Work Package 4.1
Monitoring case studies in Italy

Torre Guaceto
Marine Protected Area

REV. 20201222

Deliverables: D4.1.1, D4.1.3, D4.1.5, D4.1.6

Titles:

D4.1.1 Explorative survey with multibeam echosounder (MBES) and/or ROV/scuba
D4.1.3 Images and data transferred at land and visualized through different media
D4.1.5 Extension of monitoring execution to other parameters (i.e. biological components)
D4.1.6 Collection and reporting of obtained data

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Case study responsible: PP06 ARPA Puglia

Contributors: Torre Guaceto's Marine Protected Area

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EXECUTIVE SUMMARY

This report describes the results of a survey carried out since June 2019 until July 2021, inside the Torre Guaceto Marine Protected Area (Puglia Region, Italy) facing the Southern Adriatic Sea.
Monitoring of underwater reefs is essential for the evaluation of their structural and ecological evolution, hence their capacity of sustaining different economic activities according to principles of the Blue Economy. This monitoring activity, part of the ADRIREEF project funded by the EU through the Interreg Italy-Croatia CBC programme, was planned for the recognition of the potential underexploited sustainable use of some natural and artificial reefs located in the Adriatic Sea (n. 7 selected reefs, natural or artificial, located offshore the Italian and Croatian coasts of the Adriatic Sea).
During the survey in the Southern Adriatic Sea, innovative technologies with low environmental impact have been tested, based on the outcomes of ADRIREEF WP3.4 "*Identification of technologies for underwater monitoring of reefs*". However, small modifications were introduced to reflect Case Studies topics or to address unexpected situations occurred during operational activities at sea.
As the Case Study (CS) chosen fall back in a Marine Protected Area (MPA) with different restrictions level, several non-destructive technologies and methods have been applied. During different dives, performed by Scientific Operators, photographic and visual census methodology have been applied. Furthermore, a Remotely Operated Vehicle (ROV) has been used as a "swimming eye" to provide underwater 360° video, which can then be reviewed with equipment such as the Oculus VR.
The scope of this work also includes an assessment of the potential reef vocation for the specific CS (e.g. nature tourism, aquaculture, fishing, environmental protection).
The main objectives of this study are:

1. Implementation of the knowledge on the biological communities that characterize the typical Apulian bank-type coralligenous biogenic reefs in the MPA.
2. Identification an underwater path for divers in the MPA. Currently, no diving recreational activities (with the exception of snorkelling ones) are implemented in the Torre Guaceto Marine Protected Area. These activities can represent an accelerator for the local economy, given the high number of tourists in the protected marine area. In fact, the Marine Protected Area can be considered as a biodiversity hotspot, so the possibility of recreational diving could increase the number of tourists.
3. To give outputs useful for an innovative touristic exploitation of a natural reef in the MPA such as: underwater videos or 360° videos (to be seen with Oculus VR), interactive GPS tracks associated with underwater photos.
4. To create the condition for planning future citizen sciences project in order to involve divers in the collection of sensitive data to increase the scientific information, fish community or others marine species of diving interest.

1. INTRODUCTION

The Regional Agency for the Environmental Prevention and Protection of Puglia (ARPA Puglia), Partner of the ADRIREEF Project, selected as Case Study the Torre Guaceto Marine Protected Area (MPA - South Western Adriatic Sea), in the Puglia Region (Italy). The MPA integrates the management responsibilities of the terrestrial natural park and the marine protected area. The manager of the AMP manages both the Natural Park and the Marine Protected Area, following the directives of the Italian Ministry of the Environment (ex M.A.T.T.M., currently Mi.T.E.) responsible of the overall program for the Marine Protected Areas in Italy. The management structure for the park and marine protected area "Torre Guaceto" lays with a consortium between the city of Carovigno (principal management responsibility), the city of Brindisi and the World Wildlife Fund (WWF).

The Torre Guaceto MPA was formally established in 1991, but entered into force in 2001. The total surface of MPA is around 2,227 ha and it is divided into two no-take/no-access zones (called A zones according to the Italian law) covering 179 ha, where any fishing activity is banned and access forbidden except for the MPA's staff, scientists and police forces (e.g. Coast Guard); the general reserve zone (B zone) covering 163 ha, where access (i.e. swimming) is permitted but fishing is banned; the partial reserve zone (C zone, hereafter called 'buffer zone' towards the exterior of the MPA), covering 1,885 ha, where access, regulated navigation and some activities are permitted (Fig. 1).

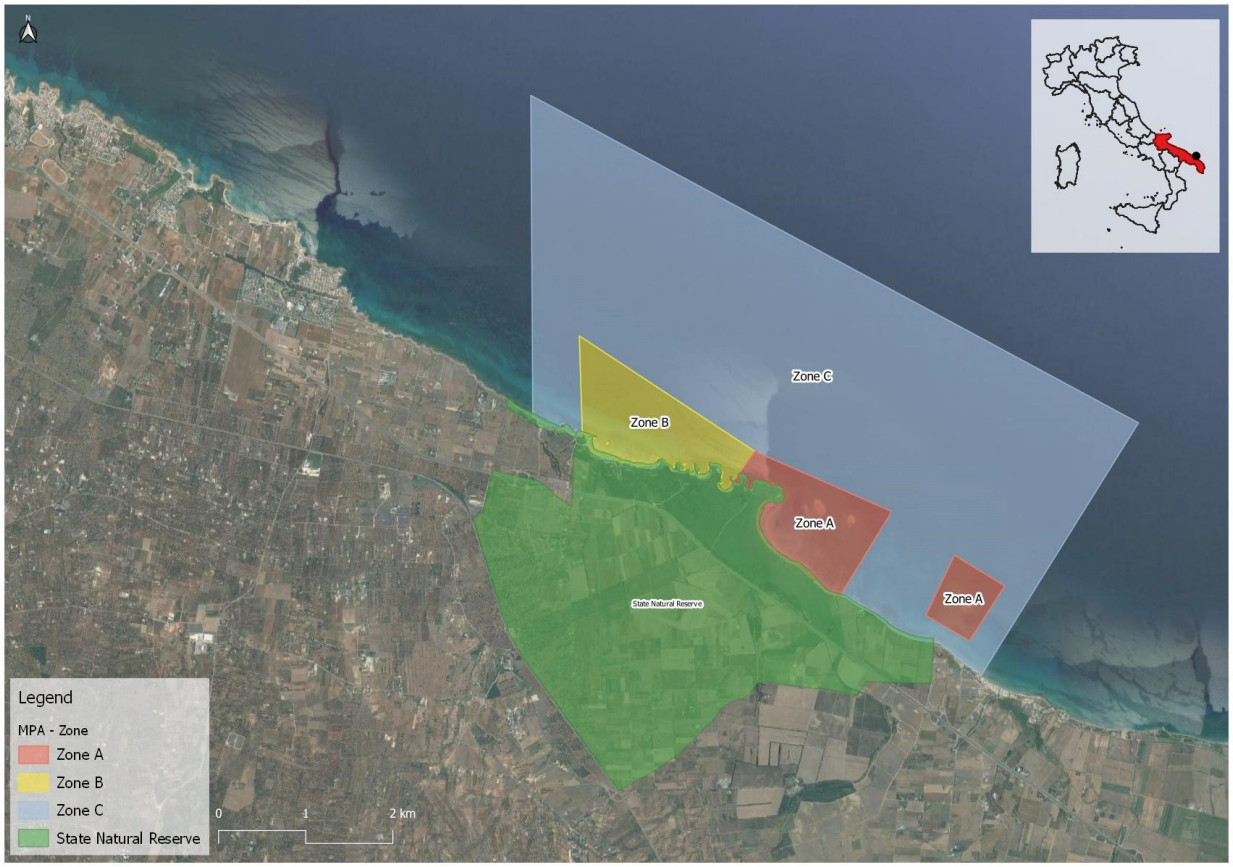


Fig. 1:Marine Protected Area of Torre Guaceto and Torre Guaceto State Natural Reserve.

In fact, inside the MPA zone C it is possible for the authorized fishermen to practice small-scale coastal fishing, with a special license. The latters participated, together with the Park Authority, to the drawning up of rules for sustainable fishery in order to avoid negative impacts on the fish populations.
As regards the anthropic impact on the pilot project area, Fig. 2 shows one of the outcomes from the previous Interreg Project SHAPE (Shaping a Holistic Approach to Protect the Adriatic Environment between coast and sea), where the DPSIR approach was applied considering drivers and pressures such as population density, agriculture, fishing, etc.

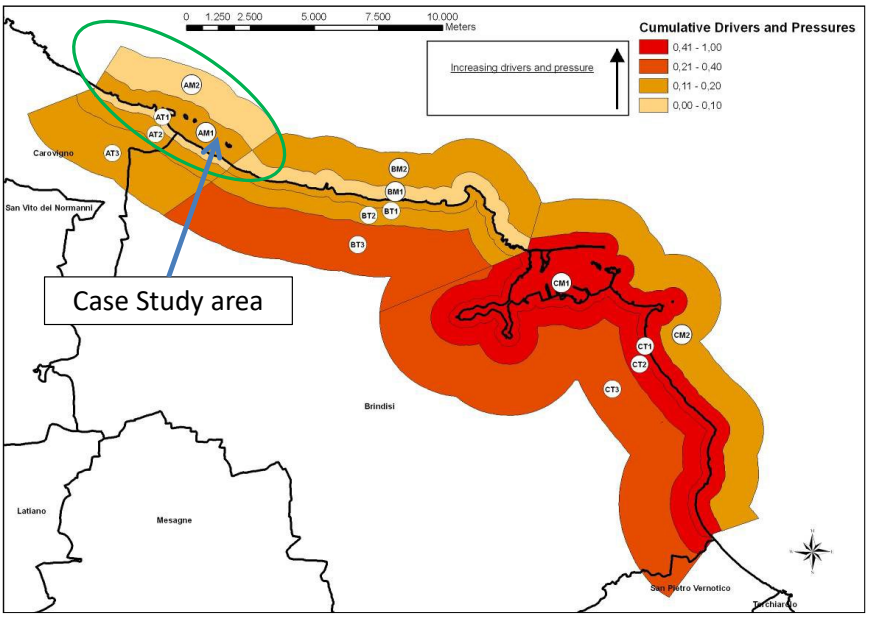


Fig. 2: Map of the Driver-Pressure cumulative values in the Brindisi coastal zone (output of the SHAPE Project. In the green oval the Case Study Area, the Marine Protected Area of Torre Guaceto).

Among the specific pressures, Fig. 3 and Fig. 4 show respectively the small fishery and the marine traffic in the study area during the year 2012 (data source: Marine Traffic.com).

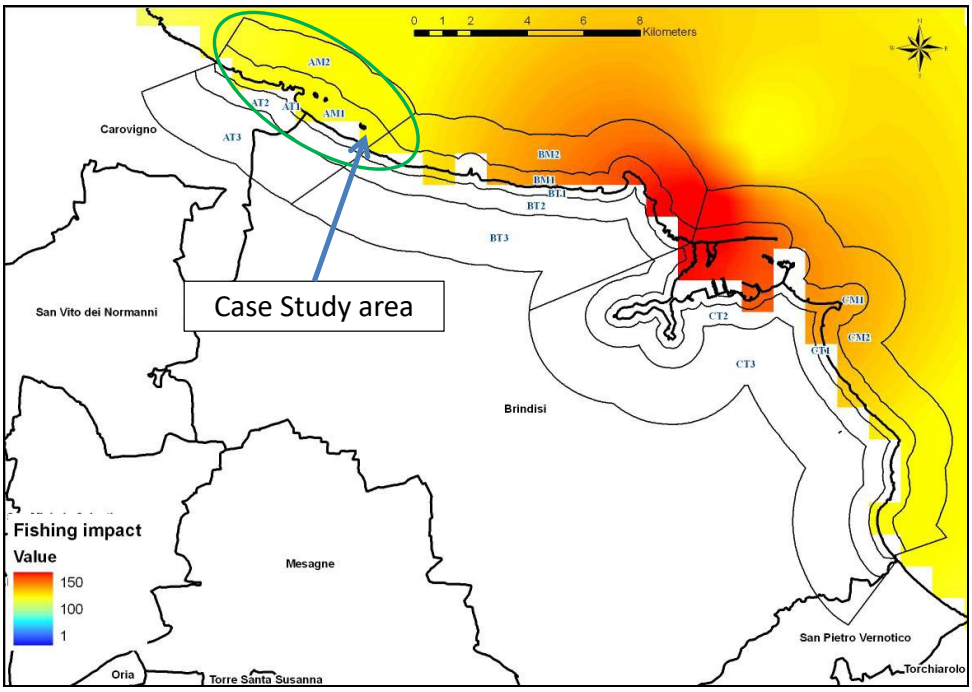


Fig. 3: Distribution probability of the small fishery pressure in the study area.

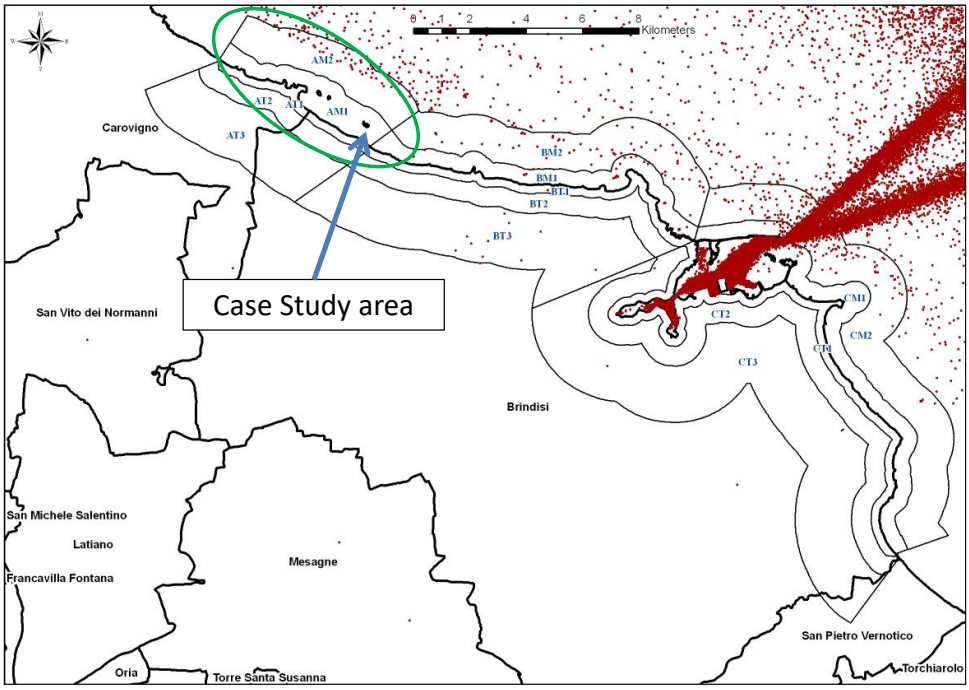


Fig. 4: Distribution of marine traffic in the study area during the year 2012 (data source: Marine Traffic.com).

The MPA coast, mainly rocky with some small beaches, is characterized by a rocky plateau that slopes from the shore up to about 10-12 m of depth. Rocky bottoms alternate with sandy areas and *Posidonia oceanica* seagrass beds. From about 20 to 35–40m depth, coralligenous formations alternate with sand-detritic substrate, while detritic–muddy sediments widely dominate at deeper bottoms (Guidetti *et al.*, 2010).

Coralligenous Mediterranean habitat is considered the second most important subtidal “hot spot” of biodiversity in the Mediterranean Sea after the *Posidonia oceanica* meadows (Boudouresque 2004). For the many environmental and biological valuable elements provided by this habitat, it has been included in the Habitat Directive (EEC Reg. 1992/43, Annex I; Habitat code: 1170 Reefs) and more recently monitored as stated by the Marine Strategy Framework Directive (EC Reg. 2008/56). Coralligenous bioconstructions could build ups into two main different geo-morphologies: rims-structures on submarine vertical cliffs and banks-flat frameworks over horizontal substrata (Pérès and Picard 1964; Laborel 1987; Ballesteros 2006, Bracchi *et al.* 2014). The apulian continental shelf, as in the case of Torre Guaceto MPA, is characterized mostly by the second morphologies that develops on a horizontal substratum, highlighting small coralligenous outcrops distributed between 30 and 100 m of depth on coarse detritic or muddy bottom (Piazzi *et al.* 2019). This kind of bioconstruction is generically called “bank-type” coralligenous biogenic reefs.

2. GEOMORPHOLOGICAL MAPPING

2.1. Description of equipment and acquisition/processing techniques

Study case investigation through MBES (MultiBeam EchoSounder) was not planned, since a recent mapping was already available for the MPA of Torre Guaceto, as output of the BIOMAP Project (BIOcostruzioni MArine in Puglia), promoted by Puglia Region (Italy).

The mentioned project mapped and classified most of the Apulian coralligenous reefs, including those of the study case area of Torre Guaceto MPA (Fig. 5). The project results (shape files and maps) are available at the following link:

http://www.sit.puglia.it/portal/portale_rete_ecologica/ricognizione%20geositi/Download

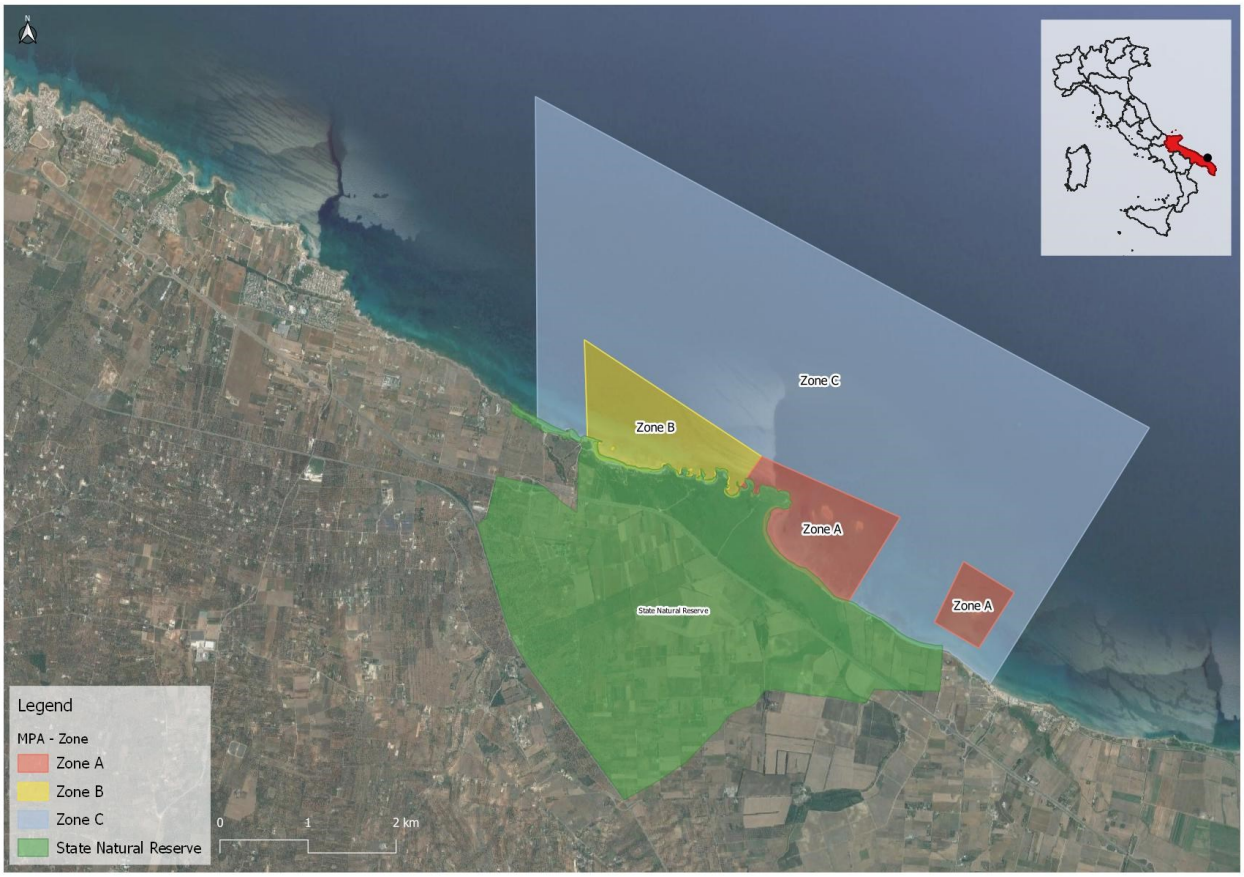


Fig. 5: Marine Protected Area of Torre Guaceto. Boundaries of protection regime and Coralligenous reefs classification from BIOMAP Project.

In order to identify a coralligenous bioconstruction required by the project, three sites have been investigated by dive during pre-surveys (carried out 28-29-30/08/2019 - Tab. 1Tab. 1, Fig. 6). The sites have been chosen matching the information achieved by BIOMAP project, the ones achieved during the past year of ARPA Puglia's monitoring activities and those available to the Torre Guaceto MPA's staff. The dives have been performed by four ARPA Puglia Scientific divers and one Torre Guaceto MPA's diver. In order to choose the best MPA natural reef for the purposes of the project, several environmental data and some video recordings have been collected during the scuba pre-surveys.

Tab. 1: Geographic coordinates WGS84 of the pre-survey stations.

Site ID	LATITUDE	LONGITUDE
Pre-survey 28/08/2019	N40.72172	E17.81147
Pre-survey 29/08/2019	N40.72320	E17.81580
Pre-survey 30/08/2019	N40.72754	E17.80965

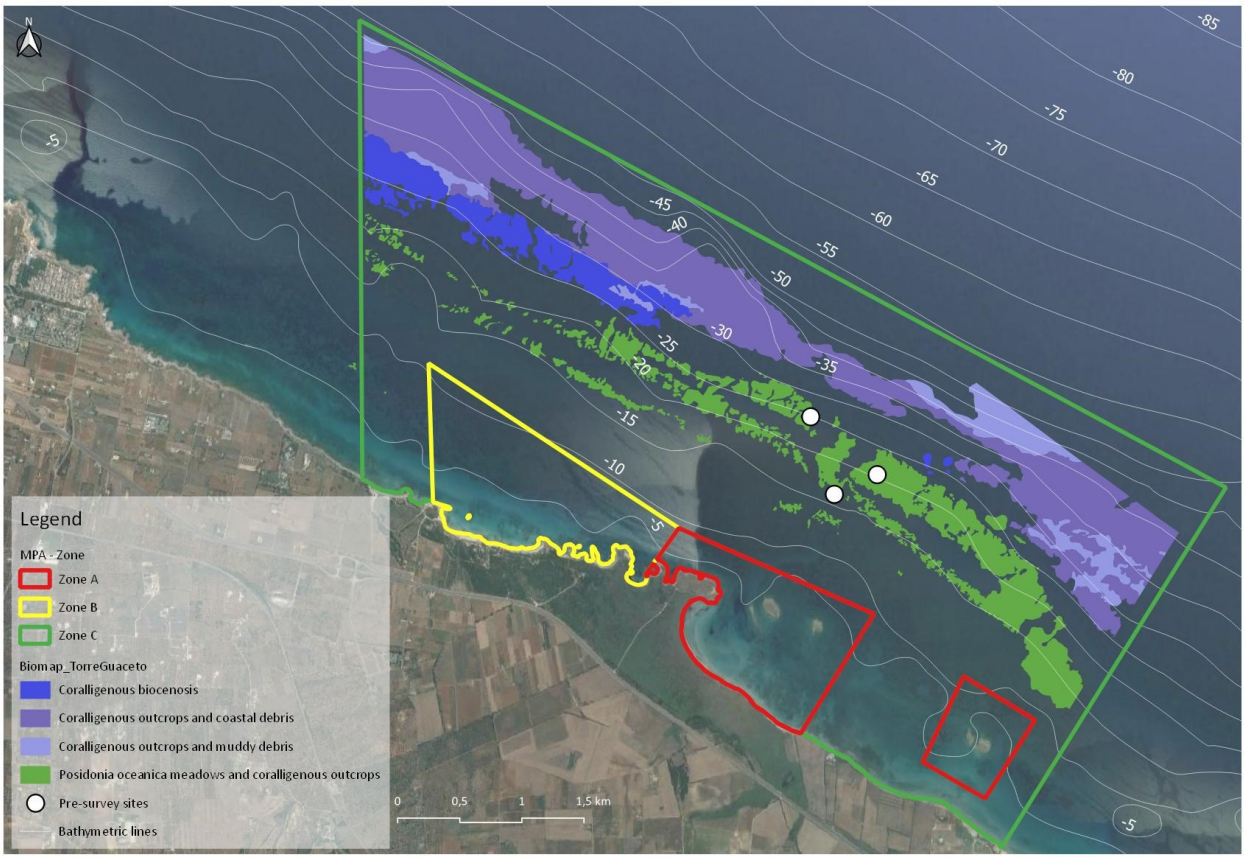


Fig. 6: Pre-survey sites, white dots

2.2. Survey results

According to BIOMAP project, four subtypes of coralligenous habitat were identified inside the Study Case area. Bank-type coralligenous is well represented into the area and different outcrops have been found.

During the pre-survey dives, different information has been acquired such as:

- presence/absence of coralligenous outcrops;
- presence/absence of a diversified fish community;
- presence/absence of a diversified benthic community;
- extension of the reef along a north south gradient;
- presence of a horizontal and sloped faces on the reef;
- depth.

The identified natural reef, as study site, is located 2 km far from the Ancient Watchtower, following a route of 60° N (Fig. 7).

Fig. 7: Location of the natural reef identified.

To better define the morphological features of the study site, a digital elevation model (DTM) in raster format have been developed. The attribute relating to the absolute quota has been associated with each pixel, the digital files have been provided by the Earth Sciences and Geo-Environmental Department of University of Bari. The DTM was subsequently managed with GIS software (Q-GIS ver. 3.16.0-Hannover) through which it was possible to extract the isobaths with an interval of 1 meter (Fig. 8 and Fig. 9).

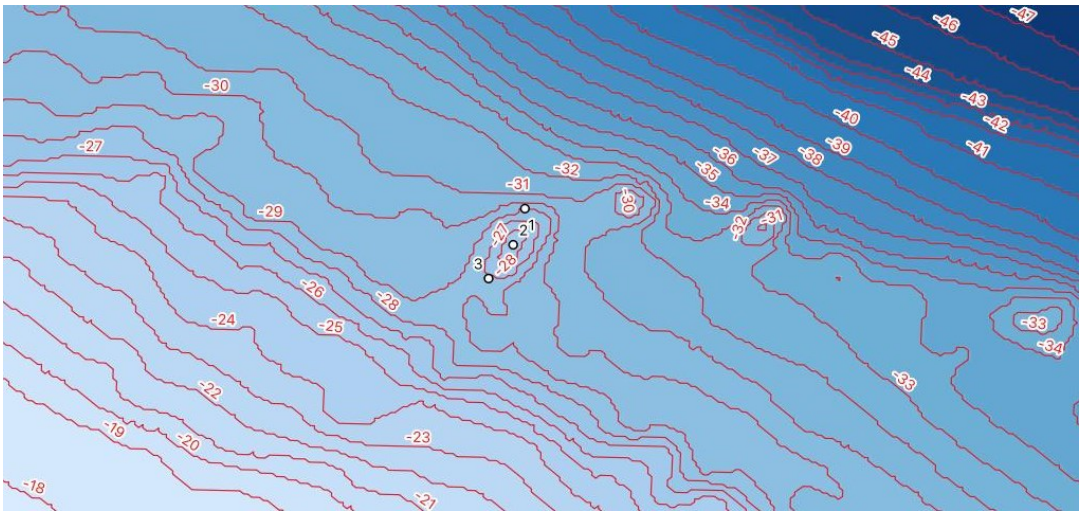


Fig. 8: Q-Gis map showing the DTM and the isobaths.

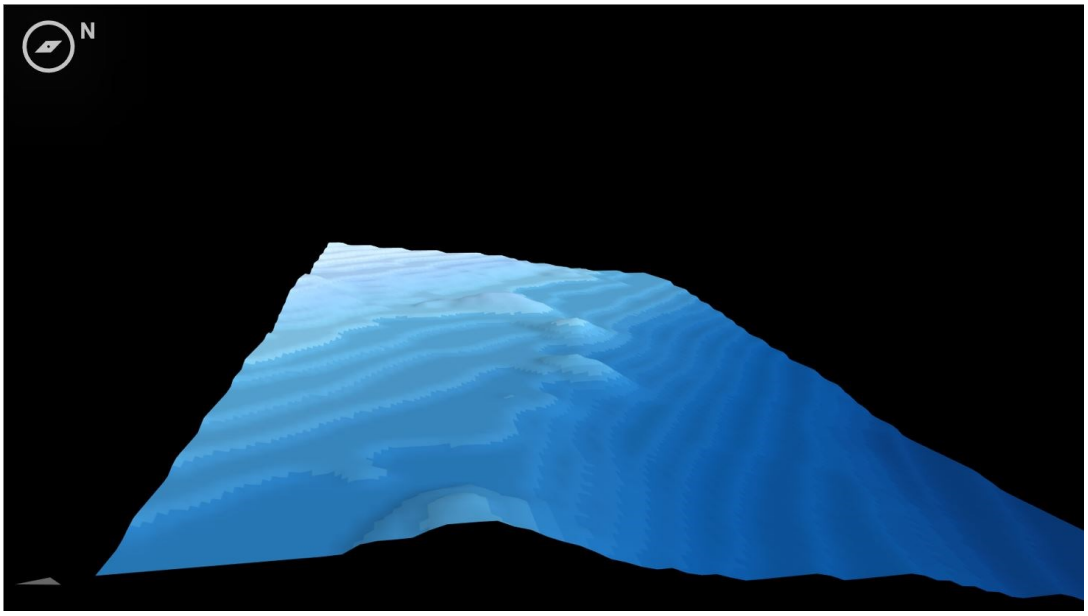


Fig. 9:Q-Gis picture showing the 3-D representation of DTM.

The geomorphological mapping shows the natural reef identified as composed by different bank-type coralligenous outcrops that create a raised structure with an overall elliptical shape, North-South oriented. This discontinues bioconstructions lay on a bathymetry between 27-29 m depth and the top of them is developed at 24-25 m depth. On the East side, there is a discontinuous vertical wall 3-4 m high. The estimated total surface of the reef is about 6,700 m², its perimeter is about 350 m and the longest axis is 140 m.

The reef, that falls into the C zone of the MPA, the 'buffer zone', so under partially level of protection, could be used both as a reference point to enlarge the knowledge of this kind of coralligenous formation, but also as a case study for the implementation of some activities, such as recreational diving, in an environmentally sustainable way.

The study site chosen satisfies the sampling design requested by the specific task of WP4, which provides the monitoring of the “Benthic community settled on the reef” and of the “Fish assemblage”.
The required needs to perform this monitoring are: a North-south gradient, the presence of horizontal and vertical faces and a natural environment suitable to host a diversified sedentary and vagile fauna as in the case of the coralligenous outcrops.
Along the longest axis, three sampling sites have been identified as reported Tab. 2 and in Fig. 10 and Fig. 11.

Tab. 2:Geographic coordinates WGS84 of the survey stations.

Site ID	LATITUDE	LONGITUDE
Station A, Nord	N40.72436	E17.82101
Station B, Middle/Central	N40.72393	E17.82087
Station C, Sud	N40.72353	E17.82058

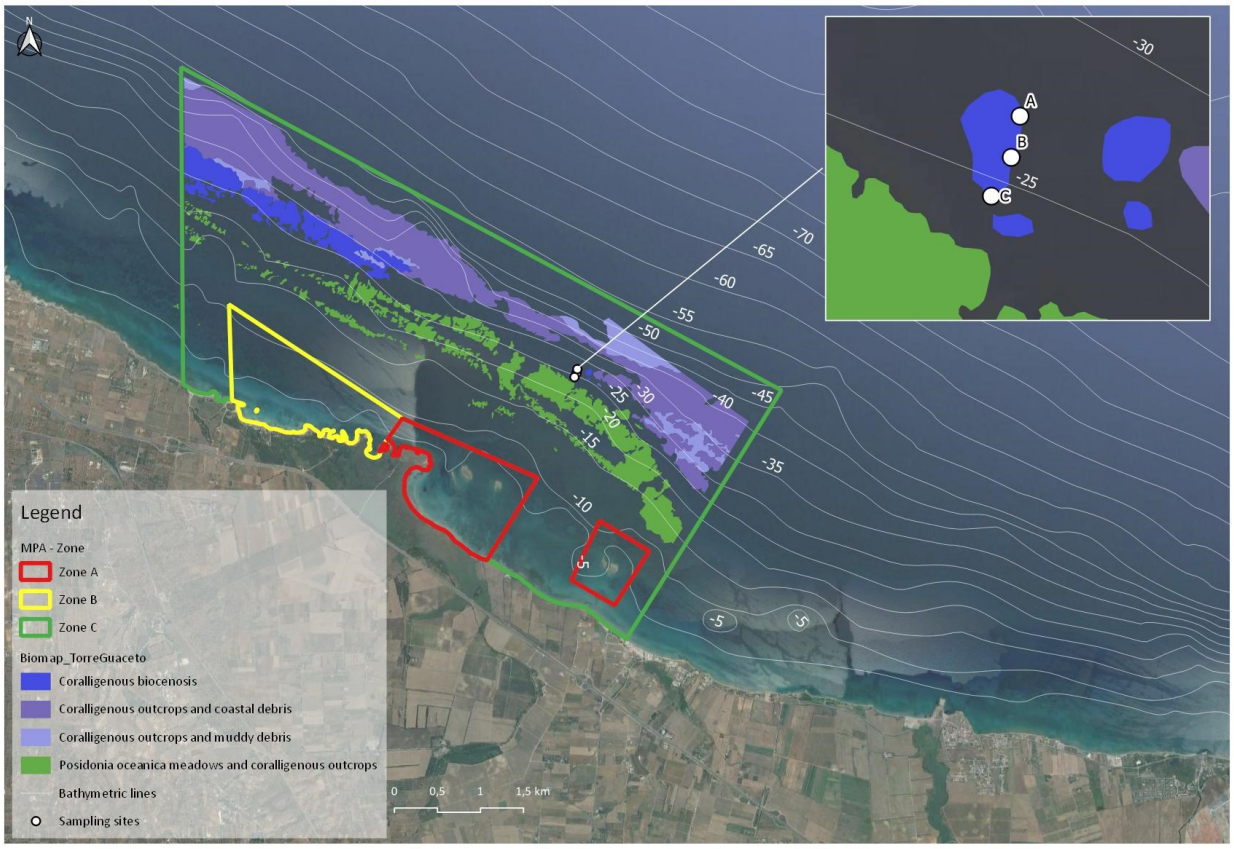


Fig. 10: Sampling sites (white dots).

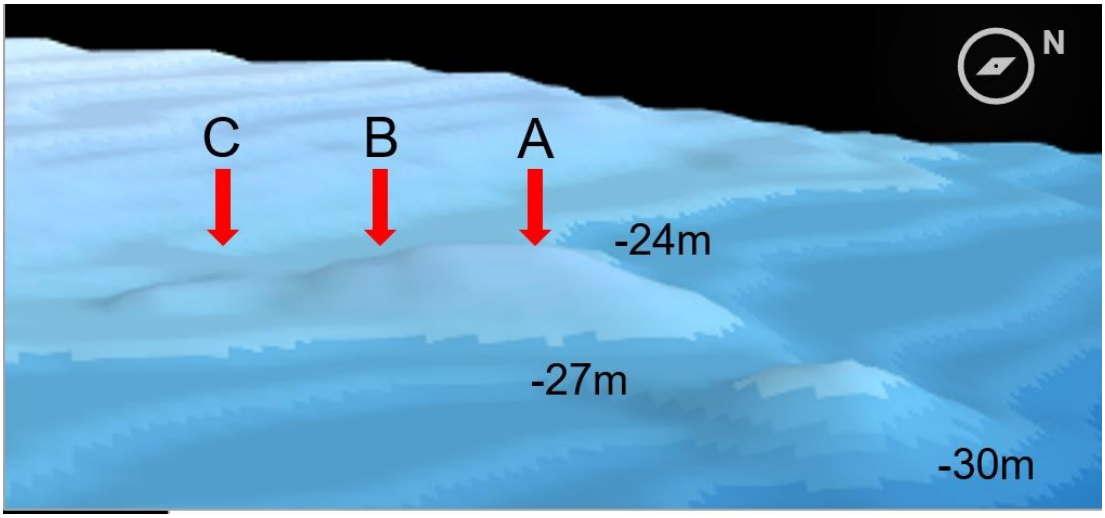


Fig. 11: Q-Gis elaboration showing the DTM and the survey stations localisation

Due to the relatively shallow depth of the study site and since the presence of seascapes and formations such as ravines and cavities created by the bioconstructions, the selected reef could be considered as a fine location for recreational diving activities.
Thus, the chosen study site could satisfy the needs for a future development of these recreational activities in the marine protected area, also with the support of qualified scuba guides.

3. SAMPLING TECHNIQUES AND METHODS OF ANALYSIS

3.1. Water column parameters

The marine water chemical-physical variables useful for the project were measured in a monitoring station codified as MC-TG 02, closed to the study case area.
The same monitoring station (coordinates WGS84: N40.72353 and E17.82489), located north of Brindisi at 1,750 m from the coast, is one of the no. 84 Apulian marine-coastal sites investigated according to the Water Framework Directive (WFD, 2000/60), as provided by the monitoring plan approved at regional level (Puglia Region, DGR n.1429 of 30/07/2019).
The aforementioned monitoring station is about 300 m far from the sites A, B and C of the investigated natural reef; during the WFD monitoring surveys, surface and bottom water (-33 m) samples were taken and some chemical-physical water parameters were measured (using a multiparametric probe mod. OCEAN SEVEN 316 plus – IDRONAUT along the water column), being representative of the study case area. (Fig. 12)

Fig. 12: Measurement of chemical-physical parameters by means of a multi-parameter probe and water sampling during autumn-winter time.

The physical-chemical parameters acquired by the probe were: Depth (m), Temperature (°C), Salinity (psu), pH, Dissolved Oxygen (%), Dissolved Oxygen (mg/l), Chlorophyll "a" (µg/l), Turbidity (NTU). The Transparency was measured by means the "Secchi Disk".
With regard to the trophic characteristics of the marine waters, the concentration of macro-nutrients was estimated in the same monitoring station; for this purpose, the water sampling was carried out at two depths, i.e. at -1 m from the surface and close to the bottom, using a NISKIN bottle 3 liters volume (Fig. 10). After sampling, laboratory analysis was carried out.
for the determination of Si-SiO4, N-tot, N-NH4, N-NO2, N-NO3, P-tot, and P-PO4.

3.2. Benthic community settled on the reef

One of the goals of the project-WP4 was the evaluation of the biological status of the reefs in terms of species assemblages and coverage and to provide information for recreational divers as well as for investigate on the attractiveness of the reef with respect to the marine benthic organisms. Moreover, since the project foresees as a priority the enhancement of available technologies with low environmental impact, different non-destructive investigation methods have been applied for the biological characterization of the reef.

For this purpose, a photographic sampling of standard areas frames was used as first method, with a stratified sampling strategy and taking into account the north-south gradient and the inclination of the reef. To satisfy the north-south gradient factor, three sampling sites allocated at the north, central and south-side of the reef have been identified along the study area's longest axis (A, B, C), with a distance from each other of 50 m (Fig. 10 - 11). The A, B and C sites have been identified during the first survey deploying an underwater transect 100 m long across the East side of the reef, close to the vertical wall.

The inclination factor includes two levels: "Horizontal face" and "Sloped face". The sampling sites have been located on the East side of the reef, where a discontinue vertical wall allows the operator to easily move between the two faces.

According to the above mentioned assumptions, no. 4 scientific surveys have been carried out, two in the autumn period (15/10/2019 - 12/11/2020) and two during the summer season (23/07/2020 - 08/07/2021) with a total of 72 photographic samples collected.

For the georeferencing of the natural reef and the photographic samples, a dive buoy has been equipped with a GPS Garmin Oregon 600, used by divers during the activities.

A Sony RX-100 VI camera, equipped with underwater housing (FantaSea) and underwater lighting systems (a SEA AND SEA YS-01SOLIS flash and a SUPE PV32-T Light mounted on Flex-Arm), was used for the photo acquisition. The camera was used together with a 21*29 cm square, to define the standard sampling surface area for the image analysis (Fig. 13).

The free software *PhotoQuad* v1.4 has been used for the Image Analysis of the benthic community (Fig. 14). *PhotoQuad* process 2D photographic samples, and it is dedicated to ecological applications as for the study of sessile benthic communities. The software integrates a set of methods for the extraction of the surface occupied by the single species (percentage coverage or presence/absence information), including the "grid cell counts (CL)" that consists in a grid of square cells with user defined unit cell area (ACL, cm^2) projected over the image's effective area (Aeff). In the same software, the image calibration tool provides a pixel to real-distance conversion factor (fclb pixels×cm−1), that allows the image scaling to metric units and the estimation of the surface occupied by the species and/or related descriptors (V. Trygonis & M. Sini, 2012). For the purpose of this study, a grid of square cells has been generated and superimposed on each photographic sample with the sampling surface area measurements (grid of 21x29 squares of 1 cm^2 each (ACL) for an Aeff of 610cm^2).

For the image analysis, a list of species was prepared as an excel file (composed by "SpeciesName" and "Phylum" columns) and uploaded in the software in order to link the marine organisms visualized in each image with a species name.

A reference number (Species ID and Group ID) for each species has been generated automatically by the software. For each recognized species the analysis outputs includes the species presence area, calculated as $Ai = Ni \times ACL$ (cm^2), and the species coverage, $Ci = Ai \times Aeff -1 \times 100$ (V. Trygonis & M. Sini, 2012).

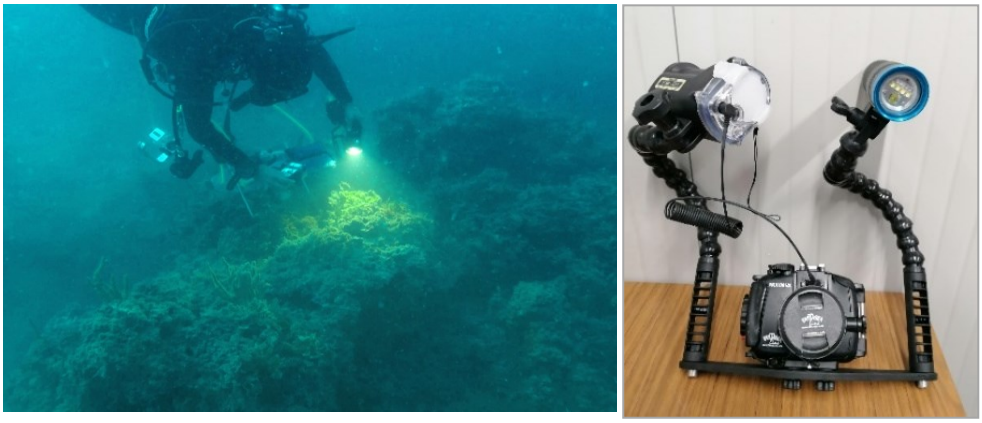


Fig. 13: ARPA Puglia SD during the photographic sampling survey and the Sony RX-100 VI camera used.

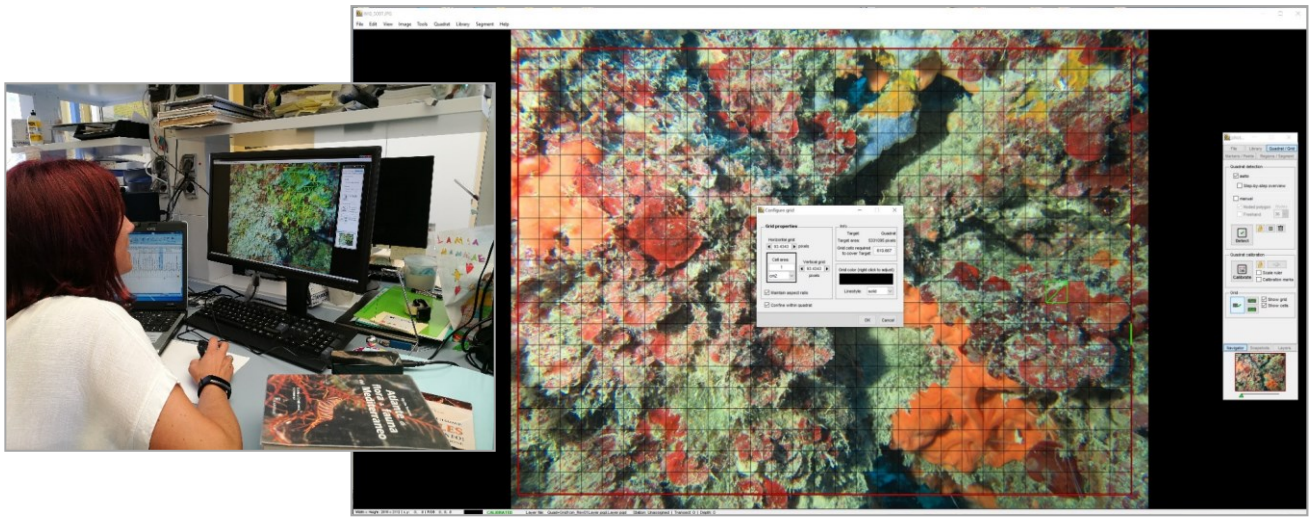


Fig. 14: Data analysis phase and PhotoQuad v1.4 software desktop.

Another task of the WP4 is the recognition of the possible benthonic ASPIM species present in the study site in order to create an underwater route with several points of interest. The route could be used by divers appropriately trained to collect data on presence/absence of habitat/species of interest. Thus, the involvement of citizens could be useful to improve the scientific knowledge (citizen science). According to this approach, data of the presence/absence and recognition of ASPIM or benthic species of interest for divers have been collected using three different methodology: 1) visual census along a belt-transect 100m length x 2m wide has been carried out in the second survey by scientific divers, moving through the A, B, C sampling sites; 2) during the third survey the same census have been performed using the ROV's video recording; 3) during the fourth survey videos have been recorded using GoPro 8 by the scientific divers moving at 1,5 m above the bottom, so framing a 2m belt-transect wide.

3.3. Fish assemblage

To describe the fish community (species composition and abundance), different methodologies are applied based on different sampling techniques. These can be divided into capture methods, mixed methods and non-capture methods. According to the environmental goals of the project and the provision for the use of monitoring technologies with low environmental impact, some non-destructive technologies and methods were applied in this investigation.

At first, methodology of the underwater visual census (UVC) with a Stationary Point Count in fixed monitoring stations has been chosen. This monitoring strategy followed two factors: the geographic exposition as north-south gradient (three sites corresponding to three sampling areas allocated at the north, central and south-side of the reef); the aggregation effect of natural reef, considering different levels of coralligenous patchiness and morphology (presence of canyons, height and morphology of the reef), the biological characteristics (presence of species, abundance, biodiversity, etc.) and the hypothetical attractiveness for recreational divers.

The monitoring of fish assemblages has been performed carrying out 4 seasonal surveys (15/10/2019 - 23/07/2020 - 12/11/2020 - 08/07/2021). The scuba activity involved simultaneously 3 underwater scientific operators on the three fixed monitoring stations previously identified (A, B, C) (Fig. 15).

During the operations, the scientific divers collected data on fish species and their size class (0-10; 10-20; 20-30; 30-40; 40-50 cm), within a visual range of at least 5 meters, using a PVC slate or a digital support (i.e. tablet) for data recording. The visual census total time was 20 minutes, 5 minutes for each direction N-E-S-W.

Fig. 15: Scientific Diver during the Visual Census method.

The underwater visual census was also carried out by a ROV (Remotely Operated Vehicle) during 2 surveys (13/11/2020 - 24/06/2021).

The ROV used, was equipped with a full HD video camera for navigation and supported by 2 other video cameras model GORPRO 8 and GOPRO MAX 360° mounted on it (Fig. 16).

Fig. 16: ROV activity

During the first survey (13/11/2020) n. 2 linear transects have been investigated by video, the first 240m long (TR1) moving among the sites A, B and C, the other 103m long to investigate the deepest and most external area of the reef (Fig. 17).

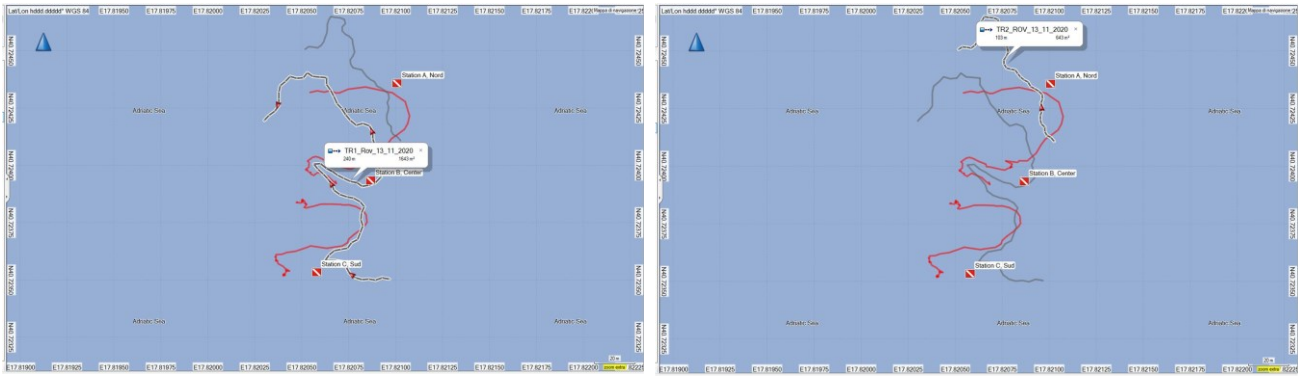


Fig. 17: Tracks recorded during the ROV activity in the first survey.

In the second survey (24/06/2021). both the two transects have been investigated by video, the first (TR1) 118m long between the sites C and B, the other (TR2) 147m long between the sites B and A (Fig. 18); moreover, 3 replicates of Visual Census in the fixed stations A, B and C have been made using the 360 ° camera.

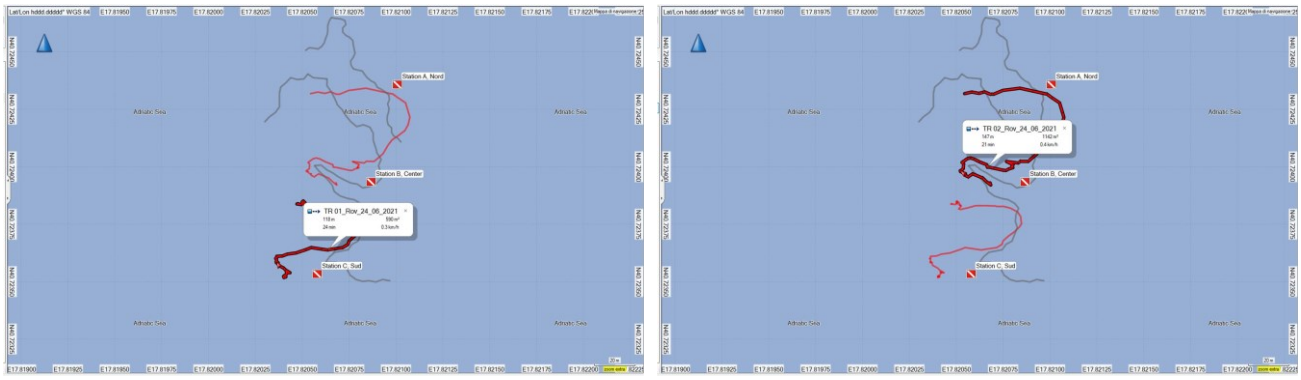


Fig. 18: Tracks recorded during the ROV activity in the second survey.

The combined use of both Scientific Divers and ROV was useful to verify the effectiveness of the different methods, comparing and cross-validating the data obtained by each of them.

Moreover, the obtained results through the use of ROV and video cameras (standard and 360°) can be shared by traditional media in order to promote the ADRIREEF project. The materials will be also useful for the preparation of informative outputs such as posters and roll ups, as well as 360° or 180° videos. These last two types of output can be reproduced through modern technologies such as Virtual Reality viewers as innovative tool. (Fig. 19).

Fig. 19: Video production and editing video 360°

4. RESULTS AND DISCUSSION

4.1. Water column parameters

The average values of the main chemical-physical parameters per each sampling day, recorded along the water column in the MC_TG02 monitoring station, are reported in the following Tab. 3.

Tab. 3: Average values of temperature, salinity, pH, dissolved oxygen (%), dissolved oxygen (mg/l), chlorophyll a and turbidity in the water column.

Survey	Monitoring Day	Temperature (°C)	Salinity (PSU)	pH	Dissolved Oxygen (%)	Dissolved Oxygen (mg/l)	Chlorophyll "a" (µg/l)	Turbidity (NTU)
feb-19	19/02/2019	11,21	37,94	7,65	106,36	9,18	0,59	7,28
mag-19	02/05/2019	15,95	38,52	7,81	108,25	8,45	0,58	4,79
ago-19	29/08/2019	27,40	37,97	8,05	98,73	6,30	0,27	3,22
ott-19	14/10/2019	22,48	38,38	7,91	100,45	6,95	0,41	4,65
dic-19	16/12/2019	15,25	37,28	7,60	102,40	8,16	1,46	5,24
gen-20	31/01/2020	12,66	37,60	8,10	102,75	8,62	0,81	3,88
mag-20	13/05/2020	15,37	38,74	8,24	107,21	8,45	0,22	1,13
giu-20	30/06/2020	20,98	38,58	8,18	106,23	7,56	0,33	1,21
lug-20	23/07/2020	24,53	38,85	8,16	100,53	6,69	0,20	0,71
ott-20	14/10/2020	21,10	38,82	8,17	96,96	6,85	0,27	0,75
nov-20	13/11/2020	18,24	38,22	8,11	103,86	7,77	0,66	1,59

As shown in the table, the minimum temperature value was recorded in February 2019 (11.21 °C), while the maximum value in August 2019 (27.40 ° C). The trend of the values is represented in the Fig. 20.

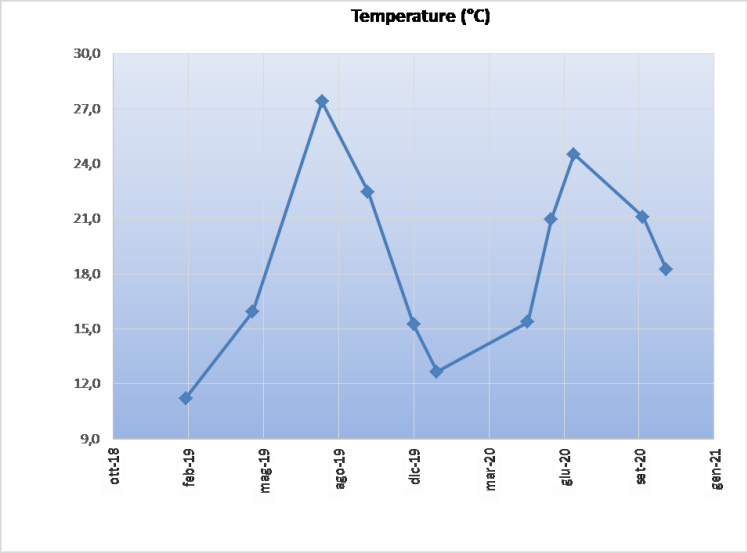


Fig. 20: Trend of the average temperature recorded along the water column.

Fig. 21 shows the trend of the average salinity, ranging between a minimum value of 37.28 PSU, recorded in December 2019, and a maximum value of 38.85 PSU, recorded in June 2020.

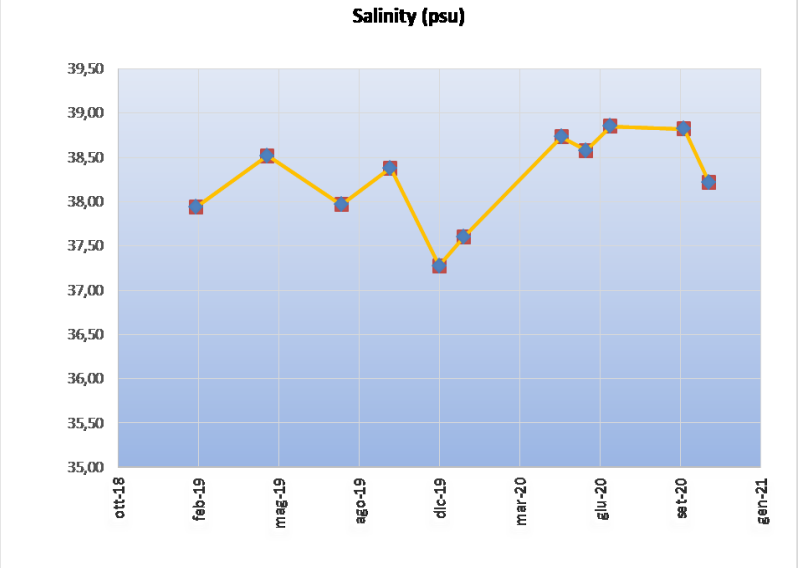


Fig. 21: Trend of the average salinity recorded along the water column.

As regards dissolved oxygen (saturation %), the maximum values have been recorded in May 2019 (108.25%) and May 2020 (107.21%), while minimum values in August 2019 (98.73 %) and in October 2020 (96.96%) (Fig. 22).

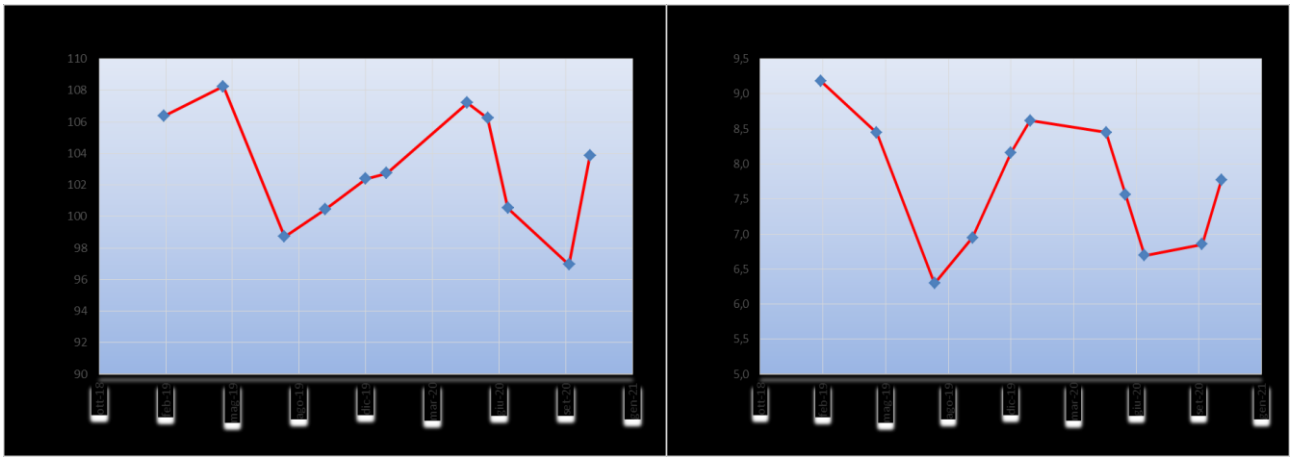


Fig. 22: Average dissolved oxygen trend (saturation percentage values) recorded along the water column.

As regards Chlorophyll "a", the measured concentration ranged mostly between 0.20 and 0.66 µg/l, except for the survey in December 2019 when a maximum value of 1.46 µg/l was recorded; this last value corresponds to a peak of turbidity (5.24 NTU) in the same monitoring day (Fig. 23, Fig. 24).

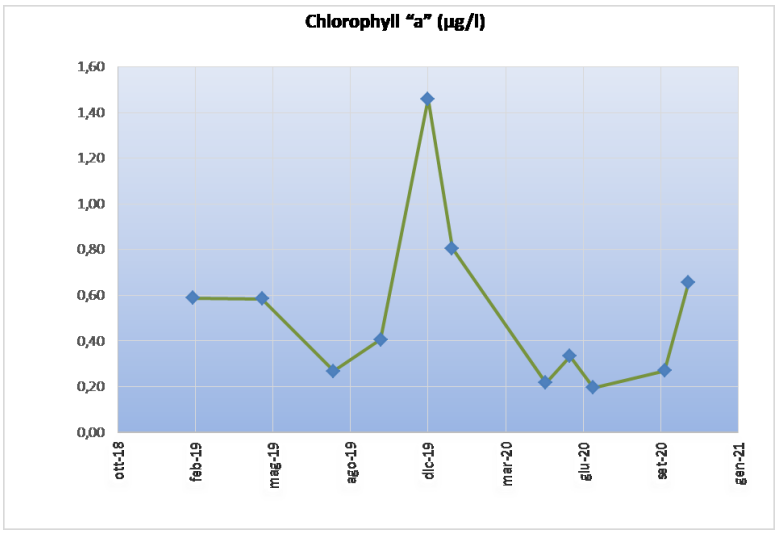


Fig. 23: Concentration average of Chlorophyll "a" recorded along the water column.

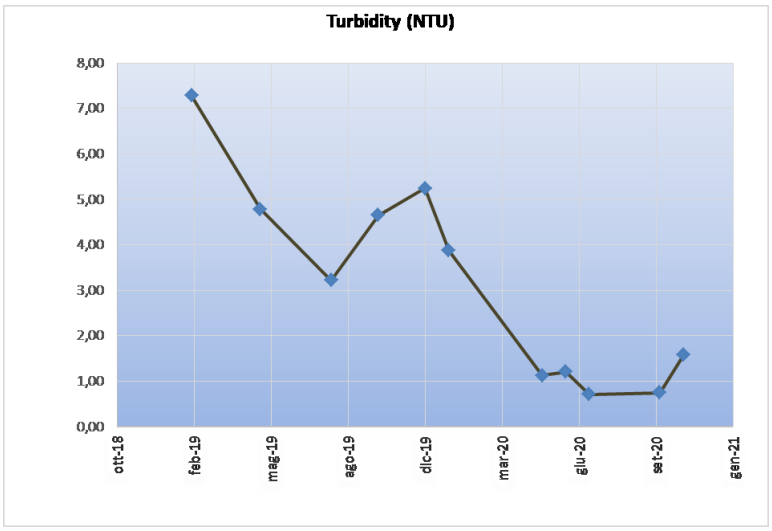


Fig. 24: Turbidity average of the water recorded along the water column.

As a rule, most of parameters were fairly stable along the water column except for the temperature profile dated 13/05/2020, highlighting a slight thermocline at about 10 m depth with a decrease of 2 °C, and the ones dated 30/06/2020, when a sudden drop of temperature at -5 m depth (about 3 °C) and a continuous decreasing trend until the bottom was recorded (the difference between the surface and bottom temperature values was 9°). The vertical profiles related the main chemical-physical parameters of the water column are represented in the following figure (Fig. 25).

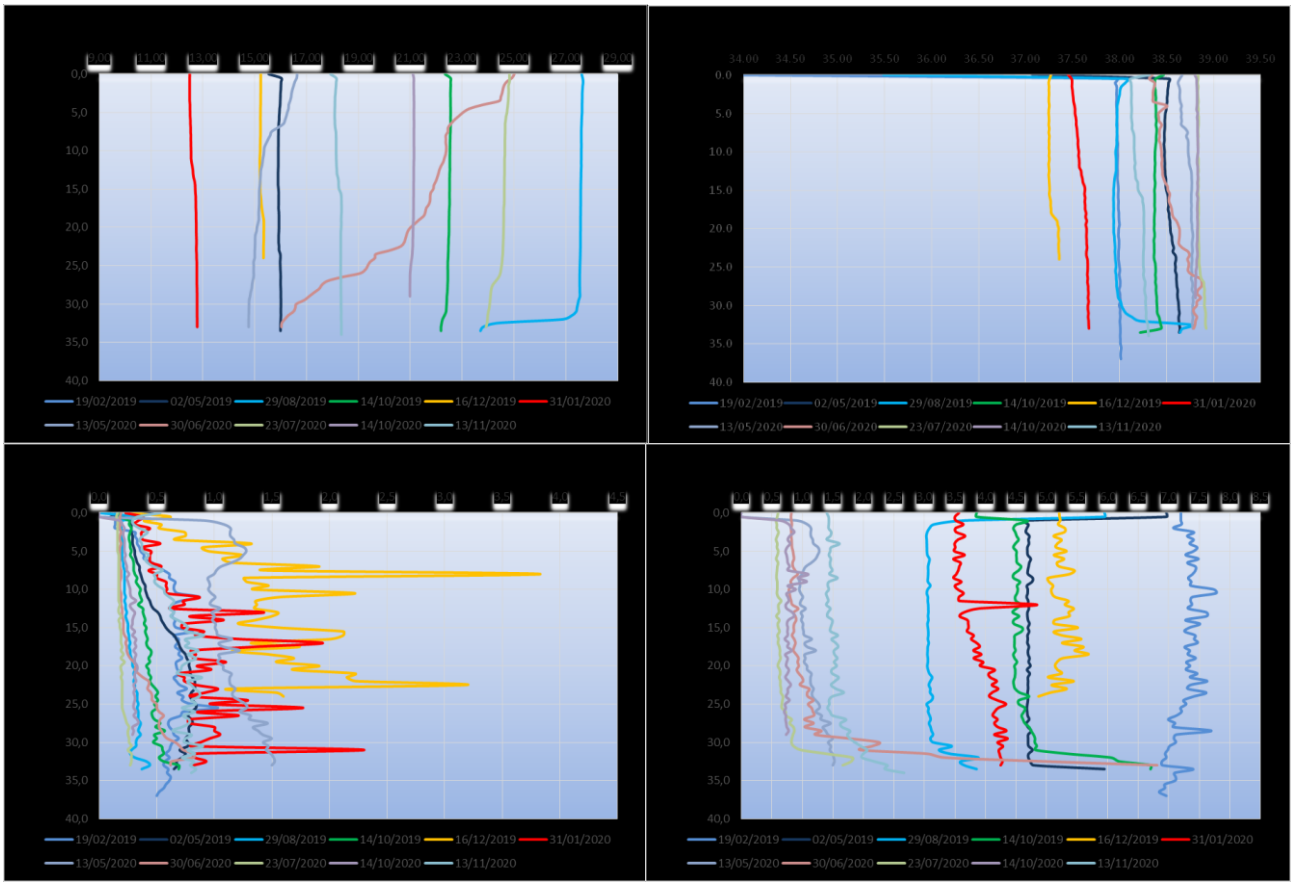


Fig. 25: Vertical profiles for the parameters Temperature, Salinity, Chlorophyll, Turbidity measured during no. 11 monitoring surveys.

The nutrient concentration values, obtained from the laboratory analysis of surface and bottom water samples taken during the monitoring surveys, are reported below (Tab. 4).
All values are within, showing a low risk of eutrophication for the study area.

Tab. 4:Nutrients concentrations at two depths (surface and bottom) in the MC-TG02 monitoring station.

DEPTH - 1 m							
Monitoring day	Si-SiO4 (µg/l)	N-tot (µg/l)	N-NH4 (µg/l)	N-NO2 (µg/l)	N-NO3 (µg/l)	P-tot. (µg/l)	P-PO4 (µg/l)
19/02/2019	63	109		7.3	36	5.4	
02/05/2019	28	99	18	< 2	31	< 5	< 5
29/08/2019	28	126	29	< 2	38	< 5	< 5
14/10/2019	< 20	266	< 10	< 2	< 5	< 5	< 5
16/12/2019	29	504	<10	<2	<5	<5	<5
31/01/2020	<20	515	<10	12	36	<5	<5
13/05/2020	32	1066	18	3	<5	23	<5
30/06/2020	<20	199	12	6	<5	<5	<5

23/07/2020	< 20	146	< 10	2	5	< 5	5
14/10/2020	42	105	12	3	<5	41	<5
13/11/2020	29	185	14	3	9	29	<5

DEPTH - 32 m							
Date Survey	Si-SiO4 (µg/l)	N-tot (µg/l)	N-NH4 (µg/l)	N-NO2 (µg/l)	N-NO3 (µg/l)	P-tot. (µg/l)	P-PO4 (µg/l)
19/02/2019	65	144	4.7	7	48	58.3	46
02/05/2019	29	120	< 10	< 2	< 5	< 5	< 5
29/08/2019	28	137	< 10	< 2	21	< 5	< 5
14/10/2019	< 20	283	< 10	< 2	< 5	< 5	< 5
16/12/2019	28	124	<10	<2	13	<5	<5
31/01/2020	21	585	<10	11	32	<5	<5
13/05/2020	43	1449	15	5	5	22	<5
30/06/2020	<20	177	<10	7	<5	<5	6
23/07/2020	33	129	< 10	5	< 5	< 5	< 5
14/10/2020	38	125	12	2	<5	39	<5
13/11/2020	26	135	15	3	7	31	<5

Nevertheless, the TRIX multi-metric index was calculated to estimate the overall trophic state of the marine waters in the study area; the index includes metrics related to dissolved inorganic nitrogen (DIN), phosphorus and chlorophyll concentration, as well as oxygen saturation.
The following Tab. 5 shows the results from the calculation of the TRIX index, expressed both as a single value (annual average) per sampling site and as an average value for the whole marine-coastal water body "AMP Torre Guaceto", with the respective quality class estimated for the year 2019 according to the established rules by the Italian Ministry Decree n. 260/2010.

Tab. 5: Year 2019: values and classes of the TRIX index referring to the sampling stations and the whole marine-coastal water body "AMP Torre Guaceto".

Water Body	Macrotype	Sampling site	TRIX Site (avarage)	TRIX Water Body (average)	Quality class for Water Body
AMP Torre Guaceto	Low stability	MC_TG01_(500)	2,8	2,8	Good
		MC_TG02_(1750)	2,9		

Based on the above data and information, the study site can be suitable for diving during the whole year, although July-September period remains the best for scuba activities due the higher water temperature and visibility.

4.2. Benthic community settled on the reef

In order to georeference the natural reef and an hypotetical underwater path, the photographic samples have been downloaded in Geosetter free software as a first project output (Fig. 26).

Fig. 26: GPS Garmin Oregon 600 tracks with the georeferenced photos (https://geosetter.de/en/main-en/)

The image analysis of 72 photographic samples acquired for the evaluation of the benthic communities (four surveys, three study sites; some examples in Fig. 27) give as a result the identification of 61 taxa (Tab. 6, Fig. 28, Fig. 29, Fig. 30). The most represented taxa were the red macroalgae (Rhodophyta) of the genera *Peyssonnelia* and *Mesophyllum*, considered as the main builders of the coralligenous bioconstructions. Moreover, filamentous algae (AF), the so-called "Turf", are the second group recognized, mostly in the images from the summer surveys. Porifera is the third phylum most represented in the reef with 23 different taxa. Mostly of them are erected species as *Axinella cannabina*, *A. damicornis* or *A. polypoides*. These species are source of attraction for divers as they can have different shapes and host different associated organisms, such as the nudibranchs (i.e. *Phyllidia flava*). Another commonly recorded porifera is an encrusting one, *Spirastrella cunctatrix*. Several erected Briozoa were identified also, the most common *Myriapora truncata* and *Pentapora fascialis*. As regards the Cnidaria, *Parazoanthus axinellae* and *Leptopsammia pruvoti* have been recognized, these species are very interesting for recreational scuba diving.

As the number of taxa identified among the three study sites does not differ significantly, the North-South gradient probably don't affect the species presence and distribution. Some differences have been instead appreciated according to the slope gradient, with a major number of taxa on the vertical face.

The green algae *Caulerpa cylindracea* is the only alien species recognized and it is present in a few photos, while among the ASPIM species *A. polypoides*, *A. cannabina, Sarcotragus foetidus* and *Spongia (Spongia) officinalis* have been found.

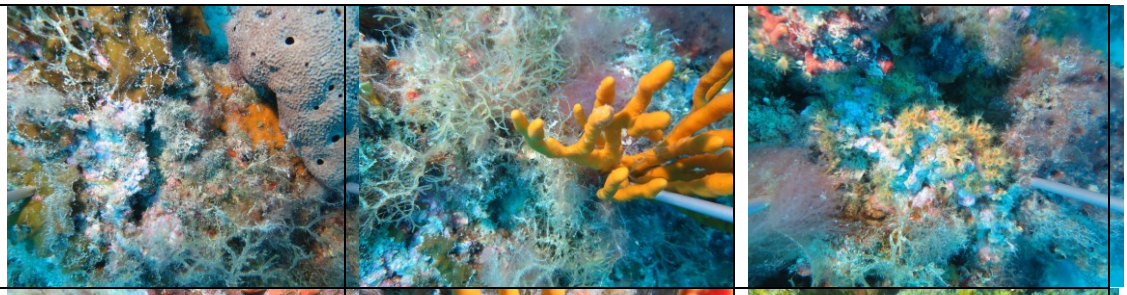
Horizontal face	
Vertical face	

Fig. 27: Example of photo samples collected on the horizontal and vertical faces.

Tab. 6: List of species identified and the relative cover percentage average across the 4 campaigns.

Media di Cover Percentage	Etichette di colonna			
Etichette di riga	1	2	3	4
Peyssonnelia	37.44	33.33	25.73	18.91
Mesophyllum	35.72	37.55	16.15	
AF	20.30	28.12	28.57	23.34
Lithophyllum stictiforme		40.78	0.98	
Spongia (Spongia) officinalis		9.99	16.38	
Dysidea fragilis	13.10			
Madracis pharensis			12.28	
Sarcotragus foetidus	18.01	3.77	13.84	12.53
Parazoanthus axinellae	27.02	3.36	1.64	8.55
Axinella polypoides	5.50	16.21	5.32	9.66
Zanardinia		8.68		6.26
Ircinia variabilis	4.59		10.07	
Spirastrella cunctatrix	4.47	5.32	7.85	8.46
Dictyota dichotoma	3.21	5.93		9.92
Phorbas tenacior	8.35	5.16	4.99	
Petrosia (Petrosia) ficiformis	2.51	1.47	10.41	
Axinella cannabina		3.11	8.02	
Flabellia petiolata	7.12	0.53	7.61	
Haliclona (Halichoclona) fulva	5.32			
Agelas oroides	3.03	4.91	5.57	
Ircinia oros		3.88		5.40
Florideophyceae	3.96	3.50	3.52	8.67
NC	2.37	2.71	5.06	5.98
Dysidea avara	0.66	0.98	9.01	
Sediments	3.28	2.98	4.22	0.76
Myriapora truncata	2.99			
Demospongiae	3.09	3.31	2.62	
Dictyota	1.64	4.34	0.33	
Halimeda tuna	2.29	2.72	4.59	
Cliona viridis	3.03	0.98	2.95	0.49
Eudendrium		1.64	2.95	
Cutleria	3.97	0.82	1.58	
MA	1.58	4.50	0.90	4.09
Haliclona (Soestella) mamillata	2.13			
Terpios fugax			1.97	
Cladocora caespitosa				1.97
Didemnidae	1.88			
Gelidiales	1.80			
Caryophyllia sp.	0.82	0.98	2.17	
Crambe crambe	0.33	1.64	2.62	
Cheilostomatida	1.39	1.14	1.74	0.62
Ulvophyceae	0.82	1.28	1.28	3.11
Padina pavonica			1.31	
Axinella damicornis			1.31	
Halocynthia papillosa		1.31		
Adeonella calveti/Smittina cervicornis	1.72	0.49	1.15	
Acanthella acuta	1.80		0.49	
Laurencia		1.06		
Pentapora fascialis	0.98	1.15	1.06	
Palmophyllum crassum	0.98			
Hydrozoa		0.41	0.74	
Cliona schmidti	0.66			
Leptopsammia pruvoti	0.69	0.59	0.60	
Reteporella	0.82	0.41		
Caulerpa cylindracea		0.57	0.16	
Cliona		0.44	0.49	
Sabellida	0.33	0.40	0.15	0.16
Filograna		0.22		0.41
Terebellidae	0.44	0.16	0.15	
Valonia	0.33	0.16	0.16	0.16
Scleractinia			0.16	
Dictyota		0.16		
Rocellaria dubia		0.16		0.12

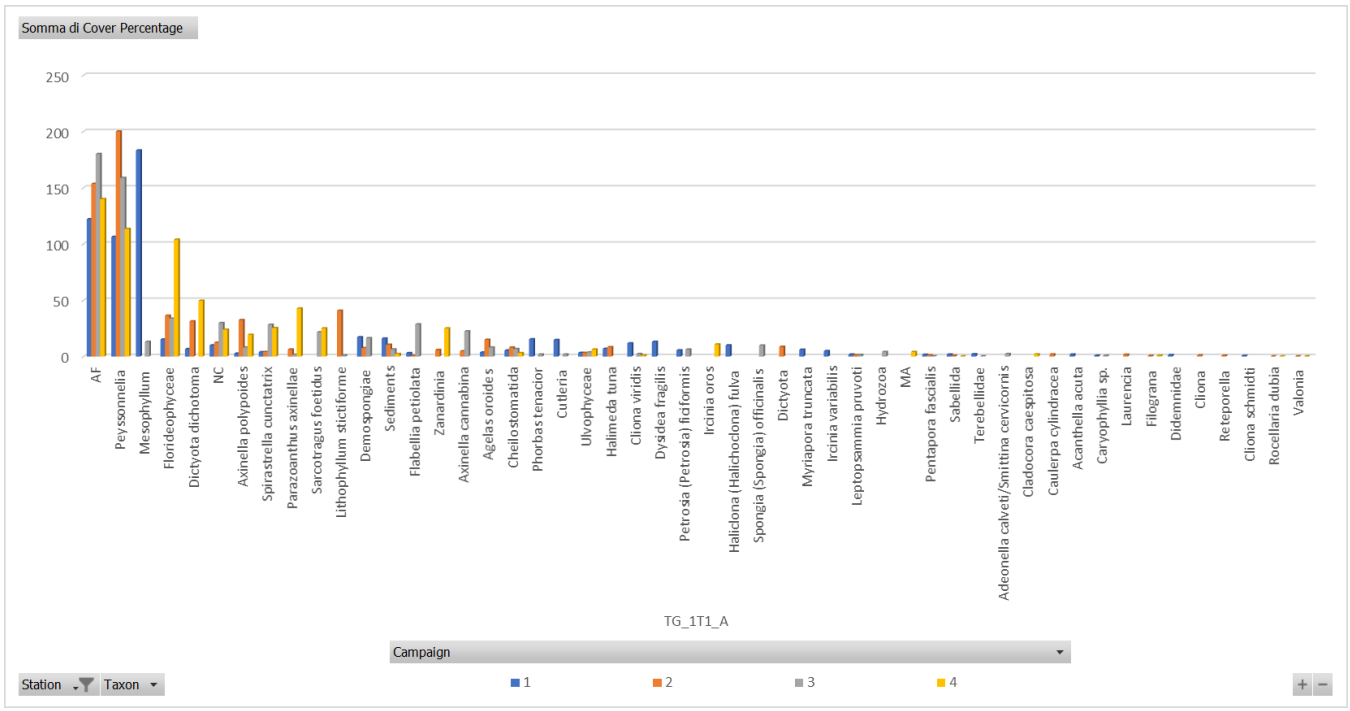


Fig. 28: Natural reef's benthic species cover percentage into the "A" sampling site, over the 4 surveys. AF= Filamentous algae; NC=Not classified, MA=Mucilaginous algae.

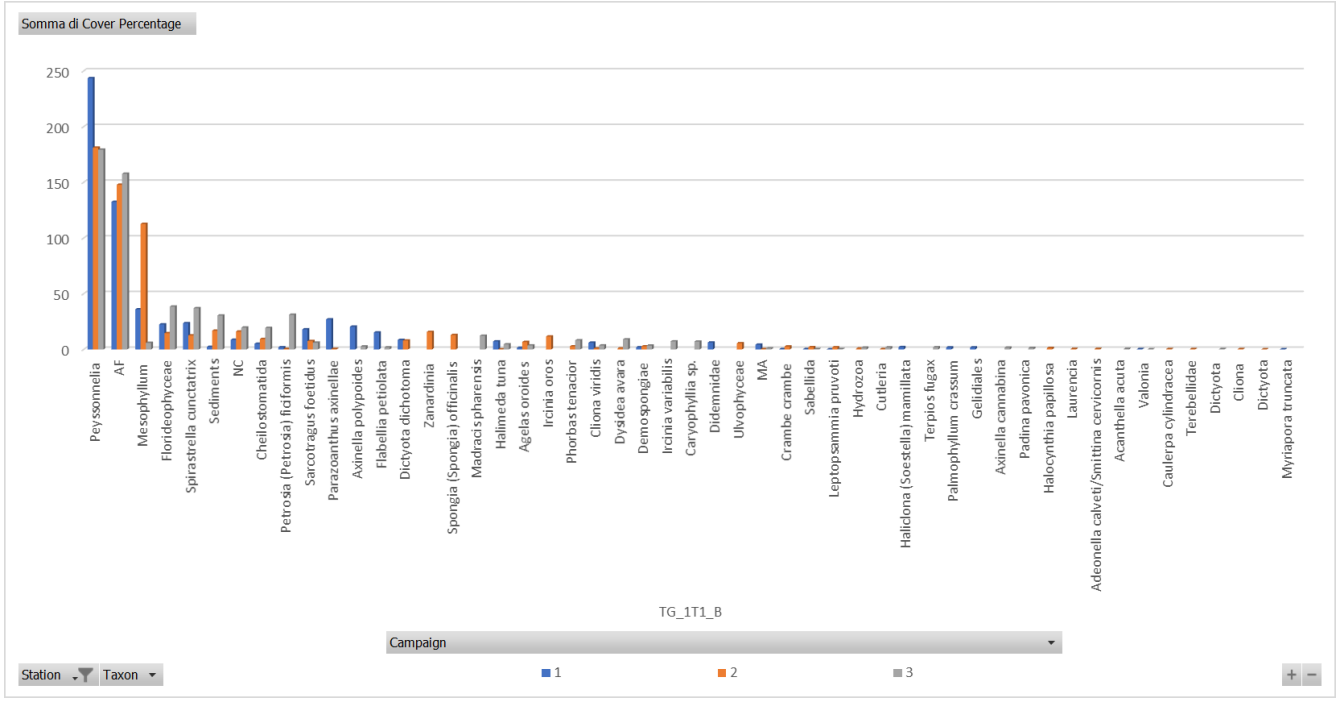


Fig. 29: Natural reef's benthic species cover percentage into the "B" sampling site, over the 4 surveys. AF= Filamentous algae; NC=Not classified, MA=Mucilaginous algae.

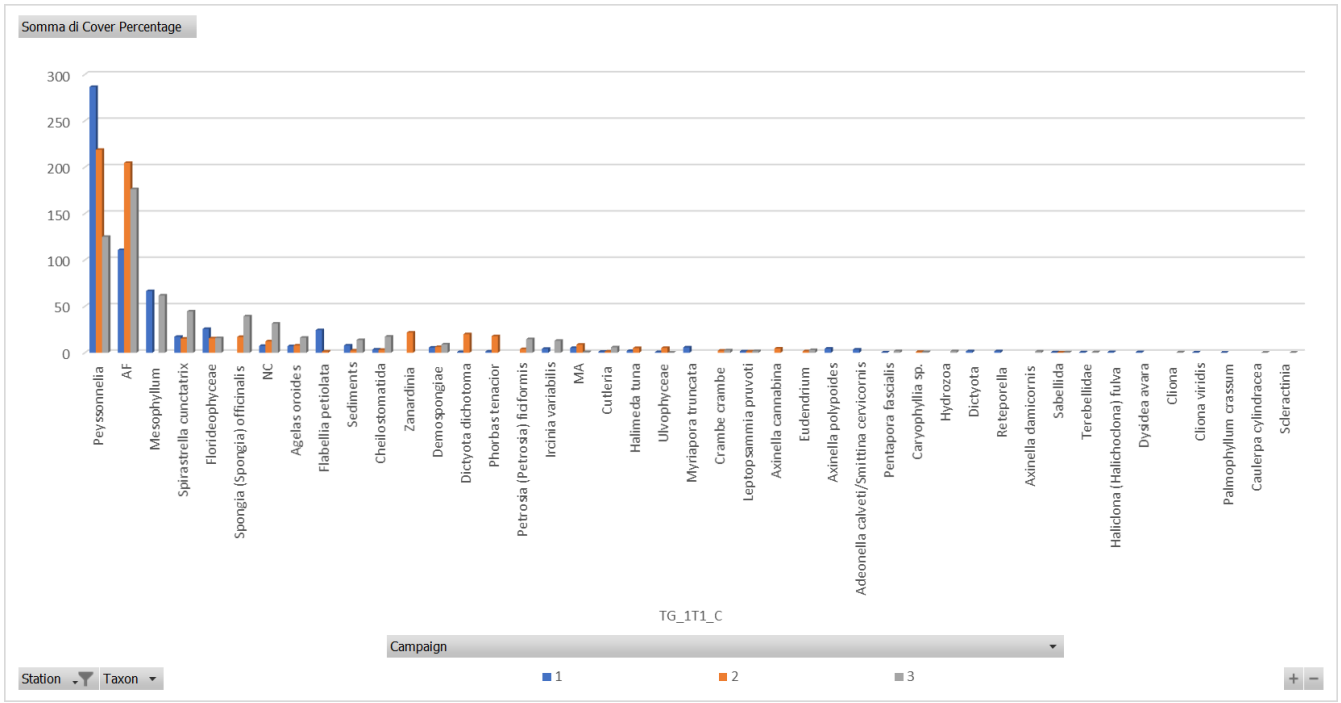


Fig. 30: Natural reef's benthic cover percentage into the "C" sampling site, over the 4 surveys. AF= Filamentous algae; NC=Not classified, MA=Mucilaginous algae.

some difference according to the used method. The greatest number of identified individuals can be recorded with the video transect methods, video camera ROV and the video camera held by the divers, in a similar value. Nevertheless, as a rule the diver's direct observation recognized a lower number of taxa but the species identification seems to be more accurate.

Thus, the video recording methods (by ROV or single camera used by divers) allows to obtain an effective information on absence/presence of marine organisms, while the direct observation by scientific divers allows to identify better, at the species level, the taxa living in the reef.

In conclusion, in the study case area no.17 ASPIM species have been identified: *Axinella cannabina, Axinella polypoides, Cladocora caespitosa, Hippospongia communis, Paracentrotus lividus, Sarcotragus foetida, Spongia agaricina, Spongia officinalis, Caryophyllia (Caryophyllia) smithii, Eunicella singularis, Eunicella cavolini, Leptopsammia pruvoti, Myriapora truncata, Muraena helena, Phorbas tenacior, Reteporella grimaldii, Sabella spallanzanii*.

4.3. Fish assemblage

Regarding the visual census about the ichthyofauna, the results obtained confirm the stability of the investigated marine environment. For all the species found, different size classes were observed, thus also highlighting a *pseudo* "normality" in the population distribution curves, indicating an apparent "climax" of the whole fish community.

The species identified during the visual census monitoring surveys and the number of individuals for each of them are reported in the following table (Tab. 7).

Tab. 7: Fish species and number of individuals identified during the visual census surveys.

TAXA	1° Campaign Autumn	2° Campaign Spring	3° Campaign Autumn	4° Campaign Spring	Total Individuals
Chromis chromis	200	233	727	1412	**2572**
Coris julis		25	21	23	**69**
Dentex dentex				1	**1**
Diplodus annularis		26		1	**27**
Diplodus sargus		13	8	8	**29**
Diplodus vulgaris	46	11	22	31	**110**
Mullus barbatus			2		**2**
Muraena helena	1	1			**2**
Pagrus pagrus		1			**1**
Sciaena umbra		8			**8**
Scorpaena porcus	2				**2**
Serranus cabrilla		16	25	27	**68**
Serranus hepatus		1			**1**
Serranus scriba		4	17	11	**32**
Spicara maena	60			60	**120**
Spondyliosoma cantharus		1	1		**2**
Symphodus ocellatus		6	4	3	**13**
Trypterigion melanurus			1	1	**2**

The most represented species in the visual census monitoring was *Chromis chromis,* found in all the four surveys with a total of 2572 individuals observed. *Diplodus vulgaris* was an other species frequently found, with a total of 110 individuals observed.

Several species have been recognized with a very low number of individuals, as in the case of *Dentex dentex*, *Muraena helena*, *Pagrus pagrus*, *Serranus hepatus*, *Spondyliosoma cantharus* and *Trypterigion melanurus*. Regarding this last one, the species does not exceed 5 cm length and usually remains hidden among the ravines of the rocks, so its recognition is not easy.

Other species were found in some surveys only, such as *Diplodus annularis, Spicara maena, Serranus cabrilla* and *Coris julis* even if the number of individuals was seasonally significant (Fig. 31).

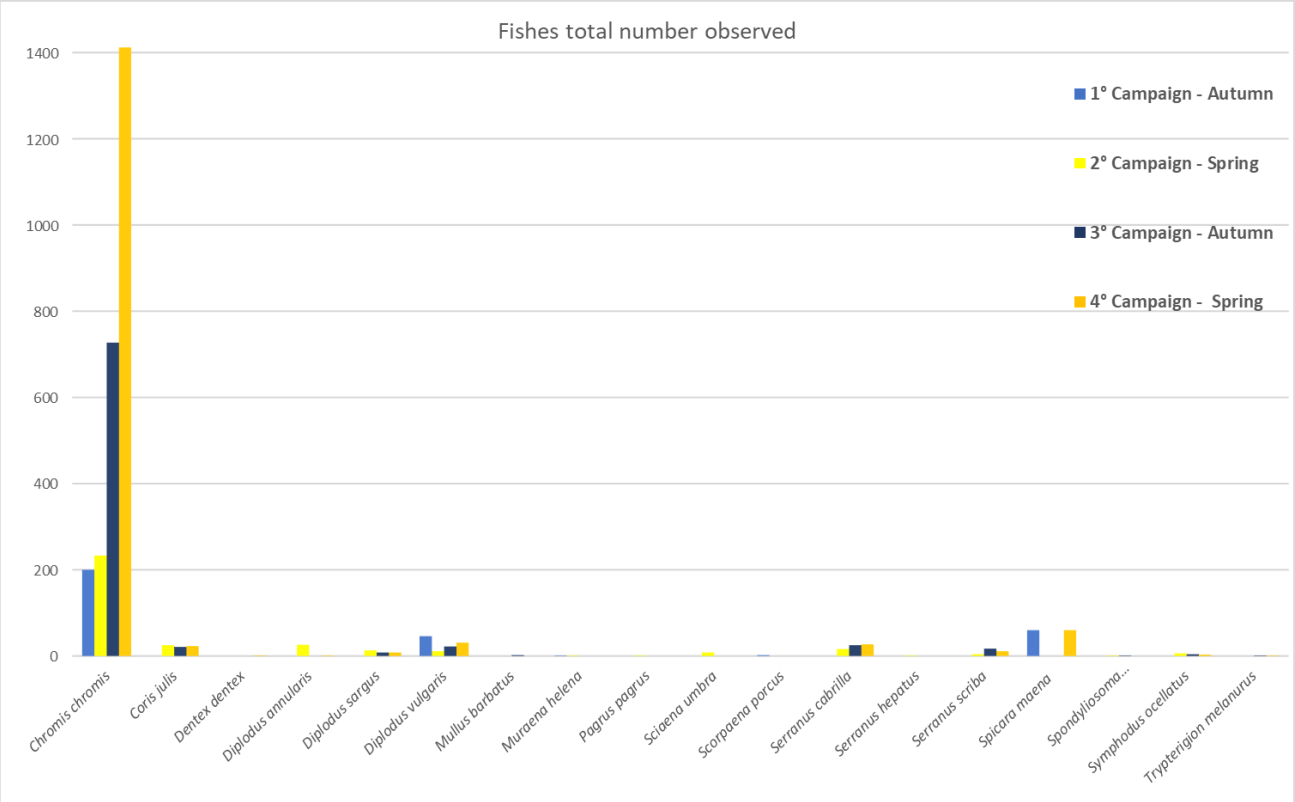


Fig. 31: Fishes total number observed during the surveys.

Most of the species appear to be sedentary or in any case closely linked to the presence of coralligenous outcrops, remaining the number of individuals quite stable during the different seasons as in the case of *Serranus cabrilla, Spicara maena, Serranus scriba, Diplodus vulgaris*, *Coris julis and Diplodus sargus* (Tab. 8). Same "flag" species as *Dentex dentex, Sciaena umbra* and *Pagrus pagrus* have been observed also, confirming the importance of the investigated reef as valuable natural habitat and biodiversity hot spot, useful for a sustainable recreational diving activity.

Tab. 8: Number of individuals belonging to the single species found in the autumn and spring surveys.

TAXA	Autumn	Spring
Chromis chromis	927	1645
Coris julis	21	48
Dentex dentex		1
Diplodus annularis		27
Diplodus sargus	8	21
Diplodus vulgaris	68	42
Mullus barbatus	2	
Muraena helena	1	1
Pagrus pagrus		1
Sciaena umbra		8
Scorpaena porcus	2	
Serranus cabrilla	25	43
Serranus hepatus		1
Serranus scriba	17	15
Spicara maena	60	60
Spondyliosoma cantharus	1	1
Symphodus ocellatus	4	9
Trypterigion melanurus	1	1

Regarding the use of ROV during the fish community visual census some critical issues have been highlighted, for example the disturbance by both the electric engines (noise) and the lights of the ROV; in fact, using ROV the fishes get scared and have the tendency to move away or keep away. Therefore, in the case of scarce visibility, the risk of underestimation or losing some information on fish species presence is very high. The same disturb take place also when a scuba diver descend in the water column, but only until the stabilization of diver position on the bottom; in any case, the impact of the diver with his bubbles appears to be lower with respect to the ROV. Probably, some forethought such as the camouflage of the ROV, as well as its painting with neutral colours, could be effective to improve data collection. In Fig. 32 a frame of the video recorded by ROV for the fish community visual census.

Anyway, the definition of the most appropriate monitoring methodologies could provide insights useful for the best management and study of these important marine habitats, also to improve the application of European Directives for the protection of the marine environments such as the Water Framework Directive (2000/60/CE), the Marine Strategy Framework Directive (2008/56/CE) and the Habitat Directive (1992/43/CE).

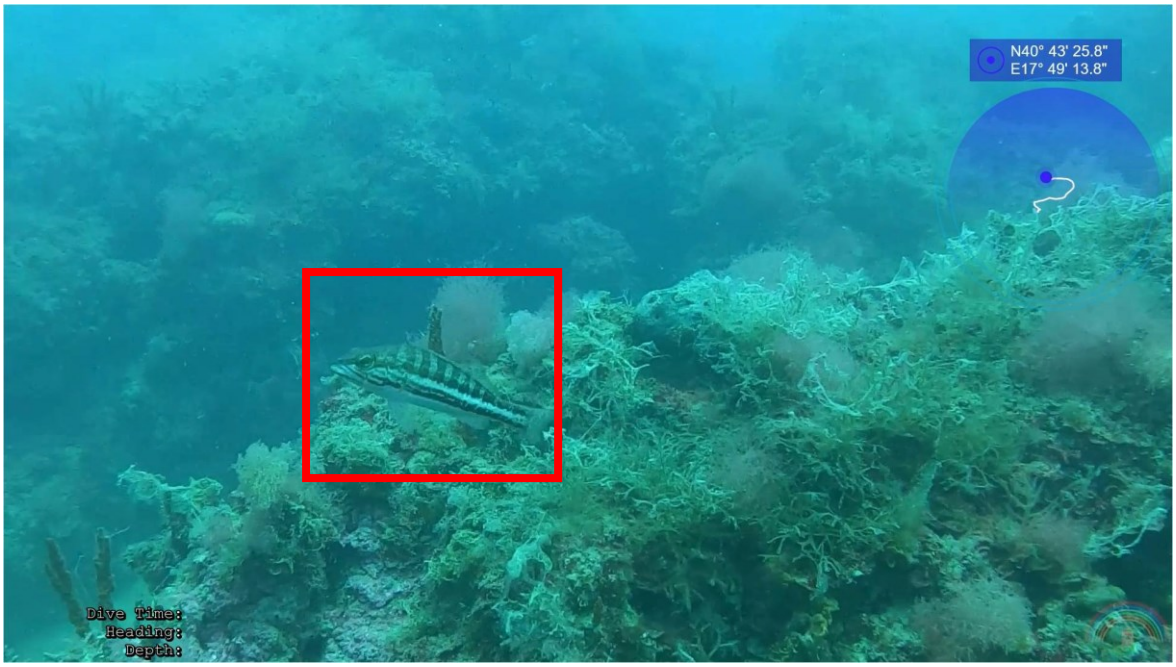


Fig. 32: Frame from video ROV, in the red square an individual of Serranus cabrilla

5. CONCLUSION

Given the results of the study case, considering the monitoring sampling strategy the selected site satisfies the purpose of the project and it can be considered highly suitable for a future tourist exploitation.
The data collected during the monitoring phase improve the information about the bank-type coralligenous bioconstruction present into Torre Guaceto MPA. The geomorphological mapping phase increases the knowledge of the coralligenous formations in the area.
The study site has been selected at shallow depths (maximum bathymetry -27m), which allow operators to dive for about 30 minutes remaining within the safety curve, being adequate for the recreational diving.
The data collected on water temperature show that scuba activities are possible all the year, of course during the coldest period using adequate diving suits; however, the best period to dive is late summer, due to the optimal temperature and water transparency.
From the point of view of natural beauty, the site shows some interesting peculiarities as fine seascapes and different formations such as ravines and cavities created by the bioconstructions, very attractive for recreational diving activities.
The analysis of the benthic community highlights a reef well preserved characterized by numerous species typical of the coralligenous habitat bioconstruction such as calcareous algae and porifera, bryozoans, etc.; in particular, the sponges of the genus *Axinella* are frequent and create a sort of forest, very interesting for divers. Nevertheless, it is worth of notice the abundant presence of filamentous algae on the bank bioconstruction, as well as a reduced presence of gorgonians.
Moreover, 17 ASPIM species have been identified by means the applied monitoring methods; the relatively high number of ASPIM species identified could be interesting for developing some citizen science projects combining the new exploration of the MPA reefs and the diving activities.
As regards the “fish assemblage” and the application of the visual census method, the data show variation between species and number of individuals observed. These results could be attributed to both natural factors (i.e. environmental conditions, biology, ecology and population dynamic of the species) and limiting factors of the monitoring technique used, including scientific diver’s difficulties in the species identification and counting due to scarce visibility.
Therefore, the data obtained, although indicative, could be consolidated with other and future studies.
Considering that one of the goals of the project is the collaboration with the MPA, it might be interesting to involve different stakeholders for a citizen science perspective. For example, fishing surveys could be carried out organizing “catch and release” trials, so collecting data on the weight and length of the fished specimens. Another way is the the possibility to open the zone at the recreational divers since currently only some activities such as swimming and snorkelling are allowed into the C zone, where is the case study site. Using special divers training and the presence of a guide, diving could be an innovative way to attract tourists into the MPA, and at the same time a tool to develop future studies on the MPA bioconstruction and the species associated, including the impact of scuba diving on the coralligenous habitat. Moreover, the open access to recreational divers can represent an accelerator for the local economy, given the high number of tourists frequenting the marine protected area.
Furthermore, the project allowed ARPA Puglia to improve its technical equipment, adding new tools useful for the operative and informative activities of the Agency.

The same video and photo materials collected during the monitoring phase will be useful for the preparation of informative outputs such as posters and roll ups, as well as interactive products; in example, it will be possible to create an interactive map where the users could interact with the GPS tracks, open the georeferenced photos and discover the benthic species in the study site, or with new technologies, such as 360° camera and Virtual Reality viewers, it will be possible to create innovative informative tools useful for teaching and for disseminating good practices for the sustainable management of the marine environment.

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