Work Package 4.2

Monitoring case studies in Croatia

Plić Seget – Vis

Deliverables: D4.2.1, D4.2.2, D4.2.3, D4.2.4

Titles:

D4.2.1 Explorative survey with multibeam echosounder (MBES) and/or ROV/scuba
D4.2.2 Set up of an integrated monitoring system in situ (including high tech foto/video and 3D filming for monitoring and communication purposes
D4.2.3 Extension of monitoring execution to other parameters (i.e. biological components)
D4.2.4 Collection and reporting of obtained data

Due date of deliverable: M22 Actual submission date: M32

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EXECUTIVE SUMMARY

The island of Vis is the most protruding Croatian island with an area of 90.30 km2. We have selected primary one city for the project activity – Seget. Secondly, we have added a new – old site Stupišća. The monitoring activity due to the remote location were only twice, during summer (June) 2020 and 2021. During the monitoring activity we have performed the geomorphological mapping, the chemical and physical analysis and analyzed the benthic and fish community. Also, in the sampling point Stupisca we have analyzed the metals because of the shipwreck. Regarding the physic – chemical data we can identify a typical open sea environment with slightly higher salinity. The concertation of nutrients was very low that is typical for the southern Adriatic Sea and oligotrophic conditions. No metals were detected probably due to the open sea locations of the two sites. The data prom the organic load was very low. We tested also two approach in the organic load using the sensor and the DOC machine in the laboratory. The data were not identical but showing the same trend. After interviewing the major stakeholders on the island and the local community we can conclude that: 1) location Seget is very attractive but still can be focused on professional divers 2) the well know location Stupišća is also very attractive and a lot of tours are visiting. We cannot identify any significant anthropological input on this site on the Vis island.

1. INTRODUCTION

Plić Seget is a natural reef located 1.5 nm from the coast of Vis island, at 10.8 m depth. The closest urban centre is the city of Komiža, 3.5 nm away. The nearest continental land (Vinišće near Trogir) is 24,4 nm far. The area is only exposed to N-NW-W winds. Plić Seget is one submarine volcanoe. It represents a series of interconnected reefs built from eruptive rock that goes down from 10.8 m, with a great slope, reaching a first flatbed placed at about 30 m, and going down again up to over 100 m depth. The flora and fauna of the reef have been not officially studied, but 181 macroalgae families, 2 seagrass species, 269 invertebrate species, 347 of phytoplankton and 100 zooplankton families have been recorded in the waters of nearby Vis islands and Biševo.

The monitornig activities has been taken in order examine exploitation potential of natural reef but also to determine morphological, chemical, biological as well other features of the reef including environmental load and quantity of maritime traffic at the reef. Furthermore, the monitoring aimed to recognise ecological and economic aspects related to the reef. Also, potential threats to reef and opportunities was analysed. The monitoring has been carried out by using innovative and integrated monitoring system. On the Vis island a lot of natural reef and present and for the remote location it is impossible to monitor different reefs. The natural reef Plić Seget (Vis) has not been yet explored systematically and was identified as a possible novel diving location. This reef could offer potential development for various commercial activities which are in accordance with the project objectives and Blue Economy requirements.

2. GEOMORPHOLOGICAL MAPPING

2.1. Description of equipment and acquisition/processing techniques

In order to get a complete structure of the reef, the most appropriate equipment is sonar. Geomorphological mapping was done in collaboration with University of Rijeka, Faculty of Maritime studies. Survey was held in June 2020 with high quality side scan sonar Humminbird Solix 12 CHIRP MSI+ GPS G2 purchased by University of Rijeka. This sonar combines tournament-ready technologies like MEGA Side Imaging+, MEGA Down Imaging+, Dual Spectrum CHIRP Sonar, AutoChart Live and intuitive Cross Touch control. Solix has the power of wi-fi, Bluetooth, Ethernet and NMEA 2000 connections built in and allows for up to four customizable viewing panes so it is possible to view multiple technologies at once. Below are explanations for some of the most important features. New Side Imaging brings crystal-clear viewing up to 200 feet on either side of a boat, while Down Imaging allows underwater clarity with coverage down to 200 feet below the boat. Dual spectrum offers two ways to search; wide mode for maximum coverage and narrow mode for maximum detail. With AutoChart Live it is possible to create real-time maps of certain spots as well as to map depth contours, bottom hardness and vegetation. Using sonar, it is possible to estimate the hardness of the reef and seabed and the presence of vegetation. The bottom layer can be displayed as bottom hardness or vegetation and you can adjust the transparency to see different layers on the view. Bottom hardness and

bottom vegetation cannot be displayed at the same time in Chart View. Bottom hardness shows strong sonar returns resulting from compact sediment, rocks, etc. The range of bottom hardness shown on the chart can be adjusted by changing the minimum and maximum range on the display. The selected range affects how the bottom hardness colours are displayed. Vegetation shows the sonar returns interpreted as vegetation on the Chart View. Vegetation will vary with the season or environment and the vegetation colours are displayed in the same way as bottom hardness.

Figure 1 Side scan sonar Humminbird Solix 12 purchased by UniRi

2.2. Survey results

This survey is based on the main geomorphological characteristics of the reef and the seabed. As mentioned before, one survey has been done in 2020 with high quality side scan sonar which has given us 100% coverage

of the seabed morphology and reef area. The size of the measurement area is approximately 710 m x 448 m or 318 080 m^2. Here below are bathymetric maps of the reef and explanations.

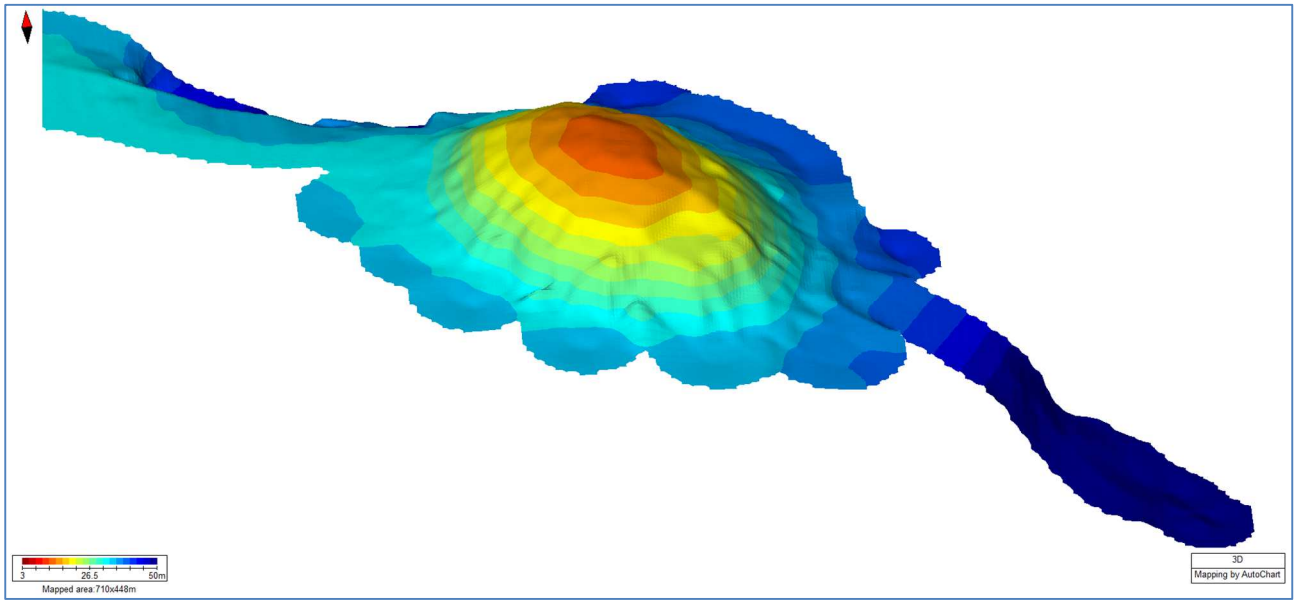


Figure 2 3D depth map of the reef

Figure 2 represents the 3D depth map of the reef. When the maps are in 3D there are several display options. Here it is presented the TAR (True Aspect Ratio) and colour and depth legend which are displayed next to the map.

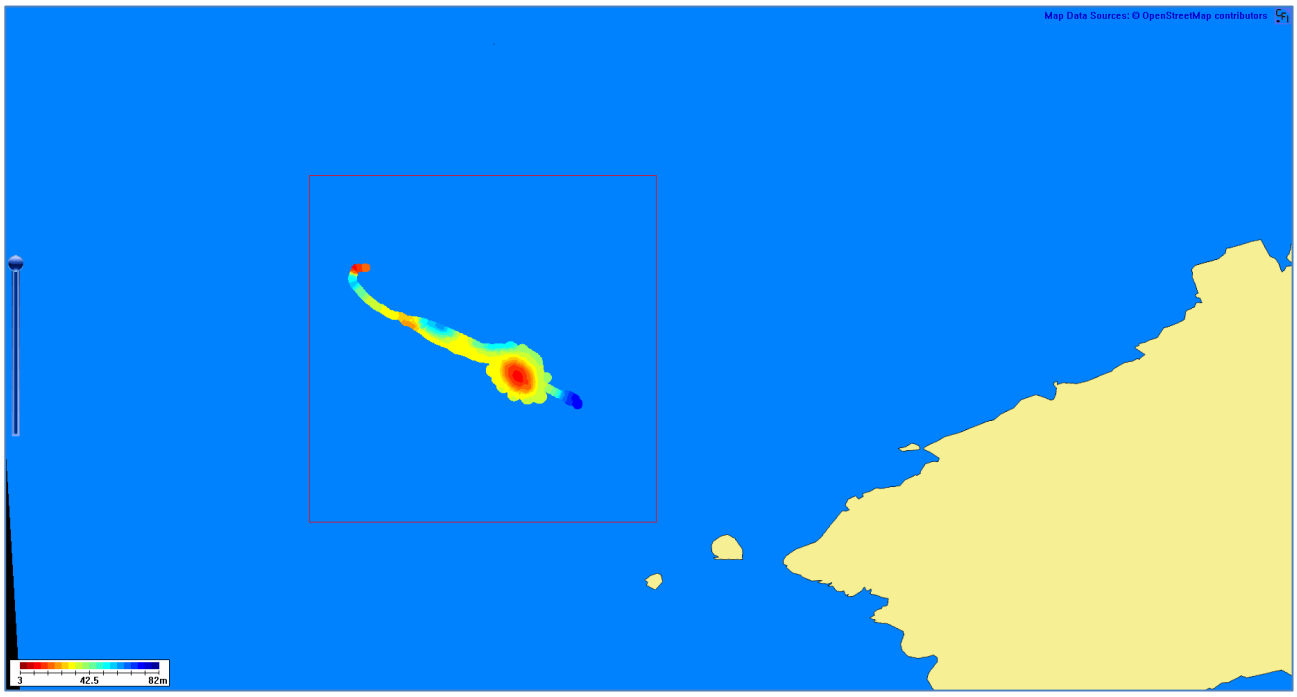


Figure 3 2D depth map

Figure 3 represents another perspective of a 2D depth map, where the depth contour lines are hidden, while colour areas of the same depth range is displayed. The background map may be selected as per built in maps and user preference, like Open Cycle Map, Open Street Map, Navionics Nautical Charts, etc. Figure 4 represents the 2D depth map with coloured depth contour lines (colour and depth legend is displayed next to the map), displayed depths (depth lables) and grid lines. Each of the mentioned data is actually a layer which can be diplayed or hidden based on user preferences.

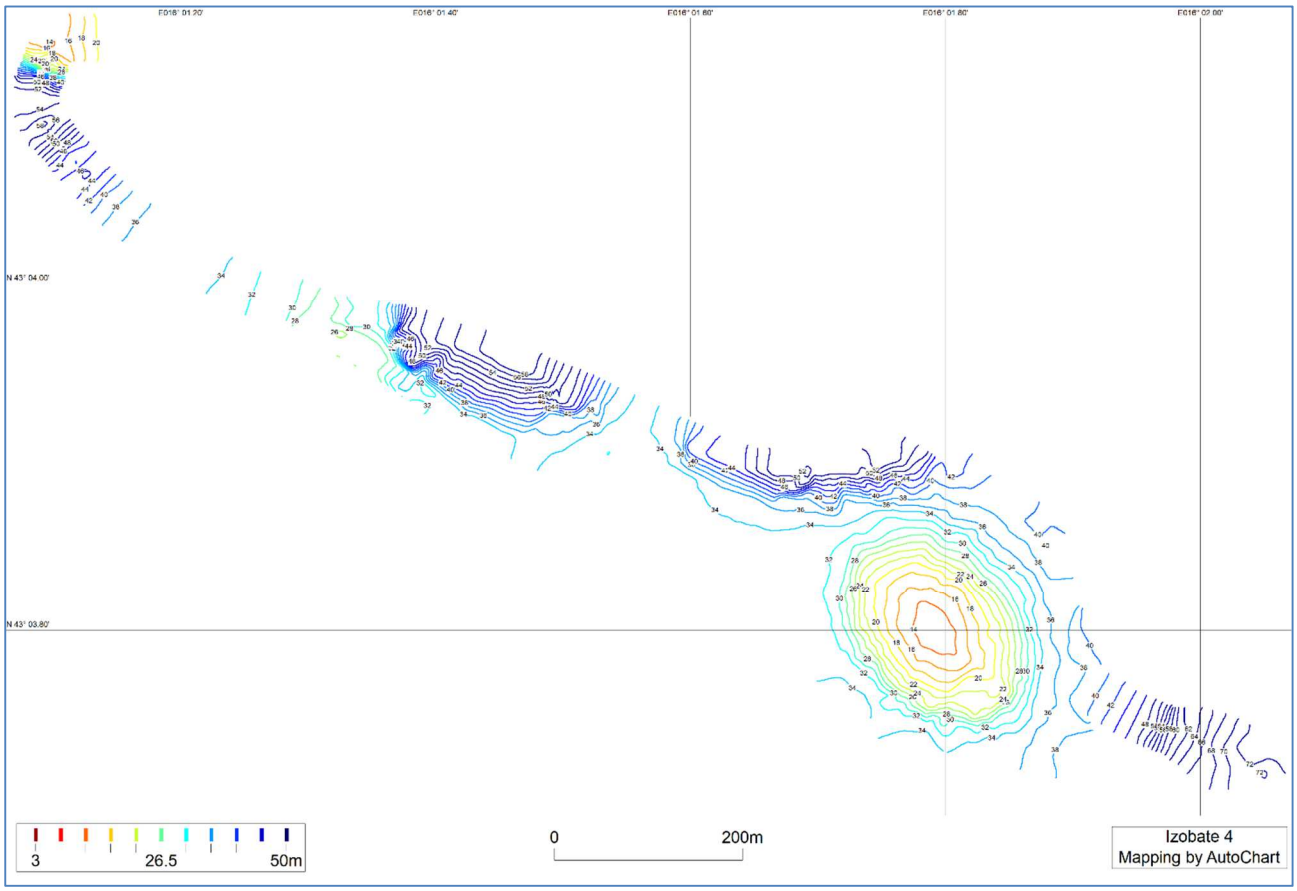


Figure 4 Bathymetric map

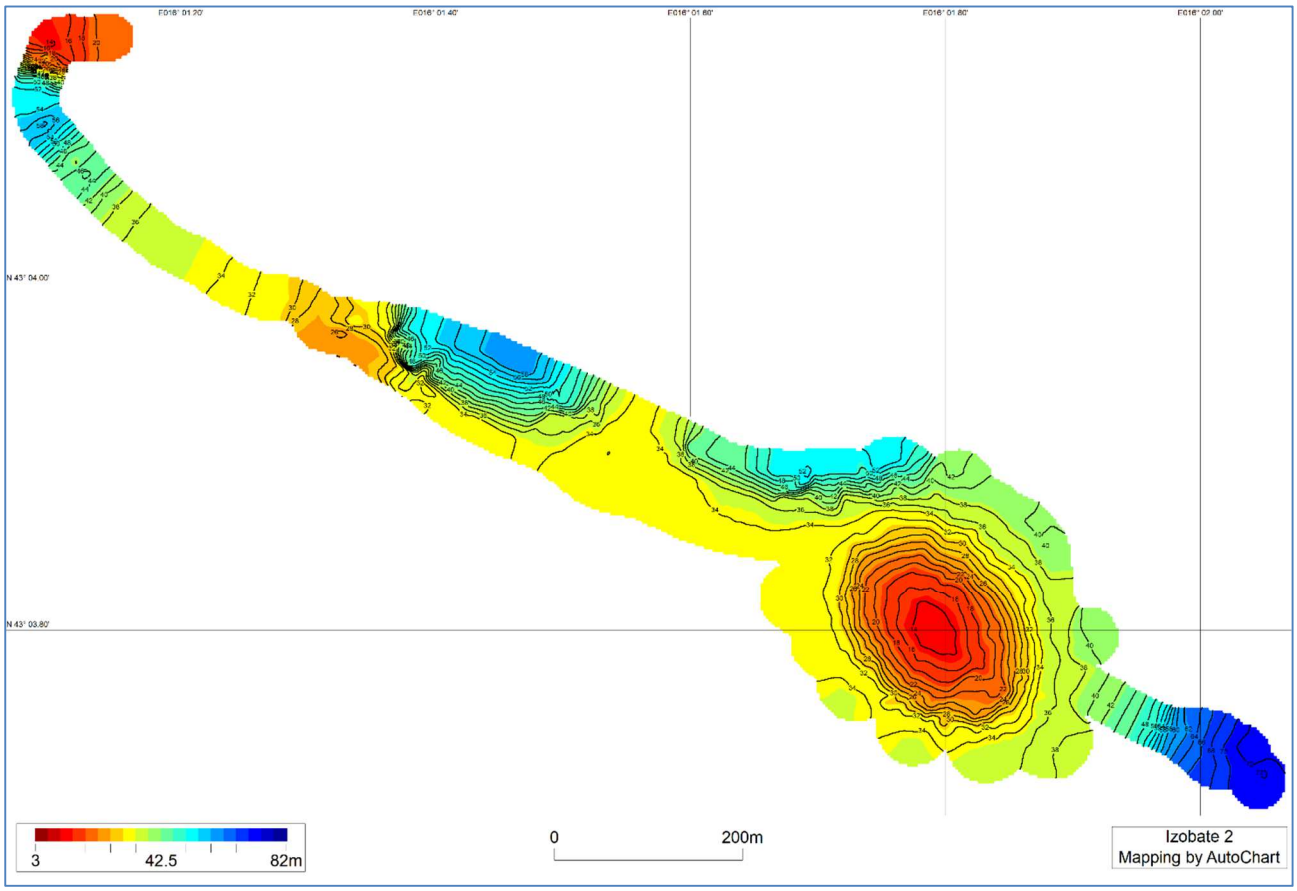


Figure 5 2D bathymetric map (marking range 3-82 m)

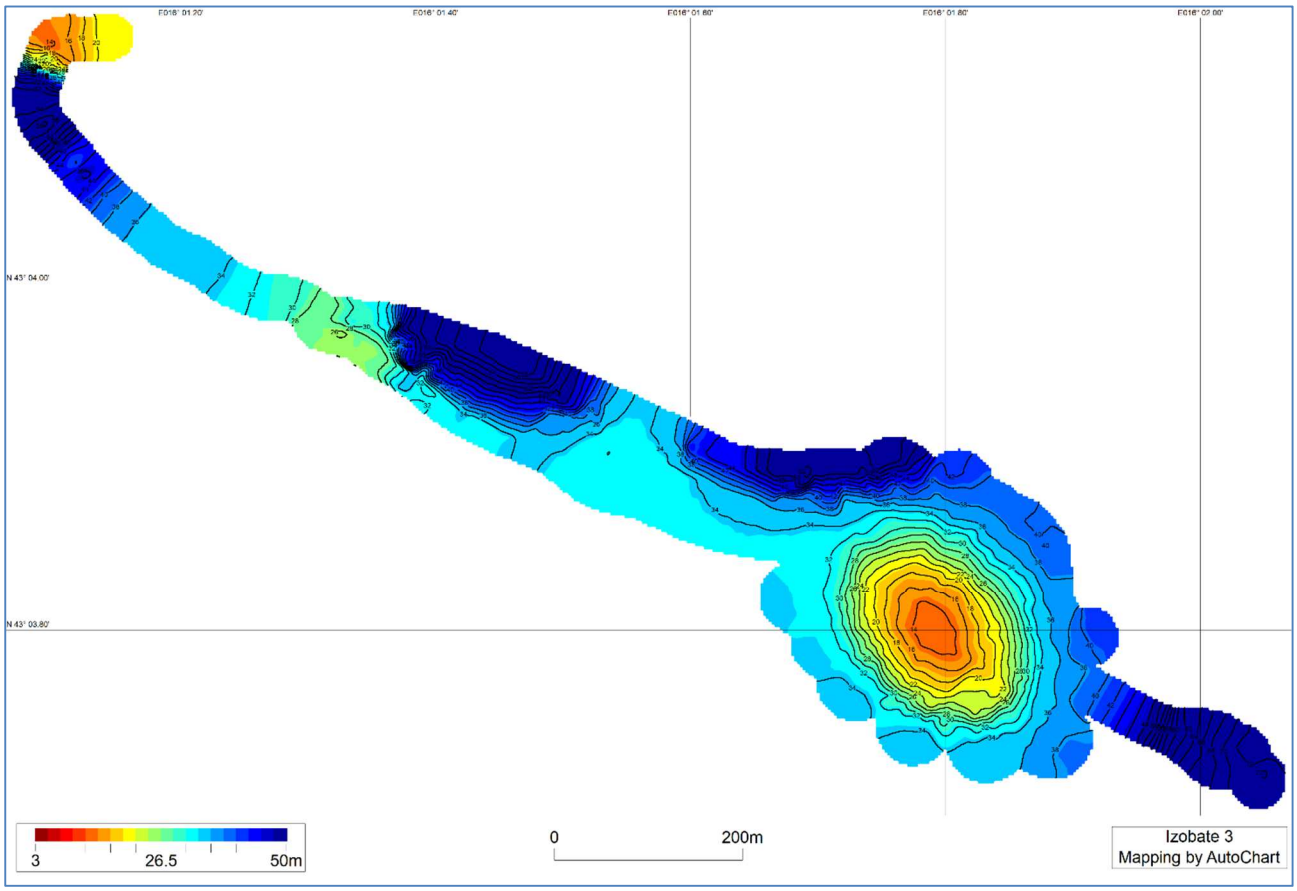


Figure 6 2D bathymetric map (marking range 3-50 m)

Bathymetric maps on Figure 5 and Figure 6 represent a 2D map with different depth marking range where all basic layers are displayed: black contour lines, coloured area of the same depth range and spatial grid lines (colour and depth legend is displayed next to the map). It is visible from the pictures above that the minimum depth is marked in red and the maximum is in blue colour.

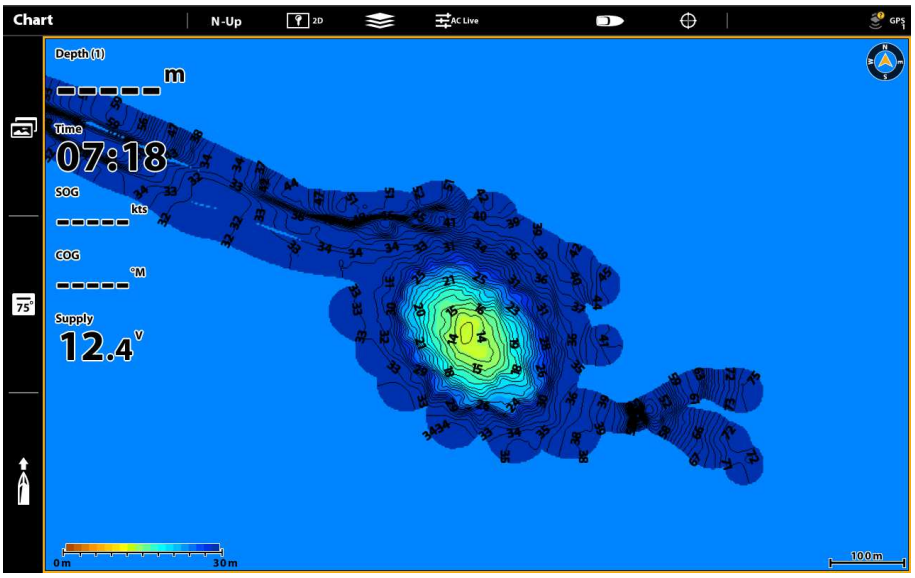


Figure 7 2D bathymetric map with colour and depth lines (reef wider area)

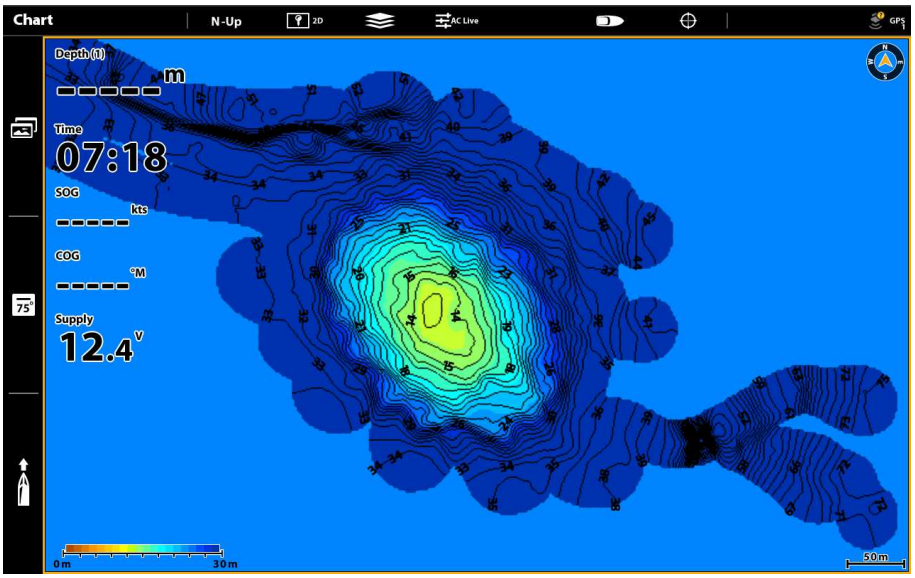


Figure 8 2D bathymetric map with colour and depth lines (reef area)

Previous bathymetric maps on Figure 7 and Figure 8 are also in 2D with colour and depth lines (colour and depth legend are displayed next to the map).

3. SAMPLING TECHNIQUES AND METHODS OF ANALYSIS

3.1. Water column parameters

3.1.1. Description of equipment and acquisition/processing techniques

The physico-chemical measurements

Exploring a coral reef is a big adventure for most people, but for a multidisciplinary team of dedicated scientists, the undersea environment provides many challenges. Continuous monitoring provides a more comprehensive view of the state of water quality in a waterbody than traditional grab sampling methods, offering a more reliable understanding of water quality. The physico-chemical parameters were taken in the field and also in the laboratory. In the filed we have used the EXO Multiparameter Sonde with integrated fDOM Smart Sensor, Conductivity / Temperature Sensor, Optical Dissolved Oxygen Sensor and pH Sensor. All these parameters were measured online and in situ. The EXO1 sonde is a multiparameter instrument that collects water quality data. The sonde collects the data with up to four user- replaceable sensors and an integral pressure transducer. Each sensor measures its parameter via a variety of electrochemical, optical, or physical detection methods. Each port accepts any EXO sensor and automatically recognizes its type. Depending upon user-defined settings, the EXO1 will collect data and store it onboard the sonde, transfer the data to a data collection platform (DCP), or relay data directly to a user's PC or the EXO Handheld.

Fig 10: EXO Multiparameter Sonde

To test the fDOM sensor in the laboratory we have used the Vario TOC cube. All parameters such as TOC, NPOC, TC, TIC, DOC, POC and TNb can be measured with the same basic unit. Analysis of ultrapure water, industrial waste water or solids represents a sample range which cannot be met by any other instrument. Injection volumes can be changed without modifications of the instrument hardware and for samples with unknown concentrations appropriate amounts can be calculated automatically via the software. The vario TOC cube has an optimized tubing and connection system that gives rise to a reliably, trouble-free handling of liquid samples containing particles. With the unique matrix separation concept, concentrated salt solutions can be analyzed even with larger injection volumes. In addition, the vario TOC cube is one of the very few analyzers on the market that allows measurement of solid and liquid samples with a single instrument – mode switching is done within minutes. The vario TOC cube operates in full compliance with all important standards for TOC/TC/TIC/TNb in liquids or solids like ISO 8245, ISO 10694, EPA 415.1, EN 1484, EN 15936, ENV 12260.

TOC measuring

The measuring principle is based on the high temperature combustion of the sample in an air or O2 stream above 680 °C. Totally bound or dissolved carbon is converted into CO2 which is quantitatively determined by means of a NDIR detector. The advantage of this method as opposed to the wet chemical UV / persulfate digestion is the absolute assurance that even stable compounds, particles or salt containing solutions will be

completely detected. Additionally, the high temperature method enables the determination of bound nitrogen (TNb). A high combustion temperature is crucial for a quantitative oxidation of bound or dissolved carbon to CO2 and a precondition for the decomposition of stable compounds and particles. The vario TOC cube can be operated at a permanent furnace temperature up to 1200 °C. In solid mode, the combustion enthalpy of the tin capsules results in a temporary temperature increase of up to 1800 °C. This allows the analysis of even refractory samples.

Nutrient analysis

The samples for nutrients: nitrate (NO3), nitrite (NO2), phosphate (PO4) and silicate (SiO4) were frozen (−22 ◦ C) and analyzed in a laboratory according to Strickland and Parsons (1972). Subsamples for ammonia were fixed immediately after collection onboard with 1 mol L−1 phenol/EtOH and determined in the laboratory according to Ivančić and Degobbis (1984). The detection limits and reproducibility for nutrients were as follows: nitrate 0.05 and 0.025 µmol L−1 ; nitrite 0.01 and 0.01 µmol L−1 ; ammo- nia 0.1 and 0.098 µmol L−1; silicate 0.1 and 0.06 µmol L−1; and phosphate 0.03 and 0.03 µmol L−1.

Figure 11: TOC machine

We have compared the data on the sensors and the DOC machine to identify if the faster methods could be used as a proxy for anthropogenic load.

Microbiological analysis

E. coli analyses were performed according to ISO 16649-1:2013 (recently replaced by ISO 16649-1:2018) for Escherichia coli determination method, filtering 100 mL of sample and transferring the membrane filter to a petri dish with Trypton-Galle-X-glucuronid (TBX) Agar (Merck, Darmstadt, Germany) and incubated at 44.5 ◦C for 24 h. After incubation time, blue colonies β-glucuronidase positives were counted as true E. coli.

Fecal coliforms analysis were performed on mFC Agar (Difco) incubated at 44°C for 24 h. Con rmation was made by selection and culturing of 10 characteristic colonies in LTLSB (Lactose-Tryptone-Lauryl-Sylphate-Broth) at 44°C for 24 h.

PAH analysis

The filtrated water samples (dissolved organic matter) were extracted 3 times using the mixture of 20 mL of hexane and dichloromethane (1:2). Collected extracts were transferred through analytically pure anhydrous sodium sulphate (Sigma Aldrich, anhydrous, ACS reagent, ≥ 99%). The extract was concentrated to nearly dry by rotary evaporation, then solvent exchanged into hexane around one mL. The extracts were cleaned up using a five mL 2:3 (v/v) alumina:silica gel chromatography column. PAHs were eluted with 10 mL of n-hexane/dichloromethane (1:1 v/v). The fractions were concentrated to one mL under a stream of pure nitrogen and stored at 4 ◦C prior to instrumental analysis.

A concentration of PAHs was determined using the gas chromatograph Shimadzu GC-2010 Plus with the Flame-Ionization Detector (GC-FID) and the Shimadzu 7683 Auto-sampler. The chromatograph was calibrated with Polynuclear Aromatic Hydrocarbons Mix Analytical Standard (Supelco, 48905-U, 16 compounds), 2000 µg mL−1 each component in methylene chloride: benzene (1:1). The PAHs with 2–6 aromatic rings were detected: Naphthalene (Naph), Phenanthrene (Phe), Anthracene (Ant), Fluoranthene (Flt), Pyrene (Pyr), Chrysene (Chr), Benzo[k]fluoranthene (BkF), Benzo[a]anthracene (BaA), Benzo[a]pyrene (BaP), Indeno[1,2,3-c,d]pyrene (IndP) and Benzo[ghi]perylene (BP), Acenaphthene, Acenaphthylene, Benzo[b]fluoranthenem, Dibenz[a,h]anthracene, Fluorene. The chromatography column: RxiR – 1ms, CrossbondR 100% dimethylpolysiloxane, length – 20 m, diameter – 0.18 mm, 0.18 um df. Temperature was set up from 55 to 300 ◦C at a rate of 10 ◦C per minute and was maintained at 300 ◦C for 15 min. Carrier gases was helium (0.99 mL min−1). The detector temperature was 320 ◦C. Each concentration of PAHs was measured 3 times. A total concentration of PAHs was obtained by sum of individual concentrations of PAHs.

A concentration ratio was determined as proportion of compounds associated with suspended particles phase (Cs) and compounds in a dissolved phase (Cw): concentration ratio = Cs/Cw.

3.2. Benthic community settled on the reef

Coralligenous assemblages were detected by photosampling with a minimum of three areas of 2,5 m2 (comprised of 10 contiguous photos of 50 x 50 cm quadrats to ensure species identification). Photos were taken with Nikon D7000 digital SLR camera fitted with a 10-24 mm lens and housed in a SEACAM housing. Lighting was provided by two electronic strobes fitted with diffusers. Such sampling enables further acquisition (through subsequent photo analysis) of data on: (i) the presence and abundance of typical (target) species, (ii) the structural complexity based on the cover of species/categories contributing to basal layer (including encrusting organisms, boring sponges, turf, bare rock and sediment) and intermediate layer (massive or bush-like organisms below 15 cm in height) (see below the description for assessment of the third, erect layer), (iii) bioconcretion (through estimation of cover of encrusting calcareous algae and macroinvertebrates contributing to build- up of the coralligenous outcrops) and (iv) bioerosion (through estimation of the cover of boring sponge Cliona spp. and enumeration of bioeroding molluscs Rocellaria dubia and Lithophaga lithophaga as well as estimation of the effects of bioeroders from their grazing marks). Besides acquisition of data on habitat structure and function, photoquadrats obtained by photosampling furnish information on disturbances through estimates of abundance of invasive species and sediments. Since the goal was also to characterize these coralligenous sites for the first time, we additionally performed photosampling of a minimum of 3 replicates of 0.5 m2 using 25 x 25 cm subquadrats to ensure a more reliable identification of organisms (as suggested previously by Kipson et al. 2011), since certain level of detail (useful for species identification) may be lost when 50 x 50 cm subquadrats are used.

Furthermore, to comply with the most integrated assessment of coralligenous ecological status so far (Piazzi et al. 2018), analysis was based on the following descriptors:

1. The percentage cover of the conspicuous taxa/morphological groups was evaluated for each sample using a Photoquad software (Trygonis & Sini 2012). Analysis of percent coverage was based on the grid method, with 625 cell division per 50 x 50 cm quadrat, assigning at least one category (species/taxa or bare substrate type) to each 4 cm2. Following Piazzi et al. (2018), the overall Sensitivity level (SL) was calculated by multiplying the value of the SL of each taxon/group (see Appendix 3) for its class of abundance and then by summing up all the final values. The cover values of each taxon/morphological group was assigned to eight classes of abundance (see Piazzi et al. 2018 and references therein): (1) 0 to ≤0.01%; (2) 0.01 to ≤0.1%; (3) 0.1 to ≤1%; (4) 1 to ≤ 5%; (5) 5 to ≤25%; (6) 25 to ≤50%; (7) 50 to ≤75%; (8) 75 to ≤100%). Hence, a higher overall score would indicate a more pristine site.

2. The richness (α-diversity, i.e. the mean number of the taxa/ groups per replicate) was computed.

3. The β-diversity was evaluated as the mean distance of all replicates within each site from centroids calculated through PERMDISP procedure (Anderson 2006, Anderson et al. 2006). In undisturbed conditions, high values of β-diversity would be expected for coralligenous, due to its high variability at smaller spatial

scales - stemming mainly from the patchy distribution of the organisms thriving there. Disturbances such as the loss of structuring perennial species and the proliferation of ephemeral algae lead to widespread biotic and to a consequential reduction of β-diversity (see Piazzi et al. 2018 and references therein).

4. The percentage cover of sediment and invasive algae was estimated for each sample.

5. The thickness of the calcareous layer was measured using a hand-held penetrometer with a minimum of six replicated measures per site. Since the calcareous accretion of biogenic reefs such as coralligenous may be impaired by human-induced impacts, the thickness and consistency of the calcareous deposit can be considered as a good indicator of the occurrence of a positive balance in the bioconstruction process, i.e. bioconstruction prevails over bioerosion. Thus, null penetration of penetrometer is indicative of a hard rock and suggests that either the biogenic substrate is absent or the bioconstructional process is no longer active; a millimetric penetration indicates the presence of active bioconstruction resulting in a calcareous biogenic substrate; and a centimetric penetration reveals a still unconsolidated bioconstruction (see Piazzi et al. 2018 and references therein).

6. The size (mean height) and the percentage of necrosis and epibiosis of erect anthozoans (gorgonians) was assessed in situ.

Visual census and video along random transects

Visual census along three 10 x 1 m horizontal transects was carried out to assess the third component of degree of structural complexity - the erect layer (by estimating the abundance of arborescent and massive species that can reach heights and/or diameters above 15 cm). One diver set the transect using a reel (marked at each 1 m length) whereas the other one estimated density of the organisms belonging to the erect layer, i.e. the ones higher than 15 cm. The latter diver observed the surface that extends 50 cm over and 50 cm below the transect, and afterwards he/she moved to the next m2.

Chemical sediment analysis

Sediment and contaminants done for summer/autumn 2019. Planned to continue in May/June 2020.

In sediments the following compounds will be determined: oxygen, PAH, dissolved organic matter, sanitary quality (faecal coliforms, E. coli).

Total organic carbon was analyzed according to ISO/TS 13137 (2001) using the TOC 5000 A instrument with model SSM 5000 A for solid samples. TOC was obtained from the difference between total carbon (TC) and inorganic carbon (IC). Total phosphorus content was performed following the method described by EPA 3051 A (2007) on inductively coupled plasma emission spectrometry (Icap 6300, Thermo, USA). Total nitrogen

content in the sediment samples was determined using Kjeldahl digestion according to Persson et al. (2008) on Kjeltec 2300 (Foss Tecator, Denmark) equipped with a block system for mineralization. The concentration of ammonia was analyzed according to ISO/TS 14256-1 (2003) filtering the extraction solution and analyzing the nitrogen fractions on spectrometry UV-1800 (Shimadzu, Japan).

The analysis of PAHs and PCBs were performed according to EPA 8270 (1998). Samples were defrosted to room temperature prior to analysis. Freeze-dried, homogenized sediment samples were extracted in a Soxhlet extractor with a mixture of hexane and dichloromethane (1:1). The extracts were concentrated on a rotatory evaporator. Clean up treatments were achieved by neutral, activated silica column for PAHs and a combination of acid and base Silica for PCBs. Elution was performed using a mixture of hexane and dichloromethane (1:1) for PAHs, and hexane for PCBs. The sulfur clean up procedure was performed according to EPA 3660 B. Evaporation of clean extracts was carried out under a stream of nitrogen. Quantification was done by gas chromatography-mass spectrometry (GCMS-QP2010 SE Shimadzu, Japan) attached to SLB-5 ms capillary GC column (Supelco Inc; 30 × 0.25 mm, 0.25 µm thickness).

The ascertained components of PAHs were: naphthalene (Naph), acenaphtylene (Aceph), acenaphtene (Ace), fluorene (Fl), phenanthrene (Phen), anthracene (Ant), fluoranthene (Flu), pyrene (Pyr), benzo[a]anthracene (BaA), chrysene (Chr), benzo[a]pyrene (BaP), benzo[b]fluoranthene (BbF), benzo[k]fluoranthene (BkF), indeno[1,2,3-c,d]pyrene (InP), benzo[g,h,i]perylene (BgP) and dibenzo[a,h]anthracene (DBgP). The ascertained PCBs were: PCB 28, PCB 52, PCB 101, PCB 118, PCB 138, PCB 153 and PCB 180.

Assessment of PAHs and PCBs concentration was made against the OSPAR Background Assessment Concentrations (BAC) and Effects Range Low (ERL). Sediments with concentrations below BAC were considered to have high environmental status, while concentrations significantly below ERL were considered to have good, and those above, bad environmental status (Webster et al., 2009).

3.3. Fish assemblage

The methods used for sampling of fish communities on the reef are all non-harmful. The methods are:

- BRUV (Baited Remote Underwater Video)
- UVC (Underwater Visual Census)
- ROV (Remote Operated Vehicle

3.3.1. Baited Remote Underwater Video (BRUV)

A fast development in technology over the last 20 years has made the use of cameras in underwater research a common thing. Whether for abundance or length of the fish, deep or shallow water, cameras are now days used for sampling of fish assemblages more than ever (Watson et al., 2005.). There are two basic ways of using cameras, mono or stereo system. Both ways cameras are pointed down or parallel with sea bottom. If the system has a bag with bait then we are talking about BRUV. Those systems can be armed with infrared lights, moving sensors, etc. The biggest pros of this method are that it can be used on big depths, several times during the day, it is non-expensive and easy to use and it is non-harmful (Langlois et al., 2010., Cappo et al., 2007.).

A comparison was made weather the use of bait increases abundance or not. It is found that the use of bait increases abundance of carnivore and omnivore species but does not decrease the abundance of herbivore species (Harvey et al., 2007). Stereo system is used when we want to have a precise length of the fish using a calibration and a software program for measuring. The program is not precise in MM but a class range of 10cm can be provided.

In our research we used a stereo and a mono system. Stereo system has two cameras put in a waterproof housing. The housings are attached to the metal frame and are pointed parallel to the sea bottom. Housings are made out of technical plastic and are waterproof up to 100 meters. The cameras used in our case are GoPro Hero 3 Silver, GoPro Hero 4 Silver Plus and a GoPro Hero Black 5. All cameras are high 4K resolution (1920 x 1080) and have a battery life up to 3 hours. In our case we also used BackPack batteries to extend that life span up to six/six and a half hour. The frame of the system is made out of stainless steel. The bar where the cameras are attached is one meter long and the distance between the cameras is 70 centimeters. The housings are moved for 8^{o} to the center of the system so that the max range of the system in clear water would be around 7 meters. The system has 4 detachable legs that can be armed with leads if the current is too strong so that it can't be moved. On the left and right side, the system is connected to the floating rope and on the other end with a buoy (Figure). For the bait we used fresh sardines. The whole system is 1m tall which is the standard height for BRUV.

Each system had 3 or 6 replicates, depending on the battery lifetime, in duration of 45 minutes. We used maximum of 6 systems per day.

Also, we used a mono BRUV system that is consisting of an open box where the camera is placed. Camera used on this system was GoPro Hero 5 and is placed in its own housing. The maximum depth range for this system is 45 meters. I have 4 detachable legs that can, as in the case of stereo system, be placed with weights so that the current can't move it. It is also made out of stainless steel (Figure). The lifetime of a camera on this system is around 3 hours and it depends on water temperature.

Data analysis was carried out in laboratory by the same fish expert so that if there is any mistake it would be the same for every survey. For each species we took N-max (maximum number of individuals for one species per frame). For the fish length measurement in all our research we use SeaGIS event measure. Fish were measured in 10cm range and divided in classes.

Figure 12: Mono BRUV system used in research

Figure 13: Stereo BRUV system used in research

Figure 14: BRUV deployment

3.3.2. Underwater Visual Census (UVC)

Limitations for using destructive sampling methods, especially in protected areas, have led up to different type of visual census methods. Most of them are conducted in shallow water and with snorkelling with or without the use of cameras. The method of UVC is fast, easy to replicate and can collect data for various parameters as species, abundance, habitat, density, etc. Cons for this method are conditions in the water such as turbidity which can make harder for a diver to recognise the species, especially fish (Lowry et al., 2012.). Biggest difficulties come from mistakes made by the diver. Most of them are related with fish behaviour which is provided by diver himself, ability of the diver to recognise certain fish species, abundance and length of the fish. Different studies indicate that a diver can attract the fish, mostly carnivore species, but also it can scare them away (Langlois el al., 2010.). One of the biggest problems is the observation of small cryptic species in well-structured habitat (Lipej and Bonaca, 2006.).

In our case we used two methods. One was a classic UVC with the use of a lure and the other one was a DOV (Diver Operated Video). UVC with the lure was conducted in shallow water on transects of deferent length

and width of 2 meters. Each length was replicated each time the survey was conducted. Beginning and the end of the transect was a well-marked object. The fish count was written on the white plastic ring with a waterproof pen.

DOV used in our research was equipped with two GoPro Hero 4 cameras that were placed in waterproof housings that were attached to the metal frame (Figure). It was used only once because the program for stereo system analysis was not working.

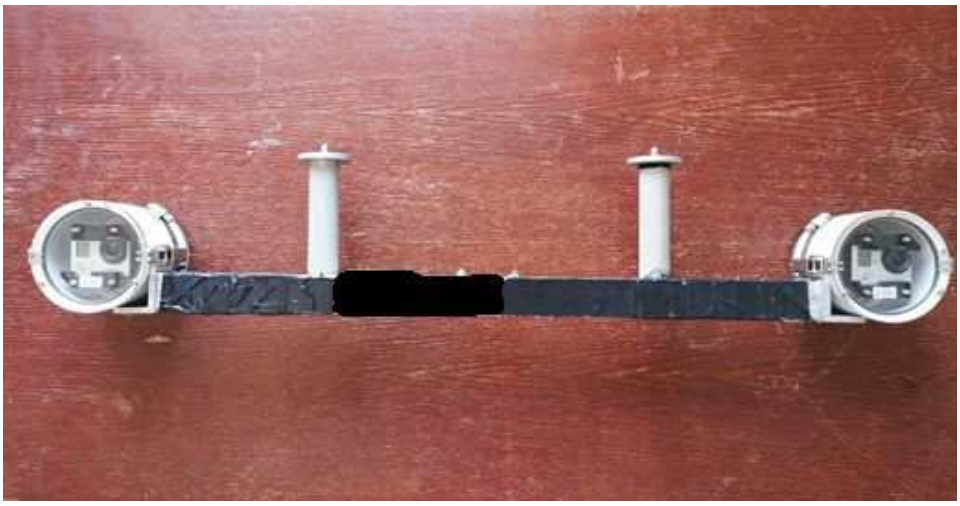


Figure 15: DOV used in research

3.3.3. Remote Operated Vehicle (ROV)

ROV (Remote Operated Vehicle) is every underwater vessel that is operated on distance with crew member. With fast technological development human crews are replaced and ROV can be operated from land or boat by remote control. Biggest advantage of these small ROV's is that they easy to navigate through small spaces such as interior of sunk ships or small underwater caves. Also, if the ROV is lost there is only material loss. In past this kind of vehicles were expensive if you wanted high resolution cameras and all advantages listed above, but nowadays that is not the case. One of such vehicles is Gladius Mini ROV by French company Chsing (Figure).

Figure 16: Gladius Mini ROV

ROV's dimensions are 15.1 x 8.8 x 5.4 inches and weighs 2,5 kilos. The colour is yellow so it can be easily found if lost or stuck. It has 5 propulsors that provide stability, direction and speed of the ROV which can be max 4 knots or 2m/s. There are two rear motors that are responsible for horizontal movement. The rest are for moving up and down and stabilization. Namely, when all the motors are turned on the system can be adjusted so that ROV moves 45 degrees regarding to the sea bottom which is the best angle for filming. It has a 4K camera (12 million pixels) that cam film videos or take pictures in high resolution. For working in deeper water, it has two LED lights, each 1200lm of power. The autonomy of the ROV is around 2 hours depending on water temperature and is 100 meters waterproof. The ROV is attached to the base station with 150 meters of optical cable covered in yellow kevlar suit. The base station has integrated memory of 64GB but additional micro-SD card can be added (Figure).

Figure 17: Base station and micro-SD card

Inside the base station there is a WiFi antenna that serves for connecting to the drive pad. Tablet or the mobile phone must be put on the drive pad so that the ROV can be operated (Figure).

Figure 18: Drive pad (console) of the ROV

On the screen you can see battery life time, water temperature for the depth on which the ROV is found at that time, picture of the situation in front of the camera and current depth (Figure). The ROV was used for vertical transects on the coralligenous wall and for the Michele shipwreck.

Figure 19: Explorative survey carried out

ENVIRONMENTAL LOAD

Tourism

The island of Vis is the most protruding Croatian island. The island has an area over 90.3 km and it rises 587 meters above sea level (Hum is the highest peak). It is located in the mid-Dalmatian archipelago, 30 nautical miles from Split (two and half hours by ferry). It is surrounded by an archipelago of smaller islands and islets: Ravnik, Budikovac, Bisevo, Svetac, Jabuka, Brusnik and Palagruza. The island has three mountains stretching across it, and between these mountains are karstic fields. The first people settled in Vis in 3000 B.C. They

were of Mediterranean background. In 2000 B.C. they were pushed aside by the Illyrians which formed their own government in the fifth and sixth century B.C. The Syracuse tyrant of Dimitrij the Elder in approximately 397 years B.C. established his colony on Vis and its settlers expanded their influence towards the central-Dalmatian islands and coast, establishing their sub colonies in Lumbarda on the island of Korcula, Trogir (Tragurion) and Stobrec (Epetion). The Illyrian king Agron I and queen Teuta, who were defeated by the Romans in 219 B.C., threatened the authority of Vis (Issa). Since then, Issa has acknowledged the authority of Rome. After the downfall of the Western Roman Empire (year 476), Vis at one time acknowledged the authority of the Goths and then the Byzantines. The Croats started settling in Vis in the seventh century. Vis was occupied and destroyed by the Venetians and under Venetian authority from 1420. With peace in Campoformio in 1797, Venice hands it over to Austria, and after peace in Požun in 1805 it comes under the French who fortify it. In March 1811, the English fleet struck a hard defeat to the French-Italian fleet and occupied Vis. After the dissolution of Austria Hungary, Vis was occupied by Italy (1918 – 1921) and the second time again by Italy in 1941. After the capitulation of Italian fascist in 1943, the island was liberated by Tito's Partisans where an allied military airport was built. The Yugoslav army left the island on May 30th, 1992, six months after the international recognition of Croatia.

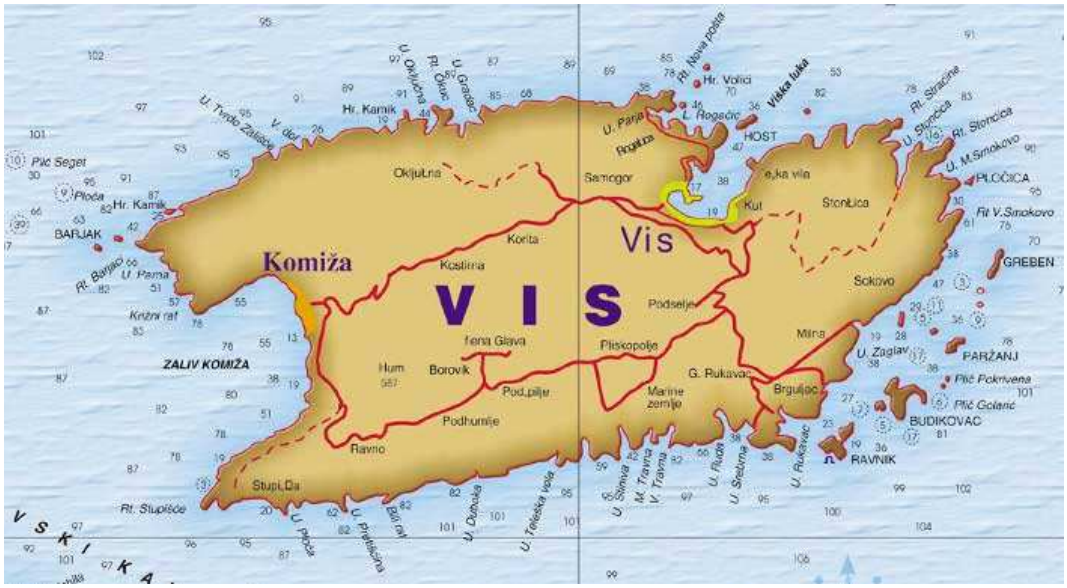


Figure 16: Map of the island of Vis (https://split.gg/vis-island/)

The city of Komiža in 2019 had 1989 beds and 273 extra beds. The total number of guest arrivals was 18,928 (12,436 foreigners). There was a total of 107,440 overnight stays (74,190 foreigners). Arrivals were at the level of 2018, and there were 1% more overnight stays.

There were 2857 beds and 537 extra beds in the town of Vis. There was a total of 32,613 guest arrivals (24,575 foreigners). There was a total of 175,211 overnight stays (135,115 foreigners). Arrivals were 4.2% more than in 2018, and overnight stays were 1.7% more.

Vis is one of the most attractive Croatian islands famed by its intact nature, clear blue sea, pebble and sand beaches, hidden picturesque bays, and spectacular undersea world. Thanks to its distance from the mainland, Vis sea area was never intensively fished, where you can still find a spectacular marine flora and fauna. The seabed around the island keeps many secrets of numerous shipwrecks and cargo ships as a witness of island's trading activity. The underwater world surrounding the island of Vis is famous for a large number of archaeological sites where many relics like amphorae, bronze cannons and various items, now lie on the bottom of the Vis sea bottom.

Here are some diving clubs that organize diving tours like:

Bisevo Blue Cave diving – Due to the cave's shallow depth and underwater opening, it is suitable for all kinds of divers. It is 3 – 20 meters deep. Contact Issa Diving Center in Komiza town or call 00385 21 713 651 or visit their website – Issa Diving.

A wreck of an Italian ship dating from the 1866 naval battle between Austria and Italy – ANMA diving center, Vis town, Street: Apolonia Zanelle 2 Tel. 00385 91 521 3944. Website – Anma.hr

Manta Diving center from Komiza organizes two types of diving, wreck diving (Wrack Teti, Wrack Vassilios, Wrack Fortunal and many others spots and flora&Fauna diving (Monk-seal cave, Green cave, Outer rock, Inner rock). Particularly interesting is so called Host diving spot with numerous amphorae.

Vis Geopark

The Vis Archipelago and its submarine area are included in the ecological net- work EU Natura 2000. The main goal of this program is to maintain or improve the condition of preservation of target- ed biological species and their habitats. This is particularly important for the is- land of Vis which is, along with its open sea islands, a bird migration corridor between the Adriatic shores.

The Vis Archipelago is the central maritime zone in the Adriatic. This triangle-shaped area comprises the island of Vis, its nearby uninhabited islands (Ravnik, Budihovac, Veli Paržanj, Mali Paržanj, Gre- ben, Host, Veli Barjak and Mali Barjak), the further removed, open-sea island of Palagruža (40 sea miles south of Vis), inhabited only by a lighthouse keeper, and the islet of Jabuka rising like a black pyramid above the sea (some 30 sea miles west of Vis). Within this triangle-shaped zone spread- ing across approximately 6,000 square

kilometers, there are also the islands of Sveti Andrija, Brusnik and Biševo, the latter being the only inhabited is- land among the three.

Among as many as 1,200 islands scattered across the Adriatic coast, the islands comprising the Vis Archipelago have the most heterogenous rock formations. In addition, these islands are also the youngest and the oldest Adriatic islands. The youngest in the sense that they are still rising, and the oldest in the sense that they are composed of volcanic, salt and sedimentary rocks formed along deep-rooted faults in the Earth's crust during the first period of the Age of Dinosaurs, the Triassic, some 220 million years ago, during the breakup of the supercontinent Pangaea and the opening of the Tethys Ocean. Triassic rocks were deeply buried in the Earth's crust beneath a few thousand-meter-thick cover of layered sedimentary rocks of the Adriatic Carbonate Platform (ACP), deposited in the area during the Jurassic and Cretaceous periods. The wider Adriatic area was then situated along a trop- ical belt within the western Tethys Sea, on a small drifting continent called the Adriatic plate or Adria. During the last few million years, the lighter Trias- sic salt and associated volcanic and sedimentary rocks began to uplift and pierce through the cover of carbonate rocks forming a salt diapir — a few kilometer tall subsurface "mushroom." The upper part of the Earth's crust was deformed and partly eroded during the slow rise of the islands, which feature spectacular cliffs built of layered carbon- ate rocks resembling "stone books" in which each layer contains the geological record from the time of its deposition. In the Quaternary period, the two-kilometer wide "head" of the "mushroom" pro- truded through more resistant uplifted carbonates, and was eroded by the rain and sea, forming the present-day Komiža Bay.

During the Ice Ages the sea level was 140 meters lower than today, and the hills were surrounded by the Adriatic steppe. The sand from the steppe was blown by strong winds up to the hills, forming sand plains and the present-day substrate for the highest quality vineyards, and some of the most beautiful sand beaches along the predominantly rocky coast. After the last Ice Age, the sea flooded the steppe, turning the hills into islands, while sub- merged caves became the most beautiful natural phenomena in the Adriatic.

Protected natural areas of the Vis Archipelago:

The Blue Cave on the island Biševo

The Monk Seal Cave on the island Biševo

The island of Jabuka

The island of Brusnik

The Green Cave on the island of Ravnik

The island of Ravnik

The Stiniva Cove

The island of Vis is of central importance for Croatian diving, as there is rarely a place where visitors like this be able to experience many different experiences in such a small area. The island of Vis will discover a wonderful world full of natural beauties of countless reefs, rocks, caves and underwater walls that are covered with colourful and interesting habitats. Due to its geographical location, Vis has been closely linked to the history of shipping and maritime affairs in the Adriatic for the past three millennia. It is therefore not surprising that their underwater world offers a unique historical collection of fantastic wrecks, from old sailing ships to iron ships from the 19th and 20th centuries to warships from World War II.

List of most significant wracks:

Steamship Teti

The Italian steamer Teti was an old ship that changed six owners. It was built in America in 1883 and in its 47th. Years of life have passed many thousands of nautical miles. On the stormy night of May 23, 1930, due to strong winds and waves, he sat on the island of Mali Barjak near Komiža. Fishermen from Komiža rescued the crew, but due to the severe damage to the hull, the steamship was unable to escape the rocks. The winter storms were so strong that it disappeared from the surface forever. The wreck of Teti lies on the island of Mali Barjak and is an ideal place for diving, especially for beginners, due to its shallow depth and conditions. In the central part of the ship there is a large steam boiler and a well-preserved steam engine, and at the stern of the ship there is a large metal rudder covered with brightly coloured sponges. On the wreck there is a special attraction of several large moray eels and conger eels that are not afraid of divers as they are sometimes fed by dive managers.

Steamship Vassilios T.

The large steamer Vassilios T. carried coal on its way from Swansea to Venice and sank near the outer Part of the Cape Stupišće. Some unreliable data indicate that the crew deliberately provoked shipwreck, so that the owner gets high insurance coverage. The Vassilios wreck is located just 20 meters from the west side of Stupišće. First you come across a large bow anchor, and gradually a huge bow of the ship emerges a few meters out of the blue in front of us. The slopes and pylons are well preserved and covered with yellow sponges, and the great red scorpionfish and conger eel regularly meet in their vicinity. In the middle of the force at the height of the top there are two vertical damages, through which the sea entered the ship and caused a sinking.

FORTUNAL fishing boat

The fishing boat Fortunal, on the morning of April 10, 1997, returned from a full-time fishery northwest of Vis, and the tired crew fell asleep after hard work. It was exactly 10 o'clock when Fortunal hit the cape of the Tvrdo Zalučje bay at full speed. Through a large hole in the underwater part of the bow, the ship very quickly

filled with the sea. The crew on deck could not do anything and quickly found themselves in the sea and Fortunal sank just a few yards from the shore, where the shore turns into a vertical underwater wall. If stops very quickly at the edge of the wall in the clear sea, you can see a light sandstone where Fortunal was tilted on the right hip. The visibility is great and the wreck is always attractive because of its relatively small size and orientation.

BRIG on the island of Grebeni

There is a small sailing ship wreck on the south side of Grebeni Island. It's an armed ship, probably a two-masted type Brik, from the late 18th to the early 19th centuries. The wreck is not far from the underwater wall, suggesting that the ship was likely hit by strong south winds, or maybe at night, when it approached the harbour unobtrusively. Long exposure the warm sea water left almost nothing of the wooden parts, but the shipwreck can be discovered through marine equipment, in this case the ship's cannons. The cannons are still lying on the sand as they were arranged along the sides of the hull. They are heavily covered with seashells and seaweed, and anchors and a variety of other marine equipment can be found not far from there. Due to its depth of 50 meters, diving in this still unexplored place is only suitable for technical divers.

Tugboat URSUS

The Italian tug Ursus sailed on January 30, 1941 from the Italian port of Zadar to Albania. He was towing an armed GM 239 pontoon. The next day, on the open sea between Vis, Korčula and Susak, the British submarine miner Rorqual suddenly came at a distance of about 1-2 miles and began shooting at Italian ships. The tug Ursus burned and sank near the Stončica lighthouse on the island of Vis. The position of Ursus is about 400 meters from the coast. It is still in that position today. The dive starts at the top of the underwater slope and at a depth of 40 meters you swim to the west and come straight to the stern. The ship is thickly covered with sponges and seaweed, and the bow with red sea fans, on the deck of which the 76 mm calibre cannon dominates.

Flying Fortress BOEING B-17

During the Second World War, the Allies built an auxiliary airport on the island of Vis, where the heavy bombers, the were damaged in aerial battles over wild Europe, could be landed. A real example was then the damaged American flying fortress B-17, which could not land at the airfield because the runway was occupied and therefore the bomber had to fly in a circle around Vis, but very quickly gave up all the fuel and the pilot was forced to land in the sea. He managed to land a large bomber on the Polivalo coast near Rukavac. The crew quickly left the plane, which soon sank and easily slid to the sea floor. Due to the great depth, a well-preserved aircraft can now only be viewed by technically experienced divers with gas mixtures. Great visibility, lots of fish and the imposing size of a heavy bomber lying on a white sandy beach will delight any diver who visits it.

B-24 Liberator TULSAMERICAN

On the open sea not far from the island of Paržanj there is still a location of a sunken aircraft from World War II. It is about the wreckage of the American heavy bombing B-24 Liberator that took place on December 17, 1944 collapsed on the failed landing. It was the last heavy bombers of the type Liberator in the Douglas Factory and nicknamed "Tulsamerican," the was painted on the nose of the aircraft. Damaged over Germany, he managed to drive to Vis, but stayed without fuel and broke off on landing in the sea and immediately sank. Three crew members were injured in the accident and seven were rescued. The main part of the wreck lies at a depth of 39 meters, which means that it is available to advanced categories of divers. While diving, one can see the remains of the ship's hulls and the pilot's cabins, wings and four radial engines. There are always fish-like fish around the wreck, and the whole wreck is covered with sponges and other brightly colored marine organisms.

Old shipwreck near the KRAVA cliff

Old shipwreck on the Krava cliff is one of the oldest discovered in the Adriatic to date. It dates from the time of the Greek colonization of Vis when the city of Issa was founded, which depended on regular sea trade and was a safe one. Was the port for the slow sailing ships at the time. Unfortunately, the weather conditions and numerous underwater rocks surrounding the entrance to the shore were fatal for many ships. An old sailing ship with amphorae from the 4th century BC went down in old unrest. The location of the shipwreck is along the southwestern cliff Krava, where the almost vertical rocky underwater wall merges into a sandy plateau. The wooden hull of the ship is torn, so that today only ceramic objects overgrown with colorful sponges and corals bear witness to the worst. On the sandy bottom lie the remains of the abdominal amphorae and the short neck with two small handles and the remains of several larger vessels.

BRIONI steamer

The passenger cargo ship Brioni of the Lloyd Austriaco company sailed on the coast to Dalmatia and Albania by he transported passengers and cargo. During the First World War, from 1914, he sailed in the service of the Navy and from 1925 sailed for the Italian company Società di Navigazione and Vapore Puglia from Bari, in whose service it continued to sail along the Adriatic coast. Because of the limited visibility and the mistake in shipping, it struck the rock near Cape Jezera on the island of Ravnik and sank. Today it is on the left flank, the narrowest part of the stern is at a depth of about 40 meters, which then turns into fine sand. The ship is densely covered with yellow sponges, surrounded of tiny fish and numerous specimens such as the Great Red Dragon Head. Because of its conservation, it is popular with technical divers.

Ancient shipwreck on the island of HOST

During the time of the Greek colonization of the island of Vis, and even more so during the time of the Roman Republic, Vis was an important junction of the sea routes. For unstable times, strong winds and summer thunderstorms, the island of Vis was a well-guarded and safe haven for sailing ships loaded with amphorae with wine and oil and various other goods. Many ships that were caught in a sudden wind have failed to entrench. So, on the rocks of the host island, two Roman merchant ships with amphorae ended up sunk on the northwest coast. On a slight underwater slope, you can find a large number of broken Roman amphorae

that testify to the shipwreck. The wooden parts of the ship have long since rusted, and only the amphorae, which are nested into one another to form a compact mass, bear witness to the old maritime tragedy. Some of the amphorae are still almost whole, and the remains of the amphorae that can still be clearly seen are dishes from the ship's kitchen and a round millstone.

Evaluation of physical garbage quantities and type on the seafloor

The term marine litter indicates any object which has been artificially manufactured or processed that reaches the marine environment after its use. Due to current high plastic consumption patterns, this material has become the main type of waste affecting marine environments. Most waste comes into the sea from the bordering lands and river mouths (Vlachogianni et al., 2017). In recent years, the growing presence of microplastics (mPs) in marine environments has provoked increasing concern, particularly considering their prevalence in water, sediment and biota. Owing to their small size, these particles can pose high risks to the environment. Globally, numerous recent investigations have documented the problems related to their collection, identification and occurrence, and the associated risks to the environment and human health, but it is difficult to compare results from different studies as methodologies, and study designs are not uniform. Only in recent years, international protocols have begun to be proposed and adopted by various territorial cooperation projects (Cheshire et al., 2009; OSPAR Commission, 2010).

Presence of garbage and a build-up rate from human activities estimated by reef survey using a remotely operated vehicle (ROV) on the beginning and the end of the peak season. Microplastics were not evaluated.

4. RESULTS AND DISCUSSION

4.1. Water column parameters

We have sampled twice the water column for the parameters that are listed in the next two figures:

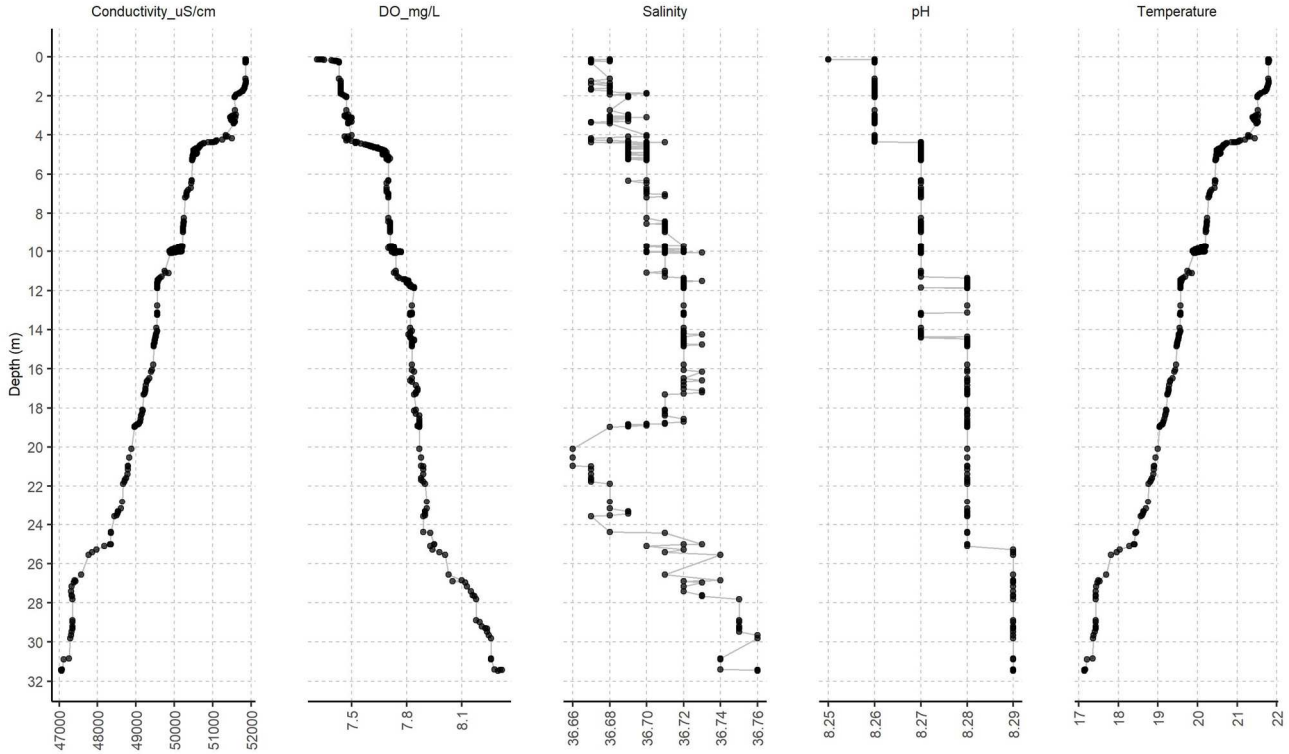


Figure17: 18.06.2020.

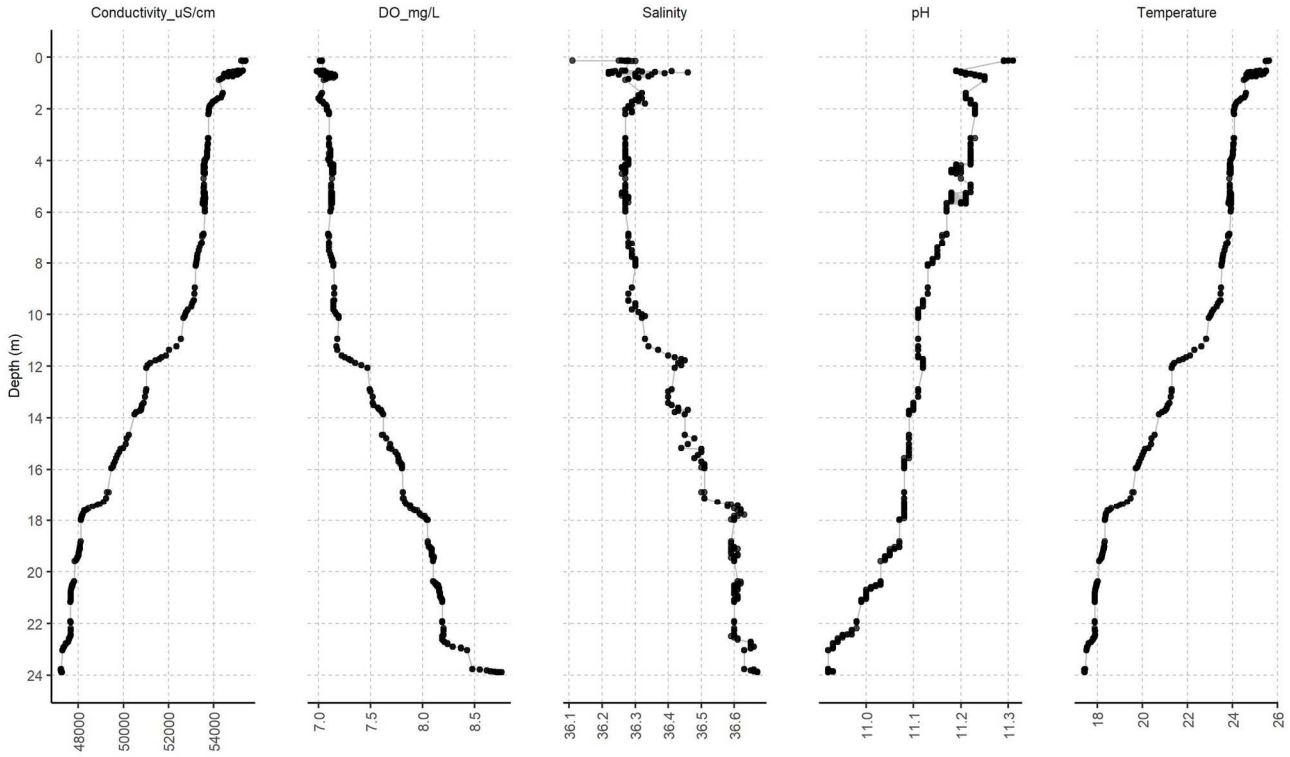


Figure 18: 26.06.2021.

All the physical and chemical parameters were typical for open seas. The temperature was decreasing with depth, as the pH and the dissolved organics. The salinity slightly increased. A similar trend was noticed in the nutrient level (all of them low) and organic load.

	2020	2021
NO_3 (µmol l^{-1})	0,67034	0,73326
NO_2 (µmol l^{-1})	0,051035	0,032697
NH_4 (µmol l^{-1})	0,908007	0,7952034
PO_4 (µmol l^{-1})	0,045308	0,027474
SiO_4 (µmol l^{-1})	8,31516	6,27164
TOC (mg l^{-1})	0,9424	0,9346

Table 1: Concentrations of nutrients

	2020	2021
Σ PAH (mg/kg)	0.001	0.001

Σ PCBs (mg/kg)	0.001	0.001

Table 2: PAHs and PCB contractions

Date	CE/ 100ml	E.coli/ 100ml
2020	<60	<100
2021	<60	<100

Table 3: Sanitary water quality

PAHs and PCBs in the water column were not detected and the sanitary quality was excellent.

Benthic community settled on the reef

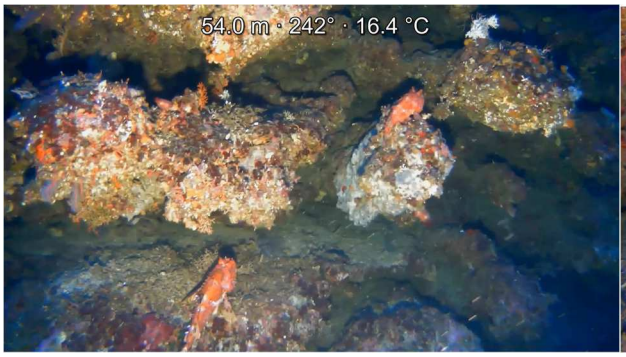
Assessment of gorgonian demography and conservation status

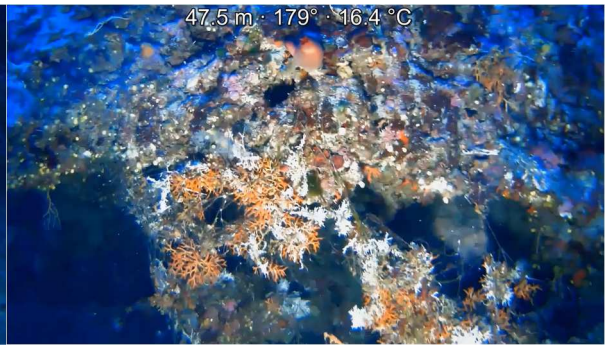
We can find at our location red (*Paramuricea clavata*) a yellow (*Eunicella cavolini*) gorgonian corals. On the Vis Island *E. cavolini* was mainly noted from 22 m depth, although few individual colonies could be observed at 18 m depth. Some species were noticed at 45 m.

The basal layer of coralligenous assemblage at Vis island site is predominantly formed by encrusting coralline algae. Some of the algae belonging to this group, namely *Lithophyllum sticteaforme* occassionaly form representative plate-like layered thalli that add to the structural complexity of the assemblage and create additional microhabitats, as well as contribute to attractiveness of recreational diving there or Peyssonneliales. Other constituents of the basal layer include several species of encrusting *Peyssonnaliacea* that are present with 18.3 % cover. Hence, encrusting red algae account in total for almost 50% cover at this site. Out of other algal species in the basal layer, notable is the frequency of occurence of *Palmophyllum crassum*. Encrusting bryozoans (4.1% cover) and serpulids (0.56% cover) are the most abundant animal species in the basal layer and the main animal builders here. Interestingly, sponges (otherwise one of the most diverse taxonomic group within coralligenous) were rarely present in the samples, and if they were, they were never abundant.

In the intermediate layer the main animal builders were branchy bryozoans (2.6% cover) such as Smittina cervicornis/Adeonella pallasi and Myriapora truncata, although present as relatively small colonies – the ones of M. truncata rarely exceeded 3-4 cm in height whereas the ones of Smittina cervicornis /Adeonella pallasi rarely exceeded 10 cm. Of other animals, mainly ascidians such as Halocynthia papillosa and Aplidium cf. tabarquensis were noted. From algae within intermediate layer Codium bursa and C. cf. effusum (0.33%

cover) were present as well as Flabelia petiolata (2.3% cover), with rare appearance of erect Rhodophyta. Also, high abundance of large colonies of bryozoan Pentapora fascialis (with 9.7% cover) in the intermediate layer, as well as of other erect bryozoans (reaching 13.5% cover in total) such as Smittina cervicornis/Adeonella pallasi and Myriapora truncata, adding considerably to the overall bioconstruction.





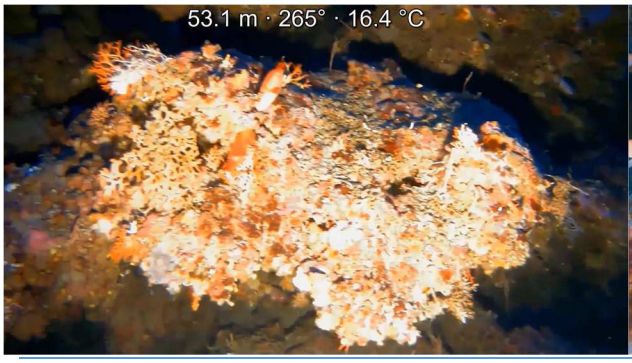


Figure 23: Benthic community

In the sediment PAHs and PCBs were not detected and the contraction of organic matter were very low (0,9 mg/kg)

4.2. Fish assemblage

The total of 21 fish species were found on Seget site during two explorative surveys. For the easier work each species was given the abbreviation name (Table). It is the combination of the first two letters of genus name and species name. Both surveys were conducted during summer or late spring which can be seen in the species structure. The most abundant species by the number of individuals are mesopelagic species that live in schools like *Chromis chromis, Boops boops* and *Spicara smaris* and they represent > 50% of all individulas on the site. In species richness most abundant are bati-pelagic and demersal ones like *Diplodus annularis, Dentex dentex, Coris julis* and *Muraena helena* (Figure).

Species name	Abbreviation name
Coris julis	Coju
Chromis chromis	Chch
Serranus cabrilla	Sec
Muraena helena	Muhe
Diplodus annularis	Dian
Sparus aurata	Spau
Boops boops	Bobo
Thalassoma pavo	Thpa
Spicara smaris	Spsm
Serranus scriba	Sesc
Symphodus melanocercus	Syme
Conger conger	Coco
Sarda sarda	Sasa
Symphodus doderleini	Sydo
Spicara maena	Spma
Diplodus puntazzo	Dipu
Symphodus tinca	Syti
Dentex dentex	Dede
Diplodus vulgaris	Divu
Phycis phycis	Phph

Scorpaena scrofa	Scsc

Table 4: Fish names and their abbreviations

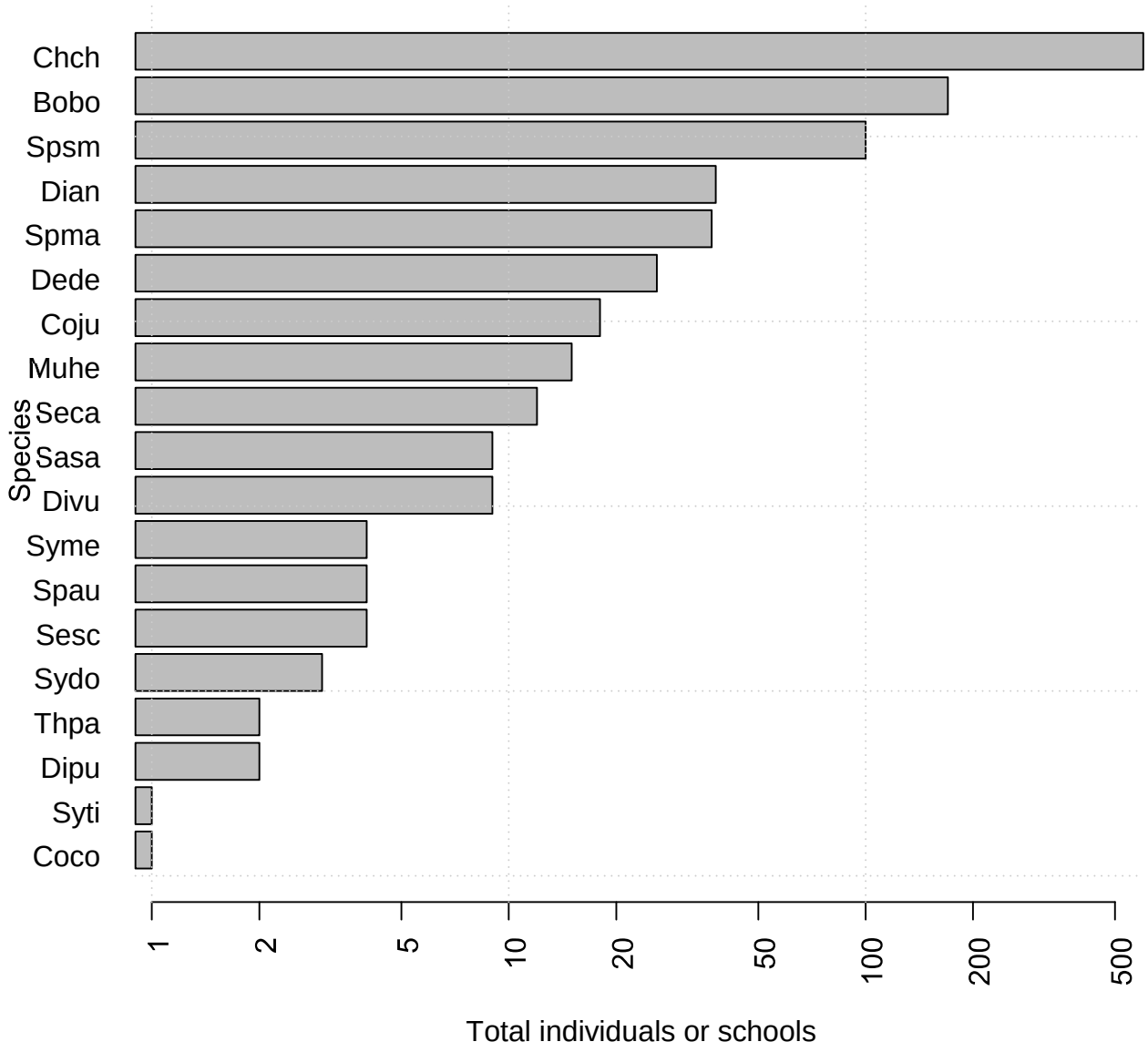


Figure 20: Total fish abundance for Seget site BRUV

As for the difference between sampling techniques it can be seen that BRUV recorded 19 species out of total 21 species. *Scorpaena scrofa* and *Phycis phycis* are the only recorded species with ROV that were not recorded with BRUV. The problem with UVC was with strong currents and therefore we couldn't use this technique because it was impossible to make a transect. Thus, we spent certain amount of time in the water and we haven't seen any large predators like *Dentex dentex* or *Sarda sarda.* Our conclusion is that they are scared of divers because this site is, as we found out talking to the local fishermen, a place where a lot of spearfishing and illegal night fishing with scuba is conducted.

Figure 21: *Dentex dentex* school on BRUV

Figure 22: School of *Boops boops* and *Spicara smaris*

Figure 23: *Muraena Helena*

Figure 24: *Serranus cabrila* in feeding proces

Figure 25: *Serranus scriba*

No aberrations were found in species length structure. All species were in their normal distribution range for this kind of habitat. Most species are between 10-20 centimetres range and mesopelagic. Therefore they represent no real potential for scuba diving or photo-safari. This location potentially can be used for fishing tourism and sport fishing tourism. Because of strong commercial fishing in Vis archipelago this site can be proclaimed as No Take Zone and help as a nursing ground for small fish and large predators such as *D. dentex* or *S. dumerili.*

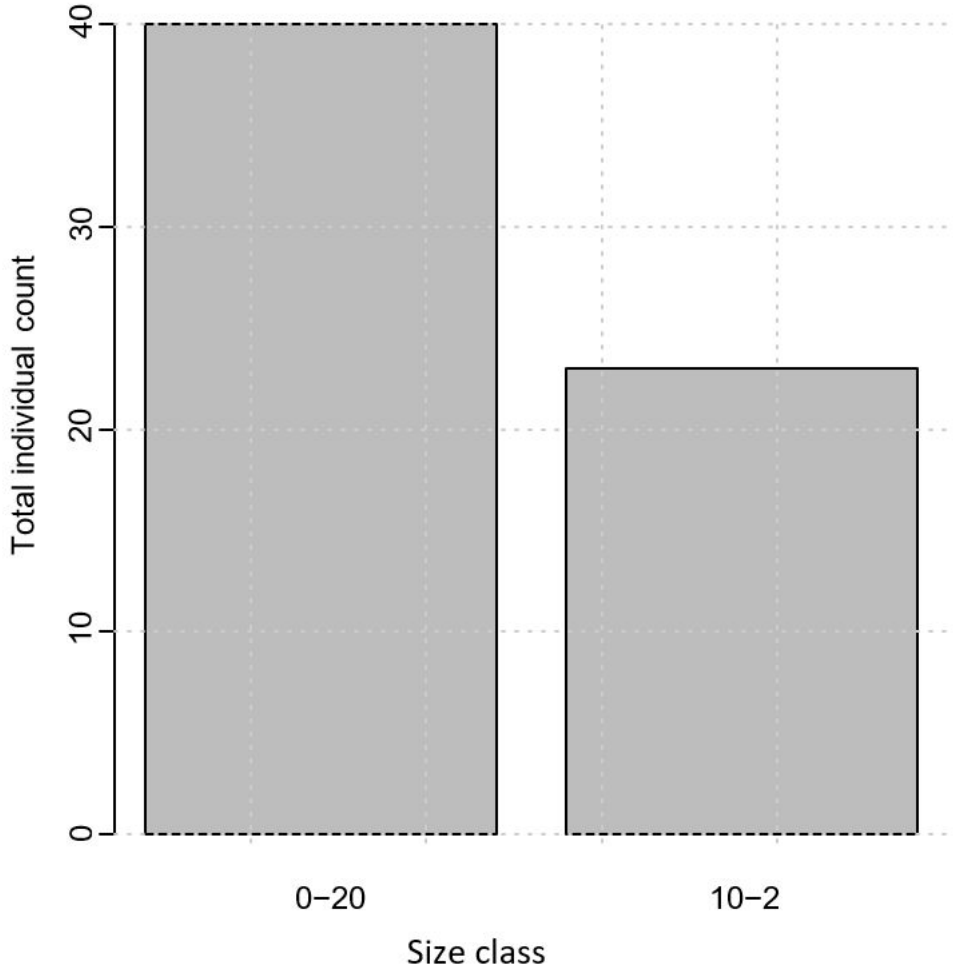


Figure 26 Fish size class for Seget site

5. CONCLUSION

Summarize here your results and include an assessment of the potential reef vocation for your specific CS (e.g. tourism, farming, aquaculture, fishing, environmental safeguard,...).

The island of Vis is the most protruding Croatian island with an area of 90.30 km2. We have selected primary one city for the project activity – Seget. Secondly, we have added a new – old site Stupišća. The monitoring activity due to the remote location were only twice, during summer (June) 2020 and 2021. During the monitoring activity we have performed the geomorphological mapping, the chemical and physical analysis and analysed the benthic and fish community. Also, in the sampling point Stupisca we have analyzed the

metals because of the shipwreck. Regarding the physic – chemical data we can identify a typical open sea environment with slightly higher salinity. The concertation of nutrients was very low that is typical for the southern Adriatic Sea and oligotrophic conditions. No metals were detected probably due to the open sea locations of the two sites. The data prom the organic load was very low. We tested also two approach in the organic load using the sensor and the DOC machine in the laboratory. The data were not identical but showing the same trend. After interviewing the major stakeholders on the island and the local community we can conclude that: 1) location Seget is very attractive but still can be focused on professional divers 2) the well know location Stupišća is also very attractive and a lot of tours are visiting. We cannot identify any significant anthropological input on this site on the Vis island.

6. REFERENCES

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