering species such as hydrozoans), old (axis covered by long-lived species such as bryozoans, calcareous algae) or has both types of necrosis (see Fig. 8). At each site a minimum of 100 colonies (of each species present) should have been examined following a random transect (Fig. 9), however occasionally this number was lower (see Fig. 29).

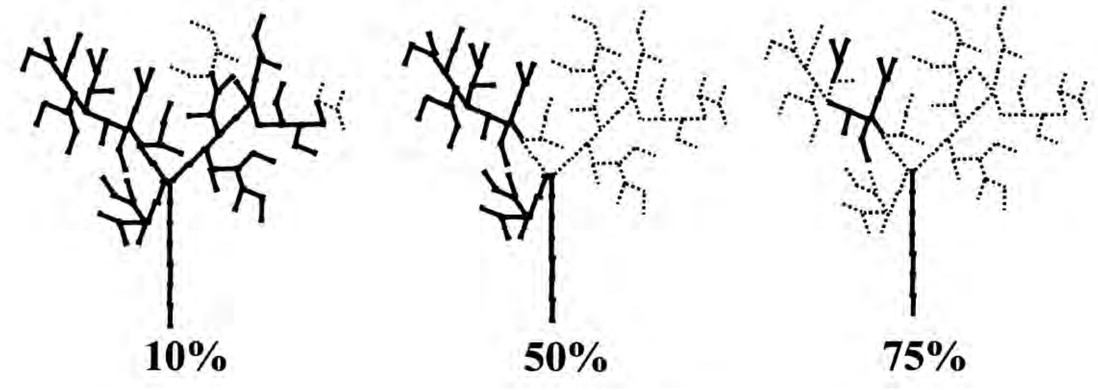

Figure. 7. Estimation of the extent of injury. According to the proposed protocol, colonies with >10% injured surface are considered to be affected (adopted from Perez *et al.* 2000).

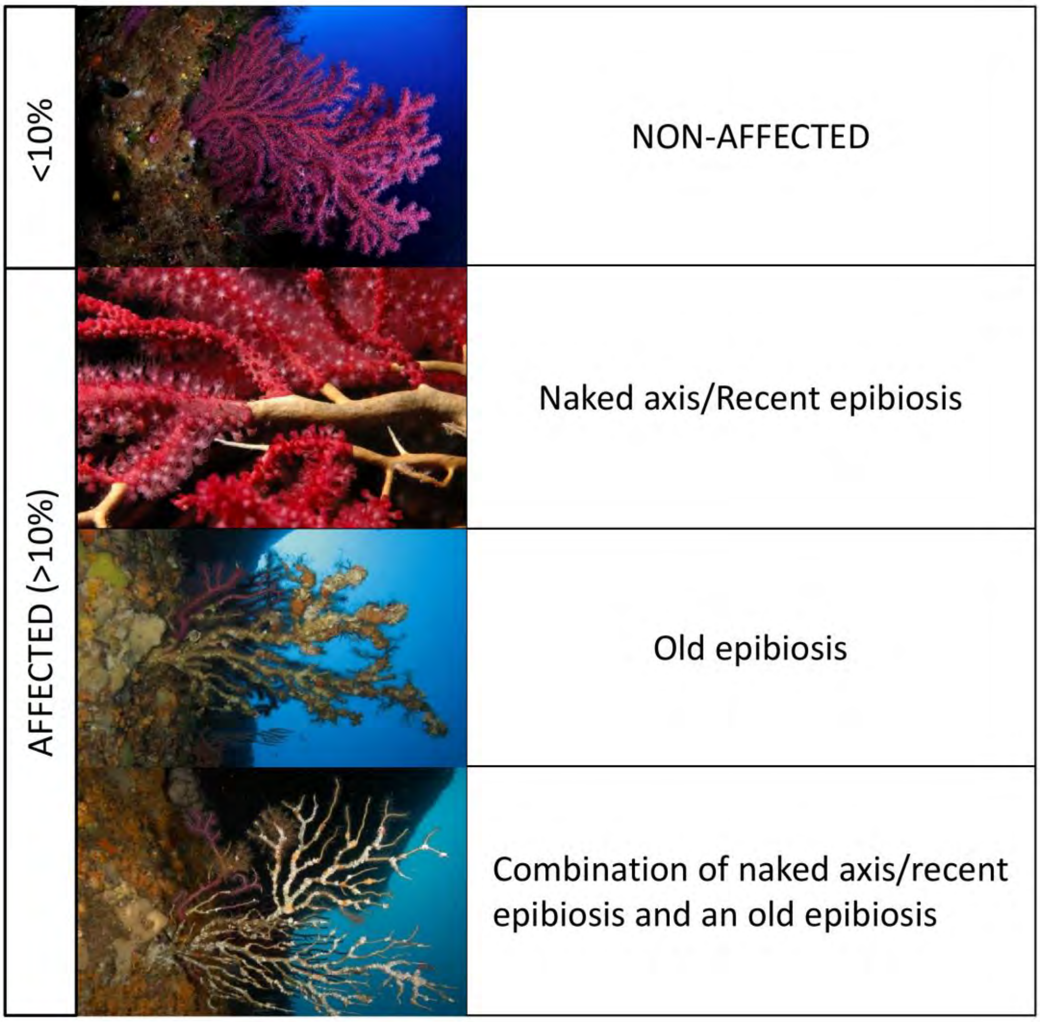

Figure. 8. Illustration of non-affected and differently affected gorgonian colonies using categories as defined in the form.

Figure. 9. Examination of gorgonians in the field. At the time of assessment (July 2013) mucilaginous algal aggregates were covering gorgonian branches. Photo credit: S. Kaleb.

(8) Fishing pressure

To estimate the impact of fishing gear on the coralligenous outcrops, divers were noting their presence and estimated their length when applicable.

2.3. Gathering of environmental data

Besides the data on habitat and species, proposed monitoring protocol also envisaged gathering of environmental data, namely the seawater temperature. For this purpose, it is advisable to deploy a temperature dataloggers at 5 m intervals down to a depth of 40 m to be able to record the summer stratification of the water column. Depending on the available funds, cheaper HOBO® Pendant Temperature/Light dataloggers or more costly but also more precise HOBO WaterTemp ProV2 dataloggers can be used (both Onset Computer Corp.). During this field work, the islet of Ćutin Mali served as a demonstration site. At this site a temperature survey was initiated in 2009 by the Laboratory for Marine Biology of Faculty of Science, University of Zagreb and it is still ongoing. This opportunity was used to make the yearly replacement of dataloggers and to demonstrate their underwater deployment (Fig. 10).

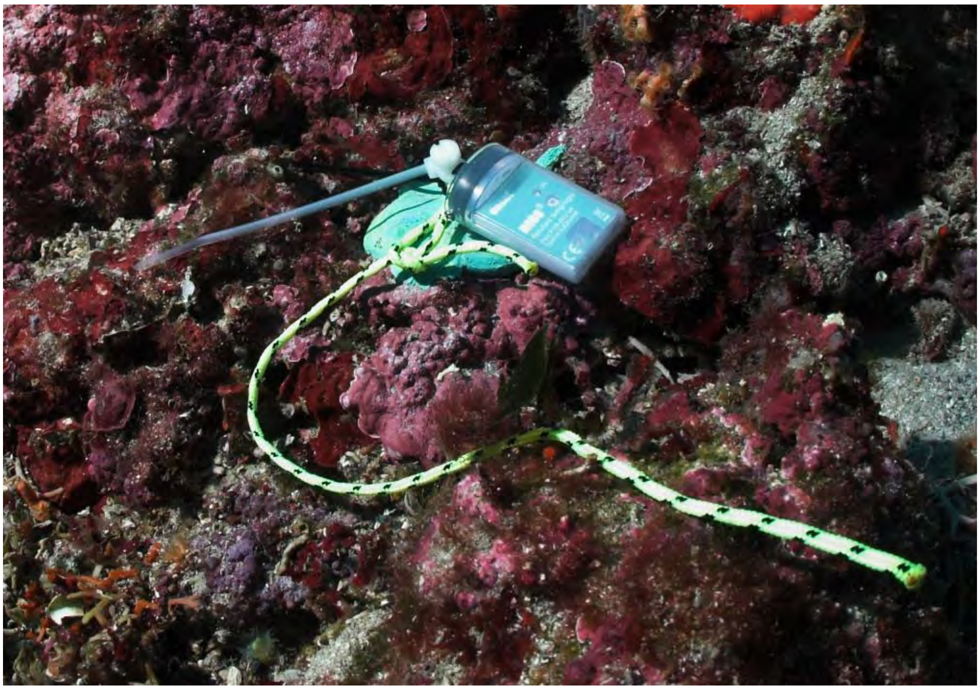

Figure. 10. Example of temperature datalogger deployed in the field. For more information on appropriate deployment visit http://t-mednet.org/ where instruction video is available in several languages, including Croatian. Photo credit: M. Kvarantan.

2.4. Data recording

Divers' briefing before the underwater work included a short presentation to recapitulate methods that will be used.

Data acquired during visual census and the assessment of gorgonian health were noted in prepared forms (see Appendix 1 and 2). These forms were printed on a special A4 paper that can be used underwater (Canson, CAD Polyester matté double face 75 µ, Ref 987102). Forms were attached to plastic slates by a duct tape (Fig. 11). Depending on the size of the slate, form can be used in A4 format or cut in 2 (for visual census and gorgonian assessment) to fit the smaller slate, in which case it may be attached at both sides of the slate. One slate was provided to each operator. Upon the transcription of the data, pencil tracks may be erased and the same form may be used multiple times. Prior to erasing the data, it is also recommended to take a photo of the slate as a back-up documentation.

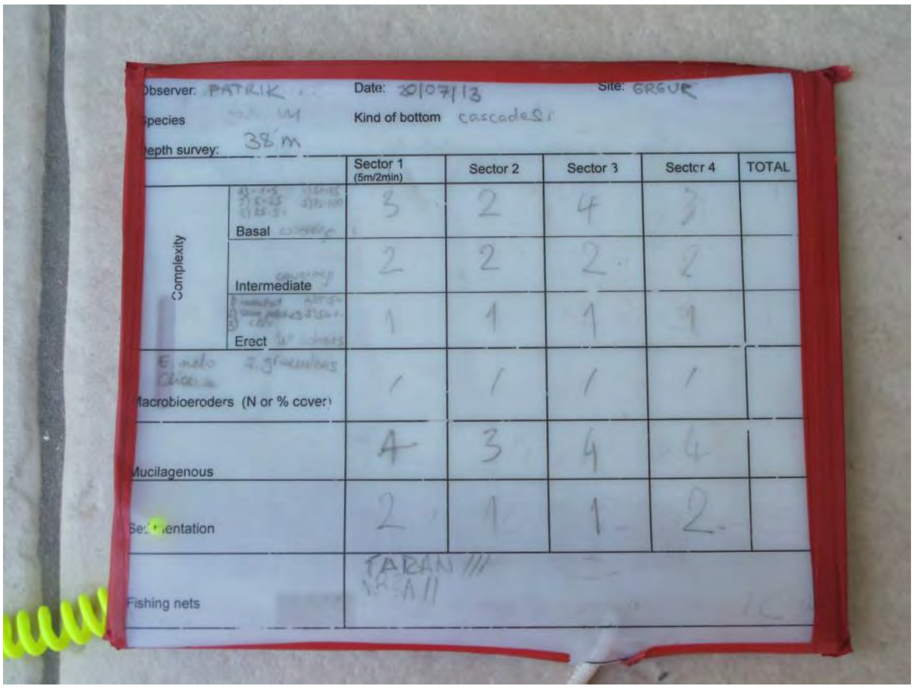

Figure. 11. Example of the form used for visual census attached to the plastic slate. Photo credit: S. Kipson.

Besides data gathering by photosampling and visual census, additional documentation of study sites, diving path and coralligenous assemblages was provided by videography (Fig. 12). Thus, this method may facilitate repeated locating of the area where assessment has been carried out as well as it can assist in characterization of the coralligenous habitat, since larger areas may be covered. In total, videos were recorded at 9 sites whereas at 2 sites (East coast of Prvić Island and Tenki at Krk Island) video recording was not possible due to technical problems.

Figure. 12. Videography proved to be a very useful tool that enabled documentation of the dive path and the assessment of greater surface of the coralligenous habitat. Photo credit: P. Kružić.

2.5. Study sites

Following criteria were applied for selection of coralligenous study sites during this field work:

- Logistics (e.g. distance from the harbour, accessibility in various weather conditions)
- Existence of some previous baseline data
- Representativeness of different assemblages based on available data
- Legal status of sites (unprotected areas vs. protected area or proposed Natura 2000 sites)
- Geographic distribution (within and outside of the Velebit channel) and distance from the mainland

As one of the goals of this study was also to acquire greater insights into otherwise poorly known coralligenous habitat along the Eastern Adriatic coast, we tried to assess as many sites as possible (time and weather permitting) in order to study a range of assemblages and potentially to identify good reference sites. In total, 11 sites have been studied (Fig. 13), where coralligenous outcrops were present at two different substrate inclinations, vertical walls (Fig. 14c) and cascade-like rocky bottom (slope intercepted by smaller walls; Fig. 14d) and where different assemblages were found, both with the domination of gorgonians (only the red gorgonian *Paramuricea clavata* was found to form a facies within the coralligenous habitat, whereas the yellow gorgonian *Eunicella cavolini* was always present but in scarce densities) and without it.

As envisaged by the protocol, each study site was documented as precise as possible, by providing GPS coordinates and a photo showing terrestrial view of the site including recognizable landmarks when possible. In addition, the diving path was described with assistance of photography and videography. All of this information was intended to facilitate the repeated locating of sites and areas where the assessment was carried out. For description of study sites see Section 4.

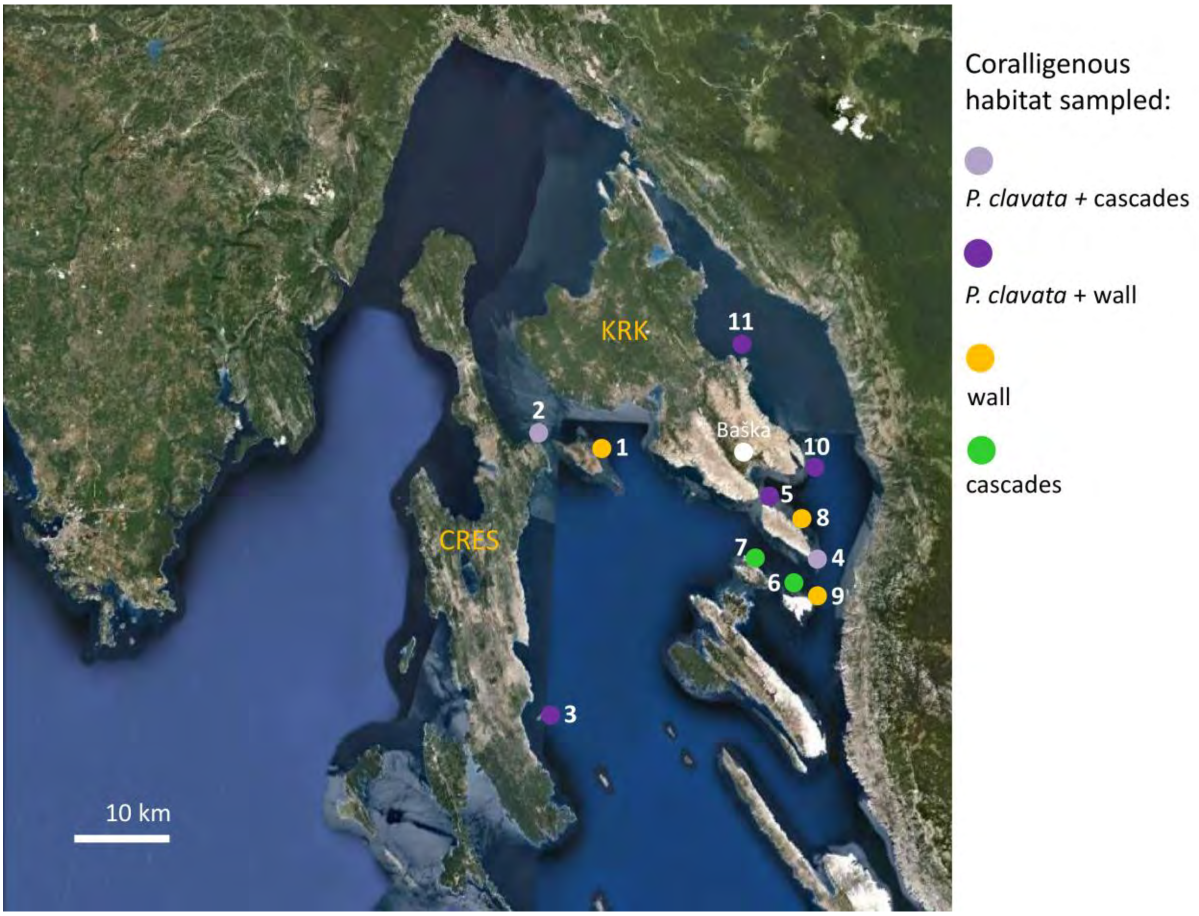

Figure. 13. Study sites of coralligenous habitat within Primorje-Gorski Kotar County (North Adriatic): 1 = Mali Plavnik; 2 = Cape Selzine; 3 = Ćutin Mali; 4 = Cape Šilo; 5 = Cape Stražica; 6 = North coast of Goli Island; 7 = Grgur; 8 = East coast of Prvić Island; 9 = Cape Markonj; 10 = Cape Sokol; 11 = Tenki. Characteristics of study sites are summarized in Table 1. More detailed maps and the overview of each site are provided in the Section 4. Map source: Google Earth, Image © 2013 DigitalGlobe.

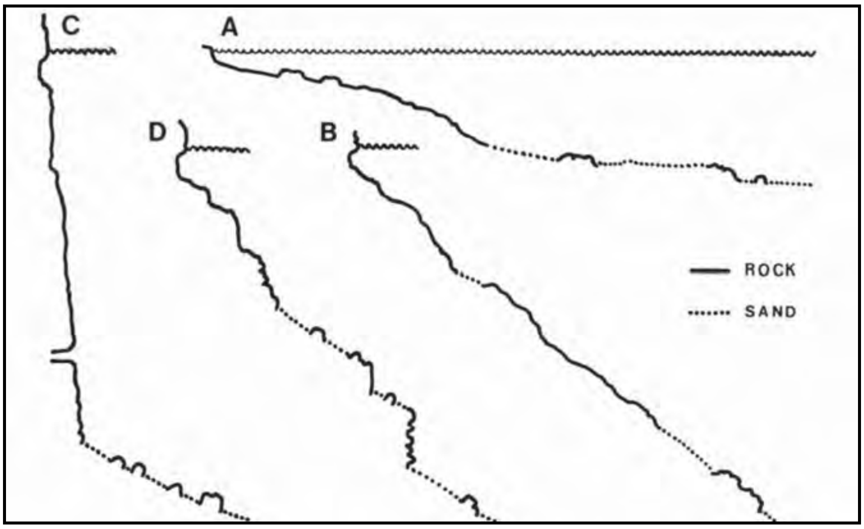

Figure. 14. Slope types: A = gentle inclined slope; B = steep slope; C = vertical cliff and D = slope + walls (adopted from Zavodnik *et al.* 2005). Coralligenous assemblages assessed within this study were developed on slope types C and D.

Table 1. Characteristics of study sites within Primorje-Gorski Kotar County (North Adriatic).

Site N	Island	Site	Abbrev.	Coordinates		Habitat	Status
1	Mali Plavnik	Mali Plavnik	MP	44°58'31.82''N	14°32'52.04''E	vertical walls	Natura 2000[2]
2	Cres	Cape Selzine	CR	44°58'56.37''N	14°28'10.87''E	cascades	unprotected
3	Ćutin Mali	Ćutin Mali	MC	44°43'27.36''N	14°29'38.95''E	vertical walls	Natura 2000
4	Prvić	Cape Šilo	PRSI	44°53'02.87"N	14°50'19.05"E	cascades	MPA, Natura 2000
5	Prvić	Cape Stražica	PRST	44°56'05.18''N	14°46'13.65''E	vertical walls	MPA, Natura 2000
6	Goli	North coast	GO	44°50'59.20''N	14°49'46.24''E	cascades	MPA, Natura 2000
7	Grgur	Grgur	GRG	44°52'41.55''N	14°45'37.06''E	cascades	MPA, Natura 2000
8	Prvić	East coast	PRS	44°55'03.64''N	14°48'51.17''E	vertical walls	MPA, Natura 2000
9	Goli	Cape Markonj	GOM	44°50'48.89''N	14°50'21.13''E	vertical walls	MPA, Natura 2000
10	Krk	Cape Sokol	KRS	44°58'14.19''N	14°49'13.04''E	vertical walls	Natura 2000
11	Krk	Tenki	KRPT	45°04'17.88''N	14°43'17.07''E	vertical walls	Natura 2000

[2] Status “Natura 2000” actually means that the sites are proposed as Natura 2000 sites (proposed Sites of Community Importance (pSCI)) to the European Commission. After the evaluation process and subject to approval, these sites will be proclaimed as Natura 2000 (Special Area of Conservation (SAC)) sites.

3. Synthesis of Results and Recommendations

3.1. Gathering of community data for the characterization of the structure and dynamics of coralligenous habitat

3.1.1. Photosampling

(1) Identification of Species/categories (community composition) based on photosampling

Main results: Overall, 424 images have been examined and a total of 101 macrobenthic taxa (i.e. categories of sessile organisms) were identified from photographs: 25 macroalgae, 42 sponges, 10 anthozoans, 1 hydrozoan, 3 polychaetes, 1 bivalve, 10 bryozoans and 9 tunicates (see Appendix 3). Based on photosampling, the highest number of taxa was recorded at the North coast of the Goli Island (68 taxa) and the lowest at the Cape Sokol at the Krk Island (40 taxa) (Fig. 15). It has to be emphasized that the latter site was characterized by representatively developed plate-like thalli of *Lithophyllum stictaeforme* that covered considerable proportions of sampling replicates (see e.g. Fig. 52 c). For that reason the overall recorded biodiversity at the Cape Sokol might be lower. Approximately 20 of identified taxa were present at all sites (see Appendix 3).

The most common algal builders were encrusting calcareous red algae *Mesophyllum macroblastum*, *Lithophyllum stictaeforme* and as yet unidentified encrusting Corallinacea, as well as calcifying *Peyssonnelia* species, most commonly *Peyssonnelia rubra (*Figs. 16, 17*).* In addition, encrusting calcareous red algae *Lithothamnion minervae* was recorded at two sites and *Neogoniolithon mamillosum* was recorded at one site (Fig. 17). It should be emphasized that accurate identification of these algae to the species level is not possible based on photographs. Identification of algal species mentioned above was confirmed by collected specimens.

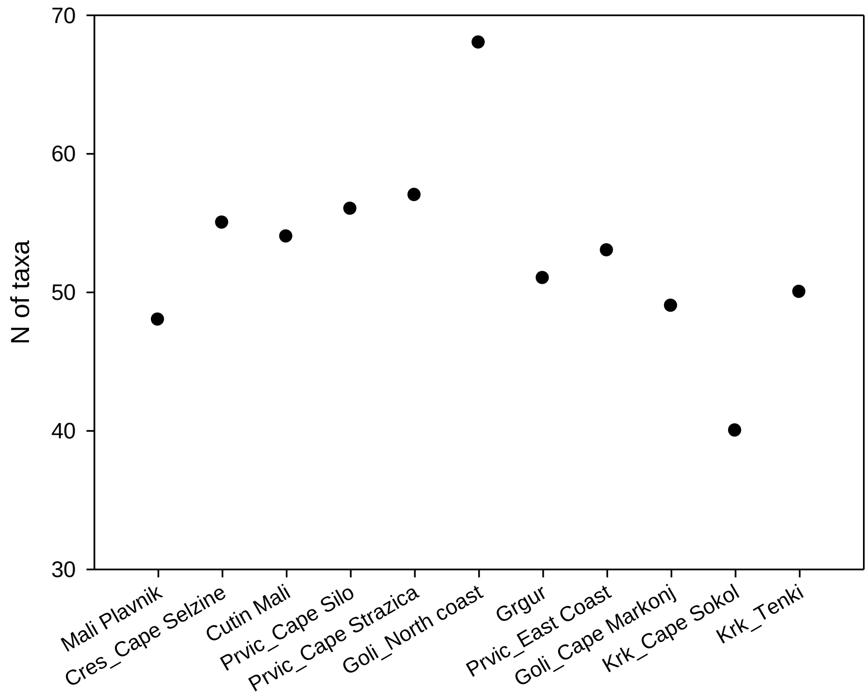

Figure. 15. Species richness of coralligenous assemblages in Primorje-Gorski Kotar County (North-Eastern Adriatic Sea) based on photosampling.

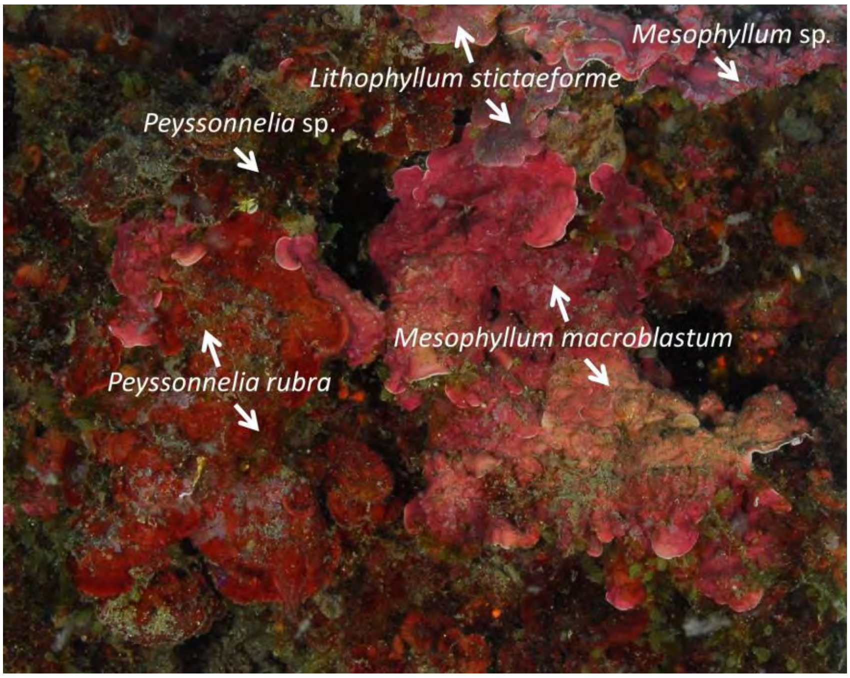

Figure. 16. Diversity of encrusting and non-encrusting red algae present in the coralligenous habitat within Primorje-Gorski Kotar County (an area of 400 cm^2 is shown). Identification of these algae to the species level was enabled by the collection of voucher specimens.

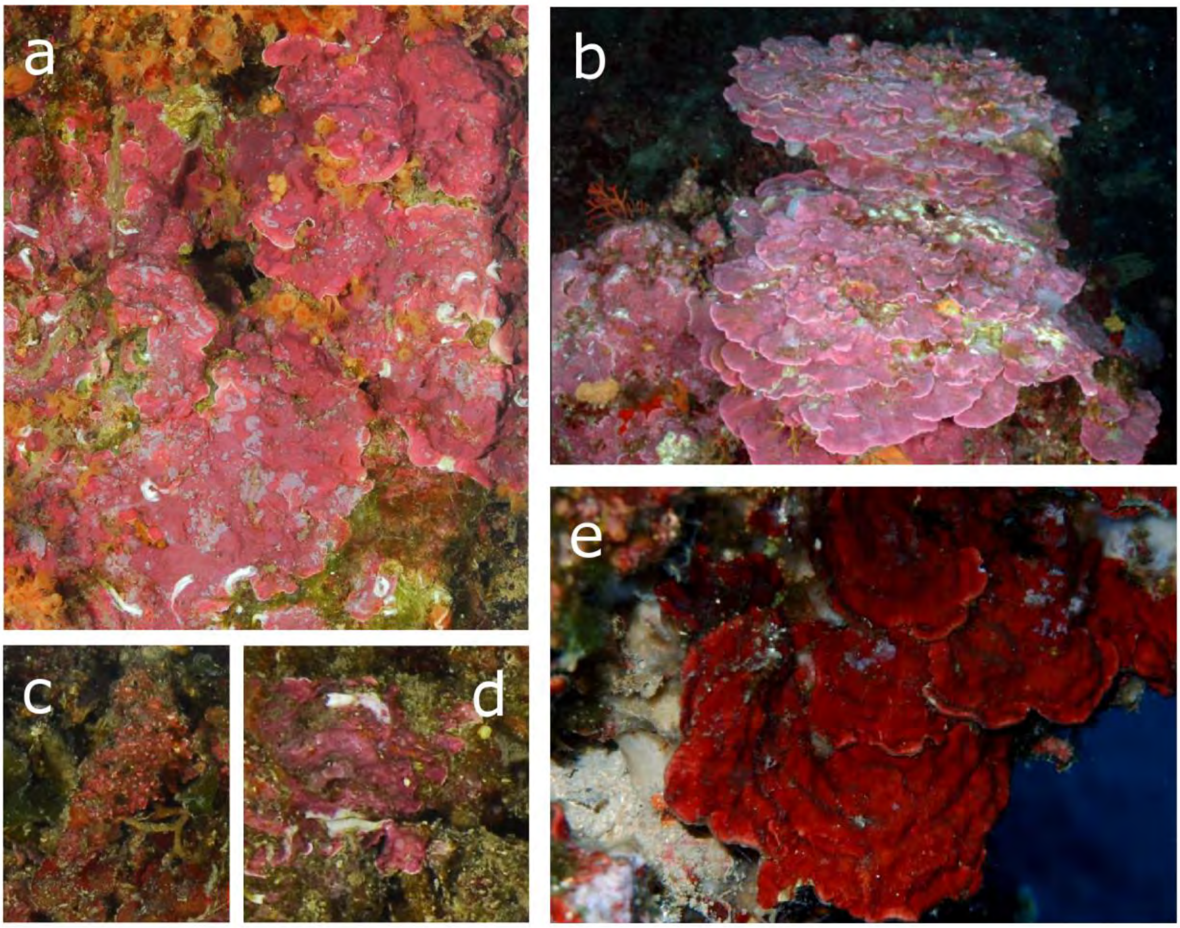

Figure. 17. Main coralligenous algal builders within Primorje-Gorski Kotar County as identified by this study: a) *Mesophyllum macroblastum;* b) *Lithophyllum stictaeforme;* c) *Lithothamnion minervae;* d) *Neogoniolithon mamillosum;* e) calcareous *Peyssonnelia* sp.

The most common animal builders were bushy bryozoans *Myriapora truncata* and *Smittina cervicornis/Adeonella pallasii* as well as a group of orange encrusting bryozoans. Other frequent animal builders were serpulid polychaeta and scleractinian corals *Leptopsammia pruvoti, Caryophyllia smithii,* and *Caryophyllia inornata* (Fig. 18).

Among agglomerative species sponges *Fasciospongia cavernosa* and bryozoan *Beania* sp. were noted. Furthermore, the main bioeroders were boring sponges *Cliona* sp., and the endolithic bivalve *Gastrochaena dubia* (Fig. 19). Especially abundant species were zoantharian *Parazoanthus axinellae,* sponges *Petrosia ficiformis, Hexadella racovitzai,* and *Haliclona (Halicohlona) fulva.*

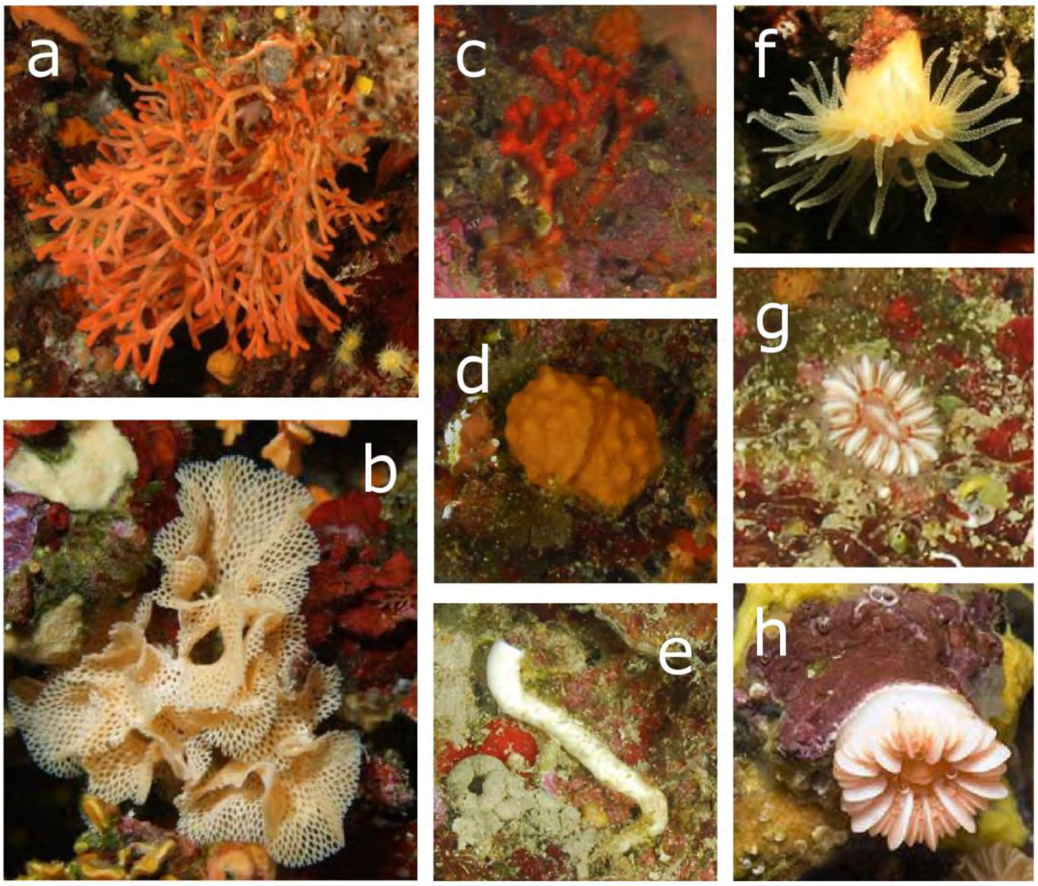

Figure. 18. Some of coralligenous animal builders identified within Primorje-Gorski Kotar County. Bryozoans: a) *Smittina cervicornis/Adeonella pallasii*, b) *Reteporella* sp., c) *Myriapora truncata* and d) globulated orange encrusting bryozoan; e) Serpulid polychaeta; Scleractinian corals: f) *Leptopsammia pruvoti*, g) *Caryophyllia smithii* and h) *Caryophyllia inornata.*

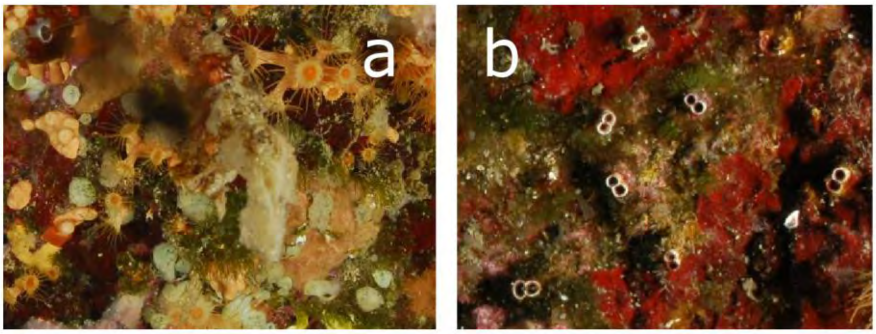

Figure. 19. Some of bioeroders identified in the coralligenous habitat within Primorje-Gorski Kotar County: a) *Cliona* sp. (greyish-green oscula and ellipsoid ostia are visible); b) mollusc *Gastrochaena dubia* (only siphon holes are visible).

The species most commonly forming the erect layer and contributing to the structural complexity of the outcrops were gorgonians *Paramuricea clavata* and *Eunicella cavolini* as well as sponges *Axinella cannabina*, *Axinella polypoides* and large specimens of *Aplysina cavernicola* (> 15 cm in height). Whereas the red gorgonian *Paramuricea clavata* was present in well-developed populations at 6 study sites, forming a facies of coralligenous habitat, the yellow gorgonian *Eunicella cavolini* was present at all study sites, but in sparse densities.

The most common non-calcified red algae were *Peyssonelia* spp., whereas *Flabellia petiolata*, *Palmophyllum crassum* and filamentous algae *Pseudochlorodesmis furcellata* were the most frequent green algae. From all identified taxa, sponges were the most diverse group (Fig. 20), with *Axinella* sp., *Phorbas tenacior*, *Fasciospongia cavernosa*, *Hexadella racovitzai*, *Haliclona (Halicohlona) fulva,* and *Aplysina cavernicola* among the most common.

Data on species present within the coralligenous habitat acquired during this field trip, complimented by the data available from other sites in the Adriatic Sea, will be used to compile the list of typical species, i.e. species to be considered in the inventory and/or monitoring of Adriatic coralligenous assemblages.

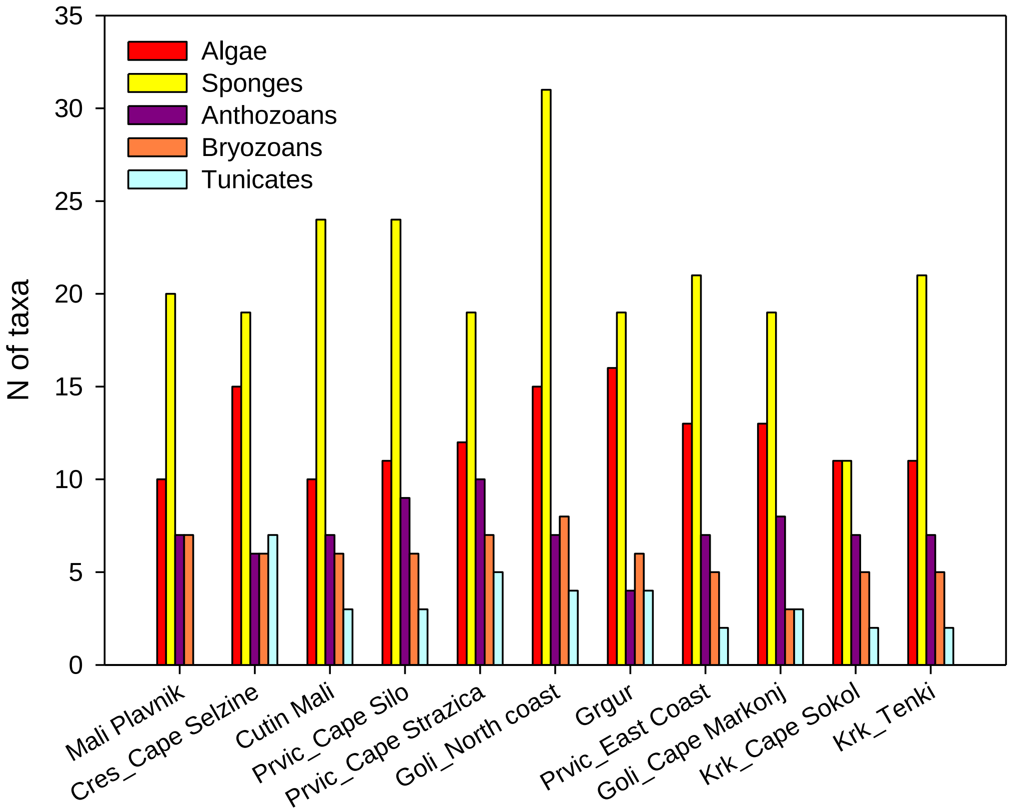

Figure. 20. Taxa richness of the 5 main subsets of taxa in the 30 - 40 m depth range at each of the 11 studied sites (based on photosampling).

Applicability: This part of the protocol was implemented without problems. Four to five sets of 8 contiguous photos of 25 x 25 cm were obtained in each sampling site. A 50 x 50 cm quadrat divided in 4 subquadrats (25 x 25 cm) proved to be practical for underwater use as the quadrat needs to be moved only once in order to obtain photos of the whole replicate (8 contiguous photos per replicate). In the depth range from 30 to 37 m, between 10 and 14 min was needed to carry out photosampling of 4 to 5 replicates (i.e. to take between 32 and 40 photographs) at each site.

Improvements: As previously noted by Kipson (2013), limited area can be assessed by photosampling and often not all of easily recognizable species can be identified in this way. By examination of additional photos and videos it is possible to compile more comprehensive species lists and to acquire a more complete picture of different aspects of the coralligenous habitat present at the site.

(2) Estimate of the impact of invasive species based on photosampling

Main result: Within the coralligenous habitat at all investigated sites there were no signs of invasive macroalgae such as *Womersleyella setacea* or *Caulerpa racemosa.*

Applicability: Physical samples of filamentous red algae need to be collected for unequivocal identification to the species level. As pointed out by Kipson (2013) there is a possibility that such algae remain undetected by photographic method if present in small abundances.

Improvements: the same as noted for assessment of community composition (1).

3.1.2. Visual census along transects

General comment on the application of visual census: The application of this method to assess different parameters as described above was generally regarded as fairly simple and achievable within available time at depth. In order to assess the replicability of the method we used the data obtained by different operators at different sites. In particular, data were collected:

(a) by different operators along the same transect (marked by the rope) (two sites: Cape Markonj and Cape Sokol)

(b) by different operators along random transects at the same time (5 sites)

(c) by different operators along random transects at different times (1 site Cape Stražica)

Finally, at three sites the visual census was carried out by a single operator.

(3) The degree of complexity of coralligenous habitat

Main results: In general, the estimates of cover of the three strata differed largely between operators. The largest differences were found for the basal and intermediate strata while for the erect one the differences were lower. Bearing in mind one of the main goals of the monitoring program, i.e. to detect significant changes in the habitat, and the fact that the proposed method envisaged the assessment within large categories, we considered that differences exceeding one category on average (of the transect) indicate methodological problems. This was clearly evident when the assessment was carried out along marked transects, i.e. when potential differences due to spatial variability found at the site/depth (as it may be the case when random transects were carried out) could be completely avoided.

In the assessment of basal and intermediate strata the differences in cover estimates ranged from a maximum of about 4 to a minimum of 0.5 (Figs. 21-22). In the case of marked transects assessed by three operators, two of them provided similar estimations while the estimation of the third one largely differed (Fig. 21). Overall, the assessment of cover of these two strata displayed no differences between two operators just in one case (Tenki). In the assessment of the erect stratum differences were less pronounced and both in marked and random transects estimates rarely exceeded one category (Figs. 21-23). From these estimations most of study sites showed an erect stratum characterized either by isolated colonies or by few colonies per m^2, except at Ćutin Mali where the abundance of organisms belonging to the erect stratum was the highest (Fig. 24).

Applicability: several concerns arose during implementation of this part of the protocol that influenced the assessment. Despite of explanation during the briefing, some operators were confused with delineation of the basal and intermediate layer. For example, a doubt arose whether non-calcifying species of the genus *Peyssonnelia* should be considered within the basal or intermediate layer as basically they have two-dimensional structure and follow the substrate but are not attached to the substrate with the entire thallus. If, for example, these prostrate non-calcified *Peyssonnelia* spp. are considered within the intermediate layer (because they are not attached to the substrate with the entire thallus) this would imply the same level of complexity as for some massive sponge or bush-like bryozoan, which is clearly not the case. Therefore, it was questioned whether more layers should be defined in order to accommodate such species or they should be more clearly delineated as species of the basal layer.

A need also arose to emphasize that assessment should focus on the morphology/size of the organism and not on its taxonomic identity, as the same species could be attributed to different layers, depending on the size of the actual specimen. For example, bushy bryozoan *Pentapora fascialis* or sponge *Aplysina cavernicola* could be attributed to intermediate layer if colonies are smaller than 15 cm, whereas larger colonies (>15 cm) would qualify for the upper layer (the erect stratum).

Improvements: Taking into account the obtained results we conclude that the assessment of basal and intermediate strata has to be completely reconsidered.

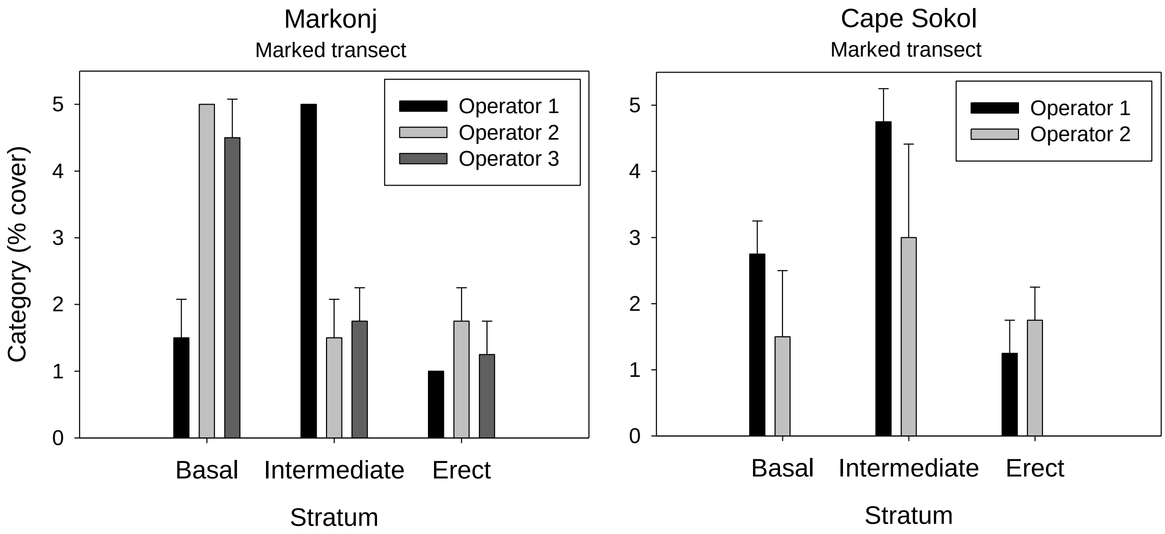

Figure. 21. Estimation of habitat complexity by different operators along a marked transect.

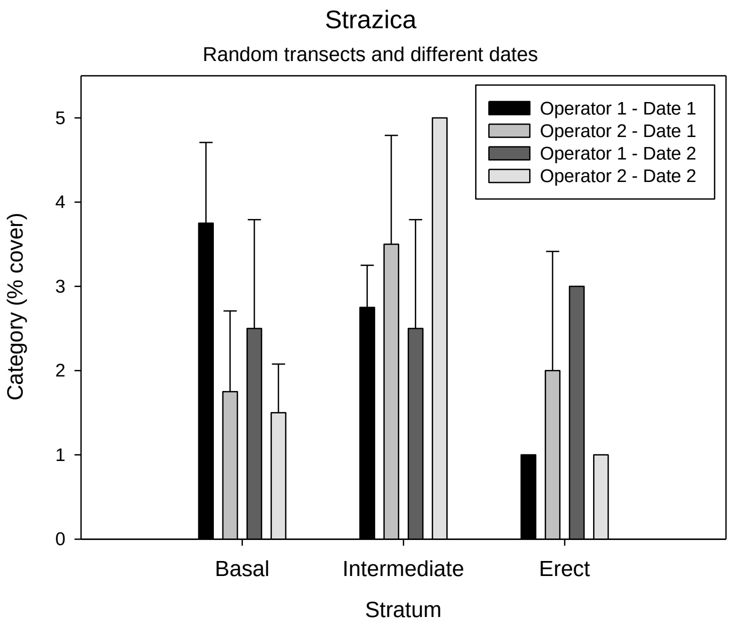

Figure. 22. Estimation of habitat complexity by different operators along random transects at the same site but at different times.

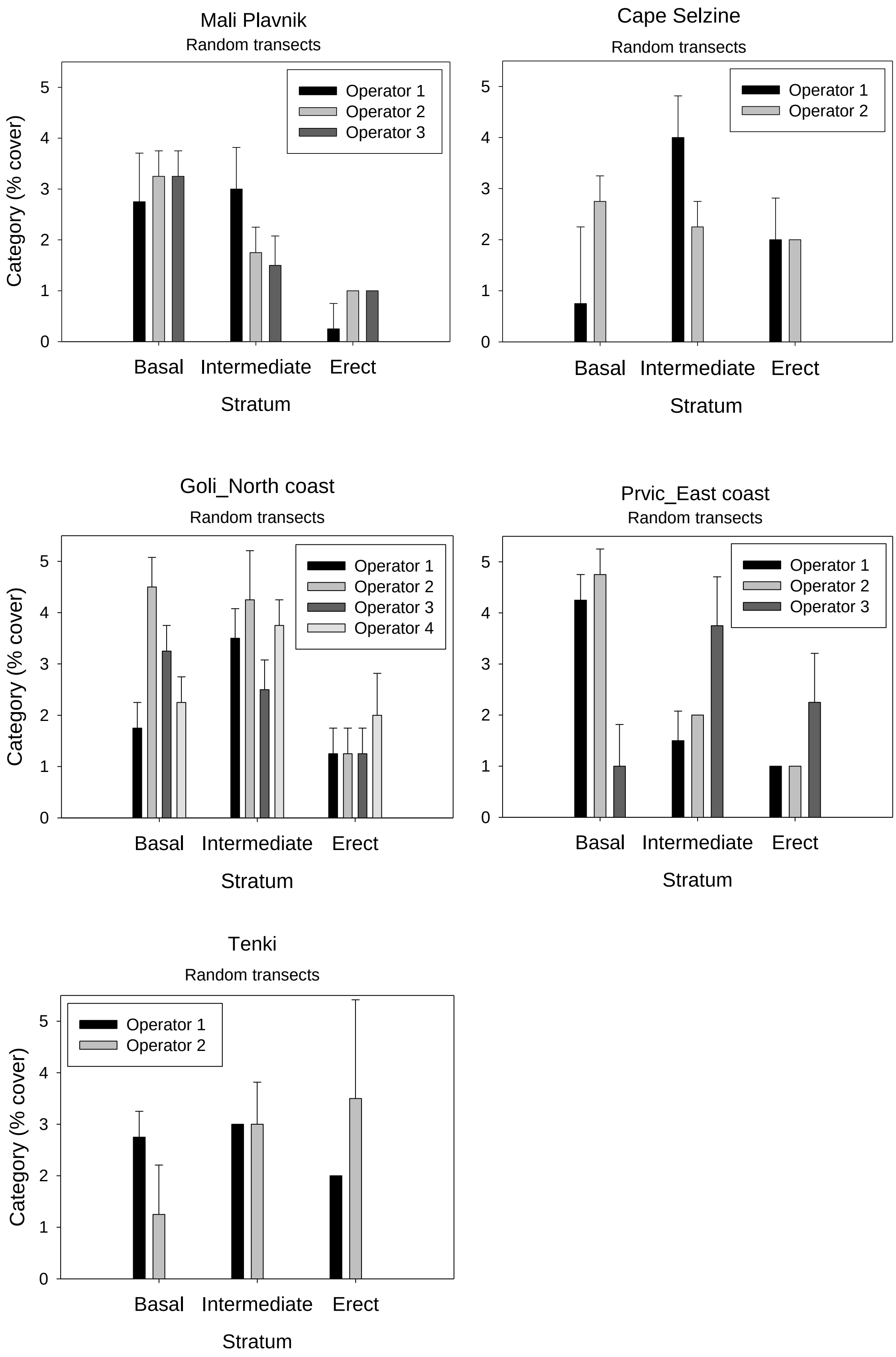

Figure. 23. Estimation of habitat complexity by different operators along random transects.

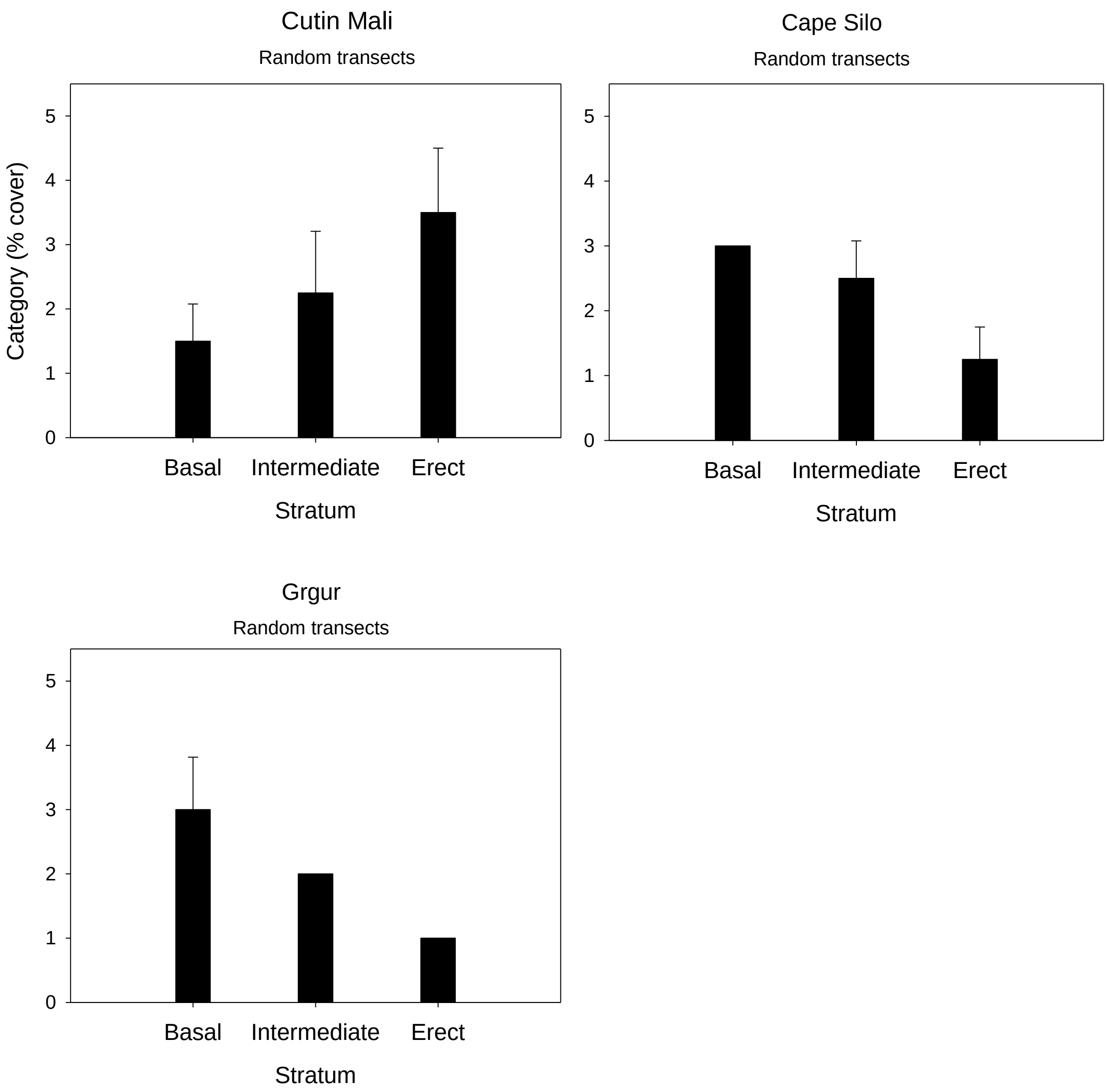

Figure. 24. Estimation of habitat complexity by a single operator along random transect.

(4) Estimates on the abundance of main macro-bioeroders

Main results: At 7 sites the assessment was not carried out (Figs. 25-28) due to methodological problems (see below). When this parameter was assessed, the estimates were similar among operators (Fig. 26). At most sites low abundance of macrobioeroders was estimated (Figs. 26-28) and no sea urchins were observed along transects.

Applicability: Estimation of cover of macrobioeroders such as clionid sponges over 5 m transect sections proved to be difficult in the field whereas the enumeration or estimation of sea urchin abundance could be satisfactorily employed.

Improvements: Due to difficulty to assess cover of clionid sponges along transects in the field, this part of protocol should be reconsidered.

3.2. Assessment of stressors affecting the coralligenous habitat

3.2.1 Visual census along transects

(5) Estimate of coverage of mucilaginous aggregates

Main results: Mucilaginous aggregates were present at all monitored sites (Figs. 25-28). The assessment of cover displayed differences among operators that reached up to 3-4 category values (Figs. 26, 27). In general, these differences were still lower than in the assessment of basal and intermediate strata. For instance, along marked transects the assessments showed comparable results (Fig. 25). From the obtained results cover of mucilaginous aggregates varied from 20% (e.g. Markonj; Fig. 25) to almost 100% (e.g. North coast of Goli Island; Fig. 26).

Applicability: At times it proved to be difficult to estimate the cover of mucilaginous aggregates over 5 m transects as they were dispersed around. For example, it was confusing which category to assign when mucilaginous aggregates were partially covering gorgonians but the understory was less covered or left uncovered.

Improvements: Categories used for estimation of coverage of mucilaginous aggregates need to be reconsidered. There is a need for decrease in number of categories and increase of their robustness.

(6) Estimate of the impact of sedimentation

Main results: Sedimentation cover was always estimated as being lower than 50 % of the transects (Figs. 25-28). In general, most operators reached similar estimations of sedimentation when assessing the same transects or the same site (Figs. 25-27).

Applicability: At times it proved to be difficult to estimate the cover of sediment over fairly large area i.e. sections of 5 m of the transect as sediment patches were dispersed.

Improvements: the method to estimate the impact of sedimentation needs to be reconsidered.

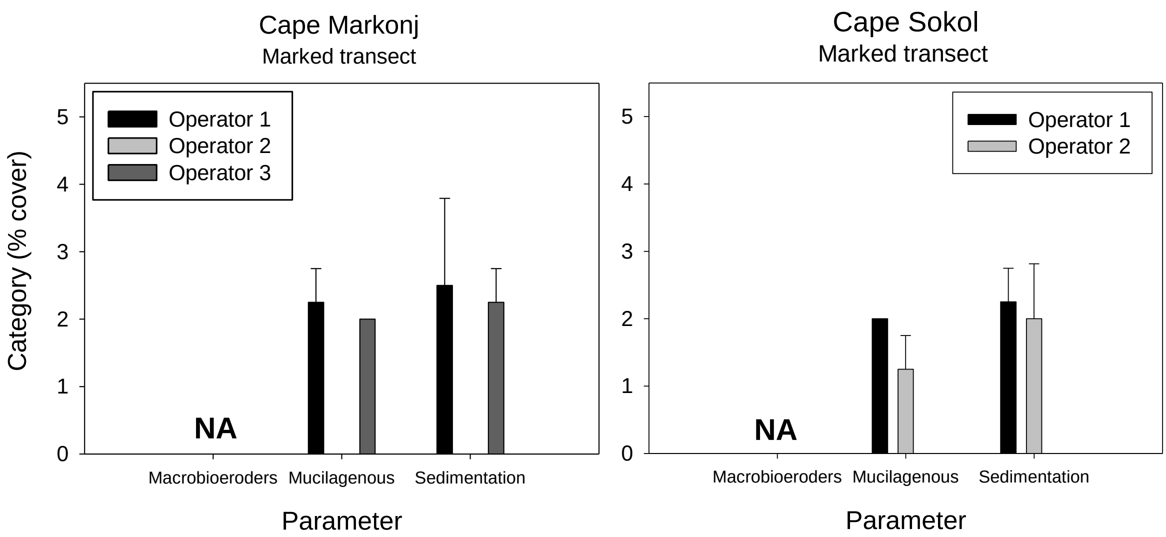

Figure. 25. Cover of macrobioeroders, mucilaginous aggregates and sediment assessed by different operators along a marked transect. NA = not assessed.

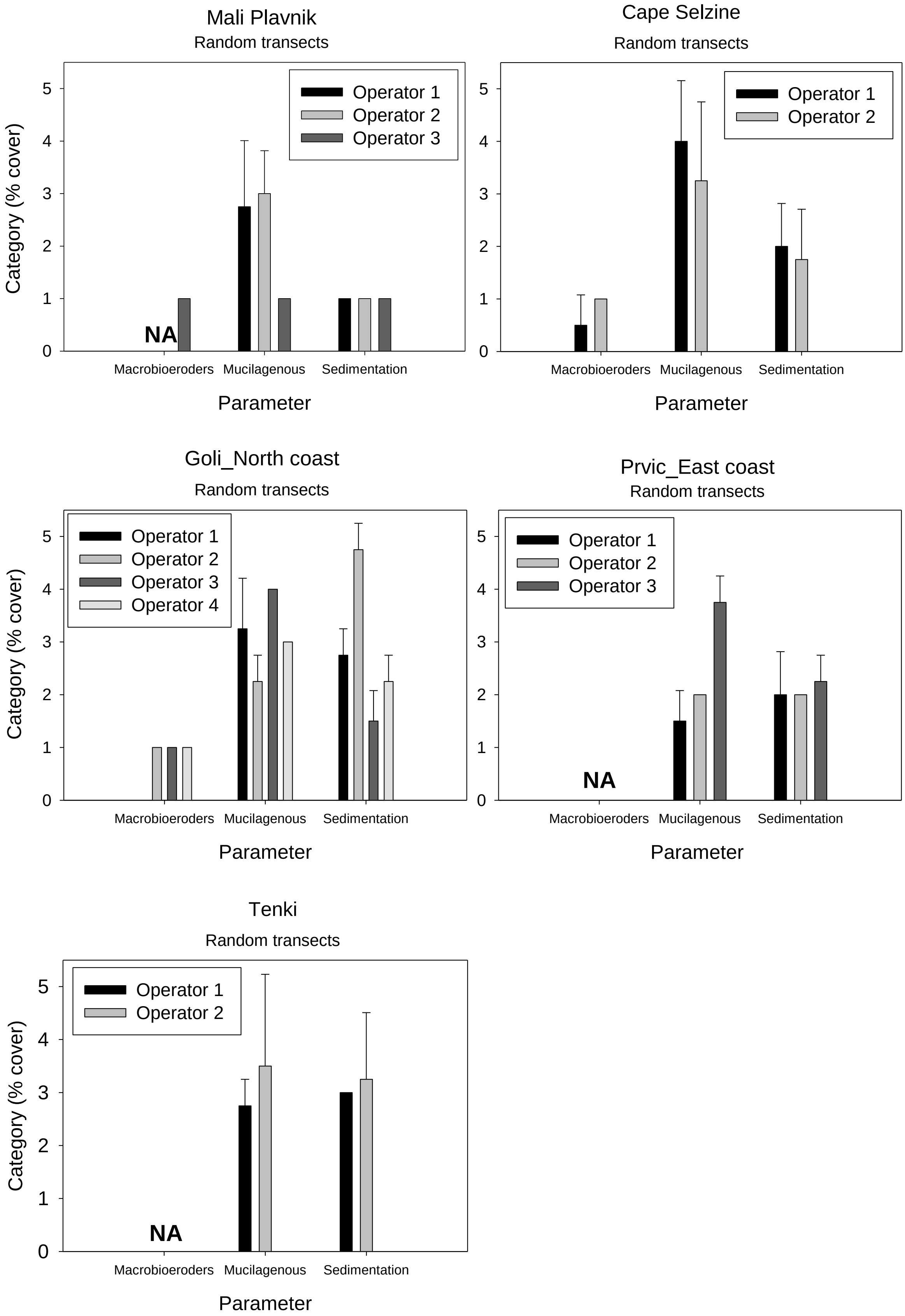

Figure. 26. Cover of macrobioeroders, mucilaginous aggregates and sediment assessed by different operators along random transects. NA = not assessed.

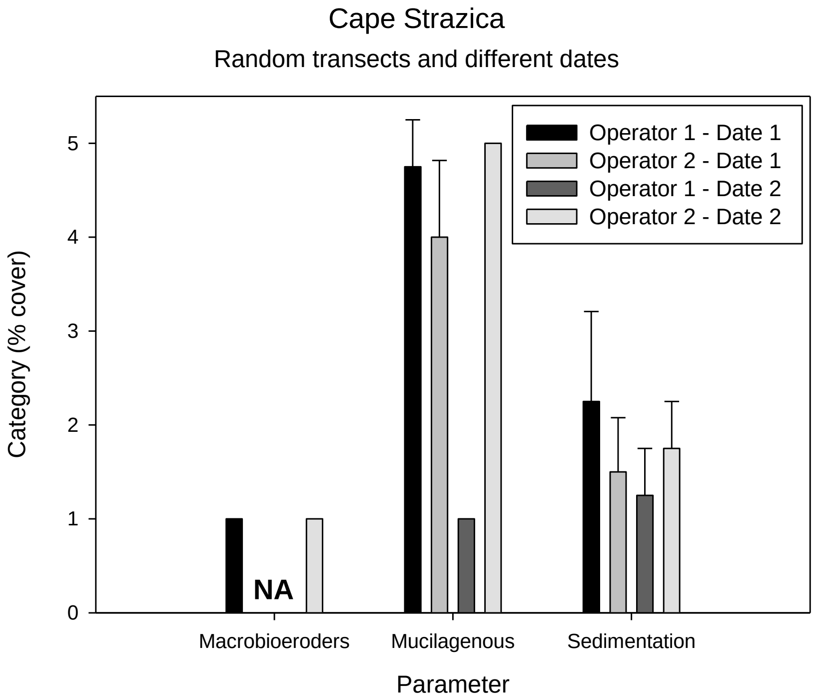

Figure. 27. Cover of macrobioeroders, mucilaginous aggregates and sediment assessed by different operators along random transects at different times at the same site. NA = not assessed.

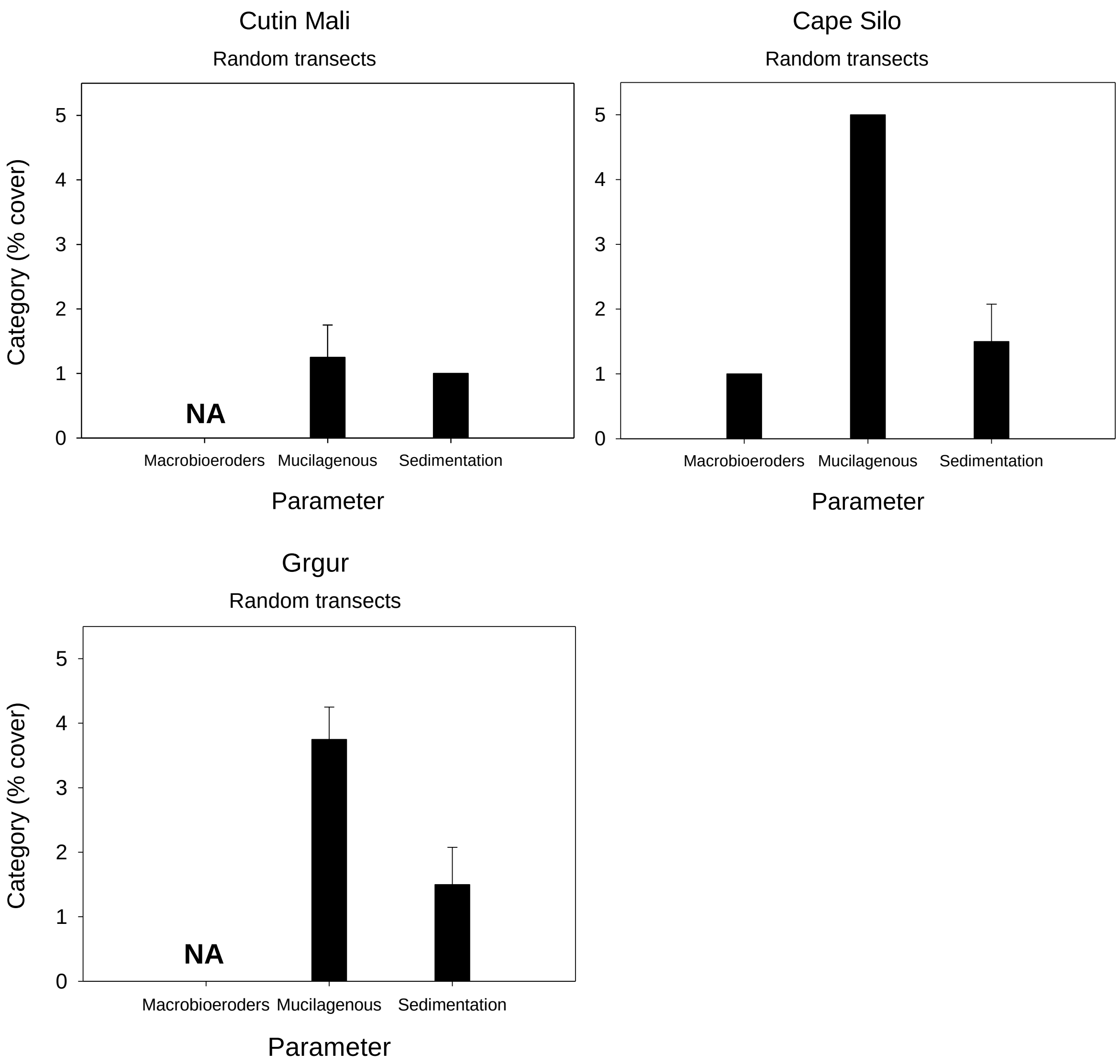

Figure. 28. Cover of macrobioeroders, mucilaginous aggregates and sediment assessed by a single operator along random transect. NA = not assessed.

3.2.2. Visual census not associated to transects

(7) Assessment of gorgonian health status (mass mortalities)

Main results: the red gorgonian *Paramuricea clavata* was examined at 6 sites whereas the yellow gorgonian *Eunicella cavolini* was examined at 2 sites. The yellow gorgonian was usually present in sparse densities; therefore, the number of examined colonies (from 45 to 71) was below recommended minimum of 100 colonies. In general, percentage of affected colonies (with >10% of injured surface) was low at most sites (not exceeding 15%).

Exceptions were studied sites at Krk Island (Cape Sokol and Tenki) where the same operator estimated more than 40% of affected *P. clavata* colonies. Likewise, an estimated 60% of *E. cavolini* colonies at Grgur Island were affected. Most of the affectation was old, however 5 to 30% of colonies were assessed as being also recently affected (Fig. 29).

It should be emphasized that reported extent of injuries were observed before the putative impact of mucilaginous algal aggregates that were present at each sampling site at the time of assessment. Therefore, injury levels may have increased after summer of 2013.

Applicability: In general, operators considered rapid assessment of gorgonians as described above easily achievable within the available diving time. The practicality of this method was confirmed and no major unclarities arose during its application.

Improvements: Not considered.

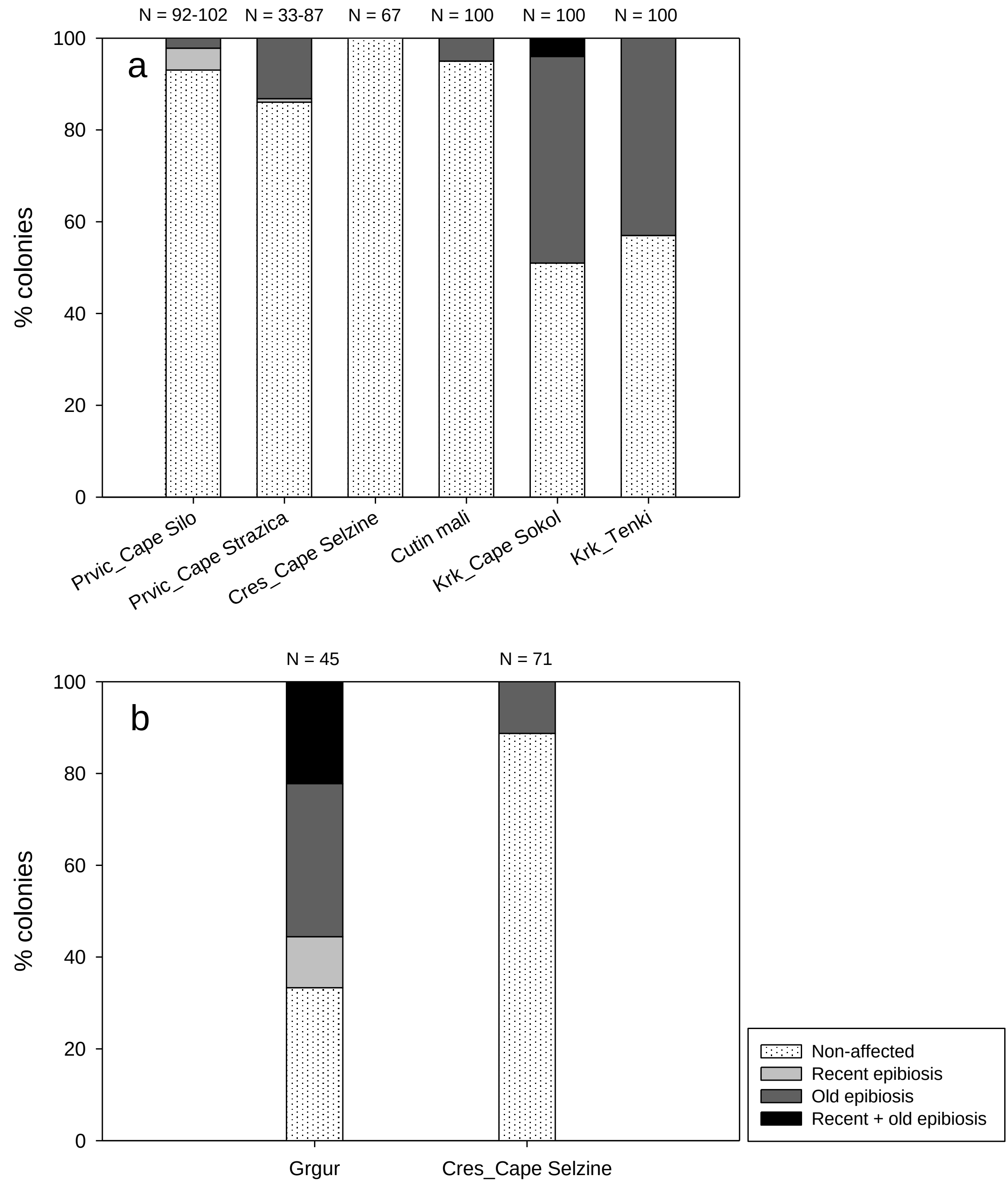

Figure. 29. Health status assessment of: a) the red gorgonian *Paramuricea clavata*; b) the yellow gorgonian *Eunicella cavolini*. Reported is a percentage of affected colonies (with >10% injured surface). N = number of examined colonies at each site.

(8) Estimate on the impacts of fishing

Main results: Discarded fishing gear was recorded by operators at 6 sites. Long-lines were the most common fishing gear encountered but nets and traps were also observed. At most sites observations were available only from 1 operator, whereas at two sites, Mali Plavnik and North coast of Goli Island, observations were made by 2 and 3 operators, respectively. The estimation of the length of net affecting the coralligenous outcrops was made only in one case (10 m long net affecting coralligenous at the North coast of Goli Island).

Applicability: No problems were detected during implementation of this part of the protocol.

Improvements: Categories that will provide an estimate of the impact still need to be determined.

Table 2. Enumeration of the observed fishing gear within the coralligenous habitat.

		Fishing gear		
Location	Site	Long-line	Net	Trap
Plavnik	Mali Plavnik	4	1	1
Prvić	Cape Šilo	2	1	1
Prvić	Cape Stražica	2	0	1
Goli otok	North coast	1	2	1
Grgur	Grgur	3	0	2
Prvić	East coast	2	1	0

3.3. Gathering of environmental data

We were able to recover 5 out of 7 temperature dataloggers previously put at the islet of Ćutin Mali, and have deployed a total of 7 new dataloggers. Missing were the shallowest dataloggers, deployed at 5 and 10 m depth. Since deployment of temperature dataloggers during this field trip was for demonstration purposes only, temperature data are not further analysed and discussed within this report. As the islet Ćutin Mali is part of the TMedNet network of observation sites, some data from this site are already available at http://t-mednet.org/.

Implications for the coralligenous monitoring protocol

The insights obtained during this field trip resulted in modification of the first version of the protocol. In summary, it was decided that:

- Macrobioeroders (except sea-urchins), basal and intermediate layers and sediment cover should be assessed from photographs;
- Photosampled area should be increased to accommodate the assessment of above mentioned parameters (in addition to the assessment of previously determined parameters); and
- Categories used for the estimation of cover of mucilaginous aggregates should be simplified.

Recommendations for selection of future monitoring sites

In the process of selection of coralligenous monitoring sites in Croatian waters, a care should be taken to:

- cover the whole range of coralligenous habitat in Croatian waters (based on available data and future habitat mapping);
- focus on the most representative assemblage/s (based on available data and additional screening);
- consider protection status/management regimes of the sites (sites would ideally be located within Natura 2000 sites and MPAs as well as outside);
- account for environmental conditions (e.g. seawater temperature conditions, distance from the coast) and
- select sites that are subjected to known pressures (such as anchoring, urbanization, fishing, invasive species, sedimentation, mucilaginous algal aggregates).

4. Overview of study sites

This section provides a description of 11 study sites. As envisaged by the protocol, each study site was documented as precise as possible, by providing GPS coordinates and a photo showing terrestrial view of the site including recognizable landmarks when possible. In addition, the diving path was described with assistance of photography and videography. All of this information was intended to facilitate the repeated locating of sites and areas where the assessment was carried out.

Eleven study sites included:

1. Mali Plavnik Islet
2. Cape Selzine at the Cres Island
3. Ćutin Mali Islet
4. Cape Šilo at the Prvić Island
5. Cape Stražica at the Prvić Island
6. North coast of the Goli Island
7. Grgur
8. East coast of the Prvić Island
9. Cape Markonj the Goli Island
10. Cape Sokol at the Krk Island
11. Tenki shallow at the Krk Island

1 Mali Plavnik

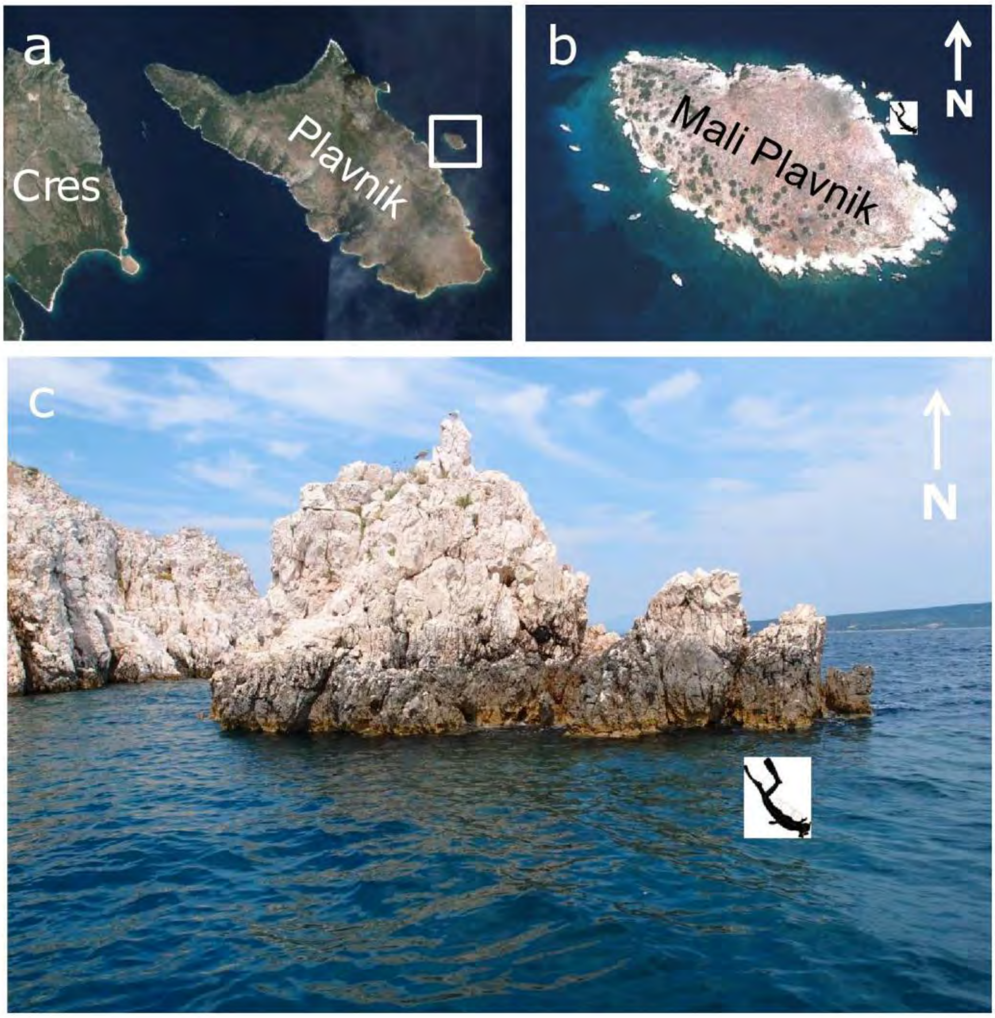

Figure. 30. Mali Plavnik dive site. Designated area of image a) is enlarged on image b); c) the rock located eastwards from the Mali Plavnik island with indicated diving position. Source: a, b) Google Earth, Image © 2013 DigitalGlobe.

GPS: 44°58'31.82''N, 14°32'52.04''E

Date and time of the dive: 15th of July 2013, 11 am

Photos IDs and number of photos: MPa1 – MPe8; 40

Number of transects carried out: 3

Video transects: 1

Description: Our diving position was located next to the rock placed eastward from the Mali Plavnik Island (Fig. 30). We dove at the south side of the rock (Fig. 31 a,b) where we first encountered a tip of the underwater pinnacle at cca 5 m depth (Fig. 31 c,d) and continued a dive towards the south-east, with the rocky wall at our right-hand side. Down to cca 20 m depth a biocenosis of infralittoral algae was present, with abundance of algae *Laurencia* sp., *Codium bursa* and sponge *Aplysina aerophoba* (Fig. 31 a-e). Continuing the dive, we passed next to several pinnacle-like rocks that occasionally formed narrow passages between them (Fig. 31 f). From 20 m depth more sciaphilic species appeared such as algae *Flabellia petiolata*, non-calcified *Peyssonnelia* spp., sponge *Aplysina cavernicola*, etc. Coralligenous habitat was noted below 25 m depth. Around 42 m depth the rocky wall was replaced by moderately inclined detritic bottom.

Photosampling was carried out between 35 and 38 m depth at the south-southeast oriented part of the wall. Visual census was performed by three operators in the depth range from 33 to 38 m, while the video transect was recorded between 34 and 40 m depth.

The basal layer of the coralligenous habitat was the best developed one and it was dominated by both encrusting and prostrate algae of the genus *Peyssonnelia*, mainly *Peyssonnelia squamaria* and *P. rubra*, whereas cover of the red calcareous encrusting algae *Mesophyllum macroblastum* (Fig. 32 a) was lower in comparison. The intermediate layer was formed by green algae *Flabellia petiolata*, massive sponges such as *Petrosia ficiformis* and *Ircinia* sp. as well as sponge *Axinella* sp. with epibiotic zoantharian *Parazoanthus axinellae.* Smaller colonies of sponge *Aplysina cavernicola* (< 15 cm in height) also contributed to the intermediate layer, whereas larger colonies formed part of the erect layer (Fig. 32 b). The erect layer was further formed by the individual colonies of *Axinella cannabina* (Fig. 32 c) and the yellow gorgonian *Eunicella cavolini* (Fig. 32 d) whereas the red gorgonian *Paramuricea clavata* was not recorded at this site.

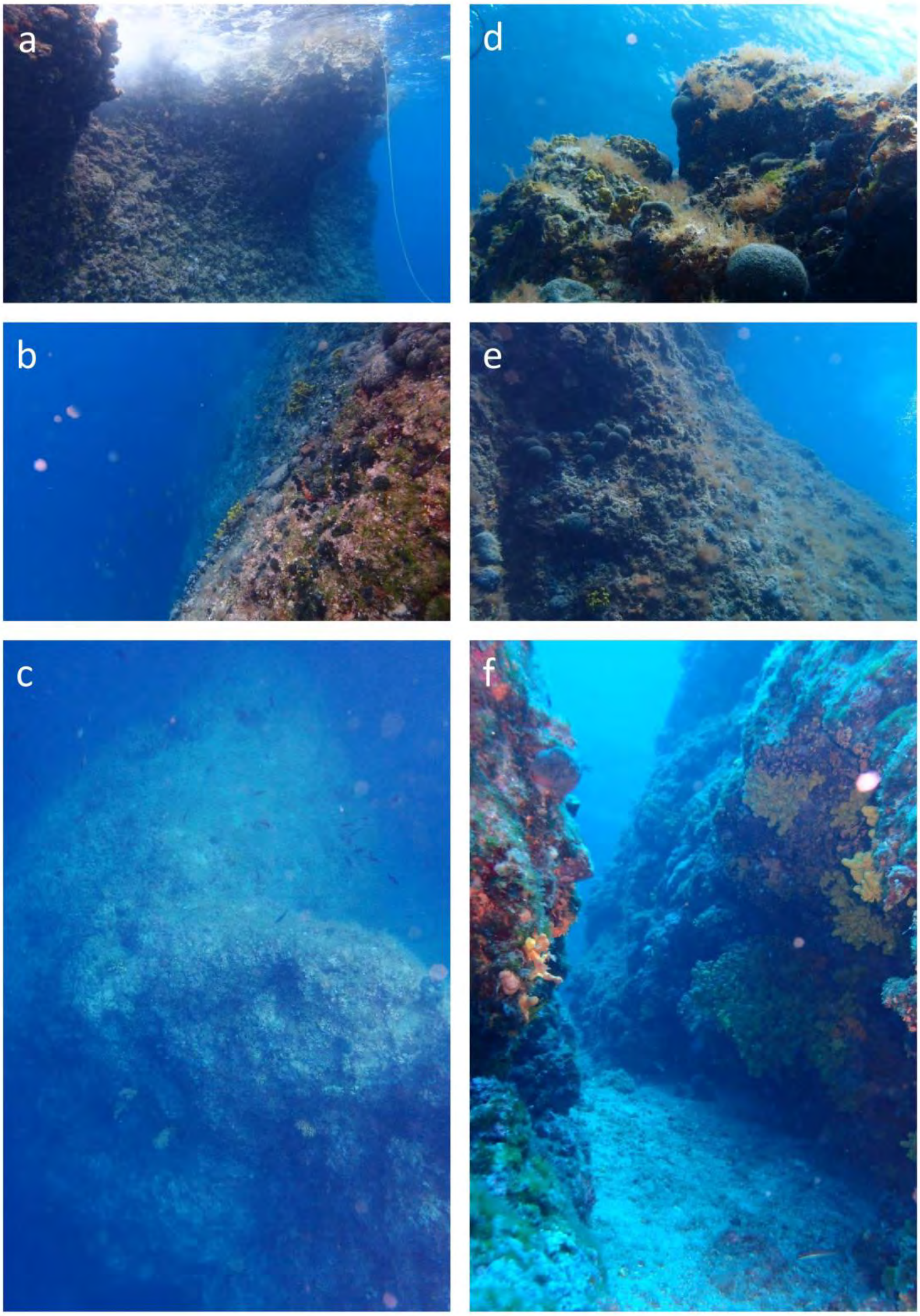

Figure. 31. Mali Plavnik dive path (from a to f). a, b) subsurface part of the rock next to which we initiated a dive; c, d) different views of the pinnacle tip at 5 m depth; e) the wall at 15 m depth hosting biocenosis of infralittoral algae with abundance of algae *Laurencia* sp., *Codium bursa* and sponge *Aplysina aerophoba*; f) rocky walls hosting coralligenous outcrops being replaced by detritic bottom around 42 m depth. Photo credit: A. Jaklin.

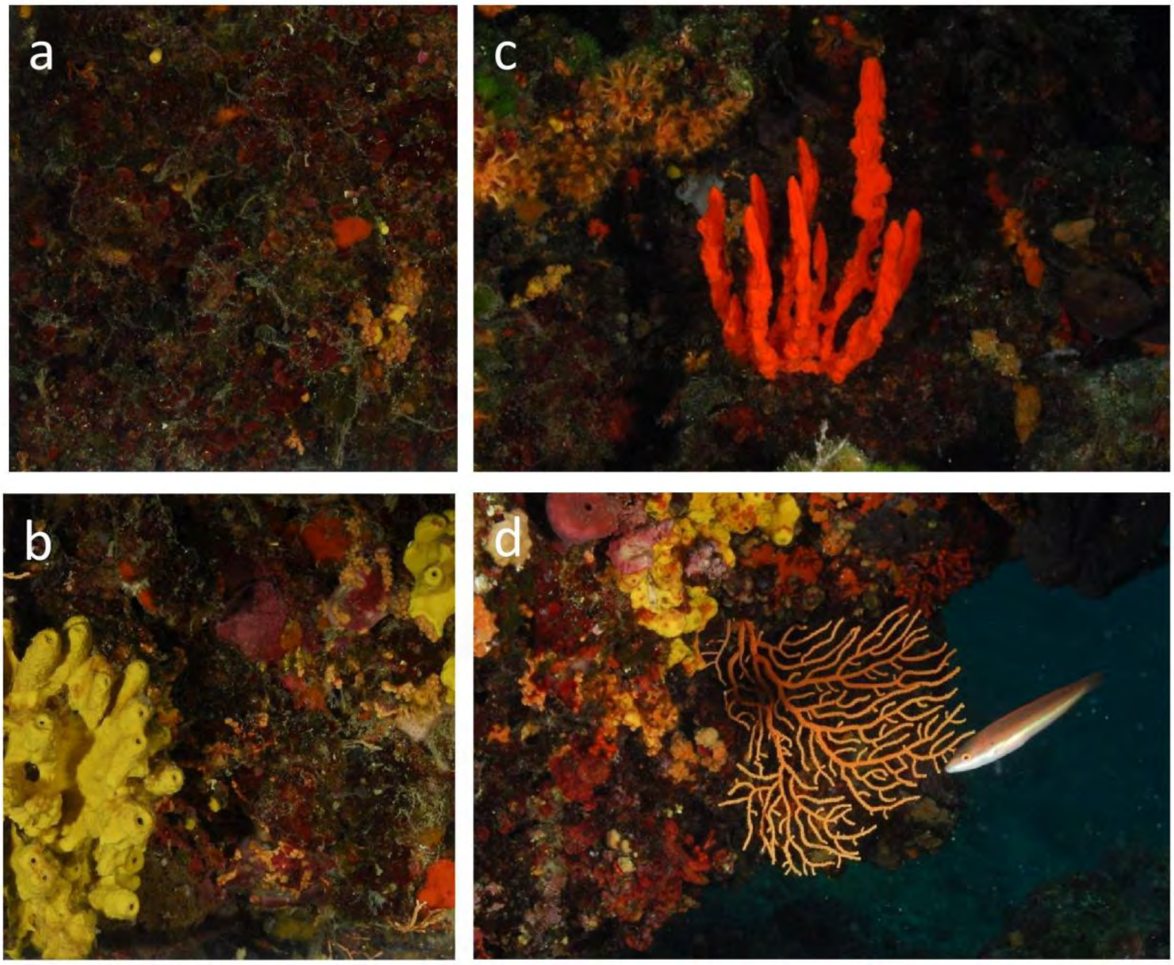

Figure. 32. Details from coralligenous assemblages at the Mali Plavnik Islet. a) coralligenous assemblage was dominated by several red algae which belong to the genus *Peyssonnelia;* b) depending on the size of the specimen, sponge *Aplysina cavernicola* may belong to the intermediate or erect layer. The erect layer was further formed by sporadic colonies of: c) sponge *Axinella cannabina* and d) the yellow gorgonian *Eunicella cavolini*. Photo credit: P. Kružić.

2 Cape Selzine

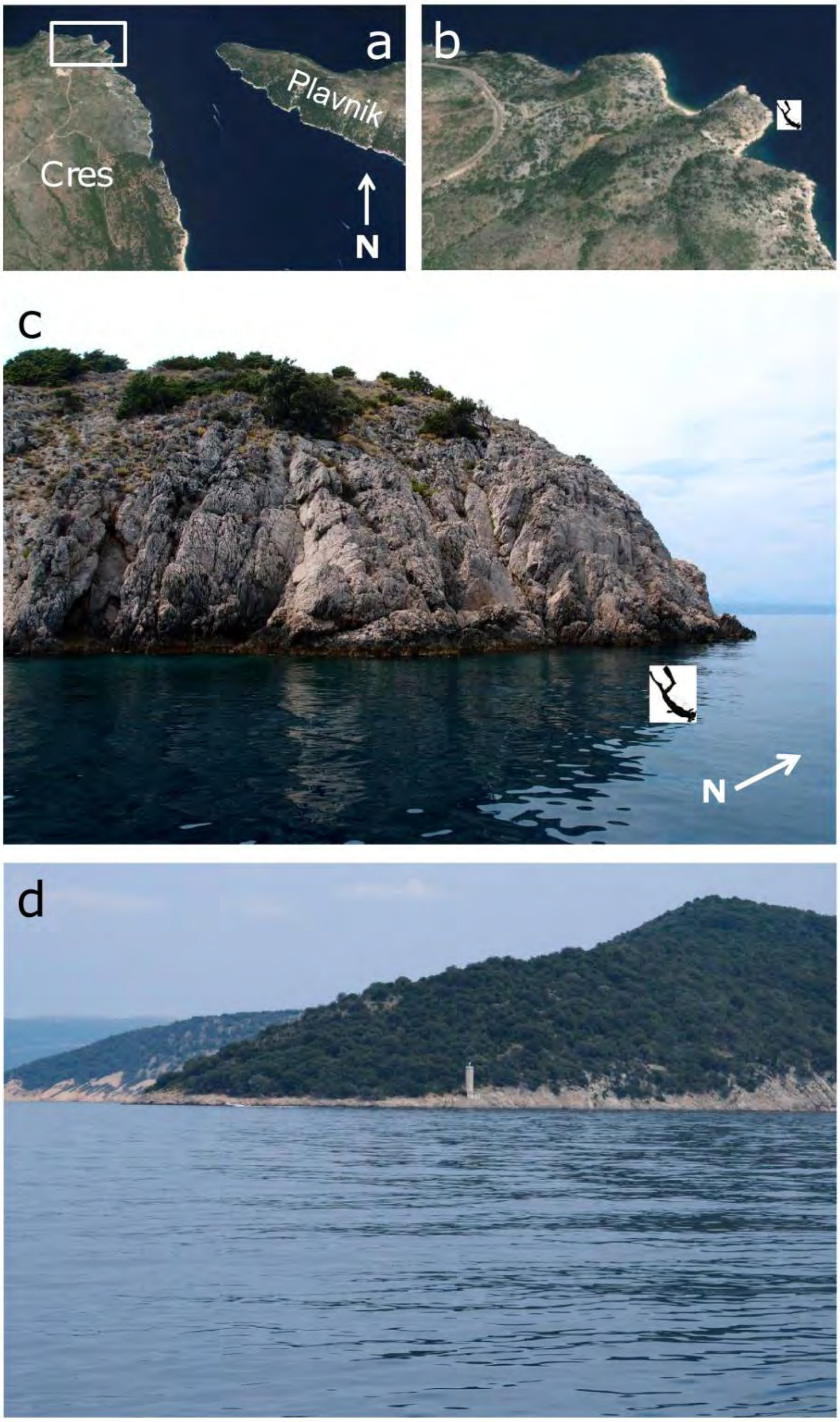

Figure. 33. Cape Selzine at the Cres Island dive site. Designated area of image a) is enlarged on image b); c) the Cape Selzine diving site; d) view of the lighthouse at the nearby Plavnik Island from the diving position. Source: a, b) Google Earth, Image © 2013 DigitalGlobe.

GPS: 44°58'56.37''N, 14°28'10.87''E

Date and time of the dive: 15th of July 2013, 3 pm

Photos IDs and number of photos: CRa1 – CRe8; 40

Number of transects carried out: 2

Video transects: 1

Description: This diving site was located at the south-east part of the Cape Selzine on the Cres Island (Fig. 33 a-c). From this site there is a view of the north-west part of the Plavnik Island and its lighthouse (Fig. 33 d). Underwater, we first dove above gently (down to 6 m depth) to moderately (down to 20 m depth) inclined slope hosting the biocenosis of infralittoral algae in which scattered colonies of the white gorgonian *Eunicella singularis* (Fig. 34 a) and alcyonacean *Alcyonium acaule* (from 9 to 18 m; Fig. 34 b) were present. Below 20 m depth the slope became steeper (Fig. 34 c) and it was intercepted by small walls, forming a cascade-like rocky bottom. From 25 m depth species characteristic for the coralligenous were noted (Fig. 34 d) but also the ones that thrived on the patches of sandy bottom (Fig. 34 e), between the outcrops. From 35 to 40 m depth a *Paramuricea clavata* assemblage was thriving on cascade-like rocky bottom and scattered rocks (Fig. 34 f-h). Around 40 m depth, the rocky bottom was replaced by a continuous slope of coarse detrital sand.

Photosampling was carried out within the *Paramuricea clavata* assemblage, at depth between 35 and 37 m. Visual census was performed by two operators at 35 m depth, while the video transect was recorded at 40 m depth. Furthermore, one operator assessed the red gorgonian health status at 35 m depth and another the yellow gorgonian health status at depth between 21 and 25 m.

The erect layer of the coralligenous habitat was primarily formed by the colonies of the red gorgonian *Paramuricea clavata,* followed by the yellow gorgonian *Eunicella cavolini* and the erect sponge *Axinella cannabina*. The intermediate layer was formed mainly by a bush-like bryozoans *Myriapora truncata* and *Smittina cervicornis/Adeonella* sp., smaller specimens of sponge *Aplysina cavernicola*, green algae *Flabellia petiolata* and zoantharian *Parazoanthus* *axinellae*. The basal layer was dominated by the red calcareous algae *Lithophyllum stictaeforme*, algae of the genus *Peyssonnelia* (mainly *Peyssonnelia squamaria* and *P. rubra*) and the encrusting sponge *Hexadella racovitzai*. Red encrusting algae *Mesophyllum macroblastum* was also present but it was less abundant, at least in the assessed transects.

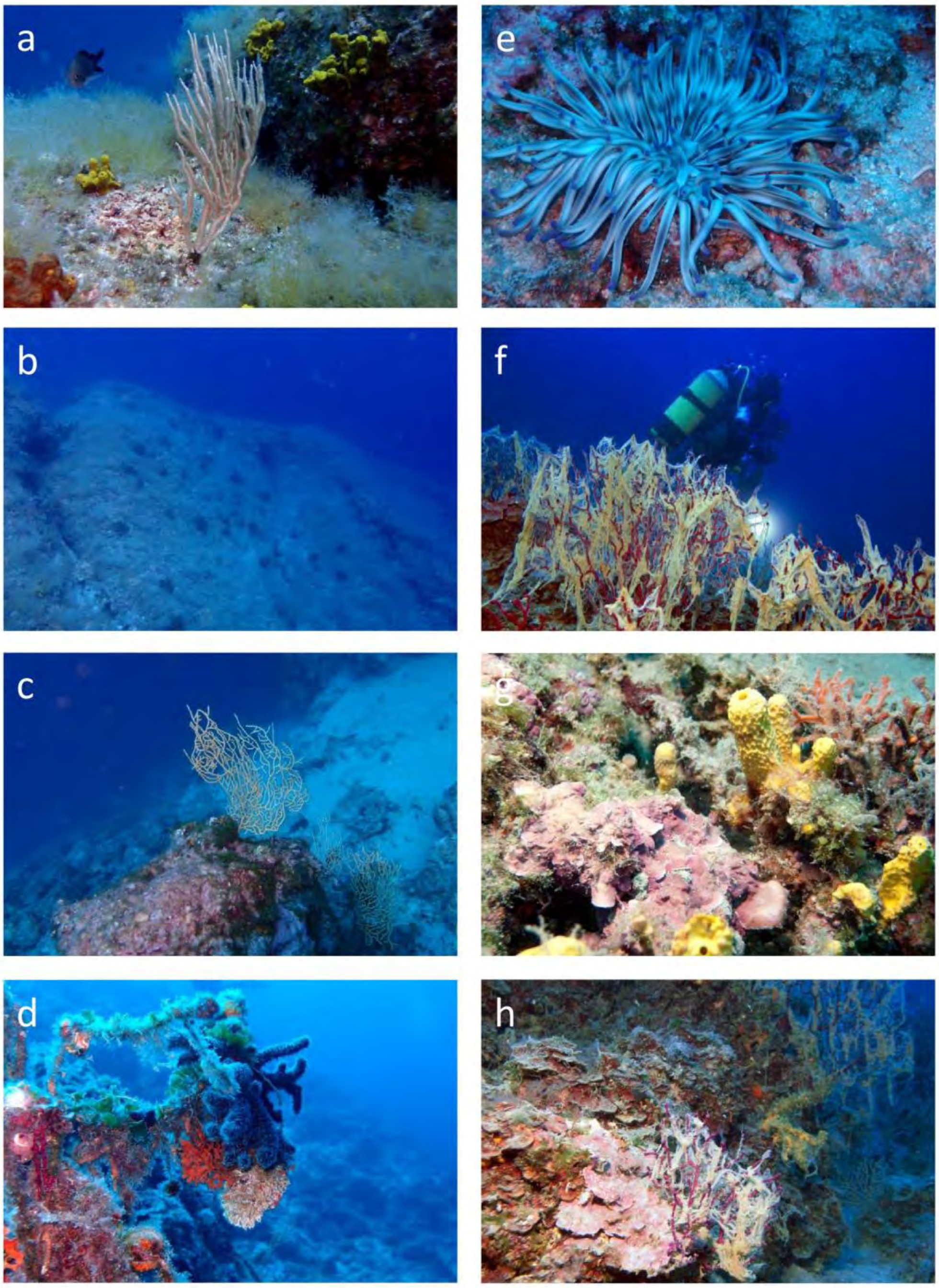

Figure. 34. Cape Selzine dive path. A) gently inclined slope at 6 m depth with biocenosis of infralittoral algae, individual colonies of *Eunicella singularis* and sponge *Aplysina aerophoba*; b) moderately inclined slope at 12 m depth with the alcyonacean *Alcyonium acaule*; c) steeper slope at 20 m depth with scattered rocks and the presence of *Eunicella cavolini*; d) discarded net overgrown by species often found within the coralligenous habitat; e) Golden anemone *Condylactis aurantiaca* thriving in a patch of sand found among coralligenous outcrops; f) the red gorgonian *Paramuricea clavata* covered with mucilaginous algal aggregates. Details from the *Paramuricea clavata* assemblage: g) basal and the intermediate layer; h) three-dimensional structure of the assemblage. Photo credits: a-e) A. Jaklin; f-h) S. Kaleb.

3 Ćutin Mali

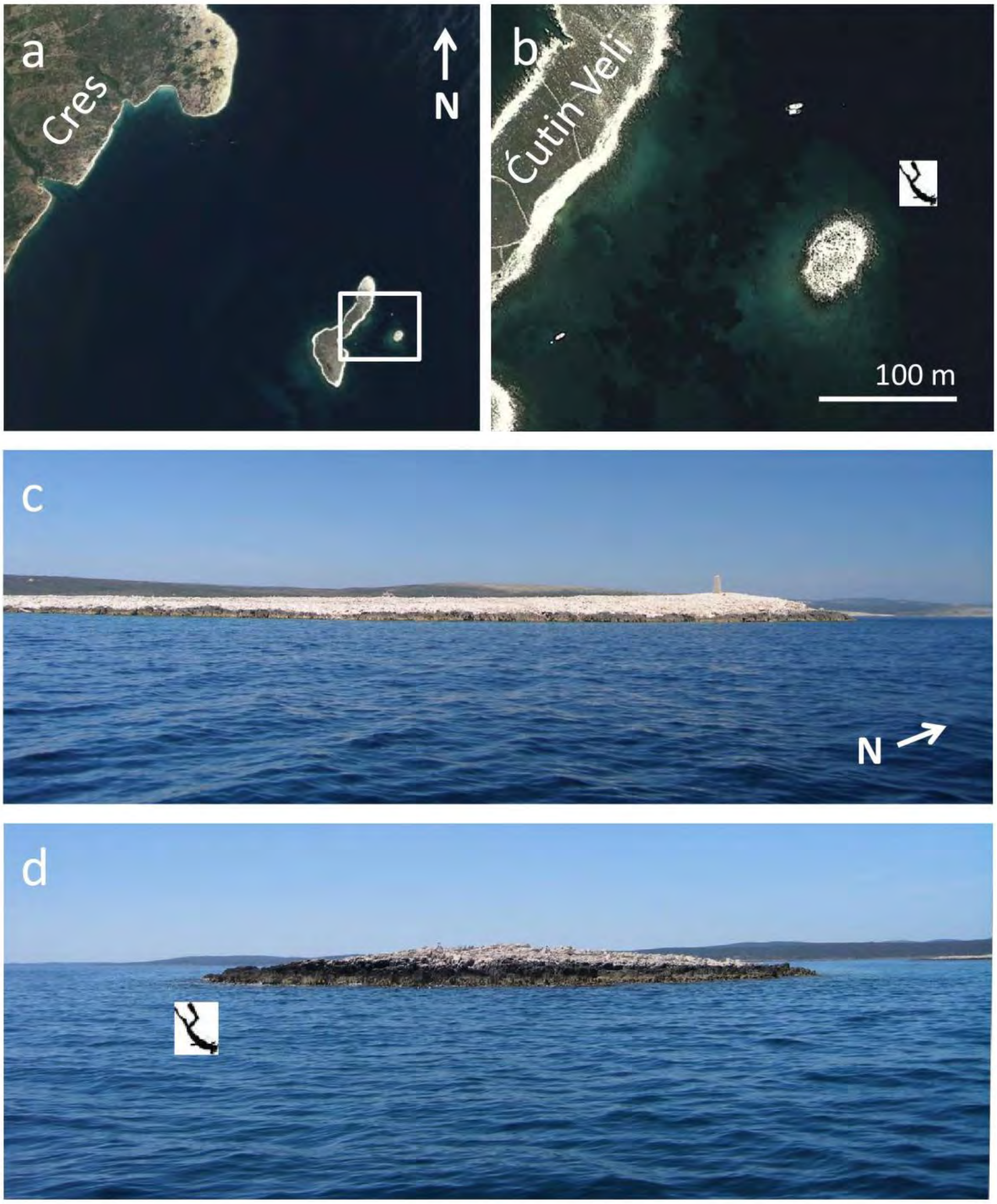

Figure. 35. Ćutin Mali dive site. Designated area of image a) is enlarged on image b); c) Ćutin Veli; d) Ćutin Mali Islet with indicated diving position. Source: a, b) Google Earth, Image © 2013 DigitalGlobe.

GPS: 44°43'27.36''N, 14°29'38.95''E

Date and time of the dive: 17th of July 2013, 11 am

Photos IDs and number of photos: MCa1 – MCe8; 40

Number of transects carried out: 1

Video transects: 1

Description: Two islets, Ćutin Veli and Ćutin Mali are situated approximately 2 km (1.1 NM) from the east coast of the Cres Island (Fig. 35). This is a popular diving site. Our dive started at the North-east side of the Ćutin Mali Islet (Fig. 35 b,d), above a small underwater canyon (Fig. 36 a) that stretches from 9 to 40 m depth. From the canyon we continued a dive along the wall placed at our right-hand side. The wall stretches from 15 m down to 38 m and the coralligenous outcrops are found below 23 m depth. Approximately 50 m from the canyon, a *Paramuricea clavata* assemblage thrives at the wall from 25 to 38 m depth (Fig. 36 b,c). At 38 m depth the wall ends and it is replaced by detritic bottom.

Photosampling was carried out within the *Paramuricea clavata* assemblage, at depth between 30 and 35 m. Visual census was performed by a single observer at 35 m depth, while the video transect was recorded at 38 m depth. In addition, at this site two divers replaced temperature dataloggers to demonstrate their deployment in the field (see section 2.3) and one operator assessed the health status of the red gorgonian *Paramuricea clavata* at 30 m depth.

The erect layer of the coralligenous habitat was primarily formed by the colonies of the red gorgonian *Paramuricea clavata,* followed by the yellow gorgonian *Eunicella cavolini* and the erect sponge *Axinella cannabina*. At parts of the wall the erect layer was dominated by large colonies of sponge *Aplysina cavernicola* (Fig. 36 d).

The intermediate layer was formed mainly by sponges *Petrosia ficiformis*, *Haliclona (Halichoclona) fulva*, *Acanthella acuta* and *Axinella* sp. with epibiotic zoantharian

Parazoanthus axinellae, cup-like anthozoan *Leptopsammia pruvoti*, bushy bryozoan *Myriapora truncata*, green algae *Valonia macrophysa* and *Pseudochlorodesmis furcellata.*

The basal layer was dominated by the red encrusting algae *Mesophyllum macroblastum*, another as yet unidentified encrusting Corallinacea, algae of the genus *Peyssonnelia* (mainly *Peyssonnelia squamaria* and *P. rubra*), the encrusting sponge *Hexadella racovitzai* and *Phorbas tenacior* as well as orange encrusting bryozoans and *Beania magellanica*. Mollusc *Gastrochaena dubia* and the sponge *Cliona* sp. were recorded as the main bioeroders at the site and 1 individual of the sea-urchin *Echinus* sp. was also observed.

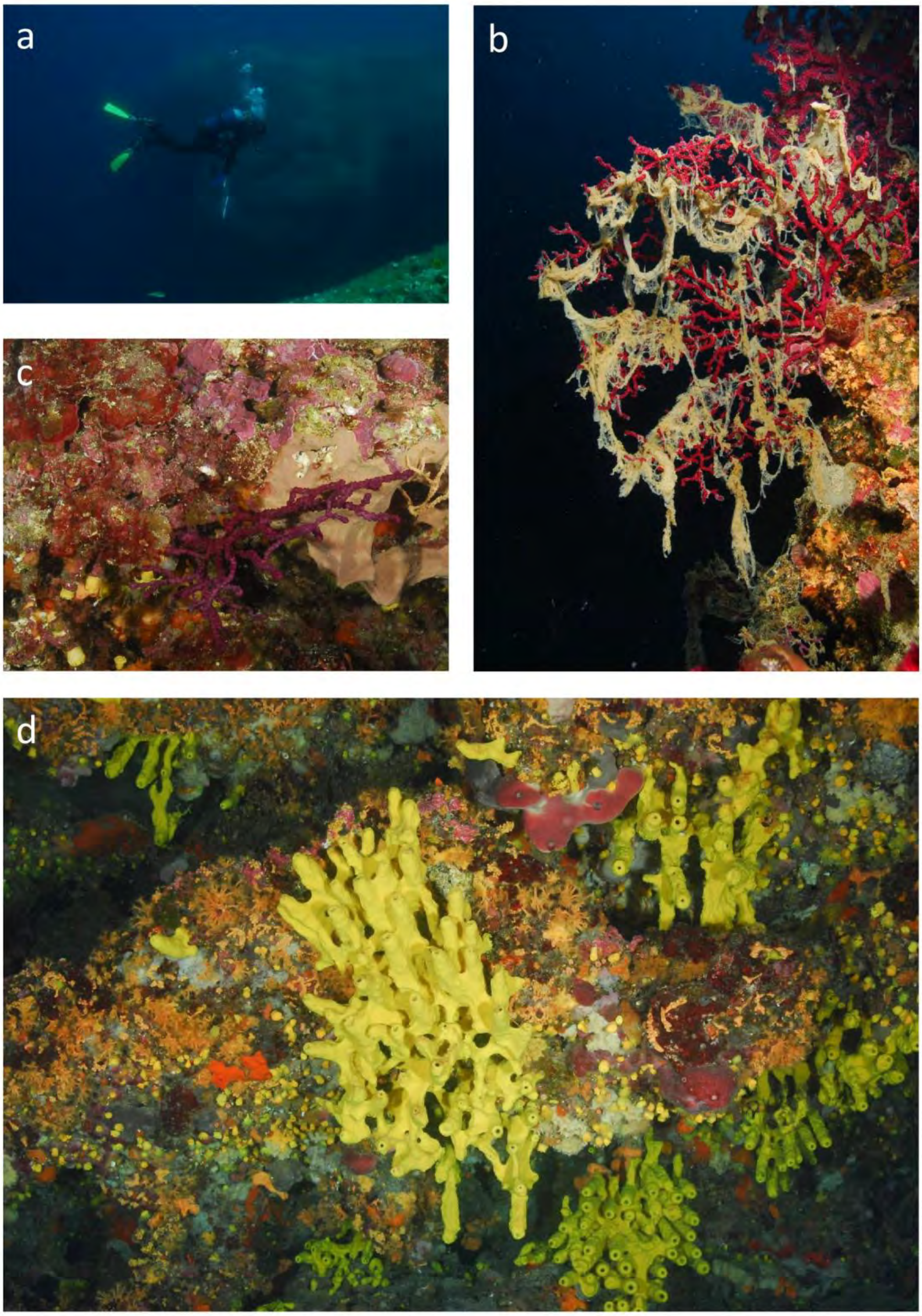

Figure. 36. Ćutin Mali dive path. a) the underwater canyon; b) *Paramuricea clavata* assemblage found at the wall from 25 to 38 m depth; c) detail of the *Paramuricea clavata* assemblage with algae *Peyssonnelia* sp., *Mesophyllum macroblastum* and sponge *Hexadella racovitzai* in the basal layer; d) large colonies of *Aplysina cavernicola* present an important component of the erect layer, adding to the structural complexity. Photo credit: P. Kružić.

4 Cape Šilo

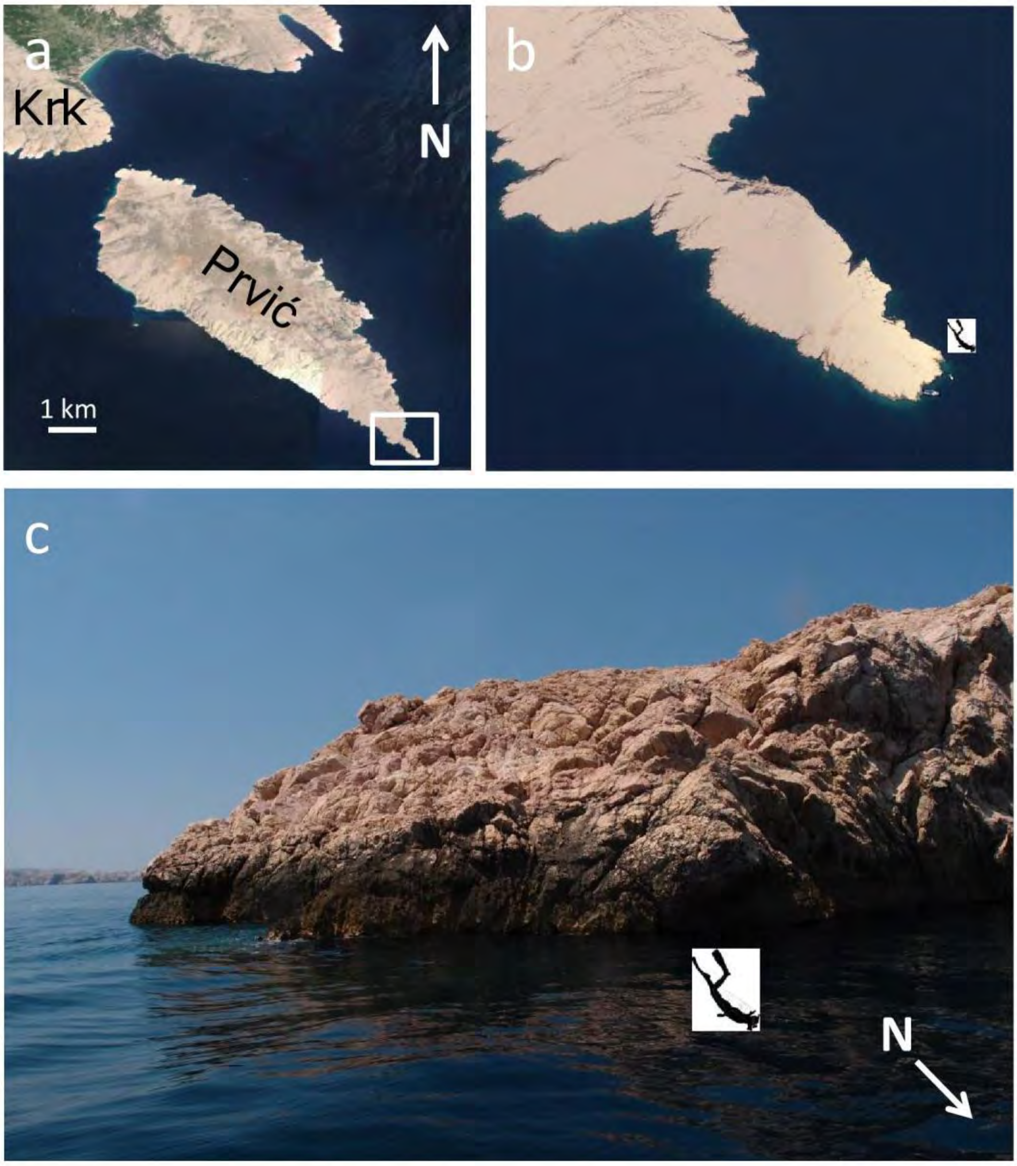

Figure. 37. Cape Šilo at the Prvić Island dive site. Designated area of image a) is enlarged on image b); c) terrestrial view of the Šilo Cape diving site. Source: a, b) Google Earth, Image © 2013 DigitalGlobe.

GPS: 44°53'02.87"N, 14°50'19.05"E

Time of the dive: 18th of July 2013, 12 am

Photos IDs and number of photos: PRSIa1 – PRSIe8; 40

Number of transects carried out: 1

Video transects: 1

Description: This diving site was located at the east part of the Cape Šilo, the south-east tip of the Prvić Island (Fig. 37). Initially, we have dived along the wall supporting the biocenosis of infralittoral algae (Fig. 38 a) with *Laurencia* sp., *Dictyota dichotoma*, *Padina pavonica* and *Cystoseira* sp. Individual colonies of the white gorgonian *Eunicella singularis* were scattered down to 17 m. Around 15 m depth a bank of the red encrusting algae *Lithothamnion crispatum* was developed with the abundance of alcyonacean *Alcyonium acaule,* green algae *Flabellia petiolata* as well as sponges *Aplysina aerophoba* and *Petrosia ficiformis* (Fig. 38b). Below 25 m depth the rocky bottom became cascade-like, supporting coralligenous assemblage with the red gorgonian *Paramuricea clavata* (Fig. 38 c,d). Thus, this assemblage was present both on the walls and subhorizontal bottoms. Occasionally it was also present on rather small rocks up to 1 m in height, surrounded by detritic bottom. Individual colonies of *Paramuricea clavata* were noted already at 23 m depth. At 42 m depth the rocky bottom was replaced by a moderately inclined slope of coarse sand rich in detritus.

Photosampling was carried out within the *Paramuricea clavata* assemblage, at depth between 30 and 35 m. Visual census was performed by a single observer at 30 m depth, while the video transect was recorded at 40 m depth. Furthermore, two operators assessed the red gorgonian health status at 30 m depth.

The erect layer of the coralligenous habitat was formed by colonies of the red gorgonian *Paramuricea clavata,* followed by the yellow gorgonian *Eunicella cavolini,* large colonies of sponge *Aplysina cavernicola* (> 15 cm high) and the erect sponge *Axinella cannabina* (Fig. 38 e).

The intermediate layer was formed mainly by green algae *Flabellia petiolata*, smaller specimens of sponge *Aplysina cavernicola*, epibiotic zoantharian *Parazoanthus axinellae*, bushy bryozoan *Myriapora truncata* and *Smittina cervicornis / Adeonella pallasii* as well as lobulated orange encrusting bryozoans.

The basal layer was primarily formed by the calcified and non-calcified algae of the genus *Peyssonnelia* (mainly *Peyssonnelia squamaria* and *P. rubra;* Fig. 38 e) followed by the red calcareous encrusting algae *Mesophyllum macroblastum* and *Lithophyllum stictaeforme* (Fig. 38 d) as well as green turf algae *Pseudochlorodesmis furcellata*. The encrusting sponge *Hexadella racovitzai* and as yet unidentified pink net-like encrusting sponge were also abundant in the basal layer.

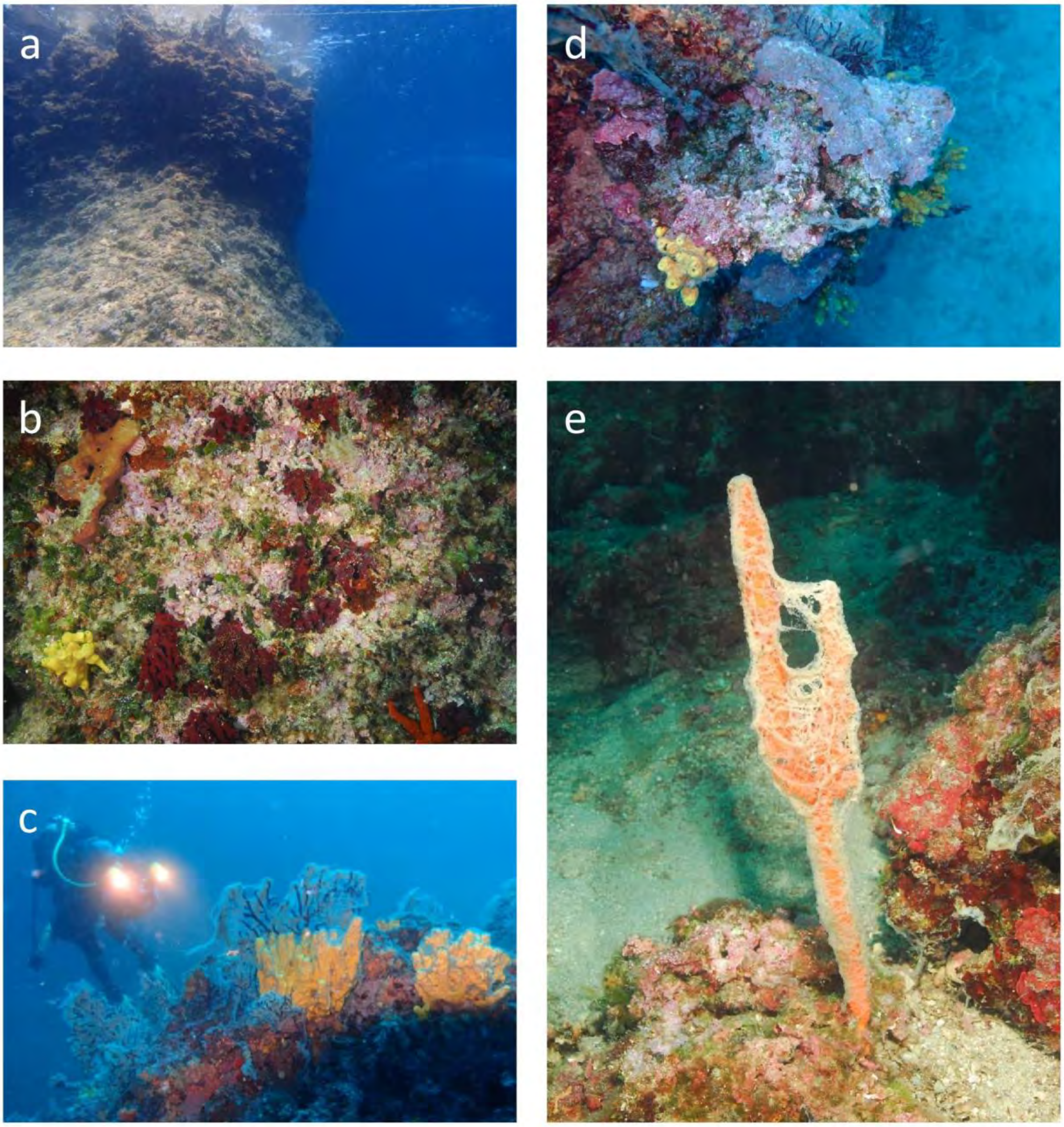

Figure. 38. Cape Šilo at the Prvić Island dive path. a) subsurface part of the wall; b) red encrusting algae *Lithothamnion crispatum* with abundant alcyonacean *Alcyonium acaule* around 15 m depth; c-d) *Paramuricea clavata* assemblage developed from 25 to 42 m depth on a cascade-like rocky bottom; e) besides gorgonians, other erect organisms such as sponge *Axinella cannabina* were the most exposed to the mucilaginous algal aggregates. Photo credits: a, c, d) A. Jaklin; b, e) P. Kružić.

5 Cape Stražica

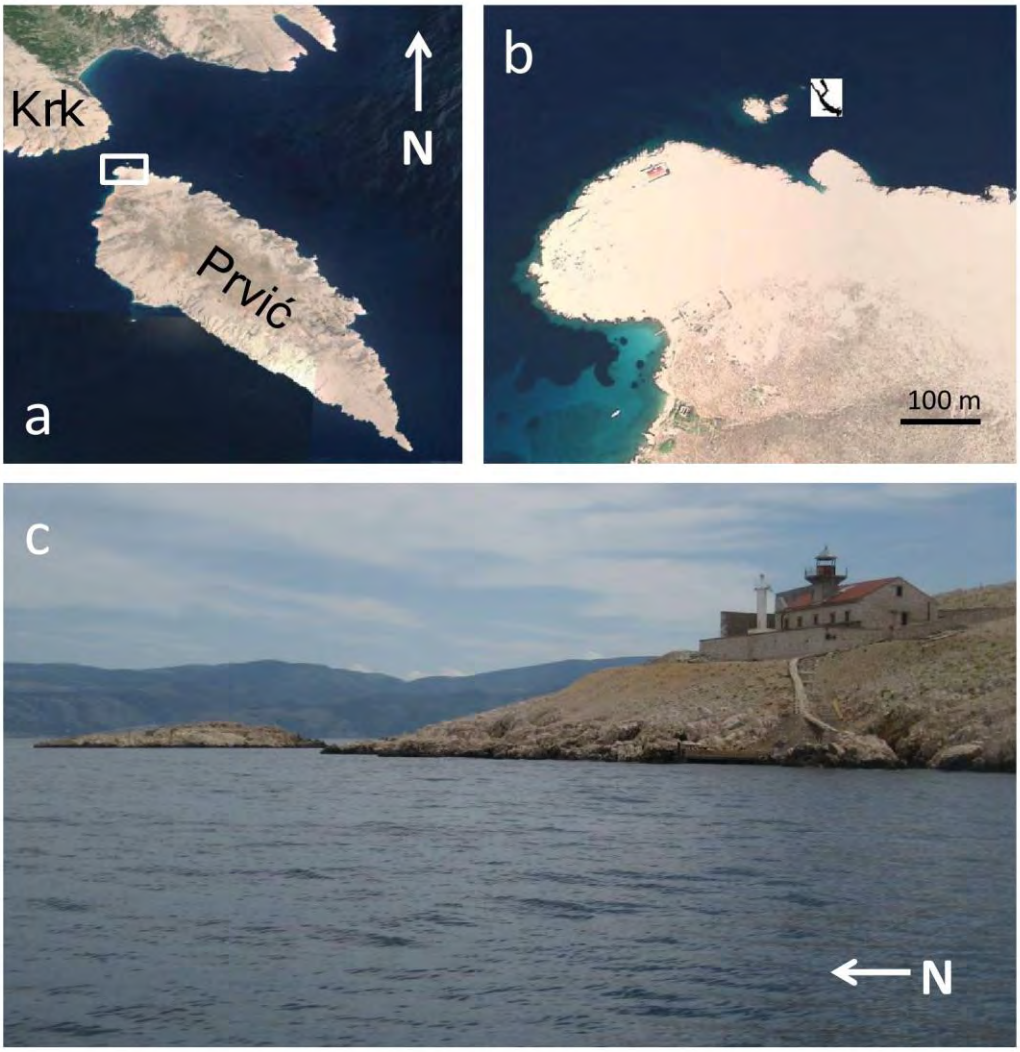

Figure. 39. Cape Stražica at the Prvić Island dive site. Designated area of image a) is enlarged on image b) and the diving site is indicated at the northeast from the rocks facing Cape Stražica; c) terrestrial view of the Cape Stražica and the rocks (at the left). Source: a, b) Google Earth, Image © 2013 DigitalGlobe.

GPS: 44°56'05.18''N, 14°46'13.65''E

Date and time of the dive: 13th and 18th of July 2013, 4.30 pm

Photos IDs and number of photos: PRSTa1-PRSTe8; 40

Number of transects carried out: 4

Video transects: 1

Description: Cape Stražica is located at the North side of the Prvić Island (Fig. 39). We began the immersion next to the small rock located eastwards from the small ridge facing Cape Stražica (Fig. 39 b). That ridge is pierced by a tunnel-like underwater passage and presents a popular diving site. Within the first several meters of depth an abundance of bioeroding mollusc *Gastrochaena dubia* was noted (Fig. 40a). The immersion followed towards the east. From 5 to cca 15 m depth moderately inclined slope hosted the biocenosis of infralittoral algae dominated by *Cystoseira* sp. (Fig. 40 b). From 15 m depth in the biocenosis of infralittoral algae the abundance of green algae *Flabellia petiolata*, red non-encrusting *Peyssonnelia* spp. and anthozoan *Alcyonium acaule* was found (Fig. 40 c). Around 22 m depth slope turned into a vertical wall where the coralligenous outcrops were present. A *Paramuricea clavata* assemblage was developed from 27 m (Fig. 40 d). Around 43 m depth the rocky wall was replaced by moderately inclined detritic bottom.

Photosampling was carried out within the *Paramuricea clavata* assemblage, at depth between 30 and 35 m. At this site visual census was performed twice (at two different dates) by the same two operators at depth between 30 and 35 m, while the video transect was recorded at 33 m depth. Furthermore, three operators assessed the red gorgonian health status at depth between 33 and 36 m.

The erect layer of the coralligenous habitat was formed by colonies of the red gorgonian *Paramuricea clavata,* followed by the yellow gorgonian *Eunicella cavolini,* large colonies of sponge *Aplysina cavernicola* (> 15 cm high) and the erect sponge *Axinella cannabina* (Fig. 40 e).

The intermediate layer was formed mainly by green algae *Flabellia petiolata*, smaller specimens of sponge *Aplysina cavernicola* and *Agelas oroides*, zoantharian *Parazoanthus axinellae overgrowing* sponge *Axinella* sp. or growing directly on the rocky substrate, bushy bryozoan *Myriapora truncata* and *Smittina cervicornis / Adeonella pallasii* and globulated orange encrusting bryozoans.

The basal layer was primarily formed by the red encrusting algae *Mesophyllum macroblastum* as well as the calcified and non-calcified algae of the genus *Peyssonnelia* (mainly *Peyssonnelia squamaria* and *P. rubra*). Furthermore, the abundance of dark orange ascidian *Didemnum* sp. at this site is noteworthy (Fig. 40 f).

Comments: The area is extremely exposed to bora winds and thus diving there is very dependant on weather conditions. The tunnel-like passage (28 m long, with entrances at depths of 5.5, 9, and 15 m) piercing the rock facing Cape Stražica (to the west from our diving position) hosts the biocoenosis of semidark caves (Zavodnik *et al.,* 2005) and could be putatively combined for monitoring of the habitat type „ 8330 Marine caves“.

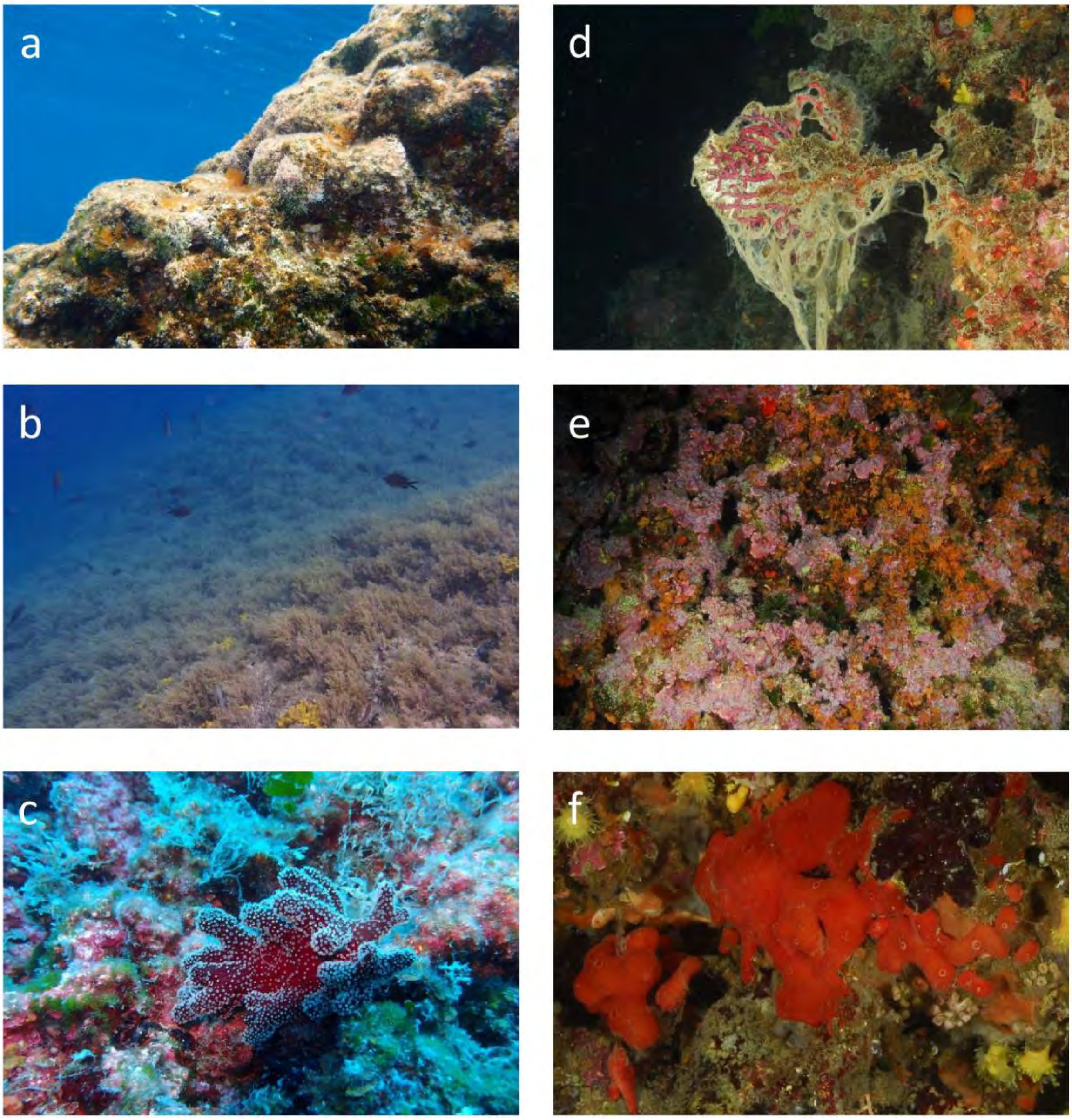

Figure. 40. Cape Stražica at the Prvić Island dive path. a) subsurface part of the rock hosted the abundant bioeroding mollusc *Gastrochaena dubia*; b) from 5 to cca 15 m depth moderately inclined slope was supporting the biocenosis of infralittoral algae with abundance of *Cystoseira* sp.; c) from 15 m depth the biocenosis of infralittoral algae was dominated by the green algae *Flabellia petiolata* and non-calcified red algae *Peyssonnelia* spp. and the abundance of anthozoan *Alcyonium acaule* was recorded; d) *Paramuricea clavata* assemblage was found at the vertical wall from cca 27 m depth; e) detail of the coralligenous outcrop with *Mesophyllum macroblastum* and *Parazoanthus axinellae*; f) dark orange ascidian *Didemnum* sp. was abundant within the coralligenous on the site. Photos: a-c) A. Jaklin; d-f) P. Kružić.

6 North coast of the Goli Island

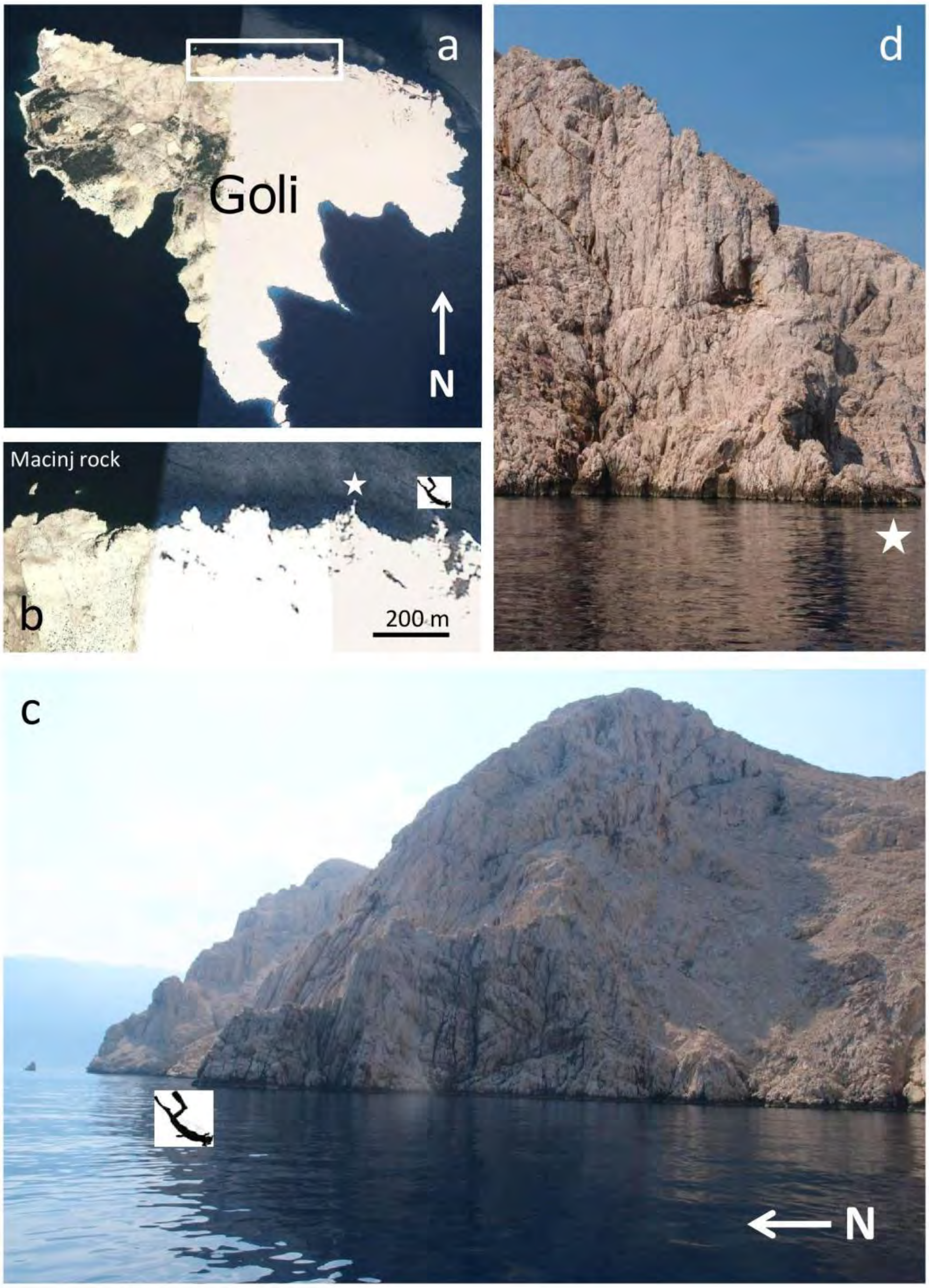

Figure. 41. North coast of the Goli Island dive site. Designated area of image a) is enlarged on image b); c) terrestrial view of the diving site; d) configuration of the coast 200 m west from the diving site, indicated by a star on image b). Source: a, b) Google Earth, Image © 2013 DigitalGlobe.

GPS: 44°50'59.20''N, 14°49'46.24''E

Date and time of the dive: 19th of July 2013, 11 am

Photos IDs and number of photos: GOa1-GOe8; 40

Number of transects carried out: 4

Video transects: 1

Description: The diving site at the North coast of the Goli Island was located approximately 1 km (0.55 NM) eastwards from the Macinj rock (Fig. 41). Underwater, the wall stretched vertically down to 7 m (Fig. 42 a) and deeper down it became intercepted by moderate or steep slopes (Fig. 42 b-d). From 15 to approximately 25 m the biocenosis of infralittoral algae was dominated by green algae *Flabellia petiolata* and *Halimeda tuna* (Fig. 42 c). Coralligenous outcrops were developed on a cascade-like rocky bottom (walls intercepted by slopes) below 25 m depth (Fig. 42 e-g).

Photosampling was carried out at depth around 30 m. Visual census was performed by four operators at depth between 30 and 33 m, while the video transect was recorded at 37 m depth.

The basal layer was algal dominated and primarily formed by the red encrusting algae *Mesophyllum macroblastum* as well as the calcified and non-calcified algae of the genus *Peyssonnelia* (mainly *Peyssonnelia squamaria* and *P. rubra*) (e.g. Fig. 42 f). Encrusting calcareous red algae *Lithothamnion minervae* and *Neogoniolithon mamillosum* were also recorded at this site.

The intermediate layer was formed mainly by green algae *Flabellia petiolata*, sponges *Petrosia ficiformis,* black Keratose sponges and smaller specimens of *Aplysina cavernicola*, and zoantharian *Parazoanthus axinellae* overgrowing sponge *Axinella* sp. or growing directly on the rocky substrate.

The erect layer of the coralligenous habitat was formed by sparse colonies of the red gorgonian *Paramuricea clavata* and the yellow gorgonian *Eunicella cavolini,* large colonies of sponge *Aplysina cavernicola* (> 15 cm high) and sporadic specimens of the erect sponge *Axinella cannabina*.

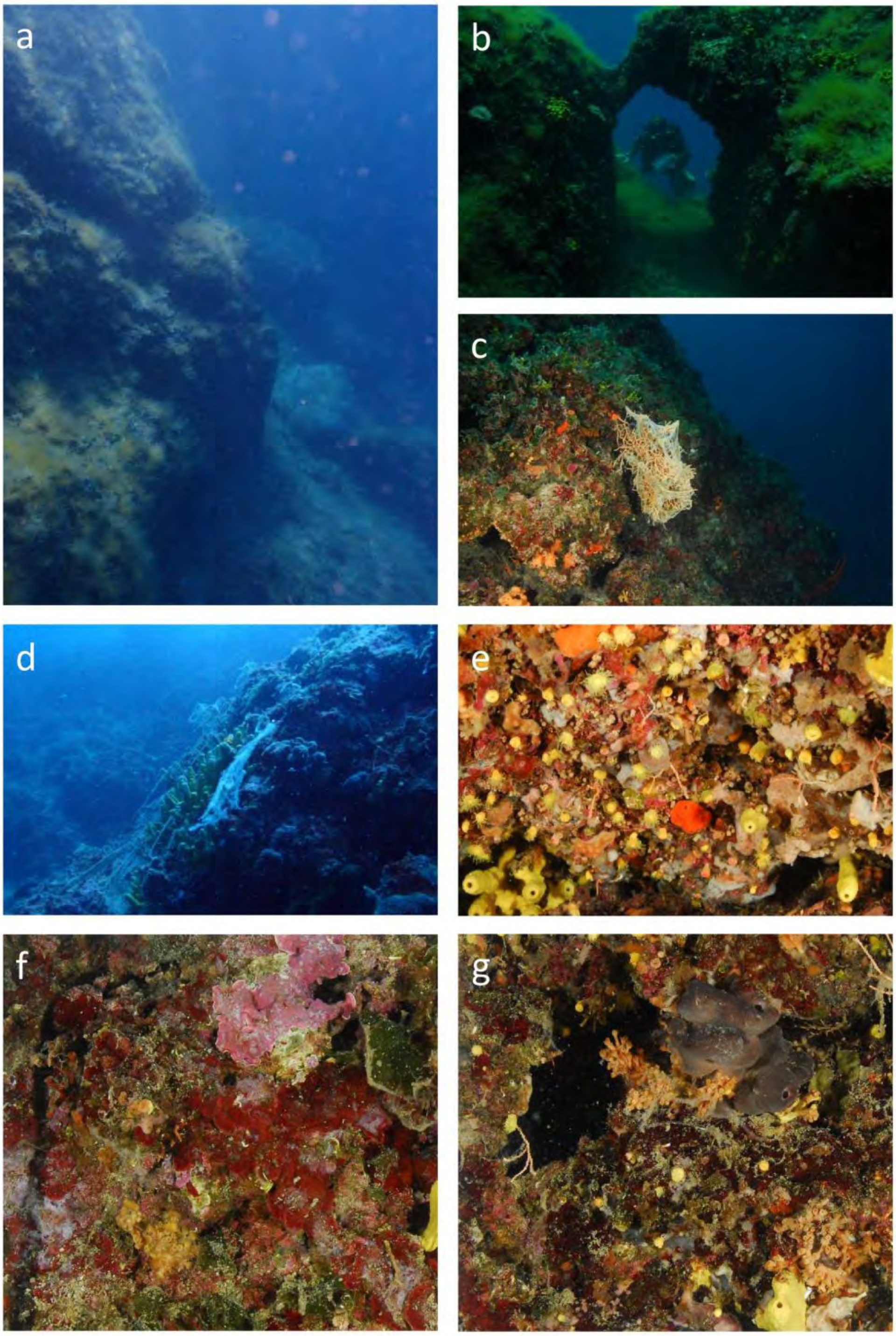

Figure. 42. North coast of the Goli Island dive path. a) almost vertical wall stretching down to 7 m depth; b) moderately inclined slope intercepting the wall at 9 m depth; c) from 15 to 25 m the biocenosis of infralittoral algae was dominated by green algae *Flabellia petiolata* and *Halimeda tuna* and sporadic colonies of *Eunicella cavolini* were present; d) the cascade-like rocky bottom hosting coralligenous habitat below 25 m depth. Details of the coralligenous habitat: e) a slight overhang with the abundance of scleractinian coral *Leptopsammia pruvoti* and various sponges; f) basal layer dominated by algae *Mesophyllum macroblastum* and *Peyssonnelia* spp.; g) intermediate layer formed by different sponges and juvenile colonies of the yellow gorgonian *Eunicella cavolini*. Photo credits: P. Kružić except a) and d) A. Jaklin.

7 Grgur

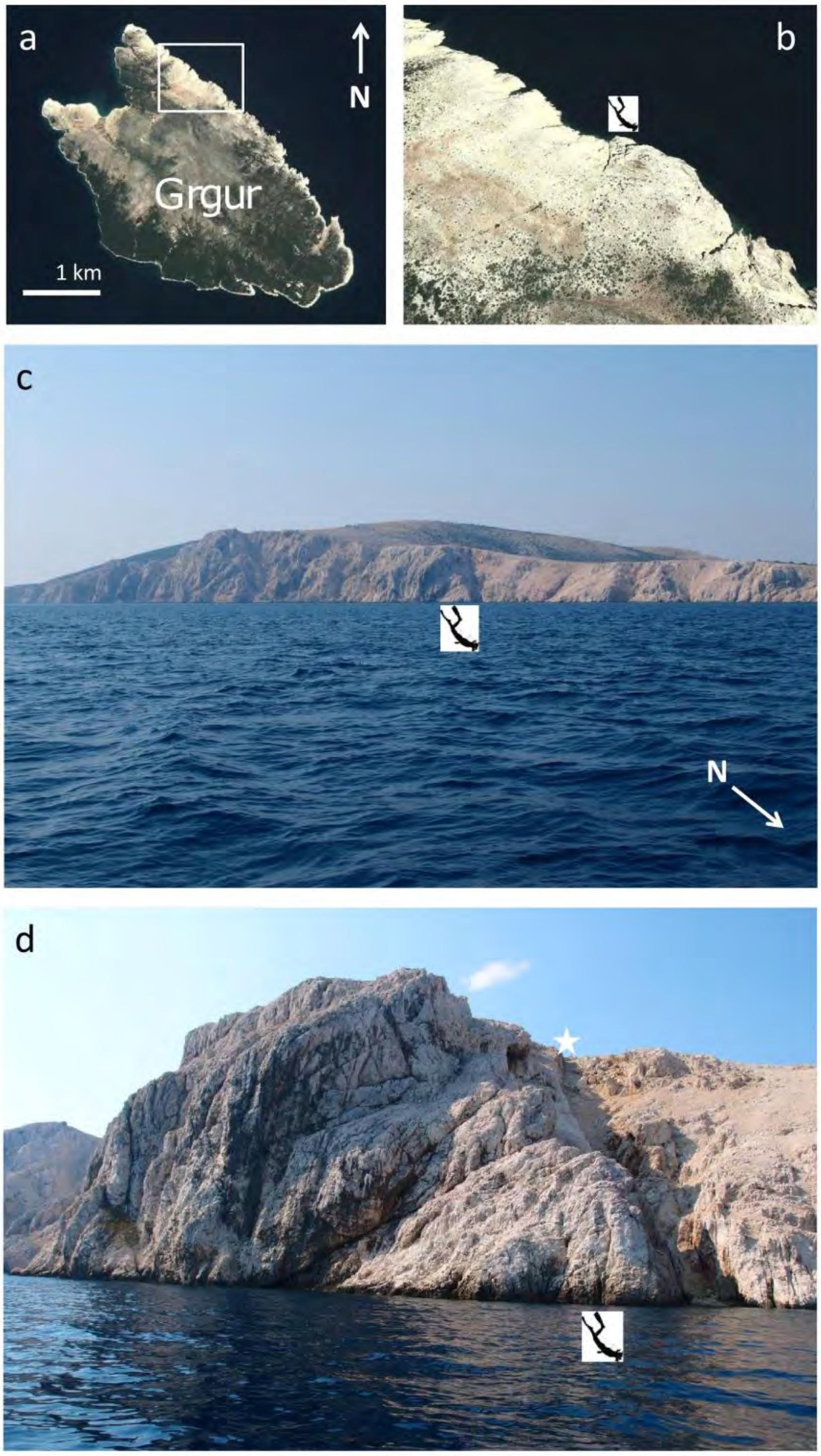

Figure. 43. Grgur Island dive site. Designated area of image a) is enlarged on image b); c) terrestrial view of the diving site; d) characteristic landmarks at the right side from the diving site were the rock creep and an old bunker on the top (indicated by a star).

GPS: 44°52'41.55''N, 14°45'37.06''E

Date and time of the dive: 20th of July 2013, 11 am

Photos IDs and number of photos: GRGa1 – GRGd8; 32

Number of transects carried out: 1

Video transects: 1

Description: This diving site was located on the east coast of the Grgur Island, 1.3 km (approx. 0.7 NM) from its northernmost tip (Fig.43). Facing the coast, at the right side from our diving site there were a rock creep and an old bunker at the top (Fig. 43 d). To reach the immersion point we swam from the boat over a shallow bay hosting the biocenosis of infralittoral pebbles and biocenosis of infralittoral algae (Fig. 44 a-c) keeping the coast on the right-hand side. We started a dive at the tip of the small cape facing north (Fig. 43 b-d). A wall extended down to 15-20 m and ended with the detritic bottom (Fig. 44 d). Continuing a dive towards the north–northeast a moderately inclined slope became intercepted by rocks (Fig. 44 e) and smaller walls where species typical of coralligenous assemblages started to appear. Between the coralligenous outcrops, species thriving on the sandy bottom such as anemone *Condylactis aurantiaca* were also present (Fig. 44 f). Along the dive, sparse colonies of gorgonian *Eunicella singularis* (Fig. 44 e) were noted down to 20 m depth. The yellow gorgonian *E. cavolini* was also recorded deeper, in the coralligenous developed below 25 m depth, but its densities were always sparse. Representative wall with coralligenous outcrops stretched from 35 to 48 m depth.

Photosampling was carried out within the coralligenous assemblage developed on cascade-like rocky bottom, between 33 and 35 m depth. Visual census was performed by a single observer at 38 m depth, while the video transect was recorded at the wall from 40 to 44 m depth. Furthermore, one operator performed the assessment of the yellow gorgonian *Eunicella cavolini* health status at 20 and 40 m depth.

The erect layer of the coralligenous assemblage developed on the cascade-like rocky bottom around 35 m depth was not well developed whereas the basal layer was the dominant one.

It was algal dominated and primarily formed by the calcified red algae *Peyssonnelia rubra, P. squamaria* and non-calcified *Peyssonnelia* spp. (Fig. 44 g), followed by the encrusting sponge *Hexadella racovitzai.* The red encrusting algae *Mesophyllum macroblastum* was also present but it was not as abundant.
The intermediate layer was formed mainly by green algae *Flabellia petiolata*, smaller specimens of sponge *Aplysina cavernicola* and epibiotic zoantharian *Parazoanthus axinellae* overgrowing other organisms or growing on the bare rock.

From 40 to 44 m depth the wall (where the video was filmed) full of holes, crevices and overhangs hosted greater abundance of sessile animals compared to shallower outcrops developed on cascade-like rocky bottom. These included encrusting and massive sponges (e.g. *Halicohlona mediterranea*, *Ircinia* sp., *Petrosia ficiformis*, *Chondrosia reniformis,* grey massive sponges, large *Aplysina cavernicola*), scattered colonies of gorgonian *Eunicella cavolini*, scleractinian coral *Leptopsammia pruvoti* and bushy bryozoan *Smittina cervicornis* / *Adeonella pallasii.*

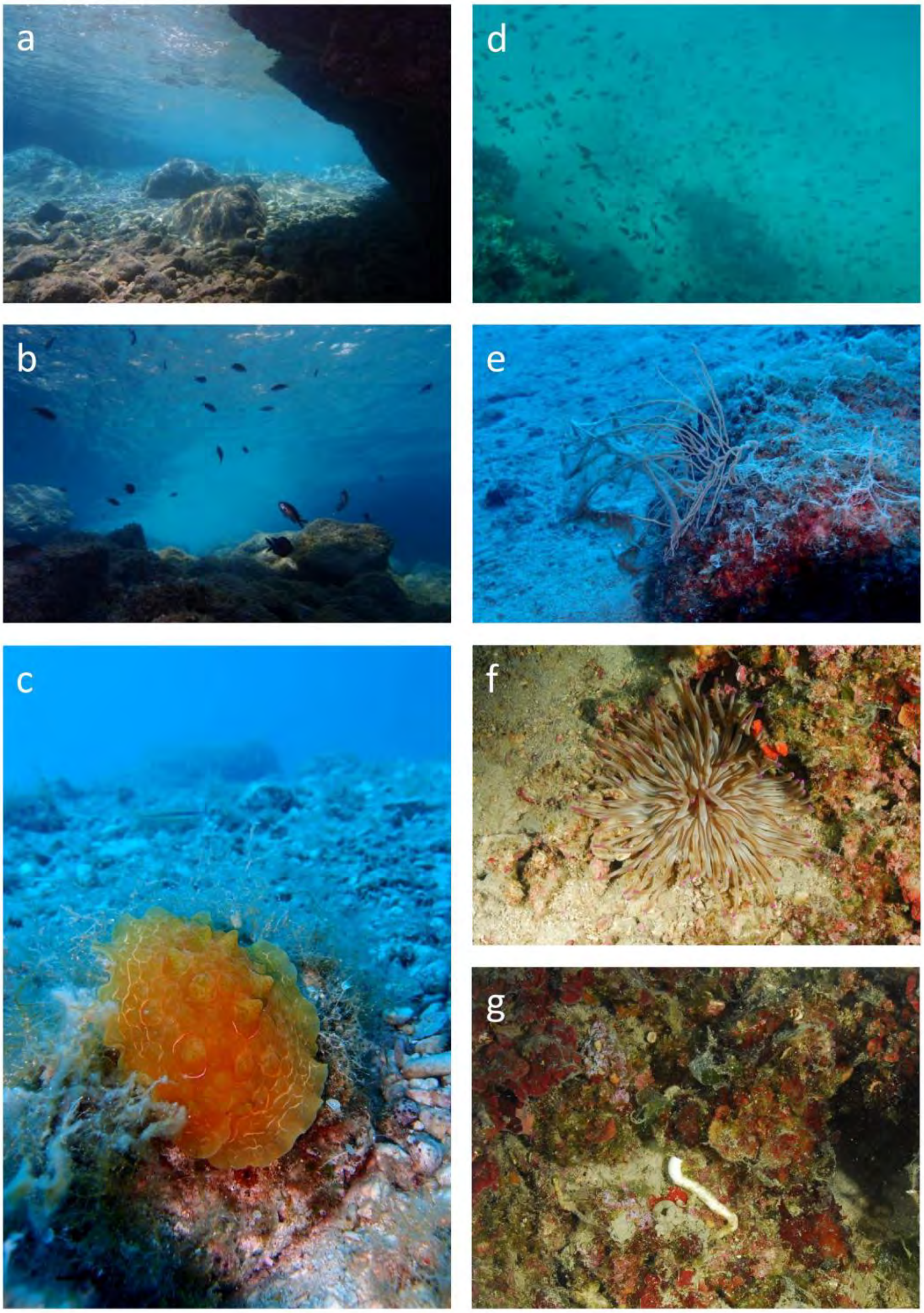

Figure. 44. Grgur dive path. a) biocenosis of infralittoral pebbles at 3 m depth; b) biocenosis of infralittoral algae with abundant *Acetabularia acetabulum* at 7 m depth c) rarely recorded sea slug *Pleurobranchus testudinarius* at 9 m depth; d) at 20 m depth the wall was replaced by detritic bottom; e) sparse colonies of gorgonian *Eunicella singularis* found at scattered rocks at 22 m; f) coralligenous outcrops thriving on cascade-like rocky bottom and isolated rocks surrounded by detritic bottom at 35 m depth; g) detail of the coralligenous outcrops dominated by encrusting red algae *Peyssonnelia rubra*, non-encrusting *Peyssonnelia* spp. and green algae *Flabellia petiolata* at 35 m depth. Photo credits: a-c) S. Kaleb; d, e) A. Jaklin; f, g) P. Kružić.

8 East coast of the Prvić Island

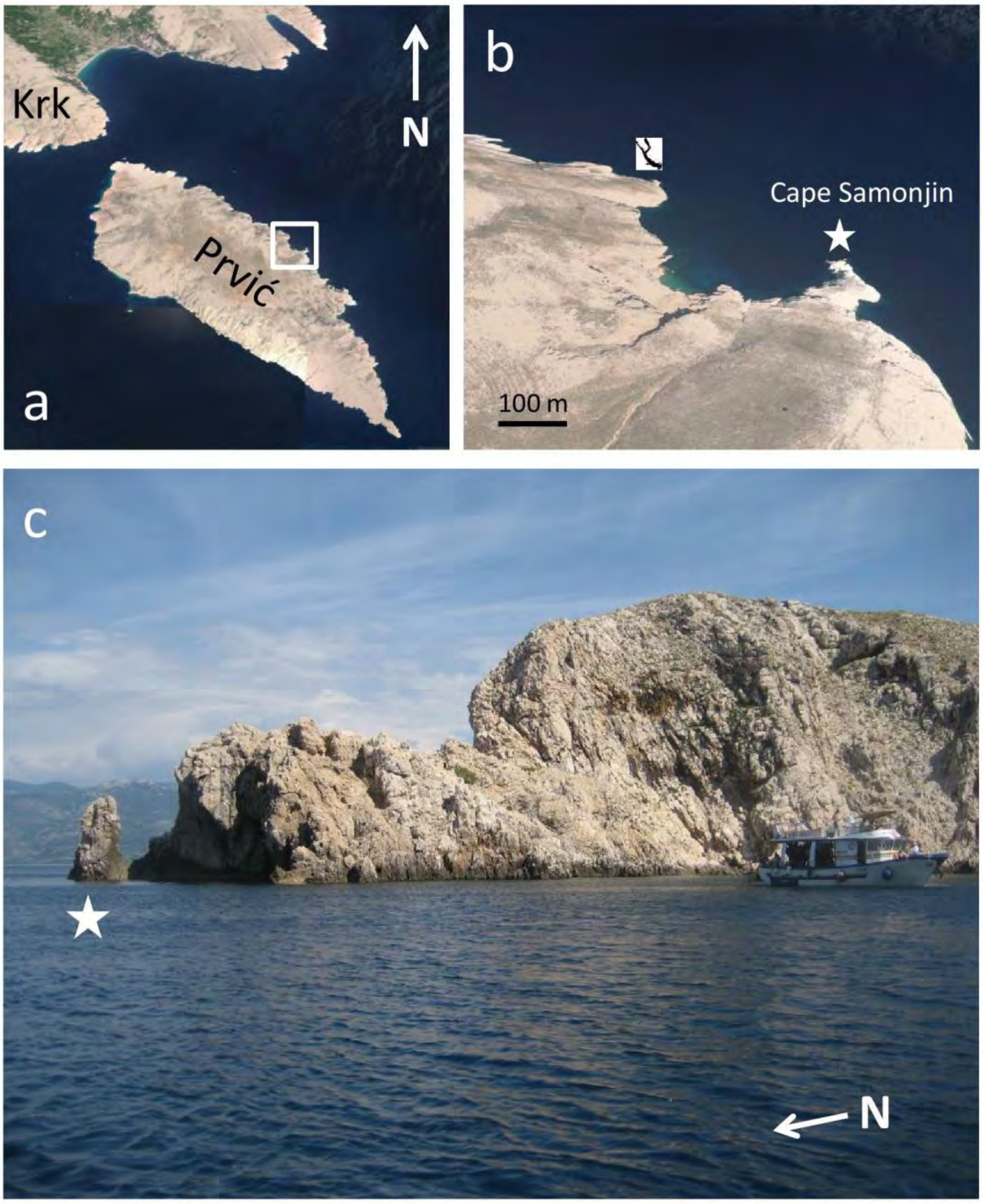

Figure. 45. East coast of the Prvić Island dive site. Designated area of image a) is enlarged on image b); c) Cape Samonjin (indicated by a star). Source: a, b) Google Earth, Image © 2013 DigitalGlobe.

GPS: 44°55'03.64''N, 14°48'51.17''E

Date and time of the dive: 20th of July 2013, 4.30 pm

Photos IDs and number of photos: PRSa1 – PRSe8; 40

Number of transects carried out: 3

Video transects: none

Description: This diving site was located on the eastern coast of the Prvić Island (Fig. 45 a), 500 m northwest from the Samonjin Cape (Fig. 45 b). The Samonjin Cape presents an easily recognizable landmark (Fig. 45 c) that facilitates the orientation. At the diving site, the wall extended down to 45 m depth. On the wall, within the biocenosis of infralittoral algae at only 3-5 meters depth, a very localized but dense patch formed by individuals of *Anemonia viridis* was noted (Fig. 46 a). Around 15 m depth a belt formed by the red calcareous algae *Lithophyllum stictaeforme* and green algae *Halimeda tuna* was present. At 20 m depth non-calcified *Peyssonnelia* spp., *Flabellia petiolata* were abundant and sparse colonies of *Eunicella cavolini* were present (Fig. 46 b). From 25 m depth coralligenous outcrops were developed (Figs. 46 c-e, 47). Below 40 m depth the red gorgonian *Paramuricea clavata* was noted but in sparse densities. At 45 m depth the wall was replaced by detritic bottom.

Photosampling was carried out between 30 and 33 m depth. Visual census was performed by three operators between 30 and 35 m depth, while the video transect was not recorded at this site due to technical problems.

The basal layer was the most developed one and it was primarily formed by encrusting and non-encrusting *Peyssonnelia* spp. (mainly *P. squamaria* but also *P. rubra*), the red calcareous encrusting algae *Mesophyllum macroblastum* (Fig. 46 d) and other as yet unidentified red encrusting algae as well as green turf algae.

The intermediate layer was formed mainly by green algae *Flabellia petiolata*, zoantharian *Parazoanthus axinellae overgrowing* sponge *Axinella* sp. or growing directly on the rocky substrate, sponge *Petrosia ficiformis* and bushy bryozoan *Smittina cervicornis / Adeonella* sp. (Fig. 46 e).

The erect layer of the coralligenous habitat was poorly developed and it was formed by sparse colonies of the yellow gorgonian *Eunicella cavolini* and the red gorgonian *Paramuricea clavata* (noted below 40 m depth).

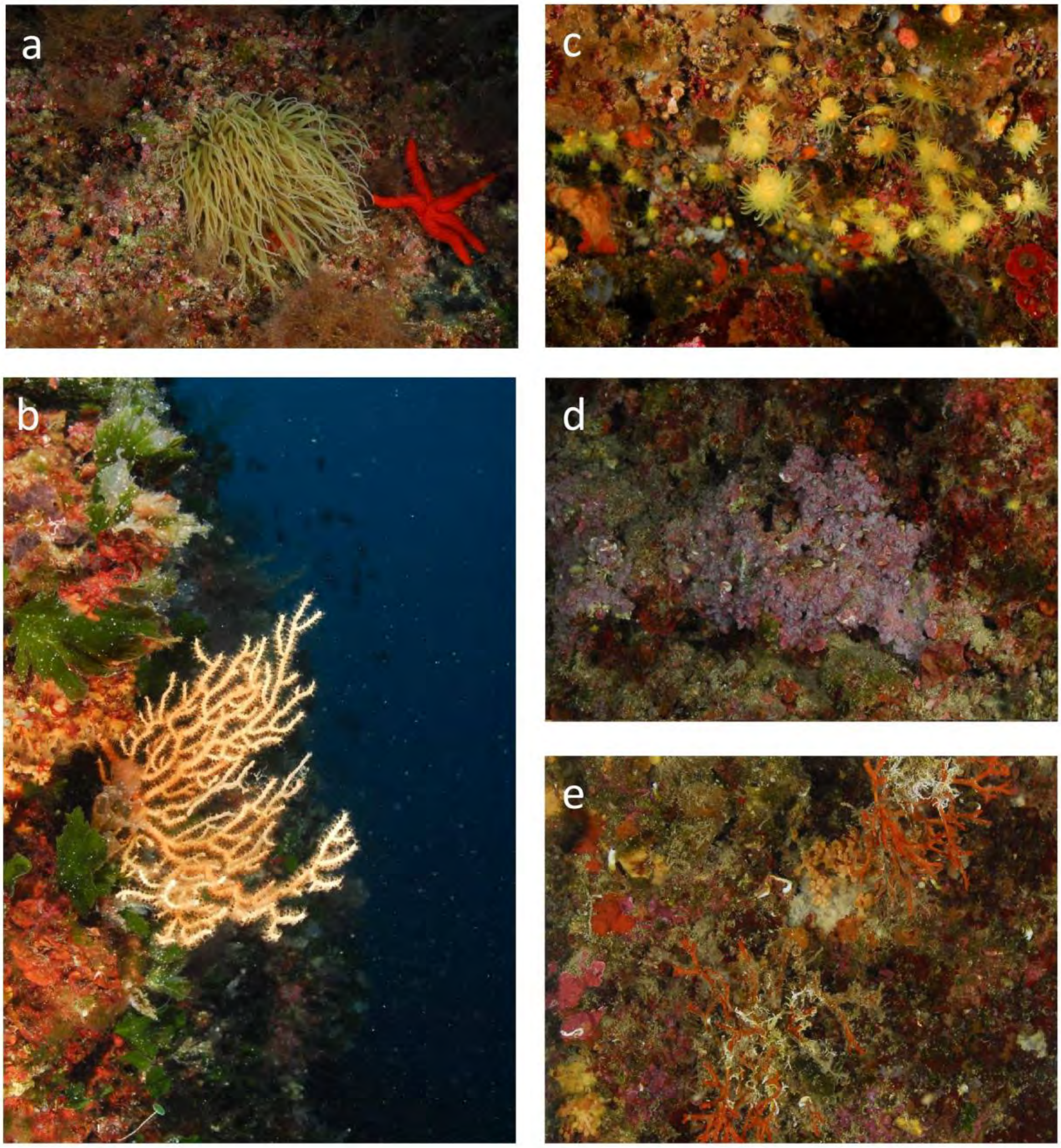

Figure. 46. East coast of the Prvić island dive path: a) biocenosis of infralittoral algae with anemone *Anemonia viridis* at 5 m depth; b) wall hosting non-calcified *Peyssonnelia* sp., *Flabellia petiolata*, *Acetabularia acetabulum* and sparse colonies of *Eunicella cavolini* at 20 m depth; c) slight overhang within the coralligenous habitat hosting abundant scleractinians *Leptopsammia pruvoti* and *Caryophyllia inornata,* encrusting bryozoan *Beania* sp. and red encrusting algae *Peyssonnelia* sp.; d) red encrusting algae *Mesophyllum macroblastum,* one of the main algal builders at the site; e) detail of the coralligenous assemblage with bush-like bryozoan *Smittina cervicornis*/*Adeonella* sp. and sponge *Axinella* sp. with epibiotic zoantharian *Parazoanthus axinellae*. Photo credit: P. Kružić.

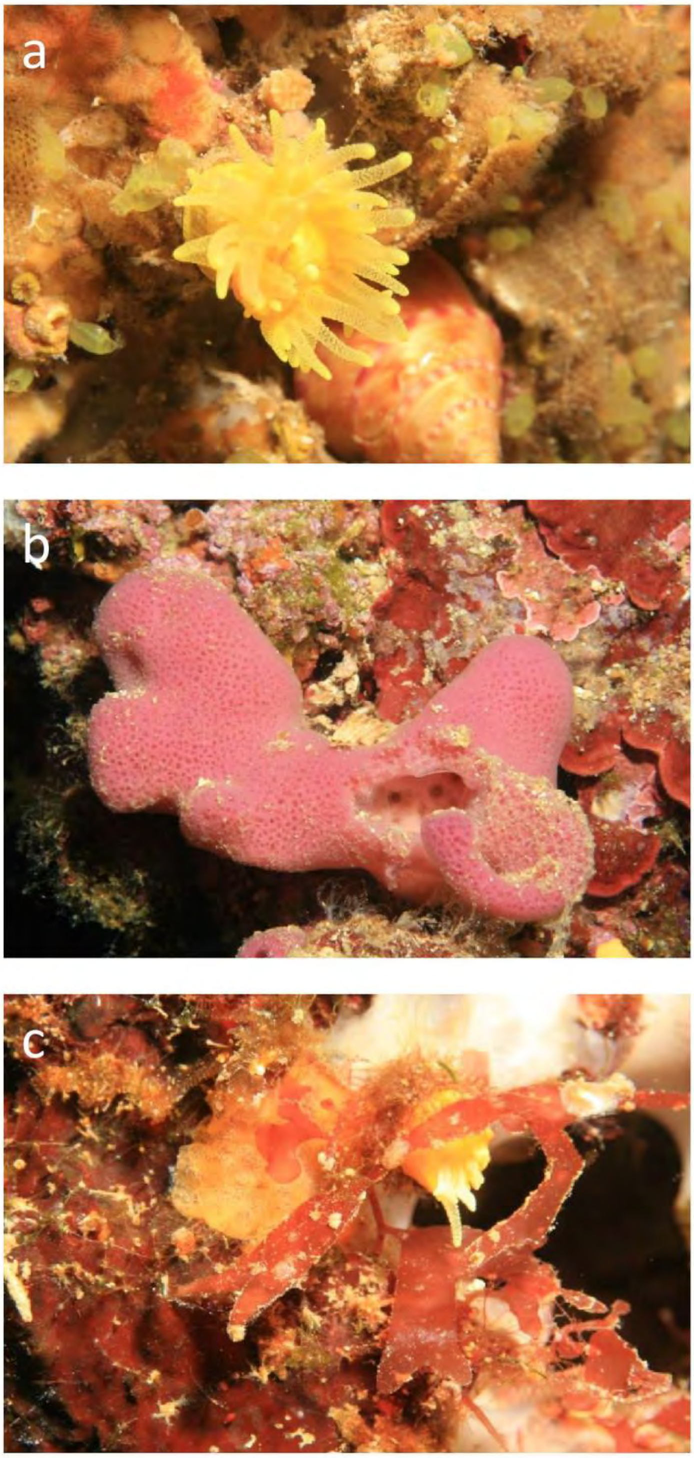

Figure. 47. Details of the coralligenous assemblages from the East coast of the Prvić Island: a) scleractinian coral *Leptopsammia pruvoti* was one of the main animal builders and the yellow ascidian *Pycnoclavella* sp./*Perophora* sp. was common; b) sponge *Halicohlona mediterranea* was found at the site but it was not recorded within the photo replicates; c) red algae *Rhodymenia ardissonei* was common at the site. Photo credit: A. Žuljević.

9 Cape Markonj

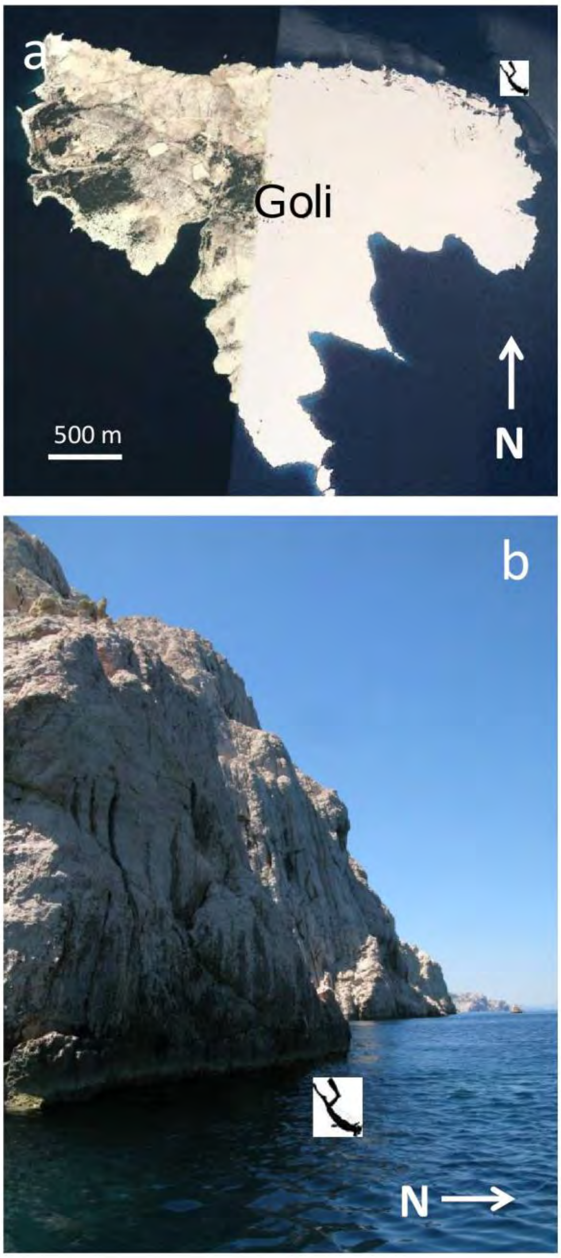

Figure. 48. Cape Markonj at the Goli Island dive site. Source: a) Google Earth, Image © 2013 DigitalGlobe.

GPS: 44°50'48.89''N, 14°50'21.13''E

Time of the dive: 22nd of July 2013, 12 am

Photos IDs and number of photos: GOMa1 – GOMe8; 40

Number of transects carried out: 3

Video transects: 1

Description: Cape Markonj is located at the north-east side of the Goli Island (Fig. 48). Our dive was initiated in front of a rather flat stretch of the wall (Fig. 48 c). Underwater, the wall reaches down to around 40 m depth, where it was replaced by detritic bottom. In the upper part of the wall, biocenosis of infralittoral algae is developed, with the abundance of algae such as *Laurencia* sp. *Halimeda tuna* and *Amphiroa* sp. (Fig. 49 a,b). The individual colonies of the white gorgonian *Eunicella singularis* were recorded down to 15 m. From 20 m depth the wall was dominated by *Flabellia petiolata*, *Peyssonnelia* spp. and zoantharian *Parazoanthus axinellae* (Fig. 49 c). From 23 m depth coralligenous outcrops were developed (Fig. 49 d-g). Scattered colonies of the yellow gorgonian *Eunicella cavolini* (Fig. 49 c) were present from 10 m depth down to the end of the wall. From 28 m depth the gorgonian *Paramuricea clavata* was also recorded, but this species was rare at this site.

Photosampling was carried out between 28 and 30 m depth, and visual census was carried out at 33 m depth. For the first time during the field trip, 20 m long transect was marked by the rope and visual census was carried out by three operators along the same transect. In addition, the same transect was video recorded.

Both gorgonians (*Eunicella cavolini* and *Paramuricea clavata*) formed the erect layer of the coralligenous habitat together with the erect sponges *Axinella cannabina*, *A. polypoides* and large colonies of *Aplysina cavernicola*.

The dominant species forming the basal layer were calcified and non-calcified algae of the genus *Peyssonnelia* (*Peyssonnelia rubra*, *Peyssonnelia* sp., *Peyssonnelia squamaria*), green filamentous algae (mainly *Psuedochlorodesmis furcellata*) and sponge *Hexadella racovitzai*.

The red encrusting algae *Mesophyllum macroblastum* was present but it was not as abundant. In addition, another red encrusting algae, *Lithothamnion minervae,* was recorded at the site. Intermediate layer was formed by green algae *Flabellia petiolata,* anthozoans *Leptopsammia pruvoti* and *Parazoanthus axinellae* as well as sponges such as *Petrosia ficiformis*, *Agelas oroides*, *Axinella* sp., and smaller specimens (<15 cm) of *Aplysina cavernicola*. Besides these sponges, many other species (e.g. Fig. 50) were observed at the site (as well as on the other sites), but their identification to the species level would require collection of the physical sample.

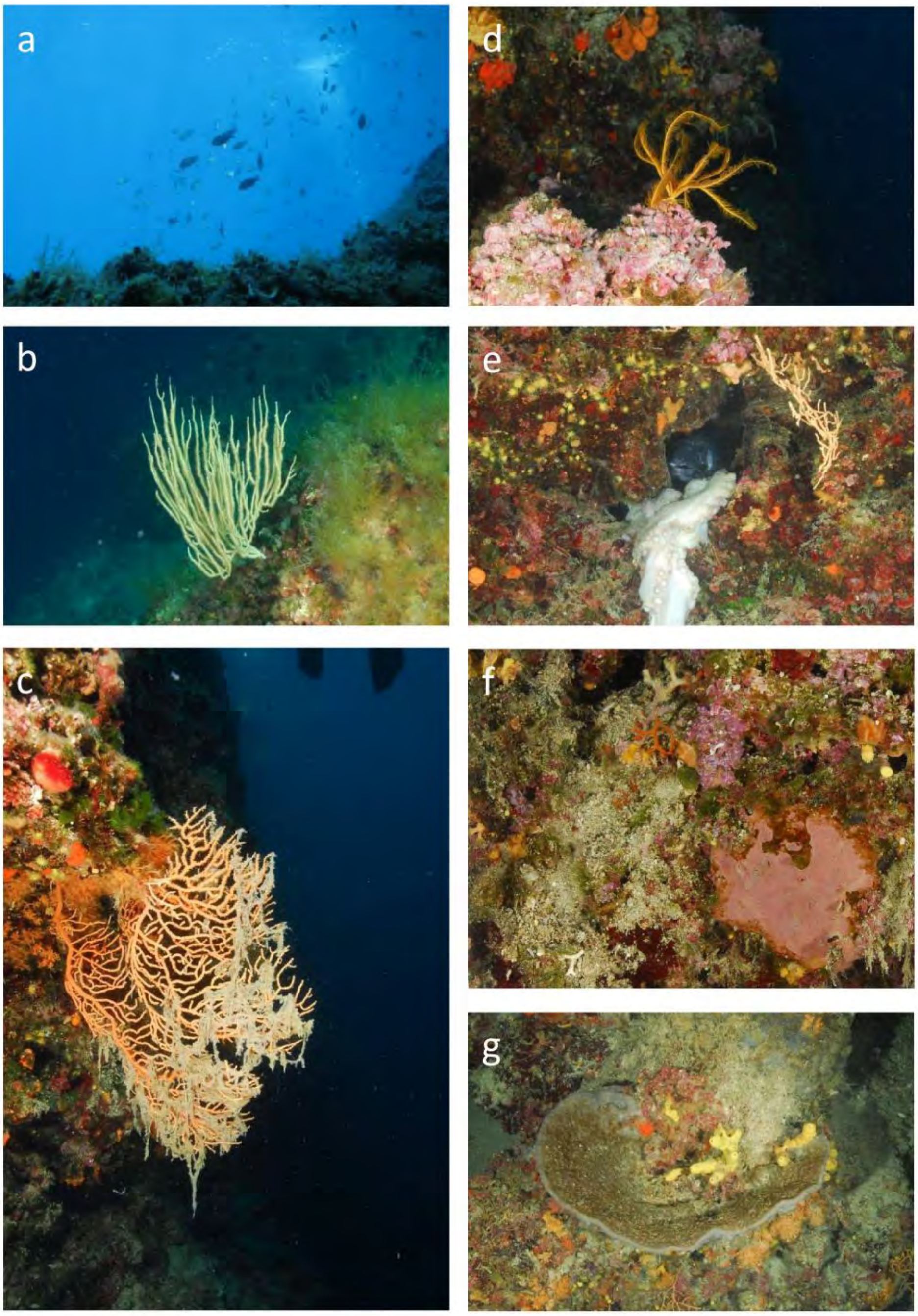

Figure. 49. Cape Markonj dive path. a) subsurface part of the wall with abundance of damselfish *Chromis chromis*; b) biocenosis of infralittoral algae at 10 m depth dominated by *Laurencia* sp. *Halimeda tuna*, *Amphiroa* spp., where individual colonies of *Eunicella singularis* were recorded; c) a wall at 20 m depth dominated by *Flabellia petiolata*, *Peyssonnelia* spp. and zoantharian *Parazoanthus axinellae*, with the presence of scattered colonies of *Eunicella cavolini*; d) Feather-star *Antedon mediterranea* was a common semi-sessile species within the coralligenous habitat; e) one of vagile species include *Conger conger,* captured while savouring his prey, an octopus; f) detail of the coralligenous assemblage with sponge *Hexadella racovitzai*, exposed to elevated sedimentation; g) large sponge *Spongia lamella* dwelling in the coralligenous habitat. Photo credits: a) D. Župan; b-g) P. Kružić.

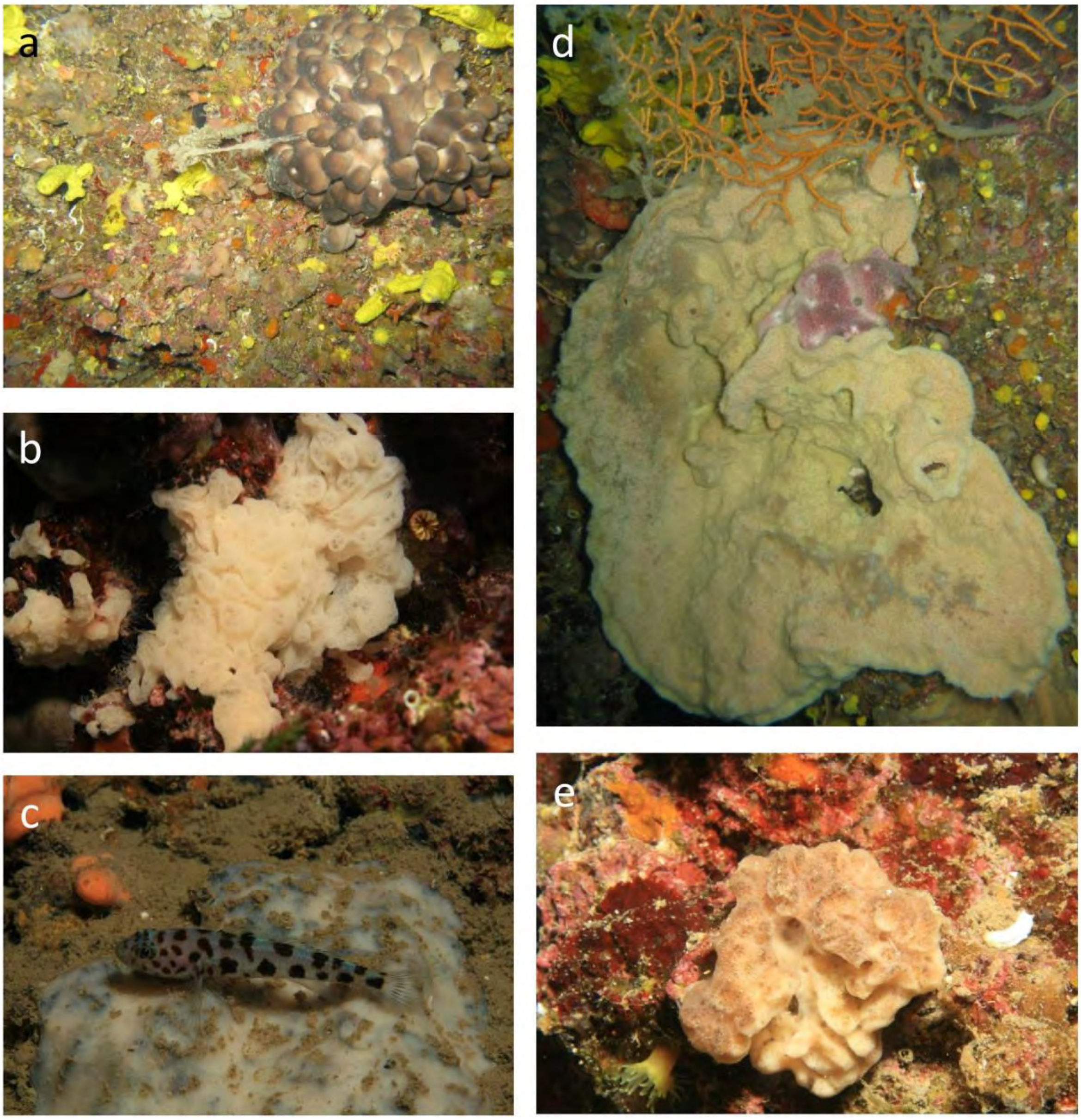

Figure. 50. Diversity of sponges within the coralligenous habitat at Cape Markonj: a, b, d, e) unidentified sponges found in the depth range from 30 to 35 m; c) leopard-spotted goby *Thorogobius ephippiatus* above unidentified greyish-white sponge in the crevice within the coralligenous habitat. Photo credits: a, d) D. Župan; b, c, e) A. Žuljević.

10 Cape Sokol

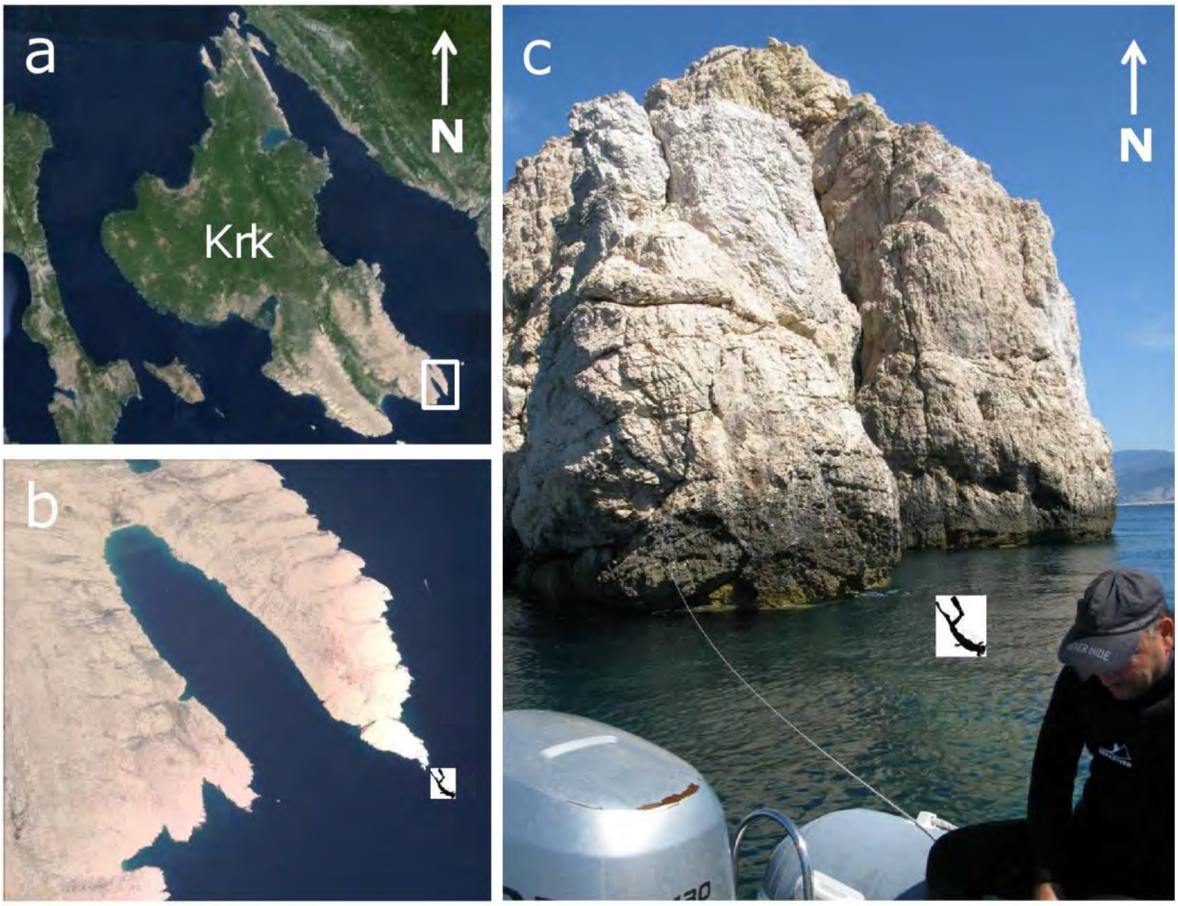

Figure. 51. Cape Sokol at the Krk Island dive site. Designated area of image a) is enlarged on image b); c) terrestrial view of Cape Sokol with indicated diving site. Source a) and b): Google Earth, Image © 2013 DigitalGlobe.

GPS: 44°58'14.19''N, 14°49'13.04''E

Time of the dive: 23rd of July 2013, 10 am

Photos IDs and number of photos: KRSa1 – KRSe8; 40

Number of transects carried out: 3

Video transects: 1

Description: This diving site was located at the Cape Sokol, the south-east tip of the Krk Island (Fig. 51). The slope at several meters depth supports the biocenosis of infralittoral algae with abundant *Cystoseira* sp. that was deeper (around 15 m depth) replaced by other algae such as non-calcifying *Peyssonellia* sp., *Dyctiota* sp., *Codium bursa* and *Halimeda tuna*. Scattered colonies of the white gorgonian *Eunicella singularis* (Fig. 52 a) and soft coral *Alcyonium acaule* were also present in this biocenosis. Around 20 m depth the slope turns into the wall. We continued the dive along the wall and kept it at the left-hand side. The coralligenous outcrops were developed from 25 m depth and sparse colonies of *Paramuricea clavata* appeared around 28 m. From 30 m depth, a well-developed *Paramuricea clavata* assemblage was present (Fig. 52 b-e; Fig. 53), characterized by large plate-like thalli of red calcareous algae *Litophyllum stictaeforme* (Fig. 52 c) and abundant *Mesophyllum macroblastum* (Fig. 52 d). Another specific feature of this site were large bush-like colonies of the bryozoan *Pentapora fascialis* (Fig. 52 e). Around 45 m depth the rocky wall was replaced by a moderately inclined slope of coarse sand rich in detritus.

Photosampling was carried out between 28 and 33 m depth, and visual census was carried out at 34 m depth. Again, 20 m long transect was marked by the rope and visual census was carried out by three operators along the same transect. In addition, the same transect was video recorded. Furthermore, one operator performed the assessment of the red gorgonian health status at 35 m depth.

The erect layer of the coralligenous habitat was well-developed and mainly formed by colonies of the red gorgonian *Paramuricea clavata,* followed by the yellow gorgonian

Eunicella cavolini and large bush-like colonies of the bryozoan *Pentapora fascialis*, that was often overgrowing the red gorgonian.

The intermediate layer was formed mainly by zoantharian *Parazoanthus axinellae* overgrowing sponge *Axinella* sp. or growing on the bare rock*,* red erect algae *Rhodymenia ardissonei,* ascidian *Halocynthia papillosa,* other bushy bryozoans such as *Myriapora truncata* and *Smittina cervicornis / Adeonella* sp*.* as well as globulated orange encrusting bryozoans.

The basal layer was mainly formed by the red calcareous algae *Litophyllum stictaeforme,* whose representatively developed, plate-like thalli may increase the structural complexity (Fig. 53 a), as well as by the red encrusting algae *Mesophyllum macroblastum* and *Peyssonnelia* spp.

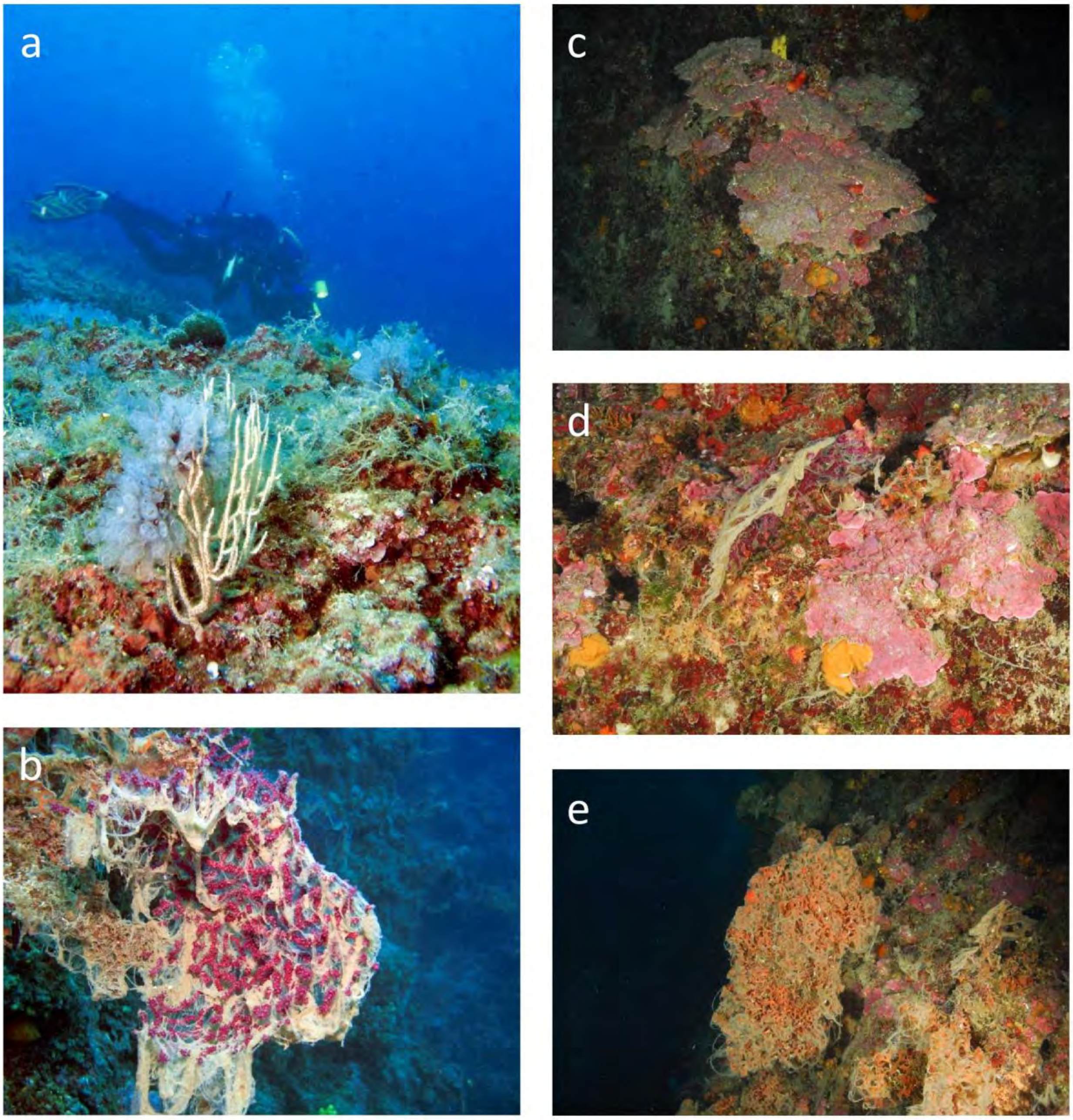

Figure. 52. Cape Sokol dive path. a) the upper part of the wall at 15 m depth hosting the biocenosis of infralittoral algae; b) *Paramuricea clavata* assemblage found below 35 m depth; Details from the *Paramuricea clavata* assemblage: c) large plate-like thalli of the red calcareous algae *Lithophyllum stictaeforme*; d) the red encrusting algae *Mesophyllum macroblastum* as another important algal builder at the site; e) large colonies of the bryozoan *Pentapora fascialis*. Photo credits: a, b) S. Kaleb; c-e) P. Kružić.

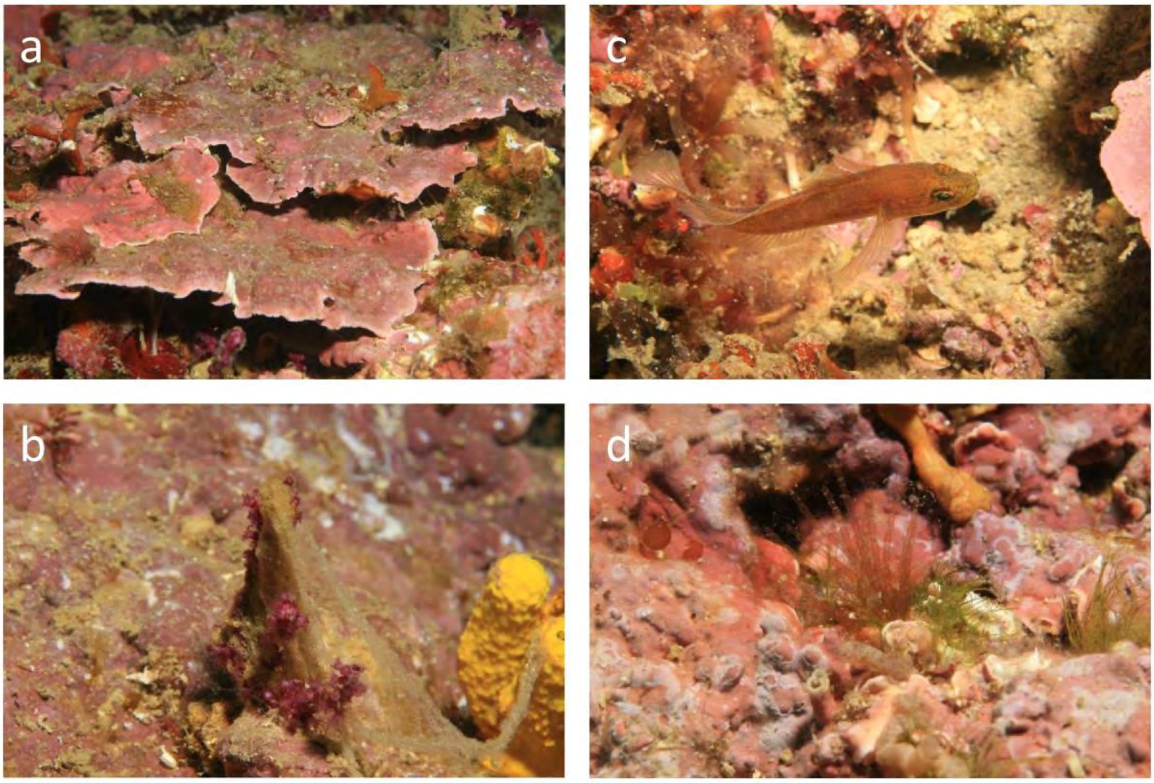

Figure. 53. Details from the coralligenous habitat at the Cape Sokol: a) representatively developed plate-like thalli of the red calcareous algae *Lithophyllum stictaeforme* enhance the structural complexity; b) juvenile colony of the red gorgonian *Paramuricea clavata* covered in mucilaginous algal aggregates; c) golden goby *Gobius auratus* – a morphotype of yellow basic colouration with longitudinal lines of red dots (Herler *et al*. 2005) found in the North Adriatic; d) some of minuscule soft algae thriving in the coralligenous habitat: *Botryocladia* sp. (a spherical red algae on the left), *Lomentaria* sp. (cylindrical red algae with axes constricted into bead-like portions in the centre) and the green filamentous algae *Pseudochlorodesmis furcellata* (on the right). Photo credit: A. Žuljević.

11 Tenki

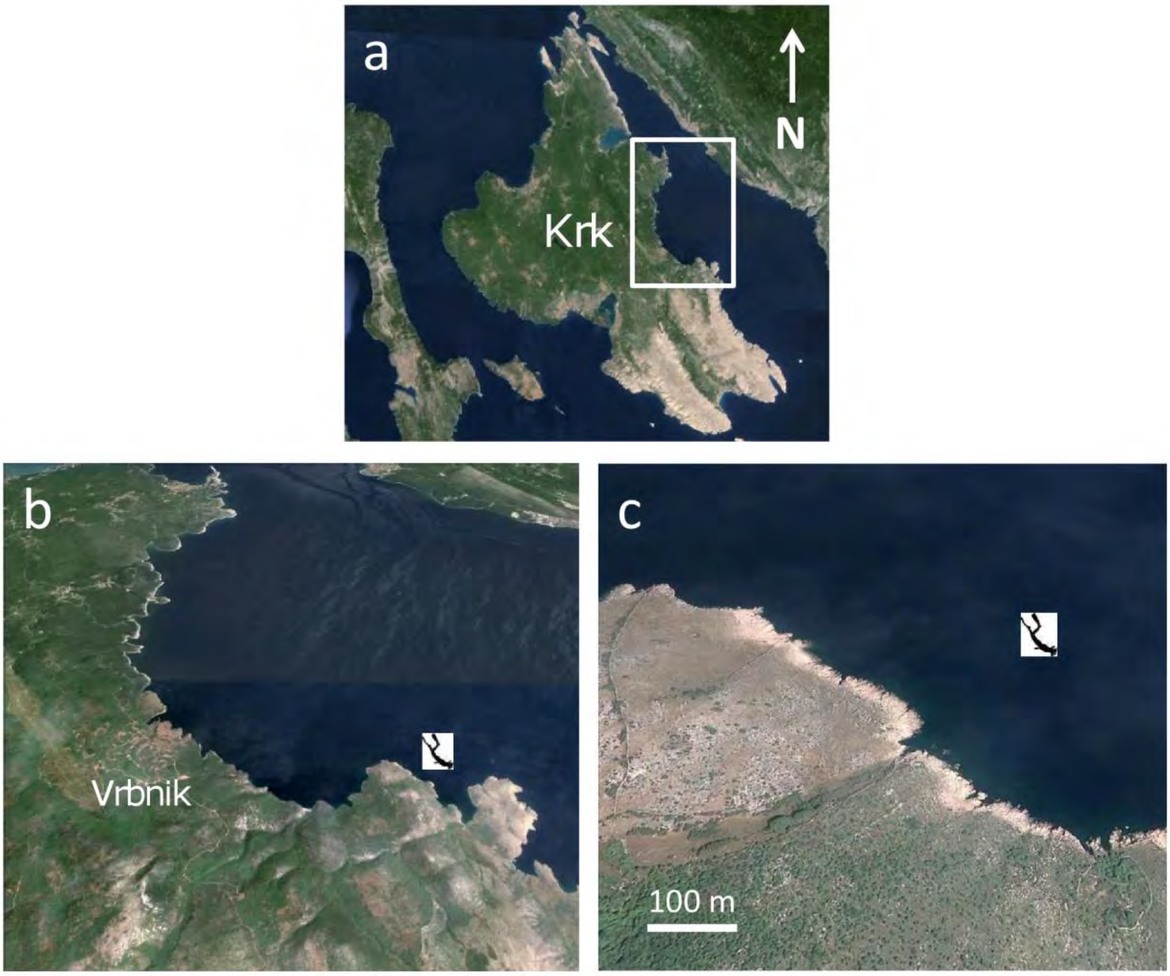

Figure. 54. Tenki shallow next to the east coast of the Krk Island. Designated area of image a) is enlarged on image b); c) closer view of the diving site. Source: Google Earth, Image © 2013 DigitalGlobe.

GPS: N 45° 04' 17.88'', E 14° 43' 17.7''

Date and time of the dive: 23rd of July 2013, 1 pm

Photos IDs and number of photos: KRPTa1 - KRPTd8; 32

Number of transects carried out: 2

Video transects: none

Description: Tenki is a shallow located approximately 200 m from the north-east coast of the Krk Island and 3.3 km (1.8 NM) south-east from the nearest settlement, Vrbnik (Fig. 54). The tip of the shallow is found at 3 m depth (Fig. 55 a). This is a very popular diving site and it is marked with a buoy. One of its main attractions is a tunnel at 4-9 m depth that is wide enough to be dived through (Fig. 55 b). In the tunnel, a characteristic community of semi-dark caves was developed with the abundance of sponges and zoantharian *Parazoanthus axinellae* (Fig. 55 c). Within and around the tunnel the damselfish (*Chromis chromis*) was also abundant (Fig. 55 b-d). Diving towards south from the north-east entrance of the tunnel (deeper end of the tunnel at 9 m) we passed over the slope hosting the biocenosis of infralittoral algae with a common sponge *Aplysina aerophoba* (Fig. 55 d) and reached the wall (at the right-hand side) where the coralligenous outcrops were found from 24 m depth. The first part of the wall was dominated by *Peyssonnelia squamaria*, non-calcified *P. rubra* and *Peyssonnelia* sp. and it exceled in the abundance of scleractinian corals *Caryophilla smithi* and *C. inornata* (Fig. 55 e). The yellow gorgonian *Eunicella cavolini* was present on the wall in sparse densities. Further south, at the second part of the wall with north-east orientation a *Paramuricea clavata* assemblage was dwelling from 28 to 43 m depth (Fig. 55 f). Around 43 m depth, the wall was replaced by moderately inclined detritic bottom.

Photosampling was carried out between 33 and 35 m depth, and visual census was carried out around 30 m depth. In addition, one operator performed the assessment of the red gorgonian health status at 35 m depth. Due to technical problems, it was not possible to record a video on this site.

Gorgonians *Paramuricea clavata* and *Eunicella cavolini* mainly formed the erect layer of the coralligenous habitat.

The main species forming intermediate layer were sponges *Aplysina cavernicola* and *Axinella* sp. partially overgrown by *Parazoanthus axinellae,* whereas other massive sponges and bushy bryozoans were not as abundant on the site, at least not within the photo samples.

Dominant species forming the basal layer were calcified and non-calcified algae of the genus *Peyssonnelia* (*Peyssonnelia rubra*, *Peyssonnelia squamaria, Peyssonnelia* sp.), green filamentous algae *Psuedochlorodesmis furcellata* and scleractinian corals *Leptopsammia pruvoti, Caryophyllia smithi* and *C. inornata*. The red encrusting algae *Mesophyllum macroblastum* was present but it was not as abundant.

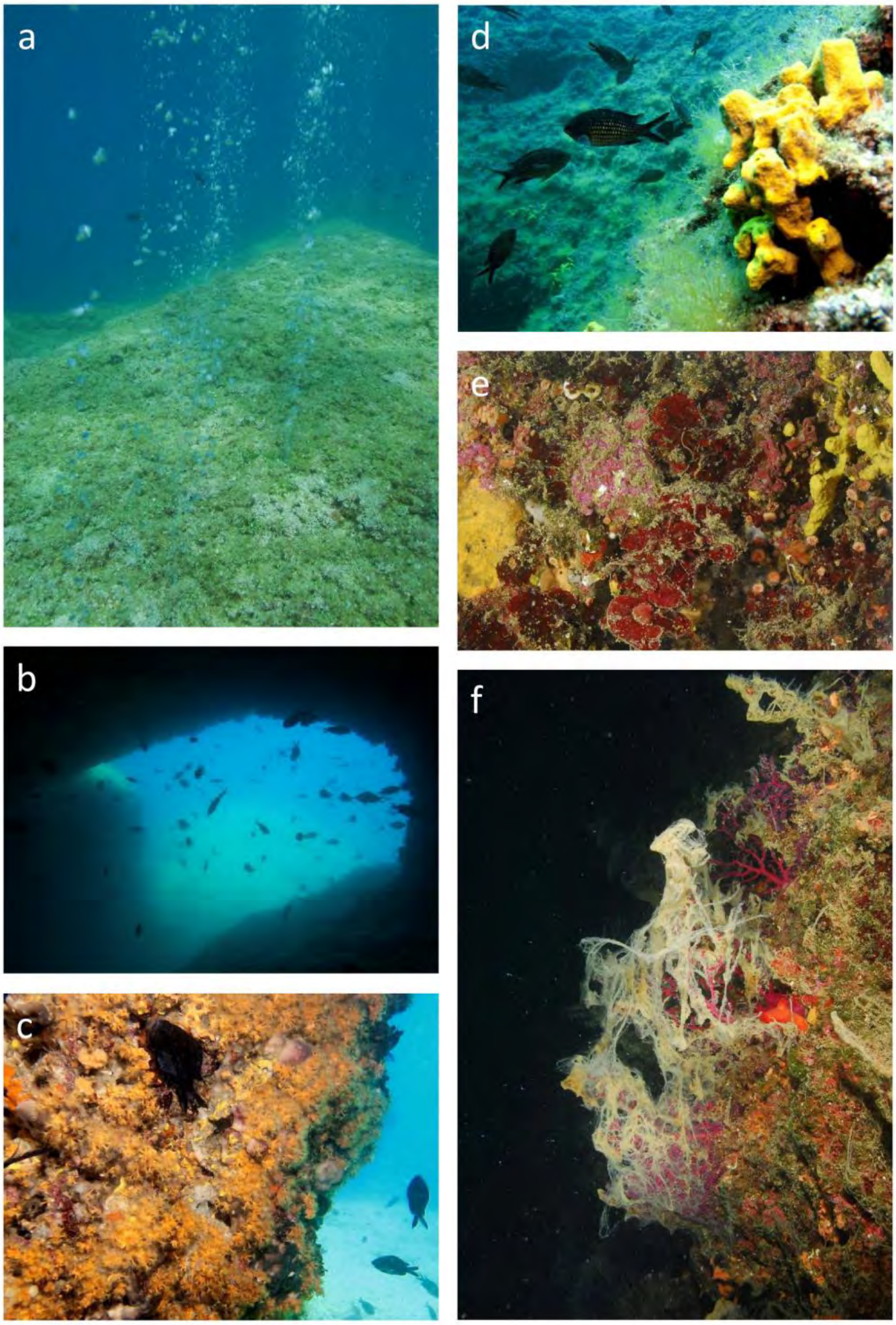

Figure. 55. Tenki dive path. a) A tip of the shallow at 3 m depth; b) a tunnel at 4-9 m depth; c) a well developed biocenosis of semi-dark caves within the tunnel, with abundant zoantharian *Parazoanthus axinellae*; d) biocenosis of infralittoral algae near the tunnel entrance at 9 m depth; e) the first part of the wall with abundant *Peyssonnelia* spp., anthozoans *Caryophyllia inornata* and *C. smithii*; f) *Paramuricea clavata* assemblage found on the wall from 28 to 43 m depth. Photo credits: a, e, f) P. Kružić; b-d) S. Kaleb.

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Appendix 1. Form used for visual census

Observer:	Date:			Site:		
Species	Kind of bottom					
Depth survey:						
		Sector 1 (5m/2min	Sector 2	Sector 3	Sector 4	TOTAL
Complexity	Basal					
	Intermediate					
	Erect					
	Macrobioeroders (N or % cover)					
Mucilagenous						
Sedimentation						
Fishing nets						
Comments:						

Appendix 2. Form used for rapid assessment of gorgonian health status

Observer:		Date:				Site:			
Species		Kind of bottom							
Depth survey:									
NON AFFECTED									
AFFECTED (>10%)									
a) Naked axis/recent epibiosis									
b) Old epibosis									
Combination a) and b)									
Comments:									

Appendix 3. Checklist of sessile macrobenthic taxa identified by photosampling within the coralligenous habitat at study sites.

'+' = presence; '-' = absence; '*'= presence of taxa assessed from additional photographs and videos (not from photosamples). For site abbreviations see Table 1.

Taxa	MP	CR	MC	PRSI	PRST	GO	GRG	PRS	GOM	KRS	KRPT
CHLOROPHYTA											
Flabellia petiolata (Turra) Nizamuddin 1987	+	+	+	+	+	+	+	+	+	-	-
Green filamentous algae	+	+	+	+	+	+	+	+	+	+	+
Halimeda tuna (J. Ellis & Solander) J.V. Lamouroux 1816	-	-	-	-	-	-	+	-	-	-	-
Palmophyllum crassum (Naccari) Rabenhorst 1868	+	*	+	+	+	+	+	+	+	+	+
Valonia macrophysa Kützing 1843	-	+	-	+	-	-	-	+	-	-	-
OCHROPHYTA											
Brown erect algae	-	+	-	-	-	-	-	-	-	-	-
Dictyopteris sp.	-	+	-	-	-	-	+	-	-	-	-
RHODOPHYTA											
Botryocladia sp.	-	+	-	+	+	+	+	+	+	-	+
Branchy red algae	-	-	-	-	+	-	+	+	-	+	+
Lithophyllum stictaeforme (J.E. Areschoug) Hauck 1878	-	+	-	-	-	-	+	+	-	+	-

Taxa	MP	CR	MC	PRSI	PRST	GO	GRG	PRS	GOM	KRS	KRPT
Lithothamnion minervae Basso, 1995	-	-	-	-	-	+	-	-	+	-	-
Lomentaria sp.	-	-	-	-	-	-	-	-	-	*	-
Mesophyllum macroblastum (Foslie) Adey, 1970	+	+	+	+	+	+	+	+	+	+	+
Mesophyllum sp.	-	+	-	-	-	+	-	-	-	-	-
Mesophyllum/ Lithothamnion/Neogoniolithon sp.	+	+	+	-	-	-	-	-	-	-	+
Mesophyllum/Lithothamnion sp.	-	-	-	-	-	-	-	-	+	-	-
Neogoniolithon mamillosum (Hauck) Setchell & L.R. Mason 1943	-	-	-	-	-	+	-	-	-	-	-
Peyssonnelia rosa-marina Boudouresque & Denizot,1973	-	-	-	-	-	-	+	-	-	+	-
Peyssonnelia rubra (Greville) J. Agardh 1851	+	+	+	+	+	+	+	+	+	+	+
Peyssonnelia sp.	+	-	+	+	+	+	+	+	+	+	+
Peyssonnelia squamaria F. Schmitz ex J.J.Rodriguez	+	+	+	+	+	+	+	+	+	+	+
Red erect algae	+	+	+	+	+	+	+	+	+	+	+
Red filamentous algae	-	+	-	-	-	-	+	-	+	-	-
Sphaerococcus sp.	-	-	-	-	-	+	-	-	-	-	-
Unidentified *Corallinacea*	+	+	+	+	+	+	+	+	+	-	+

PORIFERA											
Acanthella acuta Schmidt, 1862	+	+	+	+	+	+	+	+	-	-	-
Agelas oroides (Schmidt, 1864)	+	-	+	+	-	+	+	+	+	-	-
Aplysina cavernicola (Vacelet, 1959)	+	+	+	+	+	+	-	+	-	+	+
Axinella cannabina (Esper, 1794)	*	*	+	-	-	*	*	-	*	-	-
Axinella polypoides Schmidt, 1862	-	-	-	-	-	-	-	-	+	*	-
Axinella sp.	+	+	+	+	+	+	+	+	+	+	+
Bright yellow sponge	+	+	+	+	+	+	+	+	+	-	-
Brownish sponge	-	+	-	-	-	+	+	-	-	-	+

Taxa	MP	CR	MC	PRSI	PRST	GO	GRG	PRS	GOM	KRS	KRPT
Chondrosia reniformis Nardo, 1847	-	-	+	+	-	+	*	-	-	-	+
Clathrina sp.	-	-	-	-	-	+	-	+	-	-	-
Cliona sp.	-	-	+	-	-	-	-	-	-	-	-
Crambe crambe (Schmidt, 1862) / *Spirastrella cunctatrix* Schmidt, 1868	+	+	-	-	+	+	+	-	+		+
Cream sponge	-	+	-	+	-	+	+	+	-	-	-
Dysidea sp.	+	-	+	-	+	-	*	+	+	-	+
Fasciospongia cavernosa (Schmidt, 1862)	+	+	+	+	+	+	+	+	+	+	+
Grey sponge	-	-	-	+	+	+	-	-	-	-	-
Haliclona (*Halichoclona*) *fulva* (Topsent, 1893)	+	+	+	+	+	+	+	+	+	+	+
Halichoclona (*Reniera*) *mediterranea* Griessinger, 1971	-	-	-	-	-	-	*	*	-	-	-
Haplosclerida	+	-	+	-	-	+	*	-	+	-	+
Hexadella pruvoti Topsent, 1896	-	-	+	+	-	+	+	-	-	-	-
Hexadella racovitzai Topsent, 1896	-	+	+	-	+	+	+	-	+	-	-
Ircinia sp.	+	-	+	-	-	+	*	-	-	-	-
Keratose sponge	+	+	+	+	+	+	+	+	+	-	+
Light orange semi-encrusting sponge	-	-	-	-	-	-	+	-	-	-	-
Orange encrusting sponge	-	+	-	+	+	-	+	+	+	+	+
Orange massive sponge	-	-	+	+	-	+	-	-	-	-	-
Petrosia ficiformis (Poiret, 1789)	+	+	+	+	*	+	*	+	+	+	+
Phorbas tenacior (Topsent, 1925)	+	+	+	+	+	+	+	+	+	+	+
Pink sponge (net like)	+	+	+	+	+	+	+	-	-	-	-
Pink-violet sponge	-	-	-	-	-	-	-	+	-	-	-
Pleraplysilla spinifera (Schulze, 1879)	+	-	-	-	+	+	*	+	+	-	+
Red massive sponge	-	-	-	+	-	-	-	+	+	-	-
Red encrusting sponge	+	-	+	+	+	+	+	+	-	-	+

Taxa	MP	CR	MC	PRSI	PRST	GO	GRG	PRS	GOM	KRS	KRPT
Salmon sponge	-	-	-	+	-	-	-	-	-	+	-
Spongia (*Spongia*) *lamella* (Schulze, 1879)	-	-	-	-	-	-	-	-	*	-	-
Tethya sp.	-	-	-	-	-	+	*	-	-	*	-
Thin orange encrusting sponge	+	+	+	+	+	+	-	+	+	+	+
Unidentified white sponge	+	+	+	+	+	+	+	+	+	+	+
White sponge with yellow crust	-	+	-	+	-	-	-	-	-	-	+
Yellow encrusting sponge	+	+	+	+	+	+	+	-	+	+	+
Yellow greenish porous sponge	-	-	-	-	-	-	-	-	-	-	+
Yellow greenish smooth sponge	-	-	-	-	-	+	-	-	-	-	-
Yellow sponge	-	-	-	-	-	+	-	+	-	-	+
HYDROZOA											
Unidentified Hydrozoa	-	-	-	-	-	-	-	+	-	-	-
ANTHOZOA											
Alcyonium acaule (Marion, 1878)	+	-	-	+	+	+	-	-	-	+	-
Alcyonium coralloides (Pallas, 1766)	-	*	-	+	+	*	-	-	+	-	-
Caryophyllia (*Caryophyllia*) *inornata* (Duncan, 1878)	+	+	+	+	+	+	-	+	+	-	+
Caryophyllia (*Caryophyllia*) *smithii* Stokes & Broderip, 1828	+	+	+	+	+	+	+	+	+	+	+
Cerianthus membranaceus (Spallanzani, 1784)	-	-	-	-	+	-	-	-	-	-	-
Eunicella cavolini (Koch, 1887)	+	+	+	+	+	+	+	+	+	+	+
Hoplangia durotrix Gosse, 1860	+	-	+	+	+	+	-	+	+	+	+
Leptopsammia pruvoti Lacaze-Duthiers, 1897	+	+	+	+	+	+	+	+	+	+	+
Paramuricea clavata (Risso, 1826)	-	+	+	+	+	*	*	+	+	+	+
Parazoanthus axinellae (Schmidt, 1862)	+	+	+	+	+	+	+	+	+	+	+

Taxa	MP	CR	MC	PRSI	PRST	GO	GRG	PRS	GOM	KRS	KRPT
MOLLUSCA											
Gastrochaena (*Rocellaria*) *dubia* (Pennant, 1777)	+	-	+	+	+	+	-	+	+	+	+
POLYCHAETA											
Filograna sp. sensu Bianchi, 1981 / *Salmacina dysteri* (Huxley, 1855)	+	+	+	-	+	-	-	+	-	+	+
Protula sp.	+	+	+	+	+	+	+	+	+	+	+
Serpulidae	+	+	+	+	+	+	+	+	+	+	+
BRYOZOA											
Beania magellanica (Busk, 1852)	+	+	+	+	+	+	+	+	-	+	+
Branchy bryozoan	-	+	-	+	-	+	+	+	-	-	-
Celleporina caminata (Waters, 1879)	+	-	-	-	-	-	-	-	-	-	-
Dentiporella sp. / *Schizomavella* sp.	+	-	+	+	+	+	-	-	-	-	-
Encrusitng orange bryozoan	+	+	+	+	+	+	+	+	+	+	+
Encrusting beige bryozoan	+	-	+	-	+	+	+	-	-	-	+
Myriapora truncata (Pallas, 1766)	+	+	+	+	+	+	+	+	+	+	+
Pentapora fascialis (Pallas, 1766)	-	+	-	-	*	-	-	-	-	+	-
Reteporella sp.	-	-	+	-	+	+	-	-	-	-	-
Smittina cervicornis (Pallas, 1766) / *Adeonella pallasii* (Heller, 1867)	+	+	*	+	+	+	+	+	+	+	+
TUNICATA											
Aplidium elegans (Giard, 1872)	-	*	+	+	+	-	+	-	-	-	-
Didemnum sp. (dark orange)	-	+	-	-	+	+	+	-	-	-	-

Taxa	MP	CR	MC	PRSI	PRST	GO	GRG	PRS	GOM	KRS	KRPT
Didemnum sp. (orange)	-	+	-	-	-	-	-	-	+	-	-
Didemnum sp. (white)	-	+	-	+	+	+	-	-	+	-	-
Halocynthia papilosa (Linnaeus, 1767)	-	+	+	+	+	+	-	-	-	+	+
Orange colonial Synascidia	-	-	+	-	-	-	+	+	-	-	-
Polycitor adriaticus (Drasche, 1883)	-	+	-	*	-	-	-	-	-	-	-
Pycnoclavella sp. / *Perophora* sp.	-	+	-	-	+	+	+	+	+	+	+
White Synascidia	-	+	-	-	-	-	-	-	-	-	-

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