Report on the scientific survey operated with the UUV system in the first selected area

Activity 5.2 - Scientific surveys
WP5 - Ecosystem protection and sustainable fisheries

SUSHI DROP project (ID 10046731)

Final Version of 13/01/2022

Deliverable Number D.5.2.1

Project Acronym	SUSHIDROP
Project ID Number	10046731
Project Title	SUstainable fiSHeries wIth DROnes data Processing
Priority Axis	3
Specific objective	3.2
Work Package Number	5
Work Package Title	Ecosystem protection and sustainable fisheries
Activity Number	5.2
Activity Title	Scientific surveys
Partner in Charge	LP - UNIBO
Partners involved	
Status	Final
Distribution	Public

Contents

INTRODUCTION

The Adriatic is an oligotrophic sea with different levels of primary production in some parts, and the limiting factor is the low concentration of nutrient salts, primarily nitrogen and phosphorus (Jardas et al., 2008). Nevertheless, there are between 6,000 and 7,000 different species of plants and animals in the Adriatic, among which endemic taxa stand out, so the Adriatic is classified as a separate biogeographical entity of the Mediterranean Sea (Radović, 1999).

The natural balance in the Adriatic is mostly affected by the extremely high fishing effort, which is increasingly, directly and / or indirectly, leaving negative consequences for marine organisms. In order to establish sustainable management of renewable stocks, numerous fisheries regulation measures have been introduced, as well as systematic scientific research and monitoring of the condition of economically important communities in the Adriatic Sea (Vrgoč et al. 2008). However, all these measures apply only to the shallower areas of the Adriatic where the majority of fishing effort takes place. The deep parts of the Adriatic Sea are generally not covered by fishing regulation measures, and also, the fauna of the deep areas is poorly researched, especially in terms of community composition and population dynamics of species.

This work package is dedicated to the usage of the findings of the underwater drone system in surveying sea beds. Applications of the UUV technology in scientific research of marine ecosystems and fishery resources are just beginning. Up to 50 m deep, existing knowledge has been consolidated by several years of surveys performed with fishing gears or directly with divers; at greater depths difficulties increases because divers have physiological limits and there are rough bottoms where nets cannot be towed. Within WP5, the previously available scientific information on the Adriatic benthic biological communities will be collected by the scientific surveys, especially at depths greater than 50 m. Based on such review, two areas was identified in waters where information is poor due to environmental and logistic difficulties used to prevent a throughout analysis of the ecosystems. Such activity required the usage of the oceanographic vessels of the Institute of the Oceanography and Fisheries (Split) BIOS DVA which was used to bring and then control the navigation of the UUV in the selected areas and to perform the ecosystem monitoring with conventional technique.

Croatian fishing sea is divided in two areas: inner fishing sea and outer fishing sea. Outer fishing sea is divided in Croatian territorial waters with 4 fishing zones (A, B, C, D) and Croatian ecological protected zone (ZERP) with 4 zones (H, I, J, K). Inner fishing sea covers coastal part of Croatian territorial waters and is divided by 3 fishing zones (E, F, G); (Figure 1).

Figure 1. Fishing zones of Republic of Croatia (source: Ministry of Agriculture)

Fishing zone G covers 3965 km^2 which makes more than 10 % of Croatian territorial waters and is one of the most exploited fishing grounds in the inner sea of Croatian territorial waters. With division of 9 subareas, this zone represents almost 14 % of total Croatian catches, of which bottom trawlers catch is represented by 13 %. Planned research with UUV and trawling is planned in subarea G2 (Figure 1).

In the area of fishing subzones G2 and G3, the bottom is mostly sandy - muddy and muddy, and along the coast it is overgrown with meadows of *Posidonia oceanica*. The surface layer of the sea in this area is relatively cold due to the influence of the bura (North – Eats cold dry wind), so the surface temperature of the sea in winter drops to 9.4 ºC, while in the warmer part of the year it climbs to 25.5 ºC (Zore-Armanda, 1991).

The bottom trawl - koća is an extremely poorly selective gear that catches almost all organisms found on the trawl route during the retreat along the seabed. During trawling that lasts for several hours, the caught organisms become entangled in the openings (meshes) on the net and closing them, thus further reducing the already low selectivity.

The research was conducted in the part of the fishing zone G (between the islands Šolta and Drvenik), which is an extremely important fishing area for local professional, sport and recreational fishing. With this in mind, as well as the proximity of Split, this area is exposed to a very intensive fishing effort. The most important types of commercial fishing in this area are bottom trawl nets and purse seiners for catching small pelagic fish (sardines and anchovies). In the parts closer to the coast (especially in the part where trawling is not allowed), intensive coastal fisheries take place in this area, mainly using different set-nets. During the year there is an intensive recreational fishing, mostly angler fishing type and the target species in the catch are different species of Sparidae and especially European squid.

The majority of the zone G belongs to channel area and has been under restrictive fishing regime for many years: almost the whole area is closed to trawling from 01.04. to 31.10., yet even during open season the fishing is allowed only during daytime on Wednesdays and Thursdays, and engine power is limited at 184 kw. Also, there is also limitation based on depth range – bottom trawl fisheries are forbidden 1.5 NM from coast.

SUBJECT OF THE STUDY

The intensive exploitation of the most important commercial species undoubtedly affects the entire marine ecosystem which can lead to negative changes in qualitative - quantitative species composition of demersal communities. These changes can manifest themselves as degradation of trophic levels (overfishing down the food web), depletion of resources through excessive fishing effort, the destruction of natural habitats, and others. Also, the intensive exploitation can adversely affect the demographic structure of population, such as: length frequency structure, sex composition, biomass of adults, recruitment, etc. Furthermore, it should be kept on mind that the demersal species are potentially threatened by synergetic effect of different fishing gear, such as: bottom trawl net, setnets, traps and other gears. All these types of gear target the same important commercial species of different age structure in the entire exploited area, thus affecting the populations' recovery capacity.

Within SUSHI-DROP, a customized UUV is developed and equipped with acoustical and optical technologies in order to implement a non-invasive mean to assess environmental status of habitats, fish stocks population and, in general, to monitor the biodiversity of marine ecosystems. The final aim is to combine the georeferenced information gathered by the UUVs and the one related to the spatial extent and patchiness of fishing pressures to better understand the sensitivity of the habitats to those pressures and to design and implement more effective marine management plans. The development of such sensitivity analyses is becoming a priority for the preservation of the biodiversity in the Adriatic Sea.

The main goal of the research was to collect data on the state of demersal communities in the fishing zone G using different methodologies: conventional surveys with a trawl, sampling using divers and sampling using drones - as non-invasive sampling methods. Also, the aim is to compare the results obtained by different methods in terms of the quality of data collected, as well as the time and resources required for sampling. It will be stored in a georeferenced database.

METHODOLOGY

In the two study areas identified in the previous deliverable (D5.1.1 Report on the decision about the two survey areas to be selected to test UUV-based monitoring system), the new UUV-based monitoring technology, equipped with the suitable instrumentation, was tested. In the same two study areas, researchers collected samples by means of the traditional equipment usually used by the scientific research vessel. Maps of biological communities obtained by means of both traditional and new approach will be interpreted and the results will be analysed and compared, in terms of acquisition time, costs and productivity.

At the end of the fishing, the catch is classified into economically important species that are stored and discard, ie economically insignificant species that, mostly dead, are returned to the sea. Discard is mainly consist of economically insignificant species of invertebrates, such as various thorns, carp, shellfish, etc., and economically insignificant fish gardens that are considered inedible or small in size, and also of economically important species that have very little market value or their physical dimensions are less than allowed by law and therefore may not be placed on the market. The amount of discard in trawl catches in the northern and central Adriatic is relatively high and amount varies considerably depending on the area, technical and construction characteristics of the trawl, season and even the time of day (Vrgoč et al., 2008).
The data was collected in accordance with the plan set out in Application Form, in the following ways:

- Collecting data from the scientific research vessel in the fishing area G, with the aim to describe the state of resources using special trawl net used for MEDITS surveys named GOC 73

- Data collection through UUV

- Data collection through physical sampling (divers)

COLLECTING DATA FROM THE SCIENTIFIC RESEARCH VESSEL IN THE FISHING AREA G – TRADITIONAL TRAWLING

Analysis of biological samples using bottom trawl net included the species identification, then weighing of the total mass and counting the individuals of each caught species. The target species chosen for this study are the most important species of the Croatian commercial demersal fishery: common hake, red mullet, anglerfish, John Dory, thornback ray, poor cod, musky octopus, squid and broadtail shortfin squid. The total body length, than body weight, sex and gonad maturity stage were measured and determined to all target species organisms caught by net during sampling. If precise measuring of the total body length was not possible, due to anatomy of the measured organisms (for example, crustaceans and cephalopods), the length of cephalotorax or mantle was measured. During the study particular attention way paid to cartilaginous fish, because they are, due to their biology, extremely vulnerable to commercial fishery exploitation and are first to be eliminated from the food chain. For this reason, cartilaginous fish are referred to as indicator species for exploitation state of benthic communities.

In addition to biological sampling, oceanographic data on temperature and salinity of sea water and also the presence of marine litter, were measured and collected at each survey station.

All collected data were saved for further use, in specially designed database, in order to provide description of the qualitative and quantitative composition of demersal communities and demographic structure of the most important demersal species.

Figure 4.1. Traditional trawling with GOC 73 net and catches

The scientific fishery - biological research in the fishing area of zone G was conducted from July 11th to 16th using the research vessel BIOS DVA (henceforth: RV BIOS DVA). Research vessel BIOS DVA is a motor boat of 36.30 meters long with propulsion engine Cummins Diesel KTA38-M2, with power of 895 kW. She was designed in a way to support a wide range of oceanographic and fishery research, which are the main activity of the Institute for Oceanography and Fisheries. It is equipped with four A-frame hydraulic winches and folding hydraulic crane, three laboratories (wet, dry and microbiological lab) and electronics cabin. Six crew members are onboard and the vessel can accommodate up to 18 researchers at the same time. The autonomy of ship, at travelling speed of 11.8 knots, is 2000 Nm.

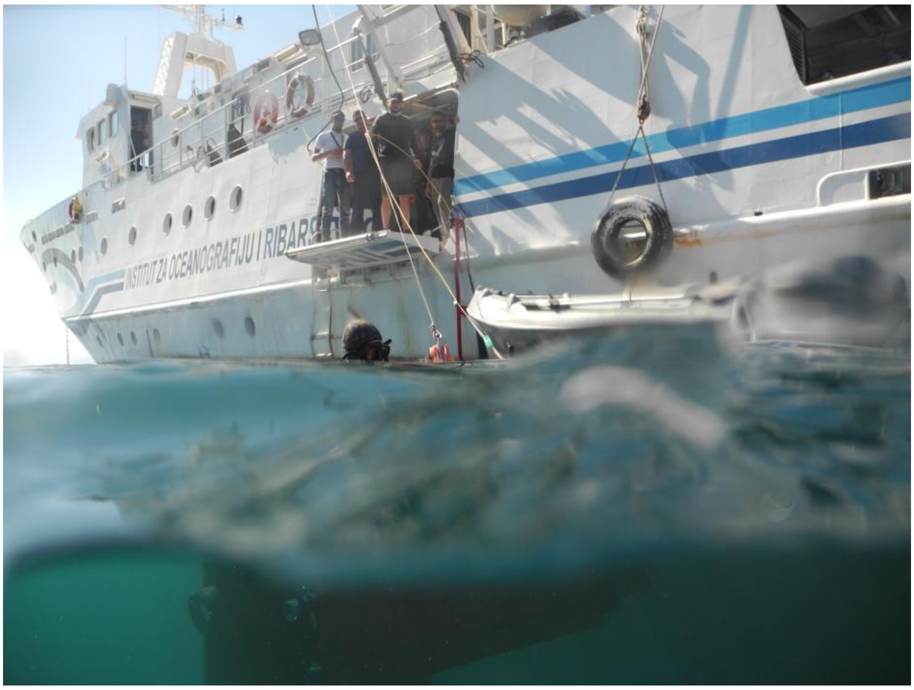
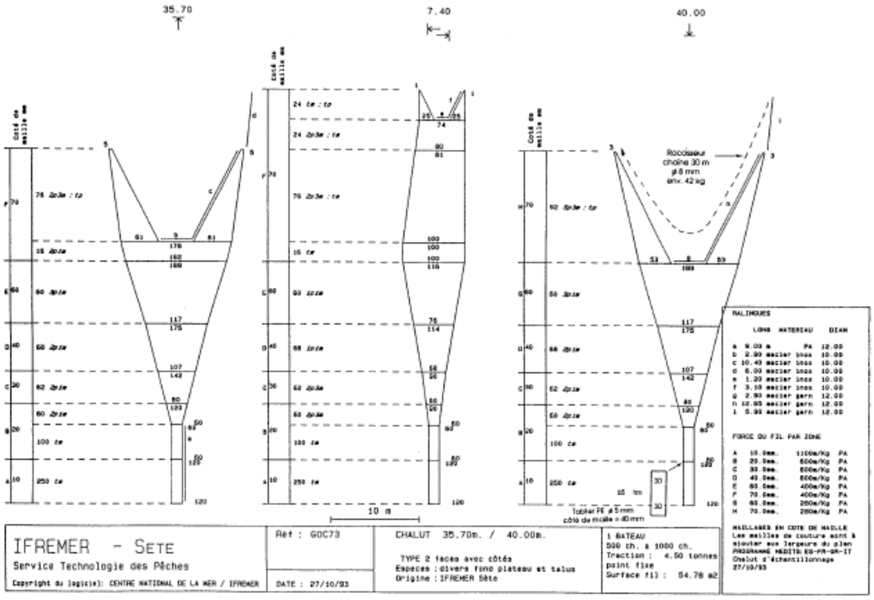


Figure 4.2. Scientific staff on BIOS DVA

Biological samples were collected with a deep bottom trawl (hut), type GOC 73 (Figure). This net differs in its technical and constructional features from the typical bottom trawls traditionally used in commercial fishing. The main difference is the mesh size at the codend of the net (saka net) which in GOC 73 is 10 mm from knot to knot, while in commercial fishing nets this opening is 20 or 24 mm, depending on the law on commercial fishing at sea . Furthermore, the GOC 73 has a larger vertical and horizontal opening at the “mouth of the net”, but poorer contact with the seabed than the typical leather mesh used in commercial fishing (Fiorentini et al., 1998).

Horizontal and vertical apertures and the position of the network in relation to the seabed were measured using the SCANMAR ultrasound system (Figure 4.3) (Fiorentini et al., 1994).



Slika 4.3. Schematic representation of the bottom trawl of the GOC 73 type hut used during the research within the SUSHIDROP project. (Bertrand et al. 2002)

The catch of demersal marine organisms was standardized per unit area using the so-called "Sweept area" method (Sparre and Venema, 1998). Biomass and abundance indices were calculated using an ATrIS computer program developed with the support of the FAO AdriaMed project (Gramolini et al., 2005) according to the Cochran (1977) equation, modified by Souplet (1996b): $I = \sum_{i=1}^{N} W_i \bar{x}$

Where;

$$\bar{x} = \frac{\sum_{j=1}^{ni} x_{i,j}}{\sum_{j=1}^{ni} A_{i,j}} \quad \text{and} \quad W_i = \frac{A_i}{A}$$

$\bar{x}$	the mean value of the measured samples per unit area in the stratum *i,*
Wi	relative weight of stratum in the total area of the study area,
A	total area of the research area,
N	total number of strata in the study area (*A*),
Ai	the area of each stratum *i,*
ni	number of hauls in stratum *i,*
Ai,j	surface of the stratum *j* in the stratum *i*,
fi	sampling fraction in the stratum *i*
xi,j	measured value in the haul *j.*

Catch structure of bottom trawl net

In period from 11th to 16th of May was conducted a survey with drone and traditional trawling. The length of sweep line was 100 m, and warpline between 300 and 500 m, depending on the sea depth. Horizontal net opening was 15 m to 16,5 m, and vertical 2,2 m to 2,4 m depending on the sea depth. Duration of the haul was limited at 30 minutes. Both hauls were made strictly during day which was defined as time period beginning 30 minutes after the sunrise, and ending 30 minutes before sunset. The cruise speed during the haul along the seabed was measured by GPS navigation system on the vessel and maintained at 3 knots. A total of 42 different species of organisms were caught, of which 25 species of Osteichthyes, 5 species of Chondrichthyes, 6 species of Cephalopods and 6 species of Invertebrates (Table 1).

Table 1. List of species in catches

Osteichthyes	Chondrichthyes	Cephalopods	Invertebrates
Boops boops	*Mustellus mustellus*	*Allotheutys media*	*Alcyonium spp*
Cepola rubescens	*Myliobatis aquilla*	*Eledone moschata*	*Astropecten spp*
Citharus linguatula	*Raja clavata*	*Illex coindetii*	*Marthasterias glacialis*
Diplodus annularis	*Squalus acanthias*	*Sepia elegans*	*Stichopus regalis*
Engraulis encrasicolus		*Sepia officinalis*	*Paguridae spp*
Lepidotrigla cavillone			
Lophius budegassa			
Merluccius merluccius			
Gadus merlangius			
Mullus barbatus			
Pagellus acarne			
Pagellus bogaraveo			
Pagellus erythrinus			
Sardina pilchardus			
Scomber colias			
Scorpaena notata			
Serranus hepatus			
Spicara flexuosa			
Spicara smaris			
Trachurus meditteraneus			
Trigloporus lastoviza			
Uranoscopus scaber			
Zeus faber			

Table 2. Qualitative and quantitative composition of catches during trawl survey in fishing zone G

Total	Haul 1		Haul 2		Average		
	Kg/km2	N/km2	Kg/km2	N/km2	Kg/km2	N/km2	%
Boops boops	11.12	229	18.81	412	14.96	320	1.05
Cepola rubescens	0.27	23	0.59	46	0.43	34	0.03
Citharus linguatula	1.33	69	0.78	46	1.05	57	0.07
Dentex macrophtalamus	5.17	343	3.75	160	4.46	252	0.31
Diplodus annularis	3.07	92	2.65	69	2.86	80	0.20
Engraulis encrasicolus	4.21	389	9.84	755	7.02	572	0.49
Gadus merlangius	109.83	2654	0	0	54.92	1327	3.84
Lepidotrigla cavillone	17.48	1075	9.52	595	13.50	835	0.94
Lophius budegassa	22.74	23	0	0	11.37	11	0.79
Merluccius merluccius	57.25	389	38.95	297	48.10	343	3.36
Mullus barbatus	164.75	5034	178.48	5057	171.62	5046	11.99
Pagellus acarne	15.33	458	3.98	137	9.66	297	0.67
Pagellus erythrinus	217.38	4805	1.37	46	109.38	2426	7.64
Sardina pilchardus	98.44	7528	203.65	3776	151.05	5652	10.55
Scomber colias	0.27	23	0	0	0.14	11	0.01
Scorpaena notata	0.78	46	249.42	18901	125.10	9473	8.74
Serranus hepatus	8.83	870	2.11	46	5.47	458	0.38
Spicara flexuosa	35.47	1876	2.97	275	19.22	1075	1.34
Spicara smaris	10.71	458	44.85	2082	27.78	1270	1.94
Trachurus meditteraneus	17.34	801	1.69	92	9.52	446	0.67
Uranoscopus scaber	4.85	23	0.00	0	2.43	11	0.17
Trigloporus lastoviza	0.00	0	26.22	686	13.11	343	0.92
Uranoscopus scaber	0.00	0	1.51	46	0.76	23	0.05
Zeus faber	0.00	0	28.51	23	14.26	11	1.00
Mustellus mustellus	645.28	46	61.78	23	353.53	34	24.70
Myliobatis aquilla	5.72	23	205.94	23	105.83	23	7.39
Raja clavata	0	0	38.90	23	19.45	11	1.36
Raja miraletus	0	0	13.82	46	6.91	23	0.48
Squalus acanthias	36.61	23	38.90	23	37.76	23	2.64
Allotheutys media	1.83	412	1.69	389	1.76	400	0.12
Eledone moschata	11.58	69	8.56	46	10.07	57	0.70
Illex coindetii	8.47	92	4.71	69	6.59	80	0.46
Loligo vulgaris	10.21	92	4.58	69	7.39	80	0.52
Sepia elegans	0.32	46	0.73	69	0.53	57	0.04
Sepia officinalis	0	0	16.06	23	8.03	11	0.56
Alcyonium spp	0.73	23	0.92	23	0.82	23	0.06
Astropecten spp	6.00	46	16.15	137	11.08	92	0.77
Marthasterias glacialis	7.55	46	3.20	23	5.38	34	0.38
Stichopus regalis	33.13	114	32.17	137	32.65	126	2.28
Paguridae spp	0	0	10.57	23	5.29	11	0.37

Table 3. Average abundance and biomass of classes in catches

Total	Haul 1		Haul 2		Average		
	Kg/km2	N/km2	Kg/km2	N/km2	Kg/km2	N/km2	%
Osteichthyes	806.65	27207	829.66	33545	818.15	30376	57
Chondrichthyes	687.61	92	359.34	137	523.48	114	37
Cephalopods	32.40	709	36.34	664	34.37	686	2
Invertebrates	47.41	229	63.02	343	55.21	286	4

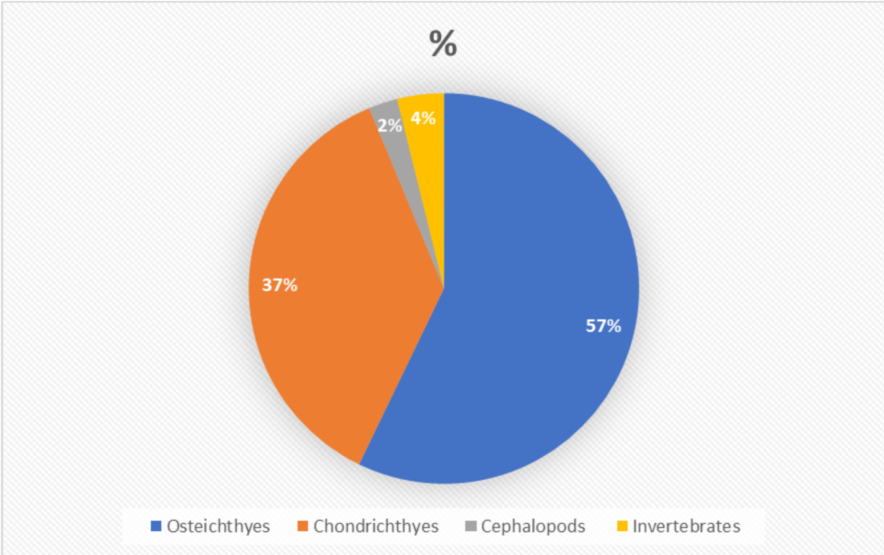
Of the total 27 fish species caught, 4 species belonged to the cartilaginous group and 23 to the bonyfish group.

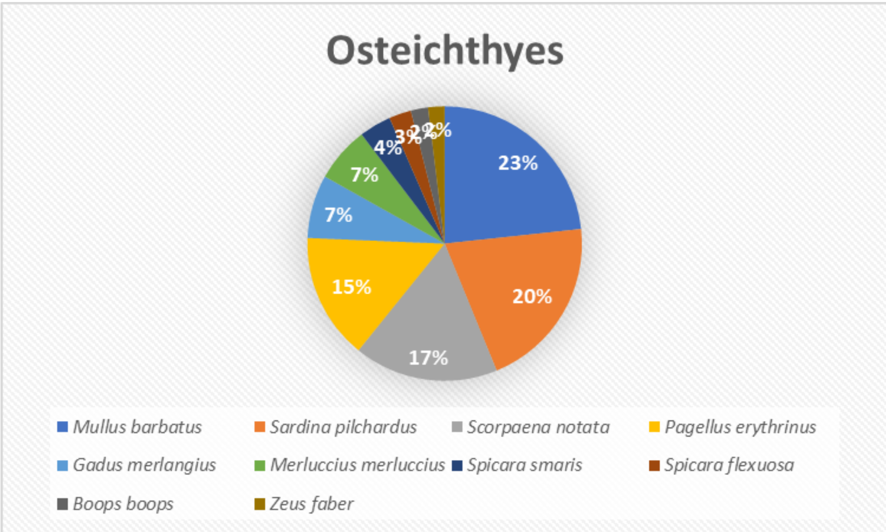
During the two hauls, a total of 125,30 kilograms of marine organisms were caught and 2747 specimens. After standardization, these values are:

- total biomass 1431,22 kg/km^2 and
- abundance 31643 N/km^2
- average biomass of bony fish was 818,15 kg/km^2 and average abundance 30376 N/km^2
- average biomass of cartilaginous was 523,48 kg/km^2 and average abundance 114 N/km^2
- average biomass of cephalopods was 34,37 kg/km^2 and average abundance 686 N/km^2
- average biomass of invertebrates was 55,21 kg/km^2 and average abundance 286 N/km^2

In catches, the most common species of bony fish by weight was *Mullus barbatus* (171,62 kg/km^2), followed by *Sardina pilchardus* (151,05 kg/km^2) and *Scorpaena notata* (125,10 kg/km^2). In the group of cartilaginous species, the most common species was *Mustellus mustellus* (353,53 kg/km^2), followed by *Myliobatis aquilla* (105,83 kg/km^2) and *Squalus acanthias* (37,76 kg/km^2). Cephalopods most common species were *Eledone moschata* (10,07 kg/km^2), *Sepia officinalis* (8,03 kg/km^2) and *Loligo vulgaris* (7,39 kg/km^2).

Most common species of bony fish by abundance were *Scorpaena notata*, *Sardina pilchardus* and *Mullus barbatus,* of cartilaginous species were *Mustellus mustellus*, *Myliobatis aquilla* and *Raja miraletus.*





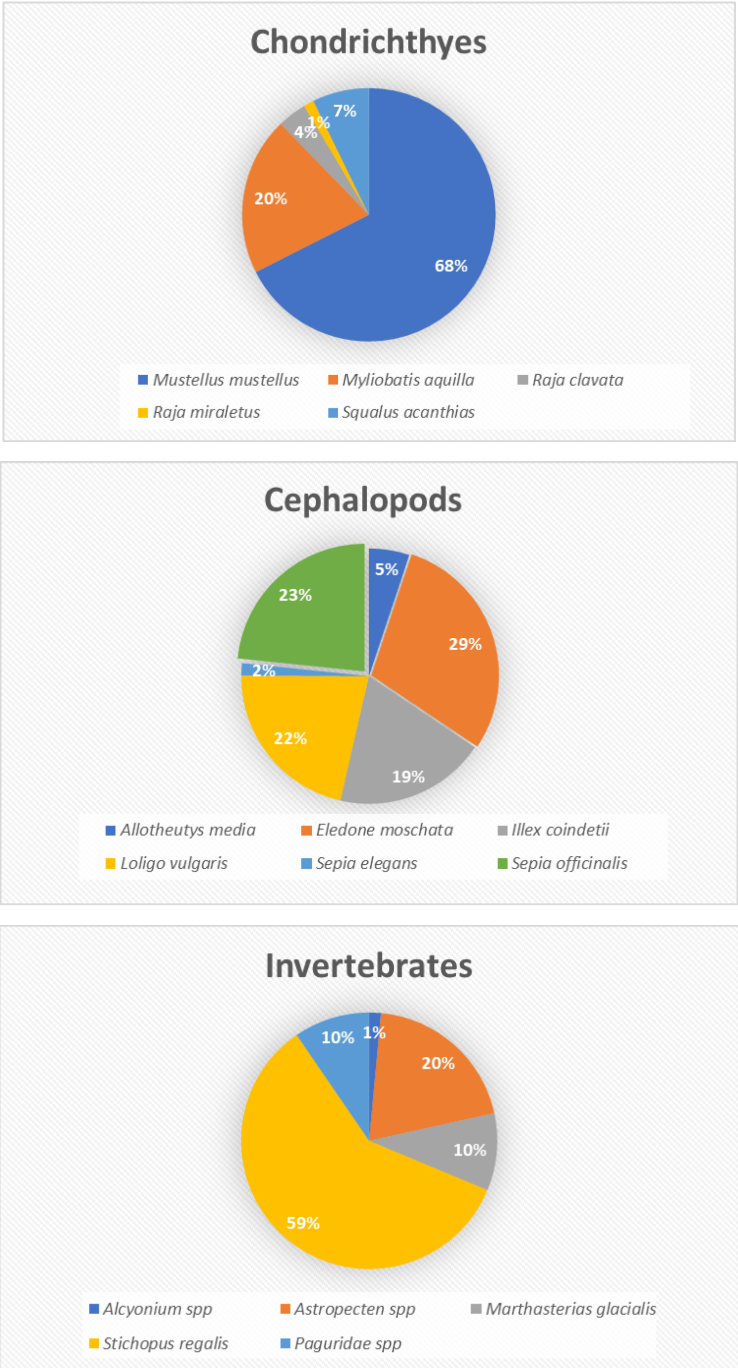
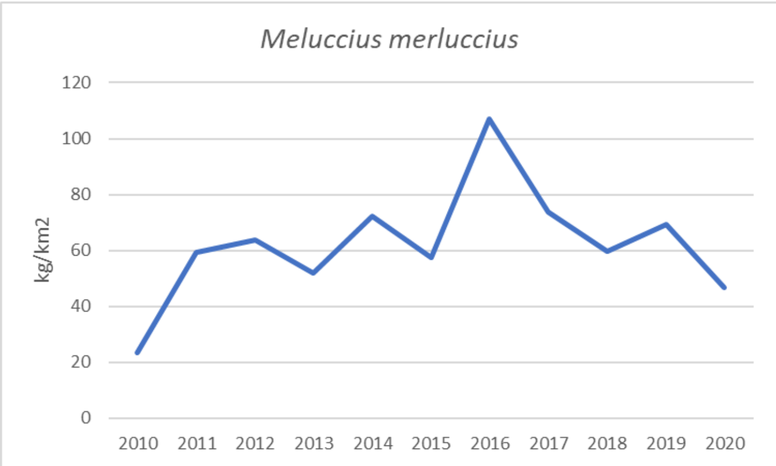
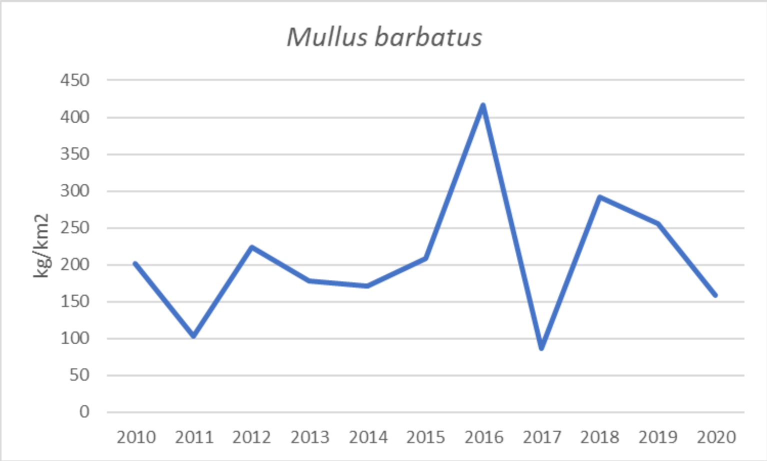


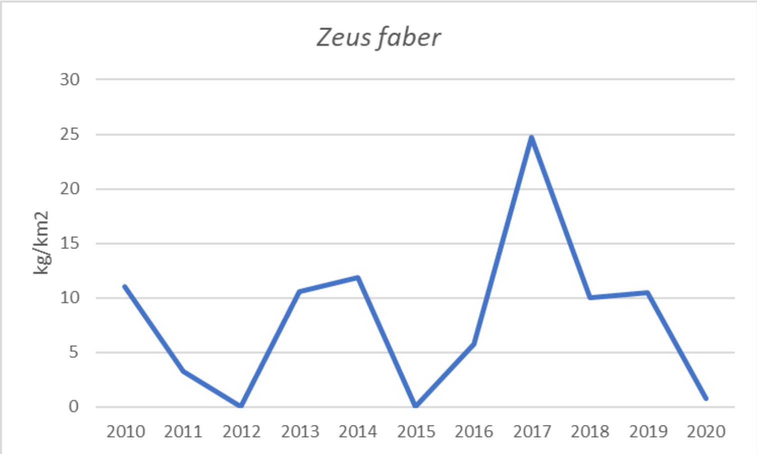
Figure 4.4. Share of biomasses of species in catches by class

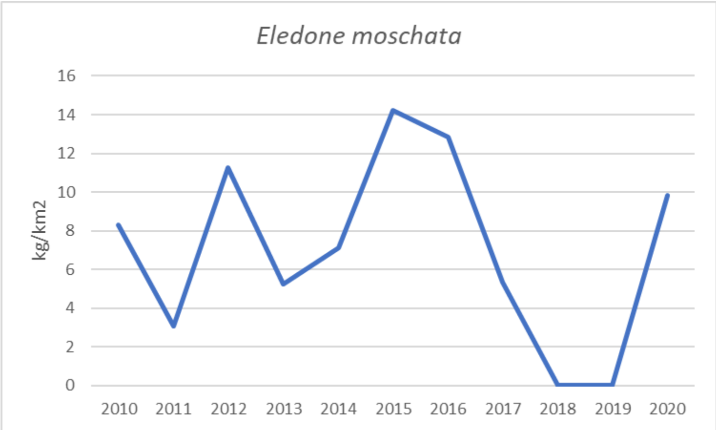
The state of demersal communities in the fishing zone G based on MEDITS survey

Description of the situation in fishing zone G is based on data collected during the MEDITS expeditions from 2010 to 2020. The results are presented through biomass index using MEDITS standard sampling protocol and data processing. When interpreting the results, it should be stressed that the spatial arrangement of the survey stations within MEDITS project is defined by the surface of certain stratum and for this reason some parts of the zone E are covered by small number of sampling stations. In the text below we will see trends in biomass of economically important species.




Mullus barbatus
kg/km2
450
400
350
300
250
200
150
100
50
0
2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020


Zeus faber
kg/km2
30
25
20
15
10
5
0
2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020


Eledone moschata
kg/km2
16
14
12
10
8
6
4
2
0
2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020

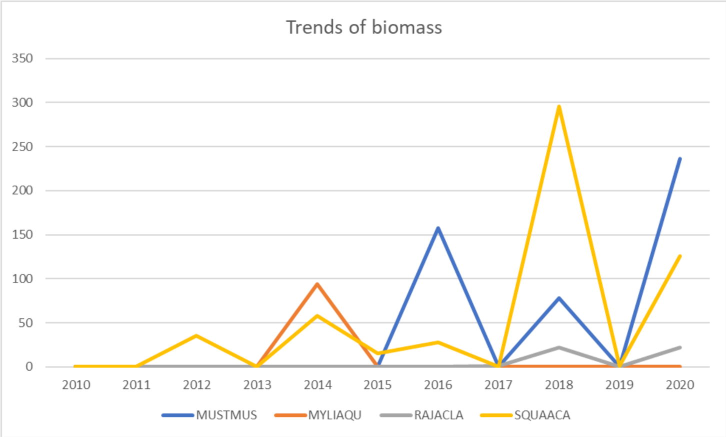


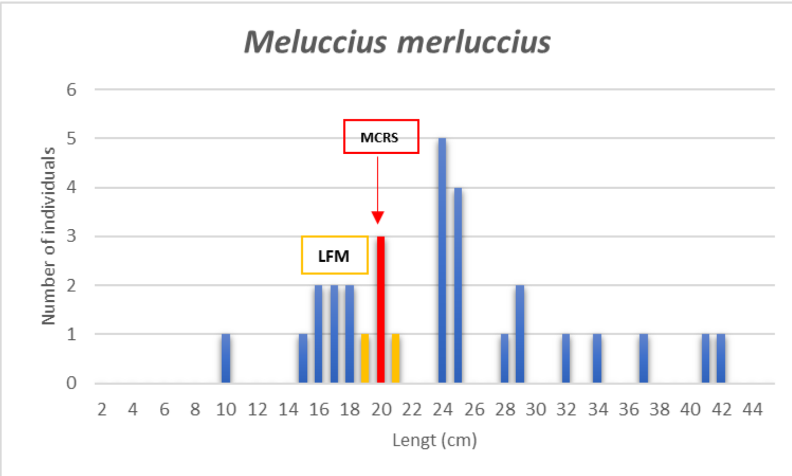
Figure 4.5. Trends of biomass of commercially important species through MEDITS survey from 2010 - 2020

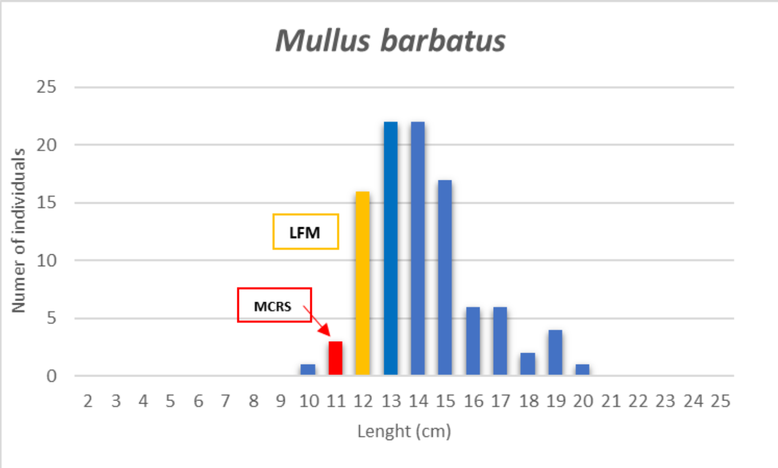
Observing the value of biomass indices, it is evident that after negative trend and decrease in biomass index during 2015, the recovery of demersal communities followed. In 2019, another decrease in biomass index occurred, but the situation is stable and slight recovery is visible. The decrease in the biomass index value has not significantly reflected on biomass of important commercial species. When comparing the biomass indices, we can see significant increase of cartilage species in 2019. in biomasses which can be indicator of improvement of demerasal resources status.

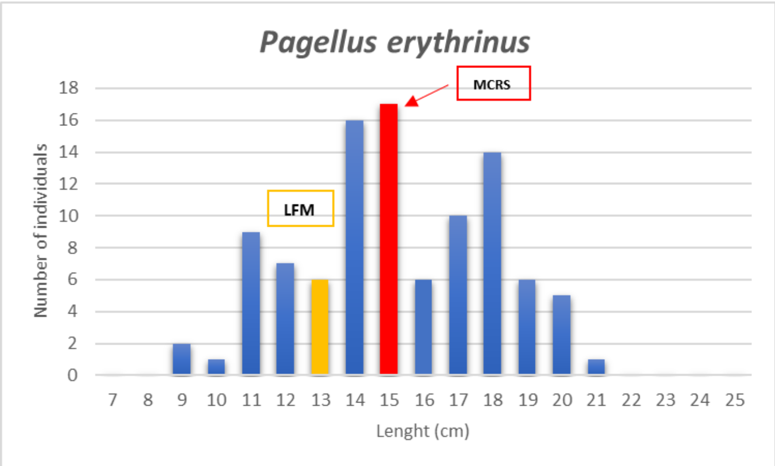
Population length structure

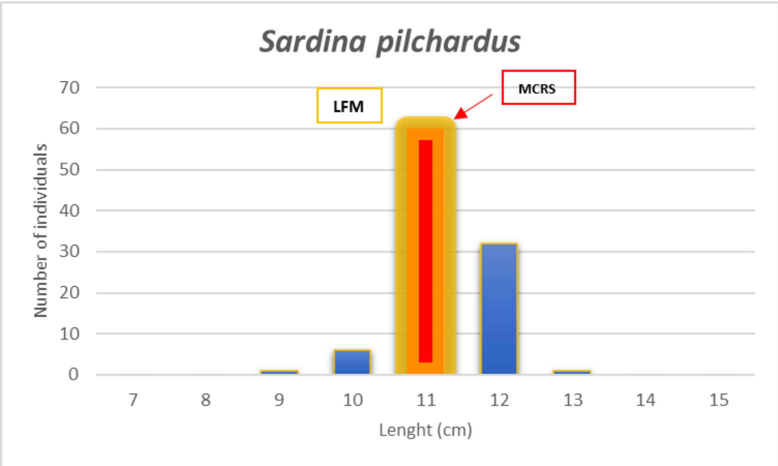
Analysis of biological samples included the species identification, then weighing of the total mass and counting the individuals of each caught species. The target species chosen for this study are the most important species of the Croatian commercial demersal fishery: common hake, red mullet, anglerfish, John Dory, thornback ray, poor cod, musky octopus and squid. The total body length, then body weight, gender and gonad maturity stage were measured and determined to all target species organisms caught by net during sampling. During the study particular attention way paid to cartilaginous fish, because they are, due to their biology, extremely vulnerable to commercial fishery exploitation and are first to be eliminated from the food chain. For this reason, cartilaginous fish are referred to as indicator species for exploitation state of benthic communities.

In addition to biological sampling, oceanographic data on temperature and conductivity of sea water and also the presence of marine litter, were measured and collected at each survey station. All collected data were saved for further use, in specially designed database, in order to provide description of the qualitative and quantitative composition of demersal communities and demographic structure of the most important demersal species.




Mullus barbatus
25
20
15
10
5
0
Numer of individuals
LFM
MCRS
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Lenght (cm)


Pagellus erythrinus
18
16
14
12
10
8
6
4
2
0
Number of individuals
MCRS
LFM
7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Lenght (cm)


Sardina pilchardus
70
60
50
40
30
20
10
0
Number of individuals
LFM
MCRS
7 8 9 10 11 12 13 14 15
Lenght (cm)

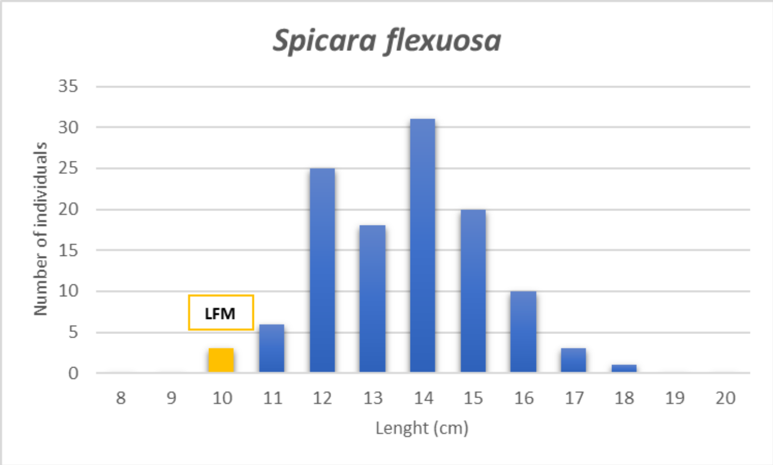


Figure 4.6. Length structure of economically most important species (LFM: Length of first maturity; MCRS: Minimum Conservation Reference Size)

The analysis of the length structure of the most important commercial species in the entire survey area makes evident the distribution of all age groups. Even though the adult specimens were present, the significant share of juveniles, which can be indicator of good recruitment, especially for hake, red mullet and blotched pickerel.

DATA COLLECTION THROUGH UUV

WP5 is dedicated to the usage of the findings of the underwater drone system in surveying seabeds. Applications of the UUV technology in scientific research of marine ecosystems and fishery resources are just beginning. Up to 50 m deep, existing knowledge has been consolidated by several years of surveys performed with fishing gears or directly with divers; at greater depths difficulties increases because divers have physiological limits and there are rough bottoms where nets cannot be towed.

The surveys are carried out by means of the oceanographic research vessels of the Split Institutes and UNIBO and the drone developed in WP3 to obtain information on the biological communities and biodiversity of the area. The outcomes will include analysis of the results significance, analysis of the work times and cartographic representation of results which shall be included in the open access database implemented in WP4.

This deliverable describes the usage of the oceanographic vessels conducted by the IZOR institute which has been used to bring and then control the navigation of the UUV in the selected areas and to perform the ecosystem monitoring with conventional technique. The scientific reporting will be focused on the evaluation of the effects on the biodiversity with respect to environmental data, climate change signals and fisheries.

1st Survey

First Survey was conducted in Croatia – fishing zone G. The survey was conducted in period from 11th to 18th of May in the waters in front of Split. In the first of the two study areas identified in the previous action, the new UUV-based monitoring technology, equipped with the suitable instrumentation was tested. Researchers collected samples by means of the traditional equipment usually used by the oceanographic research vessel – bottom trawl which was conducted by MEDITS protocol and gear. Maps of biological communities obtained by means of both traditional and new approach will be interpreted and the results will be analysed and compared, in terms of acquisition time, costs and productivity.

Due to current COVID-19 regulations, only three members of the Italian research team were able to participate.

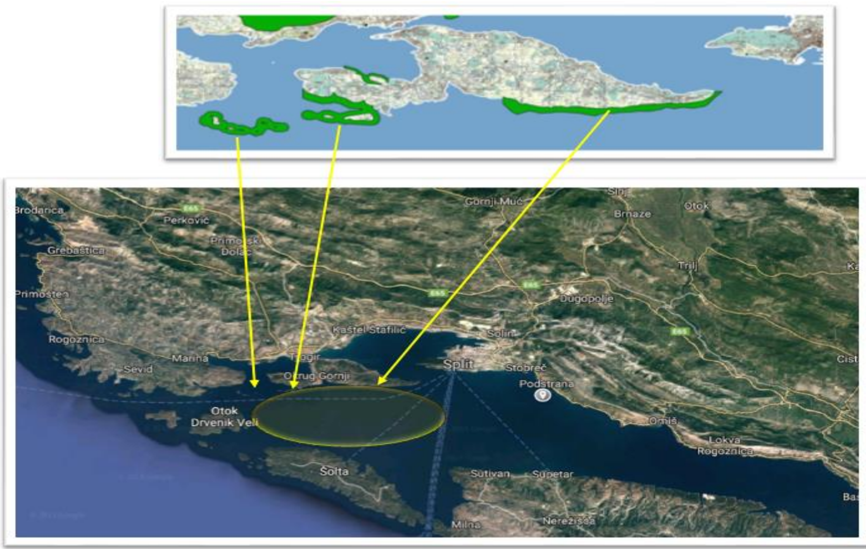


Figure 5.1. Survey Area on eastern part of Adriatic

1st day

The first day of the mission was dedicated to the following activities:

- Handling of the Drone System (Blucy, Fibre Optic winch, Ground Station, Spare parts) on board BIOS DVA vessel.
- Installation of the Ground station in Dry Laboratory.
- Dry test of Blucy to check the correct functioning.
- Meeting on planned activities.

Figure 5.2. Ground Station installed in Dry Laboratory and drone system on board Bios DVA vessel

2nd day

The following activities were carried out on the second day of the mission:

- Wet test of Blucy together with Sub operators:
    - Calibration of subsystems
    - Maneuvering tests
    - Dead reckoning tests
    - Optic data acquisition tests
    - Simulation of standard mission operations

Figure 5.3. First movement of Blucy in Croatian waters

3rd day

On the third day of the mission, the following activities were performed:

- Showcase for journalists and interview for SUSHI DROP socials
- Drone Missions:
    - Optimization of Mission operations
    - Calibrations of Scientific payloads during dead reckoning mission

Figure 5.4. Journalists interviews

Figure 5.6. Calibration of scientific payloads

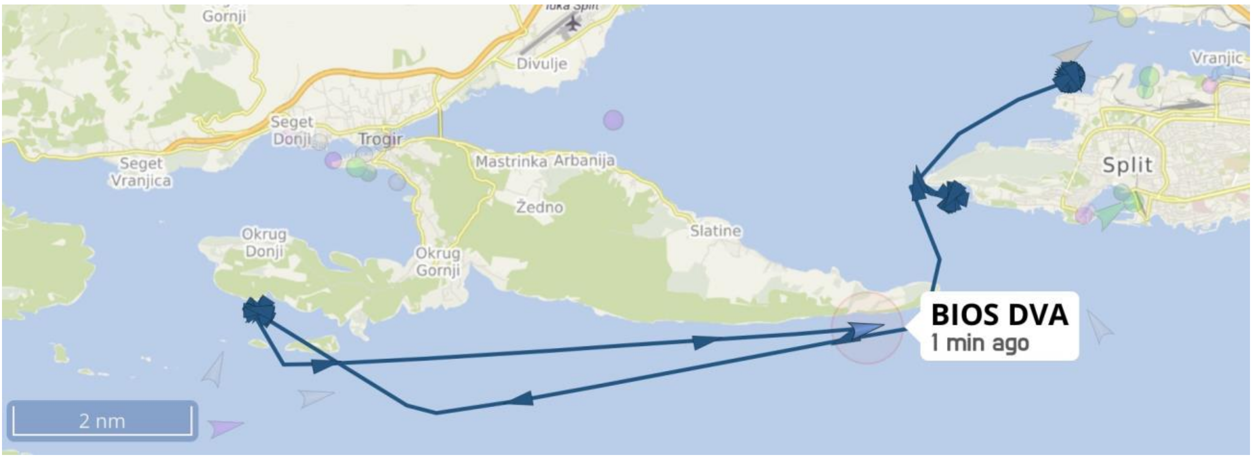


Figure 5.7. Location of Blucy missions

4th day

The fourth day of mission was dedicated to the following activities:

- Drone Mission Surveys
- Survey at 40 mt depth:
    - Mini CT and Mini SVS acquisitions
    - Bottom camera data acquisitions
    - Pilot Camera data acquisitions
- Survey in shallow waters, to compare diver survey capabilities:
    - Mini CT and Mini SVS acquisitions
    - Bottom camera data acquisitions
    - Pilot Camera data acquisitions
- Telemetry script:
    - Coding
    - Tests
- Standard Drone Maintenance

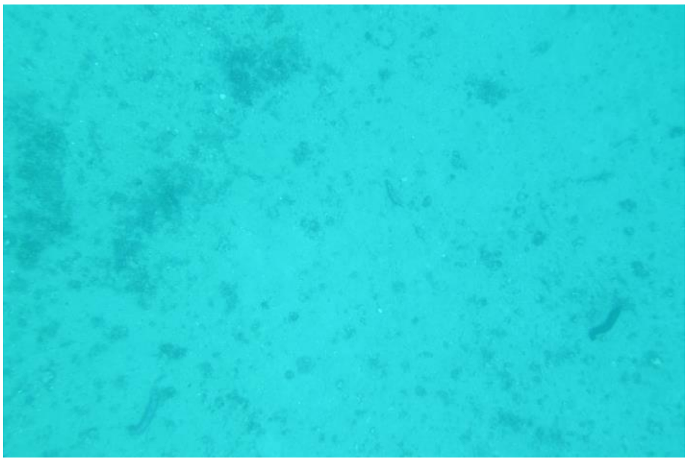


Figure 5.8. Bottom camera Image at 40mt of depth

Figure 5.9. Seagrass Meadows in shallow water survey

Figure 5.10. Blucy activities in 4th day

5th day

On the fifth day a sea mission was carried out at a depth of 70 meters to verify the environmental impact of a net trawl on the seabed. During the operations a failure of the vertical motor of the drone has occurred and it did not allow the accomplishment of the mission targets. At the end of the day, the drone and all the equipment has been reconfigured for the return

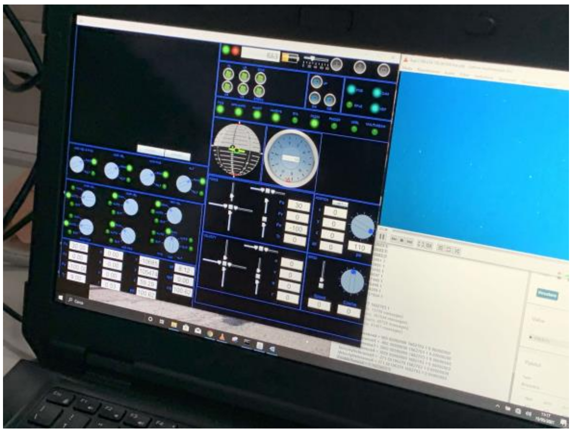


Figure 5.11. Blucy Increasing depth in last mission

Figure 5.12. Blucy recovery after last mission

DATA COLLECTION THROUGH PHYSICAL SAMPLING (DIVING)

Introduction

Reliable and accurate information on the state of marine resources is essential while making decisions on the management of ecologically important areas and their protection. With today's fishing methods, large numbers of non-target organisms are often caught, and habitat degraded. Therefore, there is a need to map marine ecosystems that would allow for monitoring the state of the environment and estimating the state of fish stock. This facilitates the assessment of the effectiveness of adopted protection measures (e.g., establishment of new marine protected areas) and the introduction of new, based on expert data.

The possibilities of monitoring the state of marine ecosystems and conducting research without a direct impact on the studied system by using unmanned underwater vehicles (UUV), i.e., underwater drones, have been increasing more recently. Compared to the use of research vessels, they represent non-invasive and cheaper methods.

The urgency of the need to develop such methods has been highlighted in the EUSAIR Action Plan and in the BlueMed Strategic Research and Innovation Agenda (SRIA). In this context, the SUSHI DROP (Sustainable Fisheries with DROnes Data Processing) project advocates the use of unmanned underwater submersibles (UUVs) equipped with sensors to monitor physical, chemical and biological characteristics. Under the SUSHI DROP project, a customized UUV equipped with acoustic and optical technology has been developed, enabling a non-invasive assessment of ecological status of the studied habitat, fish stocks and general monitoring of changes in marine ecosystem biodiversity. Combining geo-referenced data collected using underwater drones with information related to the scope of the area and different levels of fishing pressures allows for a better understanding of the study area and more effective development and implementation of marine management plans. The implementation of the underwater drone sensor system provides acoustic and optical characterization of benthic habitats in deep waters, the results of which enable the monitoring of the state of the environment and assessment of fish stocks in marine areas characterized by rocky reefs and great depths.

The SUSHI DROP project contributes to the protection of biodiversity through the use and development of autonomous robot technology, with the aim of better understanding the habitats of the Adriatic Sea. The established monitoring system will enable an increase in knowledge about the spatial and temporal patterns of fish diversity not only in the Natura 2000 areas, but also in relevant spawning areas characterized by great depths (inaccessible to divers). In these areas, it is extremely important to monitor the effects of fishing efforts (particularly trawling), as well as pollution and habitat degradation, which represent only some of the impacts on the diversity of fish species. Better knowledge of the observed habitat in the future will also enable the demonstration of the effectiveness of protection measures and facilitate the implementation of new measures based on real data, such as establishment of new marine protected areas.

In order to compare the efficiency and quality of data obtained using underwater drones, Sunce Association has conducted mapping of marine habitats in the Natura 2000 ecological network, in the traditional way, using autonomous diving equipment (SCUBA).

Figure 6.1. Interreg SUSHI DROP (Author: Sunce Association)

Surveyed area

Under the SUSHI DROP project, in the area of Split-Dalmatia County (Republic of Croatia), three areas meeting the required conditions to test an underwater drone according to their characteristics have been proposed (HR3000466 Čiovo od uvale Orlice do rta Čiova, HR3000108 Fumija I - podmorje, HR3000110 Fumija II - podmorje). All three areas are located near the city and easily accessible, which facilitates logistics and reduces resource consumption. Thanks to the shelter provided by the mainland and the surrounding islands, these areas have stable weather conditions with minimal fluctuations. Also, the sites are located within the Natura 2000 ecological network (Figure 6.2).

Figure 6.2. Areas of the ecological network surveyed in September 2021 under the SUSHI DROP project (Source: www.bioportal.hr)

Natura 2000 ecological network is composed of areas important for the conservation of endangered species and habitat types of the European Union. Its goal is to preserve or restore the favourable status of more than a thousand endangered and rare species and about 230 natural and semi-natural habitat types. So far, about 27,500 areas in almost 20% of the EU's territory have been included in this ecological network, making it the largest system of protected areas in the world. Natura 2000 is based on EU directives, areas are selected according to scientific criteria, and the management of these areas takes into account the interests and well-being of the people living in them.

Description of the surveyed area

HR3000466 Čiovo od uvale Orlice do rta Čiova

The area of the ecological network HR3000466 Čiovo od uvale Orlice do rta Čiova is located within the Split-Dalmatia County in the south-eastern part of the island of Čiovo (Figure 6.3). This is an entirely marine area, stretching from Orlice Bay to Cape Čiovo. According to the Natura 2000 Standard Data Form (SDF), in this area Reefs (1170) covering 67 ha, Sandbanks which are slightly covered by seawater all the time (1110) covering 27 ha, Posidonia beds (*Posidonion oceanicae*) (1120*) covering 33 ha, Mudflats and sandflats not covered by sea water at low tide (1140) 0,01 ha are included as target habitats. The total surface of this area amounts to 222.43 ha. Nautical sports (G01.01) are stated to have a low negative pressure on this area and diving (G01.07.) has a medium one.

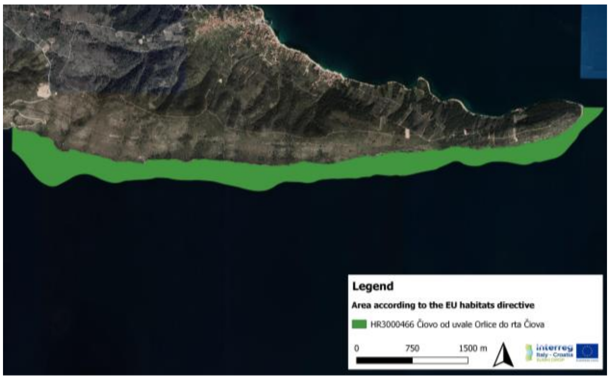


Figure 6.3. Map representation of the HR3000466 Čiovo od uvale Orlice do rta Čiova (source: www.bioportal.hr)

HR3000108 Fumija I – podmorje

The area HR3000108 Fumija I – podmorje is located south of the town of Trogir, around a small archipelago including the islands: Vela Kluda, Piščena Vela, Piščena Mala, Pijavica, Balkun, Galera (Figure 4). According to the Natura 2000 SDF, this is an entirely marine area with a total surface of 155.6 ha, and the most common habitats are Posidonia beds (*Posidonion oceanicae*) (1120*) with 47 ha, Reefs (1170) covering 18 ha and Submerged or partially submerged sea caves (8330).

The main pressures in this area come from other discharges (E03.04), fishing and exploitation of aquatic natural resources (including the effects of non-selective and incidental catches in all categories; F02) and marine pollution (and brackish water; H03). All pressures have a low impact on existing habitat types and species.

Figure 6.4. Map representation of the HR3000108 Fumija I – podmorje (Source: www.bioportal.hr)

HR3000110 Fumija II – podmorje

The area HR3000110 Fumija II – podmorje is an entirely marine area including the seabed of several smaller islands located south-east of the island of Čiovo. The total surface of this area is 200.2 ha (Figure 5). The target habitats are Posidonia beds (*Posidonion oceanicae*) (1120*) occupying a surface of 60 ha and Reefs (1170) occupying a surface of 40 ha.

The following negative pressures have been defined for this area: other discharges (E03.04) that have a medium impact, fishing and exploitation of aquatic natural resources (includes the effects of non-selective and incidental catches in all categories; F02), and marine pollution (and brackish water; H03) with low impact on existing habitat types and species.

Figure 6.5. Map representation of the HR3000110 Fumija II – podmorje (Source: www.bioportal.hr)

Materials and methods

Data collection survey on present habitat types in the Natura 2000 ecological network: HR3000466 Čiovo od uvale Orlice do rta Čiova, HR3000108 Fumija I – podmorje i HR3000110 Fumija II – podmorje was conducted on September 24, 2021. The survey followed the habitat mapping protocol which Sunce Association has been using in many different projects including project “Cross Border Marine Nature 2000 Mapping, Monitoring and Management” (4M project) funded by Cross – Border Programme Croatia – Montenegro under the Instrument for Pre – Accession Assistance (IPA). Autonomous diving equipment (SCUBA) and a diving buoy to which a watertight tank with a GPS device was attached were used to create accurate representations of the area (Figure 6.6).

Data collection was carried out along line transects set up in such a way as to cover as wide a range as possible and as wide an area as possible, in order to obtain spatially more comprehensive and accurate data on habitat types present in the study area. Each line transect started at a distance of 10 to 20 m from the coastline at a depth of 6 to 8 m. From the starting point of the transect, the divers dove perpendicularly to the coastline to a depth of 40 m or to the depth of the lower edge of the present habitat. The transect then rotated by 90º and continued in a direction parallel to the coastline, following the boundary of the habitat. The transect ended in an ascent in the direction as perpendicular to the coastline as possible. Changes in habitat types, depths and species of special interest were recorded along each line transect. Based on these data, representations (profiles) of habitat types by depth were plotted. In the case of significant differences in habitat types during (diving) descents and ascents, separate views were sketched. Diving profiles are also described in the database.

Each present habitat type was photographed for the purpose of photo documentation, as well as to help determine habitat types and their condition during data analysis. The data collected by the GPS device are stored in digital format, with a transect label. Spatial analyses were made in a geo-referencing program (QGIS 3.10.5), using satellite and orthophotos as a basis for entering line transects and creating habitat maps.

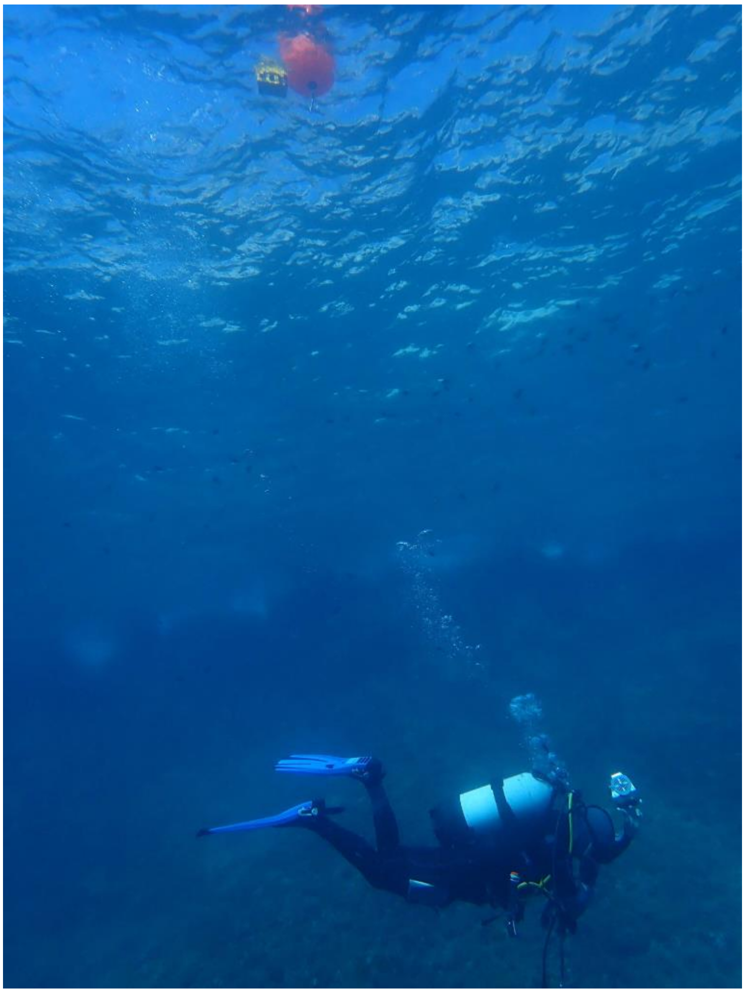


Figure 6.6. Data collection by autonomous diving with the use of buoy equipped with a GPS device under the SUSHIDROP project in September 2021. (Author: Sunce Association)

Collected data

Marine habitats recorded according to the National Habitat Classification (NKS)

Regulation on the list of habitat types and habitat maps (OG 27/21) prescribes habitat types (list of habitat types in the Republic of Croatia based on the National Habitat Classification - NKS), form, content and manner of using a habitat map, endangered and rare habitat types to be preserved in a favourable condition, as well as measures for the preservation of endangered and rare habitat types in a favourable condition. According to the NKS, the following habitat types have been recorded in the surveyed area:

- G.3.2.2. Biocenosis of well assorted fine sands
- G.3.3.2. Biocenosis of coarse sands and small gravels under the influence of bottom currents (occurs in the circalittoral as well)
- G.3.5.1. Biocenosis of *Posidonia oceanica* meadows
- G.3.6.1. Biocenosis of infralittoral algae
- G.4.2.2. Biocenosis of coastal detritic bottoms
- G.4.3.1. Coralligenous biocenosis.

G.3.2.2. Biocenosis of well assorted fine sands

G.3.2.2. Biocenosis of well assorted fine sands (Figure 6.7) is an infralittoral biocenosis extending to depths of about 2.5 to about 25 meters. Although it spreads along the entire eastern Adriatic coast, it covers much smaller areas here than along the western Adriatic coast. Associations with *Cymodocea nodosa* (G.3.6.1.2) are common in this biocenosis.

This habitat type occurs in few locations in Croatia. Most of them in the coastal part have the purpose of beaches and therefore the shallower parts are under strong human influence, especially in summer. The proximity of attractive beaches also encourages excessive construction of apartment complexes and hotels, which increases the risk of pollution. The deepest parts of this biocenosis may be exposed to trawling and fishing with shore seines (*migavica, ludar*) (Bakran-Petricioli, 2011).

Figure 6.7. G.3.2.2. Biocenosis of well assorted fine sands (Source: Bakran-Petricioli, 2011)

G.3.3.2. Biocenosis of coarse sands and small gravels under the influence of bottom currents (occurs in the circalittoral as well)

Habitat type G.3.3.2. Biocenosis of coarse sands and small gravels is influenced by bottom currents and developed in areas of stronger (sometimes extremely strong) outflow currents - the main factor shaping this biocenosis, on sand-shell and sand-gravel bottoms in all parts of the Adriatic Sea (Figure 8). It occurs in the channels between the islands and is found at depths from only 3 to 4 m up to those of 20 to 25 m, sometimes even deeper. Due to the impact of sea currents, there is no deposition of small particles in this habitat, and coarse sands and small pebbles are partly of organogenic origin, formed by the work of red algae of the Corallinaceae family. Characteristic species in this community, in addition to the red algae of the Corallinaceae family that form part of this biocenosis, are the polychaetes *Sigalion squamosus, Euthalanessa oculata* and *Armandia polyophthalma*; shellfish species *Venus casina*, *Dosinia exoleta, Capsella variegata, Glycymeris glycymeris, Laevicardium crassum*; echinoderms *Ophiopsila annulosa* and *Spatangus purpureus*; crabs *Anapagurus breviaculeatus* and *Thia cutellate*; and the lancelet *Branchiostoma lanceolatum* (Bakran-Petricioli, 2011).

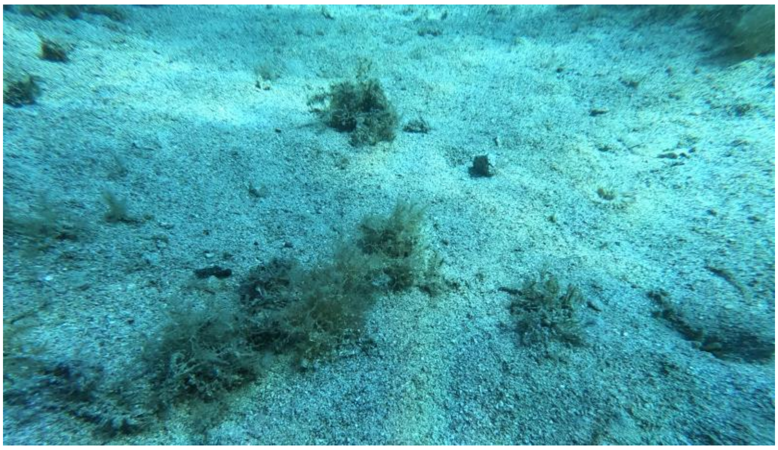


Figure 6.8. G.3.3.2. Biocenosis of coarse sands and small gravels under the influence of bottom currents (Author: Sunce Association)

G.3.5.1. Biocenosis of Posidonia oceanica meadows

Posidonia oceanica (L.) Delile is a seagrass (seed-bearing plant) endemic to the Mediterranean. In the infralittoral, where there is an abundance of light on coarse sands, with more or less mud, and sometimes on rocks, it forms dense, spacious meadows that reach almost from the surface to a depth of forty meters *(*Figure 9*).* These meadows are considered to be covering more than a quarter of the photophilous areas of the Mediterranean infralittoral, and due to numerous ecosystem services they provide, they represent one of the most important marine habitats with a high primary production.

G.3.5.1. Biocenosis of *Posidonia oceanica* meadows is growing in an area where the pressure of human activities is extremely high. The natural regeneration of Posidonia beds damaged by anthropogenic activities takes decades, which makes this species particularly sensitive and endangered. Anchoring a vessel in Posidonia significantly damages the rhizomes, which then become susceptible to wave destruction. The thriving of invasive species, such as the green algae *Caulerpa taxifolia* and *Caulerpa cylindracea* threatens Posidonia because they are its direct rivals in the fight for habitat. Posidonia meadows are endangered by all activities that increase the amount of organic matter in the water column, pollution and shading: underwater wastewater discharges, sea embankments, fish and shellfish farms, refuelling stations, marinas, harbours. Unscrupulous fishermen with trawlers sometimes run into the lower edge of Posidonia meadows and do great damage (Bakran-Petricioli, 2011).

Figure 6.9. Habitat type G.3.5.1. Biocenosis of Posidonia oceanica meadows (Author: Sunce Association)

G.3.6.1. Biocenosis of infralittoral algae

Habitat type G.3.6.1. Biocenosis of infralittoral algae appears on the hard bed of the infralittoral. It is widespread along the eastern Adriatic coast, mostly made of limestone. The depth of distribution of this habitat type is determined by the amount of light, and it is dominated by photophilous algae, especially in shallower areas. It extends from the sea surface to a depth of mostly thirty meters.

Due to the fact it develops in a narrow area along the coast where the pressure of human activities is great, this community is very endangered. Its susceptibility to increased eutrophication is high, and natural recovery after damage is slow. It is threatened by submarine wastewater discharges, construction and sea embankments, fish and shellfish farms, refuelling stations, marinas, harbours. Stone and rock dismantling in the shallow infralittoral due to illegal Date-shell extraction causes permanent damage. More recently, the thriving of invasive species, such as the green algae *Caulerpa taxifolia* and *Caulerpa cylindracea* and the red algae *Womersleyella setacea*, which compete with indigenous species for space and light, has been also threatening the community. Some of the species characteristic of this biocenosis are: algae *Lithophyllum incrustans, Padina pavonica, Stypocaulon scoparium, Dictyota dichotoma, Laurencia obtusa, Amphiroa rigida, Jania rubens, Cystoseira amentacea, Codium bursa*; sponges *Chondrilla nucula, Aplysina aerophoba*; anemones: *Anemonia viridis*, etc. (Bakran-Petricioli, 2011).

Within the biocenosis of infralittoral algae, associations with *Cystoseira sp*. (G.3.6.1.2.) are quite common. It was not possible to include the exact species and category according to the NKS in situ, so the first most similar NKS category G.3.6.1.2. Association with the species *Cystoseira amentacea* (var. Amentacea, var. Stricta, var. Spicata), with the citing of Cystoseira sp. (Figure 10) was assigned to this habitat type.

In the Mediterranean, brown algae of the order Fucales form the most important such habitats where algae of the genus *Cystoseira* with their branched thallus create a complex cover that provides specific habitat to a diverse community of macroalgae and animals (Feldmann 1937; Boudouresque 1971, 1972; Giaccone 1973; Ballesteros 1988, 1990b). The disappearance of the macroalgal cover of the genus *Cystoseira* in the Mediterranean Sea causes significant disturbances in the ecosystem, including biodiversity loss and a complete change in habitat functions (Benedetti – Cecchi et al. 2001; Perkol – Finkel). Significant changes in the ecosystem can also occur due to the reduced abundance and density of macroalgal species that shape the habitat (Maggi et al. 2009). At the end of the food web, macroalgae form significant amounts of decomposed organic matter and thus participate in the microbial cycle (Lüning 1990).

Figure 6.10. Biocenosis of infralittoral algae, association with species of the genus Cystoseira sp. (G.3.6.1.2.) (Author: Sunce Association)

G.4.2.2. Biocenosis of coastal detritic bottoms

Habitat type G.4.2.2. Biocenosis of coastal detritic bottoms belongs to the sedimentary bottoms of the circalittorals according to the classification. It is usually located along the lower border of the infralittoral zone along the coast and islands, and on the sedimentary bottoms it is adjacent to the biocenosis of well assorted fine sands (Figure 12). It is also found under the rocks that make up the coast and islands and around the seamounts in the circalittoral that do not reach the sea surface (in this case, depending on the depth, it is adjacent to the biocenosis of infralittoral algae, or coralligenous biocenosis). The upper limit of the distribution of this community is about 30 m, and the lower can seldom reach depths of 100 m (e.g. on the open sea side of our outer islands, where the gradient of the coast is almost vertical). Sediment in this biocenosis is not only sand and silt formed by rock erosion on land, but is largely of biogenic origin, formed from fragments of snail and shellfish shells, calcified skeletons of bryzoans, sea-urchin tests and pieces of calcified red algae thallus (Bakran-Petricioli 2011).

Figure 6.12. 4.2.2. Biocenosis of coastal detritic bottoms (Author: Sunce Association)

G.4.3.1. Coralligenous biocenosis

Habitat type G.4.3.1. Coralligenous biocenosis inhabits the hard bed of the circalitoral. Its basic feature is a smaller amount of light than in the infralittoral, so it is inhabited by organisms that are used to a reduced amount of light. In the Adriatic the G.4.3.1. Coralligenous biocenosis is usually present on a hard bed at a depth over 30 m and is adjacent to the community of infralittoral algae. The lower limit of the coralligenous community is usually at depths of about 100 m, but in extremely clear sea it can be deeper, up to 130 m. In less transparent sea, the coralligenous can be spread in much shallower areas, from 15 to 40 m in depth. On the vertical rocks of our outer islands and in the shaded places in the Adriatic, the upper edge of the coralligenous community can be found as low as at 10 to 15 m in depth. These places are particularly interesting for divers and anglers.

The coralligenous community in the Adriatic, in addition to inhabiting more or less vertical rocks in the circalitoral, where the biogenic accumulations of red algae are often dominated by horny corals (*Paramuricea clavata, Eunicella spp)* and sponges (*Axinella polypoides*), also inhabits horizontal parts of the seabed. (Figure).

At the transition between the infralittoral algae community and the coralligenous biocenosis, as well as between the rhizomes of Posidonia and at the base of the thallus of tall and branched infralittoral algae (e.g. algae of the genus *Cystoseira*), a community dominated by soft talus algae, e.g. *Flabellia petiolata* and *Peyssonnelia* is found.

The causes of endangerment are various environmental disturbances, such as pollution, and by changing the chemical quality of the sea and increasing the amount of suspended matter in it, it can be manifested by a decrease in the number of species and the density of their populations in the coralligenous. Excessive fishing changes the structure of populations, so some key species, such as lobsters or groupers, are becoming rare. Anchoring as well as trawling (especially in places where coralligenous is present at the bottom) can also damage organisms of the coralligenus. Intense diving visits can result in intentional or accidental plucking of the species, overturning of rocks, disturbing large organisms (Bakran-Petricioli, 2011).

Figure 6.11. G.4.3.1. Coralligenous biocenosis (Author: Sunce Association)

4.2. Results of habitat type mapping in the surveyed areas

HR3000466 Čiovo od uvale Orlice do rta Čiova

Two diving transects were made in the area of the ecological network HR3000466 Čiovo od uvale Orlice do rta Čiova. The first transect was set up from the area near Cape Barasov bok towards Cape Čiovo, with a total length of 382 m, while the second transect was started 480 m east of the first transect and also directed towards Cape of Čiovo, with a total length of 308 m (Figure 6.13).

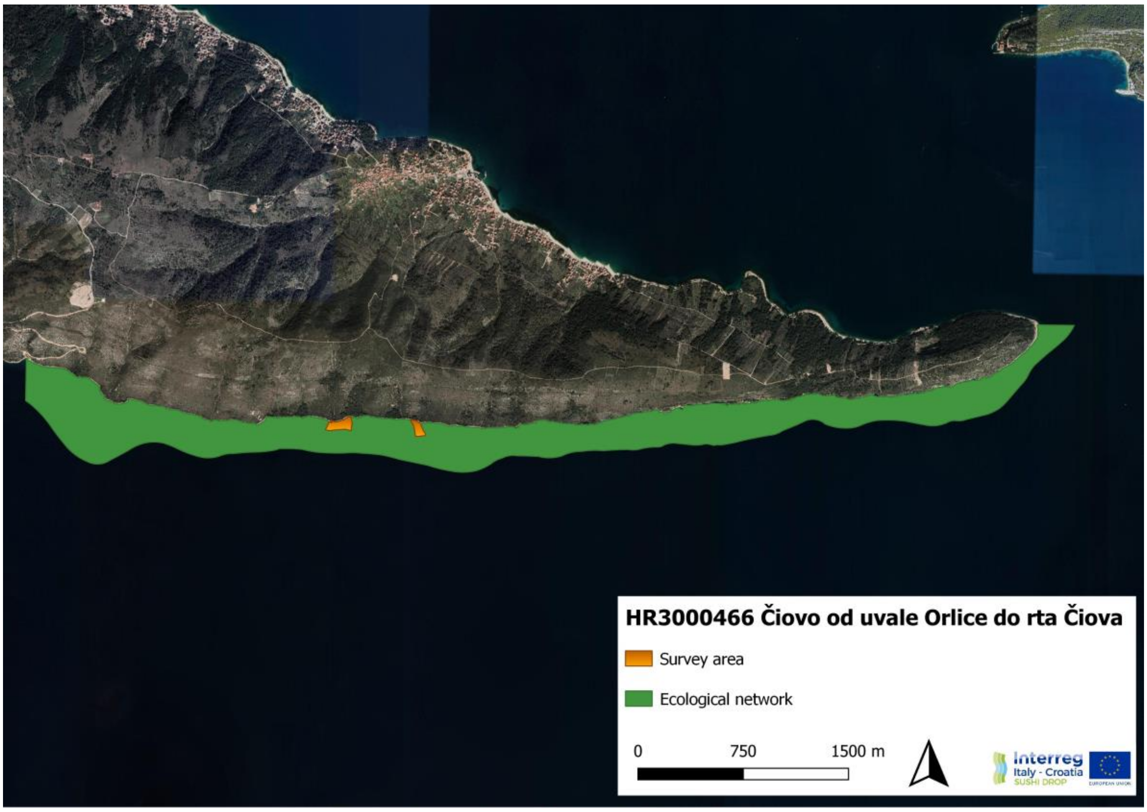


Figure 6.13. Area of survey conducted in September 2021, as part of the SUSHIDROP project in the area HR3000466 Čiovo od uvale Orlice do rta Čiova (Source: www.bioportal.hr)

Transect 1

Transect 1, extending in the vicinity of Barasov bok, was started at a distance of 8 m from the coast. Divers started the transect at a depth of 5 m on the rocks with a Biocenosis of infralittoral algae (association with *Cystoseira sp*. G.3.6.1.2.; Figure 14). The transect continued towards south where at a depth of 13 m an area of reef descending vertically to a depth of 24 m was recorded, followed by the area of G.4.2.2. Biocenosis of coastal detritic bottoms. G.4.3.1 Coralligenous biocenosis with characteristic species was recorded on the reef. Specimens of *Eunicella cavolini* were recorded, very small in stature (10 to 15 cm), but in good condition, with no damage or bleaching observed. With regard to sponges, *Aplysina cavernicola* and *Axinella cannabina* predominate. A large number of leftover fishing gear was noticed, mostly ropes, longlines and a few traps. The transect then continued in a northerly direction, following the vertical side of the ridge. In the shallower area, a plateau with a G.3.3.2. Biocenosis of coarse sands and fine gravels under the impact of bottom currents was recorded (Figure 6.15).

Figure 6.14 G.3.6.1. Biocenosis of infralittoral algae, association with Cystoseira sp. (G.3.6.1.2.), Recorded during the survey in September 2021 under the SUSHIDROP project (Author: Sunce Association)

Figure 6.15. G.3.3.2. Biocenosis of coarse sands and small gravels under the influence of bottom currents recorded during the survey in September 2021 under the SUSHIDROP project (Author: Sunce Association))

At a depth of 7 meters, the species *Cymodocea nodosa* was identified in very few sporadic areas. Rocks with a G.3.6.1. Biocenosis of infralittoral algae begin at the end of the transect, at a depth of 5 m.

Transect 2

The second transect was started at a depth of 10 m where G.3.6.1 Biocenosis of infralittoral algae with areas covered by *Cystoseira sp*. (association with *Cystoseira sp*. G.3.6.1.2.) and beds of *Codium bursa* was recorded. The transect then extends in a direction perpendicular to the coast up to a depth of 10 m where the slope of the wall is steep (Figure 16). The wall extends to a depth of 30 m and G.4.3.1 Coralligenous biocenosis (dense beds of *E. cavolini* species; Figure 17) is recorded on it. The beds are relatively equal in height, up to 30 cm tall, undamaged and no dead specimens were noticed. A small amount of marine mucilage was noticed in some specimens. The transect then followed the wall. G.3.3.2. Biocenosis of coarse sands and small gravels under the influence of bottom currents with rare settlements of the species *Cystoseira sp*. begins at the end of the transect, at a depth of 11 m.

Figure 6.16. G.4.3.1. Coralligenous biocenosis on a wall recorded during survey in September 2021 under the SUSHIDROP project (Author: Sunce Association)

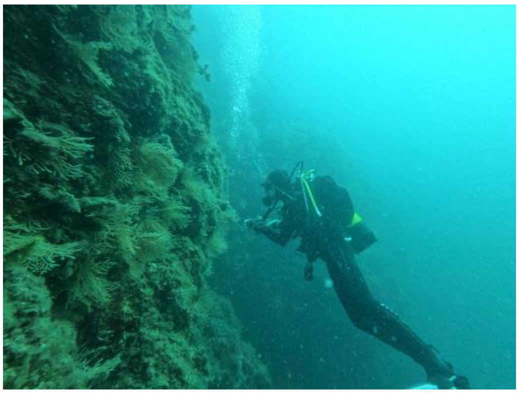


Figure 6.17. Diver reviewing the condition of the species Eunicella cavolini recorded during the survey in September 2021 under the SUSHIDROP project (Author: Sunce Association)

In this area, a total surface of 2.12 ha was surveyed, i.e., 3.16% of the total surface of HR3000466 Čiovo od uvale Orlice do rta Čiova (Figure 6.18).

Figure 6.18. Map representation of habitat types classified according to the National Habitat Classification (NKS), recorded during the survey in September 2021 within the SUSHIDROP project in the ecological network area HR3000466 Čiovo od uvale Orlice do rta Čiova (Source: www.bioportal.hr)

HR3000108 Fumija I – podmorje

In the area HR3000108 Fumija I - podmorje, divers started the transect 5 m from the coast at a depth of 5 m. The total length of the crossed transect was 375 m (Figure 19).

Figure 6.19. Area of survey conducted in September 2021, under the SUSHIDROP project in the area HR3000108 Fumija I - podmorje (Source: www.bioportal.hr)

The transect began in the area covered by the G.3.6.1. Biocenosis of infralittoral algae and was oriented southwest. A continuous G.3.5.1. Biocenosis of *P. oceanica* meadows begins at a depth of 13 m (Figure 20). The meadow extends to a depth of 23 m, where a sparse and progressive lower edge of the meadow was recorded (Figure 21). The transect continued following the lower edge of the meadow to the east. Observing the terrain, divers recorded several specimens of discarded fishing gear; ropes and trap nets. The transect continued in a north-east direction, then towards north, following the edge of the G.3.5.1. Biocenosis of *P. oceanica* meadows. At a depth of 12 m, the upper edge of the meadow was recorded. In a shallower area above the upper edge G.3.2.2. Biocenosis of well assorted fine sands was found. The transect ends at a depth of 5 m, on the rocks with a G.3.6.1. Biocenosis of infralittoral algae.

Figure 6.20. Rocks with G.3.6.1. Biocenosis of infralittoral algae recorded during survey in September 2021 under the SUSHIDROP project (Author: Sunce Association)

Figure 6.21. The lower edge of the biocenosis of *P. oceanica* meadow recorded during the research in September 2021 under the SUSHIDROP project (Author: Sunce Association)

In this area, a total surface of 0.94 ha was surveyed, i.e. 0.6% of the total surface of the area HR3000108 Fumija I - podmorje (Figure 6.22).

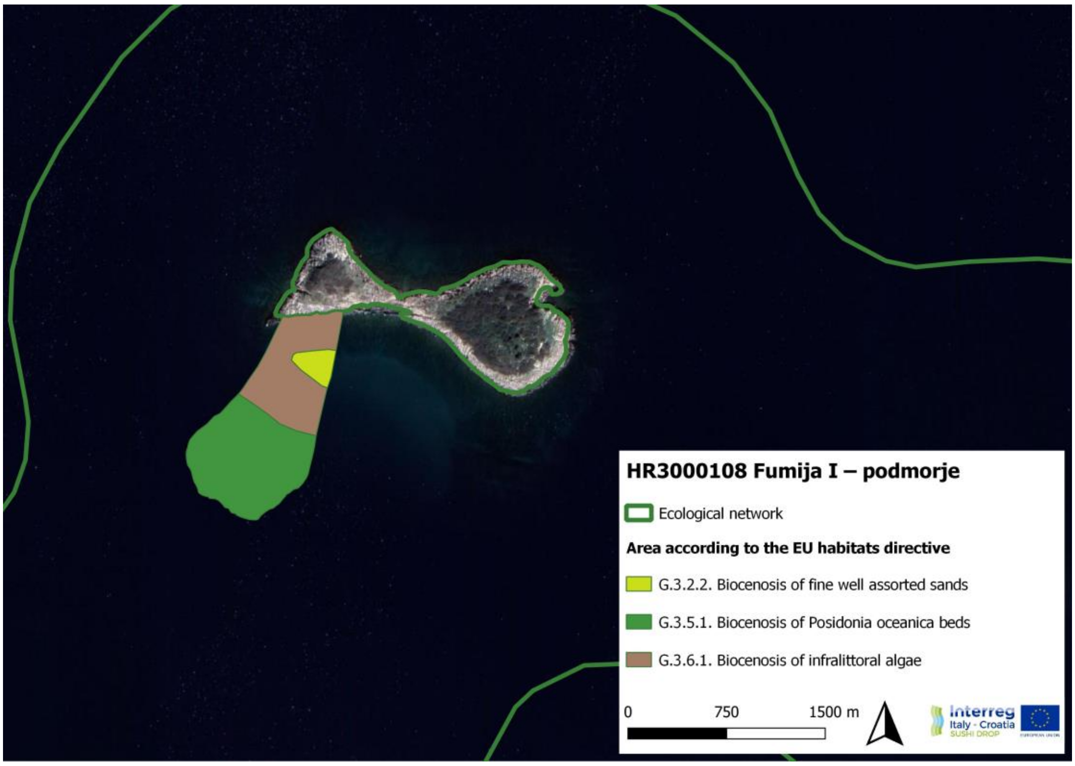


Figure 6.22. Map representation of recorded habitat types classified according to the National Habitat Classification (NKS) recorded during the survey in September 2021 under the SUSHIDROP project in the area HR3000108 Fumija I - podmorje (Source: www.bioportal.hr))

HR3000110 Fumija II – podmorje

In the area of the ecological network HR3000110 Fumija II - podmorje, a 378 m long diving transect was set up (Figure 6.).

Figure 6.23. Area of survey conducted in September 2021, under the SUSHIDROP project in the ecological network HR3000108 Fumija I - podmorje (Source: www.bioportal.hr)

In this area the divers started the transect 8 m from the coast at a depth of 7 m where G.3.6.1 Biocenosis of infralittoral algae, association with *Cystoseira sp*. G.3.6.1.2. was located. This habitat extends to a depth of 14 m, after which a slight slope of the wall begins (Figure 6.24). The wall extends to a depth of 30 m and is very sparsely populated with rare specimens of *Aplysina cavernicola*. To the east, the wall gradually ends and passes into the G.4.2.2. Biocenosis of coastal detritic bottoms (G.4.2.1.) at a depth of 23 m (Figure 6.25.).

Figure 6.24. G.3.6.1. Biocenosis of infralittoral algae, association with *Cystoseira sp*. recorded during the survey in September 2021 within the project SUSHIDROP (Author: Sunce Association).

Figure 6.25. G.4.2.2. Biocenosis of coastal detritic bottoms recorded during survey in September 2021 under the SUSHIDROP project (Author: Sunce Association)

In this area, a total surface of 2.12 ha was surveyed, i.e., 1.06% of the total surface of the area HR3000110 Fumija II - podmorje (Figure 6.26.).

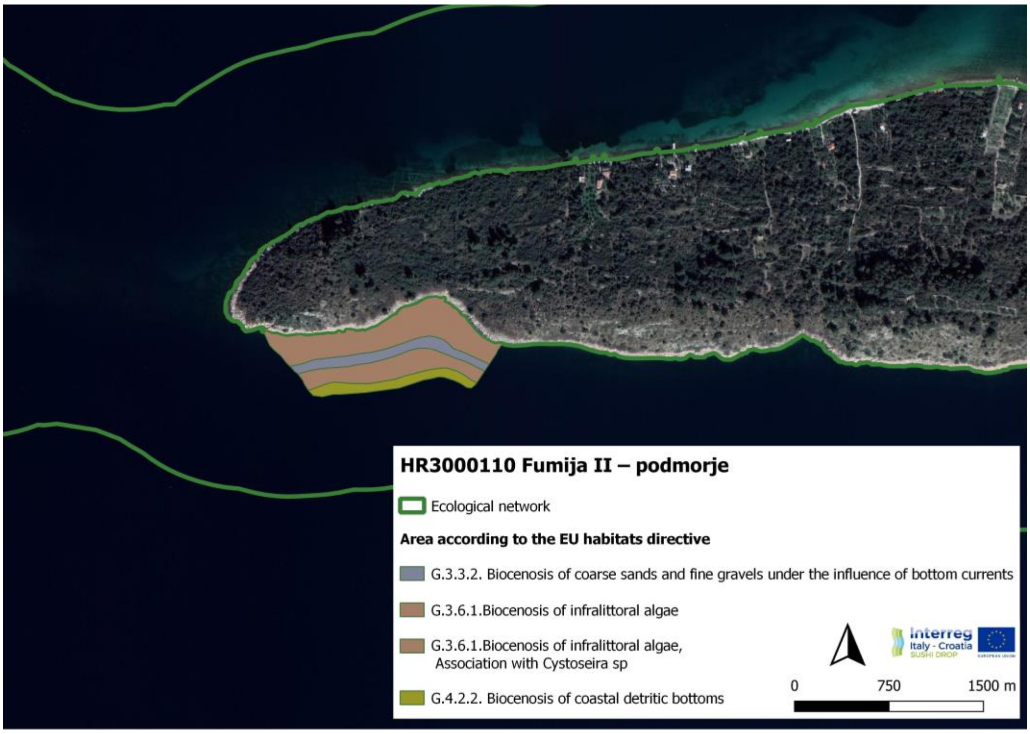


Figure 6.26. Map of recorded habitat types classified according to the National Habitat Classification (NKS) recorded during the survey in September 2021 within the SUSHIDROP project in the ecological network area HR3000110 Fumija II - podmorje (Source: www.bioportal.hr))

Analysis of the recorded data during the survey

Within the surveyed area in the ecological network HR3000466 Čiovo od uvale Orlice do rta Čiova, the largest surface is occupied by the infralittoral area of 1 ha, which is a total of 47.17% of the total surface of the surveyed area. G.3.6.1 Biocenosis of infralittoral algae associated with *Cystoseira sp.* (G.3.6.1.2.) (0.83 ha) and G.3.3.2. Biocenosis of coarse sands and small gravels under the influence of bottom currents (0.17 ha) prevail in this area. The area of the circalittoral occupies a total surface of 1.12 ha, which is 52.83% of the total surface of the surveyed area. G.4.2.2. Biocenosis of coastal detritic bottoms (0.57 ha) and G.4.3.1. Coralligenous biocenosis (0.55 ha) predominate within the circalittoral (Table 6.1).

Within the surveyed area in the ecological network HR3000108 Fumija I - podmorje, the largest surface is occupied by the infralittoral area with 0.94 ha, which is a total of 100% compared to the surveyed area. G.3.5.1 Biocenosis of *Posidonia oceanica* meadows (0.53 ha), G.3.6.1. Biocenosis of infralittoral algae (0.35 ha) and G.3.2.2. Biocenosis of well assorted fine (0.06 ha) prevail in this area of the infralittoral.

Within the surveyed area in the ecological network HR3000110 Fumija II - podmorje, the largest surface is occupied by the infralittoral 1.87 ha, which is 88.21% of the total surface of the surveyed area. G.3.6.1 Biocenosis of infralittoral algae associated with *Cystoseira sp.* G.3.6.1.2. (1.04 ha), G.3.6.1. Biocenosis of infralittoral algae without association (0.52 ha) and G.3.3.2. Biocenosis of coarse sands and small gravels under the influence of bottom currents (0.31 ha) have prevalence here. The circalittoral area covers a surface slightly smaller than 0.25 ha, which is 11.79% of the total surveyed surface. G.4.2.2. Biocenosis of coastal detritic bottoms predominates in this area.

NKS code	Habitat name according to NKS-u		Area of recorded habitat types within the ecological network (ha)			Proportion of recorded habitat types within the surface of the surveyed area		
			HR3000466 Čiovo od uvale Orlice do rta Čiova (ha)	HR3000108 Fumija I – podmorje (ha)	HR3000110 Fumija II – podmorje (ha)	HR3000466 Čiovo od uvale Orlice do rta Čiova (%)	HR3000108 Fumija I – seafloor (%)	HR3000110 Fumija II – seafloor (%)
Total mapped surface			**2.12**	**0.94**	**2.12**	**2.12**	**0.94**	**2.12**
G.3.	**Infralitoral**		**1.00**	**0.94**	**1.87**	**47.17**	**100.00**	**88.21**
G.3.2.	Infralittoral fine sands with more or less mud			0.06			6.38	
	G.3.2.2.	Biocenosis of fine well assorted sands		0.06			6.38	
G.3.3.	Infralittoral coarse sands with more or less mud		0.17		0.31	8.02		14.62
	G.3.3.2.	Biocenosis of coarse sands and fine gravels under the influence of bottom currents	0.17		0.31	8.02		14.62
G.3.5.	Posidonia beds			0,53			56,38	
	G.3.5.1.	Biocenosis of *Posidonia oceanica* beds		0.53			56.38	
G.3.6,	Infralittoral hard beds and rocks		0.83	0.35	1.56	39.15	37.23	73.58
	G.3.6.1.	Biocenosis of infralittoral algae		0.35	0.52		37.23	24.53
	G.3.6.1.2.	Association with *Cystoseira sp.*	0.83		1.04	39.15		49.06
G.4.	Circalittoral		1.12		0.25	52.83		11.79
G.4.2.	Circalittoral sands		0.57		0.25	26.89		11.79
	G.4.2.2.	Biocenoza obalnih detritusnih dna	0.57		0.25	26.89		11.79

G.4.3.	Circalittoral hard beds and rocks		0.55			25.94		
	G.4.3.1.	Coralligenous biocenosis	0.55			25.94		

Table 6.1. Surface of habitat types within the Natura 2000 ecological network recorded during the survey under the SUSHI DROP project in September 2021

CONCLUSION

Research conducted during the SushiDrop project using a commercial trawl net shows a similar situation of demersal resources as those conducted through the MEDITS survey and DCF project (commercial fishing monitoring project). The catch shows that it is an area of great biodiversity, and there were 36 different species of fish, crabs and cephalopods in the samples. Apart from being an area of great biodiversity, it is also an area of intensive fishing, both commercial and recreational.

The recent state of resources in the research area is not satisfactory. Research of most species through SAC GFCM and STECF shows that they are in a state of overfishing. However, the situation is not the same in all parts of the Adriatic Sea: the situation is much better in those parts where fisheries regulation measures are more restrictive. This is exactly the case with the researched area of fishing zone G. Namely, this area is under extremely restrictive measures of fishing regulation throughout the year. And these measures seem to be showing results. Namely, it is evident that a significant share of catches in this area is cartilaginous, which are known as indicators of the condition of the formed communities. Biomass indices are especially high for sharks, but also for organisms of the order Rajiformes. The biomass values of these species are significantly above the values in the open sea and canal areas of the northern Adriatic.

The slow recovery of demersal resources, which is also visible in these studies, can be largely attributed to the establishment of the Fisheries Restricted Area in the area of the Jabučka kotlina (Pomo Pit). As a consequence of this measure of fishing regulation, there has been a recovery of a large number of stocks whose life expectancy is related to the Jabučka kotlina, which is main

spawning and nursery area in the Adriatic Sea. The most obvious examples of recovery are in the case of hake and Norway lobster.
The fundamental requirement for biodiversity conservation is the conservation of ecosystems and natural habitats in situ and the maintenance and restoration of the population of species capable of surviving in their natural environment. The goal of habitat protection at the European level is to preserve habitat types important for protection, in good condition in the long run, which is elaborated specifically in the European Union Habitats Directive (92/43 / EEC, 1992). A classification of habitat types represented in the then 12 EU member states was made during the adoption of the Directive. This classification was further developed and extended to the whole of Europe. Today, the most widely used European classification listing habitat types present in Europe is EUNIS. It is also used in the Natura 2000 Standard Form (SDF, from the English Standard Data Form). Despite the constant development of the European classification of habitat types, none cover all the specifics of individual countries. For that reason, so many countries have developed a national classification of habitat types. In the National Habitat Classification of the Republic of Croatia, more than 900 natural and semi-natural habitat types have been described so far, divided into 11 key categories. This list includes terrestrial, marine, freshwater, cave, and even anthropogenic ecosystems habitat types.

Although a very small area was surveyed during this research considering the total area of selected Natura 2000 sites, the collected data indicate that the actual state of protected areas within the ecological network differs from the state shown in the available data. However, the data obtained is not sufficiently comprehensive to be relevant for indicating irregularities within the habitat selection and the accuracy of their area within the SDF, although it certainly indicates the need to revise the available data.

Due to the geomorphological features of the coast, formed in karst limestones, the marine habitats of the eastern part of the Adriatic are very diverse. However, these habitats are much less explored than terrestrial ones. As opposed to research on the land, research at sea is expensive and technically demanding. There are many limitations like the amount of light, sea transparency, depth, and time of in situ surveys. Therefore, traditional research methods, especially if we are talking about habitat research with the help of divers, can cover much smaller areas than when researching land habitats.

This research lasted one day and included four divers, while an area of 5.18 ha was mapped. The time of the diver's stay under the sea and the number of safe dives for one day is limited, while the maximum allowed depth of recreational diving is 40 m. Since the underwater drone has no restrictions like time and number of dives as well as the maximum possible depth is much deeper than the one the diver is allowed to work on, a much larger area would be mapped for the same time using an underwater drone. Apart from detecting changes in habitat, record depths, and GPS positions, additional features, such as high-resolution cameras and high-quality lighting fixtures, would make it possible to obtain quality photo documentation, especially at greater depths.

Furthermore, collecting data on salinity and temperature and other physical properties of the water column would potentially be very useful for reef research because, among other data, a correlation between temperature and the occurrence of marine mucilage in the area could be made. However, the collection of such data is not enough, given that the underwater drone could only obtain data on the current state of the study area, and would gain in importance only after a long period of monitoring these parameters, which is already done today with data loggers and probes. It can be used to monitor the condition of Posidonia meadows, coral extinction due to temperature, but also to monitor climate change.

The underwater drone is enabled to collect data for the production of detailed 3D views of the surveyed area, which can help in researching not only the sea bottom but also reefs. Also, the advantage of researching marine ecosystems by underwater drone at greater sea depths (i.e., the limit for most divers is at 40 m depth) lies in the fact that the exact boundaries of habitats could potentially be defined, and would provide a clearer picture of the area, for example, coastal detrital bottoms and reefs. Such monitoring of habitats with the help of an underwater drone is potentially beneficial for determining habitat changes like reduction or advancing of a habitat type, which is very important from a biological point of view.

When planning the research, it is necessary to estimate the costs based on the ratio of the price of using an underwater drone and traditional methods as well as the area that the chosen method can cover in a unit of time. It is also necessary to consider what type of data can be collected by the selected method. In the price estimation, it is necessary to include the price of the researcher's work, logistics, and data processing. Based on this assessment, it will be possible to determine which method is more cost-effective to conduct research.

According to all the above, underwater drone research, with its advantages and disadvantages, can contribute to data collection and determining the situation in the survey area. Depending on the goal and purpose of the research, it can be the only method in case it is not possible to conduct the research with the help of traditional methods, or it can be used as an additional technology in research for traditional methods.

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