WP 3_Act. 3.3 Mapping of Adriatic reef from different perspectives

Deliverables 3.3.1-3.3.2-3.3.3

D 3.3.1 Definition of the list of the reefs to be considered in this case study identification phase. Minutes of the web meeting;

D 3.3.2 In-depht analysis of the identified case studies;

D3.3.3 Final report of the activities

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Name of Activity Leader: CNR – IRBIM

Contributors: CNR – IRBIM, ARPAE Emilia-Romagna, SUNCE, University of Zadar, ARPA Apulia, OGS,

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1. EXECUTIVE SUMMARY

In the Adriatic Sea there is a large number of marine ecosystems available for Blue Economy purposes. In the Blue Innovation concept, the attractiveness of existing marine resources is relevant in order to promote economic development. Therefore, the recognition of less known and appreciated natural areas, together with the implementation of artificial reefs, which could become suitable substrata for new sustainable ecosystems (e.g. platforms, wrecks, posing of concrete structures), could be a successful way to pursue Blue Growth. In fact, both natural (NRs) and artificial reefs (ARs) are interesting not only for scientific community but, furthermore, are places where it is possible to practice several activities such as sport fishing, nautical tourism, diving and aquaculture.

An overview of best practices on the sustainable use of NRs and ARs around the world was conducted to get examples on the possible economic activities that can be implemented at the reef sites and their management.

“Good governance” examples are more common for ARs, although they globally cover a smaller area than NRs. In fact, ARs are often designed and built for specific purposes, which means they are conceived to be a service and as part of a managed framework. Conversely, NRs originate from slow natural processes and often represent vulnerable ecosystems. Because of this, management concerns of the NRs have so far focused on conservation issues, whereas sustainable economic exploitation examples are scarce.

Here we present examples of application of Blue Economy, with the aim of identifying the benefits obtainable by the proper use of different reef typologies.

Based on this overview and the experience of ADRIREEF partners, natural and artificial reefs were then selected as Case Studies representative of the different typologies of reefs existing in the Adriatic sea. The decision-making process leading partners to the definition of the CSs, is reported in detail.

The locations were chosen in favour of representativeness in terms of ecological features, levels of exploitation and presence/absence of facilities in the surroundings areas, trying to cover all the project area. In the overall, seven CSs were selected: three natural reefs, two artificial reefs and a mixed one.

Each CS will be subjected to a monitoring programme lasting at least one year (WP4), aimed to assess the biogeochemical features of each site, compliant with human activities.

2. REVIEW OF INTERNATIONAL PRACTICES ON ARTIFICIAL AND NATURAL REEFS

2.1. Introduction

Building on top of traditional sectors like shipping and energy, Blue Economy focuses on the potential of new sectors to seize the new opportunities that are already available today, and pave the way for those to come. Under such light, it currently highlights five strategic areas: renewable energies, seabed mining, biotechnology, aquaculture, and maritime and coastal tourism.

The goal of the Blue Economy is therefore not to invest more in the safeguard of the environment. Conversely, it aims to make minor investments, to create more employment and to achieve greater proceeds thanks to innovations in the five strategic areas using resources already available in nature. In this perspective, one of the targets will be to identify potential marine locations where to enhance innovative activities that could be attractive for economic sectors.

In a monotonous seabed like the Adriatic sea, mostly characterized by silty-sand sediments, rocky substrates and biogenic concretions arising from the seafloor become a real “oasis in a desert”, suitable for the settlement and development of special assemblages of flora and fauna.

In addition, over the years, further marine areas so called Artificial Reefs (ARs) have been built, which are structures often respondent to multiples purposes. In the majority of cases, the main functions of ARs around the world are (Fabi *et al*., 2015):

- protection, restoration, concentration and/or enhancement of aquatic resources;
- enhancing biodiversity, providing new substrates for algae and mollusc culture;
- enhancing professional and recreational fisheries;
- creating suitable areas for diving;
- providing a means to manage coastal activities and reduce conflicts;
- implementing research and educational activities;
- creating potential networks of marine protected areas (MPAs) to manage the life cycles of fish and connectivity.

Protection of aquatic resources, enhancing biodiversity, supporting small-scale fisheries, reduction of conflicts among coastal activities, research and education have been the main goals for ARs deployment along the Italian Adriatic coast up to date. However, also in this basin these structures may be seat of further comprehensive, innovative and competitive productive activities such as diving and sport fishing.

Nevertheless, the exploitation of the marine environment for commercial purposes not always gets along with sustainability.

Maintaining a sustainable ecosystem relies on the interaction of 4 elements:

- Productivity: the growth rate of each living part of an ecosystem, affects the basic level of resources that an ecosystem can provide;
- Diversity: number of habitats, kinds of species, amount of genetic variability, influence productivity;
- Resilience: ability of an ecosystem to resist and recover from disturbance events, influenced by both productivity and diversity (Commonwealth of Australia, 2015);
- Disturbance: natural or anthropogenic; ecosystems can balance disturbance with regrowth.

Ecosystem sustainability is determined by the relationship between these elements, and together they determine the level of resources that can be taken from an environment and still maintain it sustainable (Fig. 1).

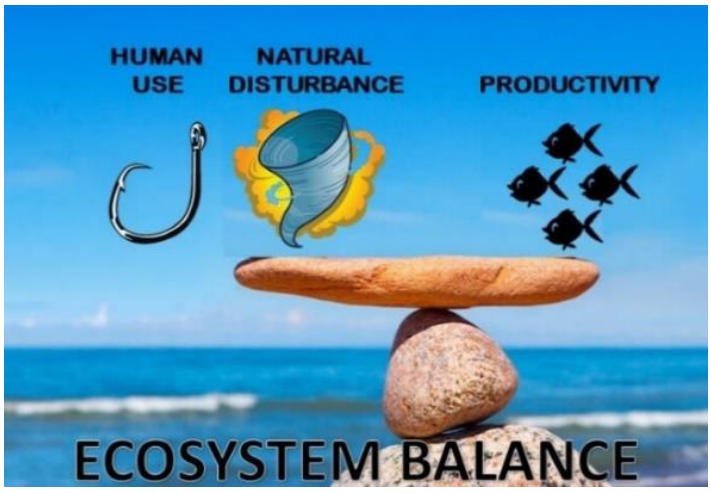

Figure 1. Ecosystem balance: ecosystems are sustainable when they are in balance between disturbance, use and productivity.

One of the purposes of ADRIREEF project is, in the Adriatic sea context, try to harmonize:

- sustainable management;
- research and monitoring;
- capacity building.

The first of the above three central elements, sustainable management, refers to actual on-the-ground efforts to manage people and their activities in and around reefs, particularly in the context of an Integrated Coastal Management (Commission of the European Communities, 2002). The second element, research and monitoring, refers to the research and monitoring programs, projects, and/or activities necessary to understand and manage reef ecosystems, including regional monitoring networks. The third element, capacity building, includes, *inter alia*, training in management practices and monitoring, information exchange, educational programs,

improvement in access to financial and technical support for management, and development of infrastructures within governments or local jurisdictions to manage the activities in and around NRs and ARs.

The goal of the project is to try to create a synergy between reefs uses and activities, in both public and private sectors, according to an agreed upon set of resource management policies and practices. However, it is not so simple.

In the case of coral reefs, the high vulnerability of corals to disturbances and the great variety of natural and anthropogenic stressors affecting them make the sustainable management of this diverse ecosystem both complicated and necessary (Uyarra *et al*., 2009). Commercial activities performed around coral reef areas should be environmentally compatible with the corals but should also be socially compatible with the traditional activities of coastal inhabitants (Zertuche-Gonzalez, 1998).

While federal and state agencies have sought to manage and protect natural habitats from an "ecocentric" perspective, state agencies have also been active in developing and maintaining purposefully placed AR habitats using *ad hoc* materials to produce largely anthropocentric benefits (Oh *et al*., 2008). Moreover, ARs are seen as a way to mitigate productivity losses in NRs and to divert human pressure from sensitive or heavily used natural areas (Osenberg *et al*., 2002). To maximise the benefits from the construction of an AR and reduce costs, the reef is often planned to achieve more than one purpose ("multipurpose artificial reef") (Fabi *et al*., 2015).

2.2. Human use of the reefs in the view of Blue Economy

The environment, particularly the marine and coastal ones, provides numerous ecosystem services. Man has learned how to benefit from these and how to gain profit from the natural resources they provide. Indeed, nowadays several sectors interact with the marine environment, and several of them are even dependent from the marine resources. However, as already mentioned before, in order to achieve benefits from an ecosystem, it is important to exploit it in a sustainable way, trying to maintain its conservation status. Particularly, reef-dependent industries, such as tourism and fishing, rely on a healthy environment for their economic sustainability. These industries, once realized their "business relationship" with the environment, in many cases implement practices to minimise harm, adapt methods and community to the effects of climate change, and promote understanding and appreciation of the reef's values.

2.2.1 Tourism

Going into detail, surely the nature-based tourism sector is one of those that mostly interact with all reefs' typologies. A good environmental status, an elevate biodiversity or the presence of a flagship species is what attracts the attention of visitors. Then, a reef in a good state of

preservation may attract tourism, and its implications (e.g., visitors and the deal of money they bring). It could provide important benefits to conservation that could be achieved by promoting sustainable tourism. However, sustainable tourism development at reefs' areas will only provide benefits if certain conditions are met (Hawkins, 1998):

1. the natural attractions of the region must be competitive with those of other international destinations;
2. management organisations capable of implementing conservation policies and managing tourism impacts must exist;
3. long-term financing support for reef monitoring and management must be ensured.

In fact, tourism itself may include various activities that develop different pressures on an ecosystem. Because of this, environmental associations make big efforts in order to educate all the reefs' users. One example is the Green Fins initiative.

Green Fins (http://greenfins.net/en) (Fig. 2), internationally coordinated by Reef-World, is the only recognised environmental set of standards with a comprehensive management approach to provide guidance and support for business owners and national authorities to promote best practices within the use of reefs (practical example at the link https://www.youtube.com/watch?v=AzThAIkmitQ). The most suitable target industries to implement good practices described in Green Fins are diving and snorkelling.

Figure 2. Green Fins initiative logo with graphic indication of "best-practices" promoted (from https://www.pattaya-scuba-adventures.com)

2.2.2 Diving and snorkelling

One of the biggest incomes from the touristic sector insisting on NRs and ARs comes from diving and snorkelling. These activities are some of the best ways to take in the spectacular underwater

views that the NRs, in particular the corals ones, offer, and to come face-to-face with their captivating marine life. Over the past three decades, recreational scuba diving has become a mass leisure activity engaging around 20 million divers worldwide. Essentially based on the observation of aquatic life and seascapes, it has been praised as a sustainable activity that can provide economic resources not only for local communities (e.g., offering a profitable alternative to extractive businesses such as fishing) but also for the implementation of conservation policies. Nonetheless, it is now clear that unregulated diving can produce serious environmental impacts too.

Although divers and snorkelers have had minimal impact upon the NRs so far, there are times when some of them can get a little too close and may stress the marine life or crush and break something. These include the abrasion or breakage of long-lived sessile organisms, disturbance of fish and mammals, and altered microscale sedimentation patterns that eventually, can lead to community shifts. Most damage occurs as a result of those who are unable to maintain good control in the water (for example, through fighting a current, or trying to get a closer look, or taking photographs).

However, if effectively engaged, divers may contribute to science, territorial management and more sustainable local economies (Cerrano *et al*, 2017).

Australian government produced a list of suggestions for diving at NRs (Table 1), in order that, by having practices, everybody will be able to preserve this special world for others to experience (http://www.gbrmpa.gov.au/access-and-use/responsible-reef-practices/diving-and-snorkelling).

• Wearing a wet suit when snorkelling or diving will help to protect from the sun burn and jellyfish's stings • Enhance the quality of the dive experience by learning about the environment you'll visit • Practice buoyancy control over sand patches before approaching a reef - test buoyancy whenever you're using new equipment such as new wetsuits, buoyancy control devices (BCDs) and cameras • Make sure of properly weighted before diving near a reef • Check that all the dive gear is secure before getting into the water so that it doesn't dangle and catch on the reef • Avoid feeding fish	• Avoid making sudden or loud noises underwater • Avoid leaning on, holding onto or touching any part of the reef • Avoid kicking up and disturbing the sand if you're over a sandy area • Avoid touching any animals or plants • Stay more than one metre away from giant clams • Keep clear of free-swimming animals (such as turtles, whales and sea snakes). • Avoid relocating any marine life, particularly when taking photos and filming. • Move slowly and deliberately in the water, relax and avoid rapid changes in direction

Table 1: list of the responsible reef practices for diving and snorkelling.

To dive at NRs could seem a better experience in respect to the ARs. Many studies on relationships between reefs and scuba diving have been site specific and have never focused on differentiating

the "value" of NRs and ARs in a same area. Oh *et al*. (2008), using interviews-based questionnaires, found that scuba diving at ARs, instead of a less valuable experience, appears to be a suitable substitute for such experiences, compared to the NRs. In other case studies, following the deployment of an AR, the diver and snorkeler use of the NRs in the surroundings declined by 13.7%, relieving the human pressure on the natural environment. Incomes within the local economy increased and additional jobs were created. Thus, it was considered a win-win situation for both the natural reef environment and the local economy (Adams *et al*., 2006). Hence, substantial value from recreational diving use of ARs suggests they serve as potential substitutes and thus may alleviate pressures on NR areas for conservation purposes (Oh *et al*., 2008).

In many cases, some ARs designed for other purposes (e.g., finfish enhancement, etc.) have demonstrated to be also attractive from the divers' point of view. Some best practice examples are described hereafter.

- **"La Casa dei Pesci"** (namely: "The House of Fishes") is the realization of the dream of an Italian fisherman and environmentalist, whose passion for the sea has animated many battles for the protection of the marine environment, empathically involving hundreds and hundreds of people worldwide. His dream was to create a space of sustainability between nature and fishing, natural beauty and art, sea protection and usability (Fig. 3).

The aim was to protect the environment, increase fishery resources, and promote culture and sustainable tourism bringing everyone to "look into the sea" to discover that there is so much nature and beauty that we normally neglect - as invisible - and to understand that the sea is every day robbed by illegal fishing, polluted with toxic waste, and cemented.

Figure 3. How it works: (1) you make a donation, (2) the artist sculpts, (3) we create an underwater art museum, (4) they repopulate the sea (from: https://www.casadeipesci.it/)

The project started from an initiative funded by the Tuscany Regional Authority in 2006 and consisting in the deployment of an anti-trawling artificial reef in the coastal area at North of Monte Argentario, Grosseto (Italy) to contrast the illegal trawl fishing within the 5.6 km (3 nautical miles) from the coast. After which, the fisherman, who was the responsible of the local small-scale fishermen association, was able to get further funds to implement the area directly involving local

Authorities, environmental associations, sport fishing and diving clubs, and private companies, as well as several citizens both at national and international level through a spontaneous web whip round. More than 100 marble blocks spontaneously sculptured by artists, have been deployed up to date in the area to implement fish repopulation and create an “underwater art gardens” as part of educational pathways including land and sea (Fig. 4).

Figure 4. 'La Casa dei Pesci' underwater sculptures (from: https://www.casadeipesci.it/)

- **Underwater museums** - A similar synergy between these purposes has been also implemented in the Oceanic context (Table 2).

Jason deCaires Taylor (https://www.underwatersculpture.com/), a sculptor, environmentalist and professional underwater photographer, is the first of a new generation of artists to shift the concepts of the land art movement into the realm of the marine environment.

The sculptures (Fig. 5) are individually designed using safe pH neutral materials with textured surfaces to create homes, breeding areas and protective spaces for marine organisms. Sited away from natural healthy reef systems on barren stretches of sea beds, they provide a crucial role in drawing visitors away from natural areas allowing them space and time to recover on their own accord. Some projects have seen marine biomass to increase by over 200% on once deserted sections of sea bed.

Figure 5. Jason deCaires Taylor Underwater art museum examples (from: https://www.underwatersculpture.com/works/recent/?doing_wp_cron=1563204970.7339780330657958984375).

On a local level, through his works he obliges local governments to consider their coastlines. In Grenada (Caribbean sea), the sculpture park was instrumental in the creation of a large scale marine protected area and in the Bahamas an oil refinery which had been leaking oil into the sea for over 10 years, was forced into preventative measures, following the complaint of some tourists. They attracted international media because during their visit at the "Ocean Atlas", they literally swam into an oil slick.

Entrance fees are charged to visitors, this crucial revenue is then put towards Conservation projects and help fund marine park rangers who monitor and protect the coastlines. Admissions and donations for entering the museums have not only a crucial role in providing revenue for marine conservation initiatives, but also represent an alternative employment for local fishermen.

NAME	LOCATION	DEPTH	INTALLATION DATE
M.U.S.A. Museo Subacuático de Arte	Cancun / Isla Mujeres, Mexico	4-8m	2009
Ocean Atlas	Nassau, Bahamas	5m	2014
Molinere Underwater Sculpture Park	Molinere Beauséjour Marine Protected Area, Grenada	5m	2006
Museo Atlántico	Las Coloradas, Lanzarote, Canary islands	14m	2016

Alluvia	The River Stour, Canterbury, England	1.5m to 80cm	2008
Nexus	Oslo, Norway	2m	2018
Coralarium	Sirru Fen Fushi, Maldives	3-5m	2018
Nest	BASK Gili Meno, Indonesia	4m	2017

Table 2: list of the Jason deCaires Taylor underwater museums.

- **Shipwrecks** may become ARs when preserved on the sea floor. Shipwrecks offer unique, spectacular and fascinating diving experiences. Many shipwrecks are important recreational resources for scuba divers, and the recreational value of shipwrecks has been well recognised among them (Edney, 2006). Governments also recognise the dive tourism value of shipwrecks. For example, the Queensland Government scuttled the decommissioned HMAS Brisbane on the 31st July 2005 off the Sunshine Coast to create a dive tourism attraction and artificial reef (Figure 6).

Figure 6. Brisbane wrecks, Mooloolaba Queensland. (from: https://www.tangalooma.com/moreton-island/tangalooma-wrecks)

Certain items were removed, however, in a minimum way, to maintain the ship's integrity and to ensure it provides interesting diving opportunities without being a threat of harm to the visitors and the marine environment. In addition to the cultural heritage, recreation and tourism values discussed above, wrecks have scientific, educational and monetary values. Since that, the sustainable use of these sites is important not only for the protection of cultural heritage and

recreational dive values, but also to protect the industries and communities that depend on the revenue from these values.

Although the marine environment may, to some extent, preserve shipwrecks and their contents (Delgado 1988), no wreck is completely stable in its environment. All wrecks are to varying extents subject to deterioration and damage from the effects of the marine environment. The extent of deterioration of shipwrecks is determined by depth, topography and composition of the seabed, temperature, salinity, oxygen content, sea conditions, water movement, and the type of material used in the ships construction (Kenderdine, 1997). Natural deterioration and disintegration processes of wrecks are accelerated by a wide range of human activities associated with the use of the marine environment (Kenderdine, 1997), including recreational diving, dredging operations, extractive industries, beach nourishment, fishing activities including damage from nets, anchors, dredging and explosives, marina developments, etc. (Edney, 2006).

Shipwrecks are protected in Australia by the Commonwealth Historic Shipwrecks Act 1976, which recognises and protects the historic, scientific, education and recreation values of this particular sites; there are historical records of over 7 000 shipwrecks off the Australian coastline, and at least 925 states with physical evidence of these wrecks have been located. Section 13 of the Act makes it an offence to do any of the following, unless the person has a permit:

- damage or destroy an historic shipwreck or historic relic;
- interfere with an historic shipwreck or historic relic;
- dispose of an historic shipwreck or historic relic; or
- remove an historic shipwreck or historic relic from Australian waters or from waters above the continental shelf of Australia;
- moor or use ships within a protected zone.

Because of the legislation, public access guidelines were developed, together with a research plan, by the Australian government to enable wrecks to be better managed and to develop a more consistent approach across the states. For example, in Australia, it is illegal to anchor on a historic shipwreck and mooring buoys have been installed, or recommended to be installed at certain wreck sites, to prevent anchor damage. Underwater interpretive wreck trails have been developed, and include concrete plinths on shipwreck sites with information plaques attached as well as published information. Their aim is to attract divers to the site and to increase appreciation and protection of the cultural heritage values of the wrecks. Permit systems are another approach used to manage divers' impacts on shipwrecks. Education is the principle strategy used to protect the underwater heritage, and includes community awareness and involvement programs, publications, exhibitions, posters and contacts with the dive industry and dive organisations. Education and involvement lead to increased awareness of the value and importance of wrecks, and education is required to modify attitudes.

There is no uniform approach to the protection and management of shipwrecks arising from the diversity of environment, political systems, cultures and economic development of the various nations.

In the Mediterranean sea there are 844 wrecks (Strauss, 2013). Most of them are ships that sunk during a battle or because of natural events or technical problems, while others were purposely sunk to create ARs. For example, the southern Albanian coastline hosts diverse and valuable marine habitats, threatened by rapidly increasing coastal development and tourism. To protect the natural habitats from excessive pressure and improve the variety of diving opportunities, the immersion of a number of ex-naval vessels was forecasted within the Pilot Fishery Development Project. Five decommissioned Albanian Navy vessels were purposely sunk in 2010 in the Ksamil Bay with the support of the United States Navy ship Grapple (Fabi *et al*., 2015; Fig. 7).

Figure 7. Ship wrecks sunk as artificial reefs for diving in Ksamil Bay, Albania. (from Fabi et. Al., 2015)

Decommissioning is the process of ending operations at an offshore oil and gas platform. Usually, the platform is completely removed; however there are options that entail reefing the submerged section of the platform structure. Rigs-to-reefs is the practice of converting decommissioned oil and gas platforms into ARs.

- **Rigs-to-reefs**. In the Gulf of Mexico about 200 structures forming some 10% of the decommissioned platforms, have been used for reefing practices. The warm subtropical waters and the good visibility of the Gulf of Mexico made these structures popular among divers (Fig. 8). A good example is the platform “High Island A389” installed about 185 km off Galveston, Texas. High Island A389 is no longer operational - all drilling for oil ceased in the early 1990s when the Flower Garden Banks National Marine Sanctuary, a site encompassing three underwater salt domes protected by the National Oceanic and

Atmospheric Administration's Office of National Marine Sanctuaries, was designated a protected site. The rig was decommissioned since it was within the site's boundaries. In the time since, local diving tour operators have begun bringing divers to the area to experience what it is like to dive a manmade reef (https://www.smithsonianmag.com/travel/gulf-mexicos-hottest-diving-spots-are-decommissioned-oil-rigs-180971728/).

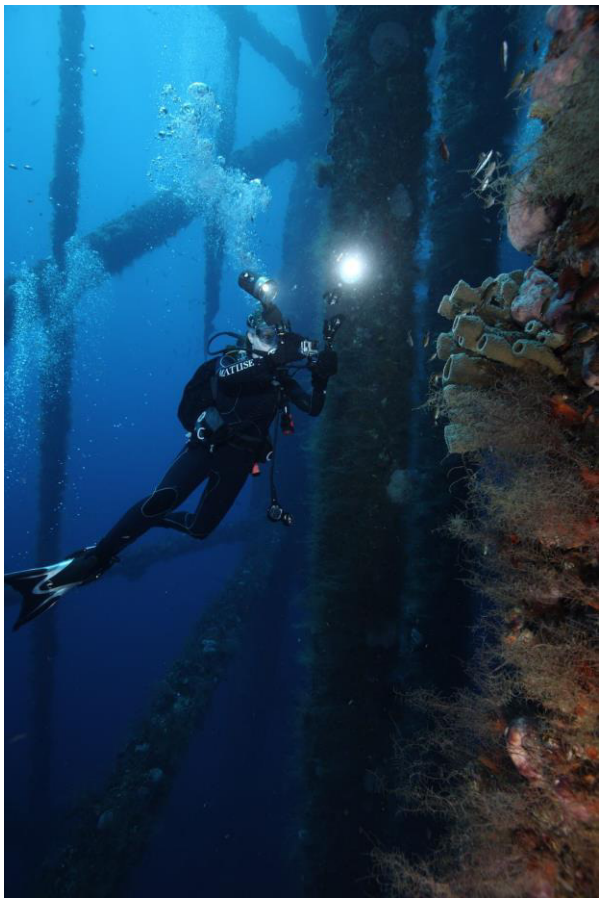

Figure 8. Rig-to-reefs in the Gulf of Mexico. (from https://www.smithsonianmag.com/travel/gulf-mexicos-hottest-diving-spots-are-decommissioned-oil-rigs-180971728/).)

Another example of Rig-to-reefs converted to diving activity can be found in the Adriatic sea. The Natura 2000 site named "Paguro" is a gas platform wreck that collapsed in 1965, located 22 km off the coast of the Emilia Romagna Region. The NGO "Associazione Paguro" is in charge for diving authorisation and managing recreational activities. The NGO acts to promote the site's cultural and natural heritage. It is connected with several diving schools and organises educational events (e.g. diving days to the site). The association is also in connection with the National Museum of Underwater Activities in Marina di Ravenna, where historical, cultural and educational activities are carried out (AAVV, 2018).

2.2.3 Citizen science

Citizen Science refers to the population participating in scientific activities and research projects related with the environment and its biodiversity, taking advantage of new technologies such as the Internet and mobile phones with recording capabilities for an easy data collection and sharing. This participatory approach, in some cases, focuses on reefs.

Founded in 1996, the **Reef Check Foundation** exists to help preserve the oceans and reefs that are critical to our survival, yet are being destroyed. With headquarters in Los Angeles and volunteer teams in more than 90 countries and territories, Reef Check works to protect tropical coral reefs and California rocky reefs through education, research and conservation. Reef Check programs provide ecologically sound and economically sustainable solutions to save reefs, by creating partnerships among community volunteers, government agencies, businesses, universities and other non-profits. Every year, the Foundation trains thousands of citizen scientist divers to voluntarily survey the health of coral reefs around the world, and rocky reef ecosystems along the entire coast of California. The results are used to improve the management of these critically important natural habitats. The involvement of citizens (whether members of the general public or dedicated volunteers) to undertake data collection for regional scale scientific studies is a key tool to achieve shared decisions in the field of biological conservation as well as to increase awareness of the large public towards the sustainable use of marine ecosystems. Reef Check Italia onlus is applying fast and effective protocols since 2008 involving both young students and recreational divers to collect data on abundance and distribution of target species along beaches and underwater (Cerrano *et al*., 2013).

Another way to directly involve people in the monitoring of marine environment, and then make them aware of possible best practices in the use of a reef, are webcams that broadcast in live streaming.

For instance, nowadays, most deployed cabled observatories bear video cameras, which may truly represent the first innovative and multifunctional sensors to monitor life activities at different levels of complexity (i.e. from the individual animals to population, species up to the level of the whole community). The **OBSEA** underwater observatory (www.obsea.es), placed at a depth of 20 m in a fishing protected area, is connected with 4 km of cable to the coast of Vilanova i la Geltrú (Barcelona, Spain). The implemented solution is an optical ethernet network that continuously transmits data from the connected oceanographic instruments. It works as a useful platform for the measurement of oceanographic and environmental parameters. It is composed of a video surveillance camera and a weather station with GPS that measures wind direction, wind speed, barometric pressure, air temperature among other parameters. The CTD records temperature, salinity and pressure at different sampling intervals, providing information on flows and blends and their seasonal variations. A broadband hydrophone (7 Hz to 100 kHz) characterizes acoustically

ambient noise and discriminates coherent signals from natural sources from anthropogenic signals. For information about the evolution of seawater acidification, they designed a pH sensor permanently connected to the observatory. It is well known that the increase in CO_2 content in the atmosphere due to human activities is causing, through the greenhouse effect, global warming. The oceans and seas are absorbing a lot of the CO_2 emitted by human activities, causing a progressive acidification of the water. This shift toward more acidic conditions is associated with a number of adverse effects on marine organisms, especially for those who calcify, such as corals, mussels, coccolithophore algae or pteropods. All the metadata are in a publicly accessible online database, directly available on the website. Every user can have a look at the data and detect natural or anthropogenic effects on the environment. The research group produces papers and relations about this data, making theme intelligible to non-expert users. Similar installations have been realized in other areas such as, for example, in 1988 at the Cesano AR in the northern Adriatic Sea (Totti *et al*., 2019).

2.2.4 Fishing activity

One of the main purposes for deployment of ARs is to enhance fisheries and improve fisheries management. Not only recreational, but also commercial fishers are potential as users of ARs in several areas (Sutton & Bushnell, 2007). Along the Italian coast of the Adriatic Sea, an important clam fishery (*Chamelea gallina*) operates with hydraulic dredges on the sandy-mud bottoms located in shallow water up to around 11 m depth. Small-scale fisheries have conflicts both with illegal trawling for resources competition and damage to the set gears and with hydraulic dredges for space competition and, again, damages to the gears. Anti-trawling structures associated with production units or mixed modules were employed (Bombace *et al*., 2000; Fabi, 2006; Fabi *et al*., 2006). These ARs led to a reduction in conflicts between fishers as they created suitable areas where small-scale fishermen can carry out their seasonal activities on the basis of the eco-ethology of the different species inhabiting the reef, often joining together in cooperatives which manage the reef areas and their resources (Fabi *et al*., 2015). From the ecological point of view, shifting a part of fishing effort towards the exploitation of the reefs' resources leads to reduce fishing pressure on the fish species usually targeted, contributing in this way to recover overexploited stocks (Fabi *et al*., 2010; Fig. 9). It also contributes to diversify the offer to the local market.

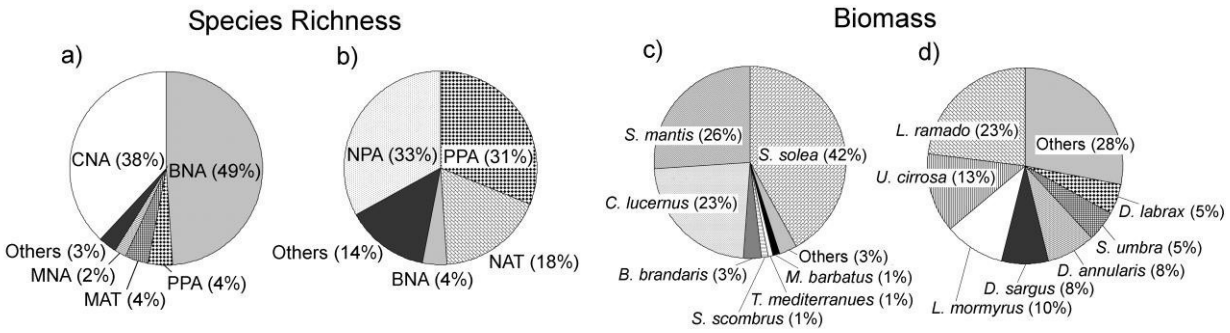

Figure 9. Composition in terms of species and biomass of the catches obtained with set nets at the natural habitat (a, c) and at ARs (b, d). CNA = crustaceans not attracted, MNA = molluscs not attracted, MAT = molluscs attracted, PPA = pelagic fish partially attracted, BNA = benthic fish not attracted, NPA = nekto-benthic fish partially attracted, NAT = nekto-benthic fish attracted. Attraction is referred to the reefness towards natural and/or artificial hard substrates (from Fabi et al., 2010).

Recreational fishery also targets other typologies of ARs worldwide, such as Rigs-to-reefs. In 1985, NOAA produced the National Artificial Reef Plan that outlines the respective roles of federal state and local governance in the permitting, oversite and ongoing management of this kind of ARs.

A virtuous example comes from the Louisiana State. Here the construction of ARs started in 1987 (Louisiana Artificial Reef Plan) and more than 80 sites have been created up to date. Louisiana has designated 9 approved sites for the disposition of oil and gas structures and in the period 1987-2006 about 147 structures have been reefed. The Artificial Reef Council oversees the Artificial Reef Development Program and gives guidance on policy-making, site selection, procedures and allocation of funds, while the Department of Wildlife & Fisheries is in charge of monitoring and managing the Artificial Reef Development Plan. Louisiana operators that leave their structures offshore donating them to the Artificial Reef Trust Fund (Bull & Love, 2019). Moreover, the Mississippi Department of Marine Resources (DMR) is responsible for AR development in Mississippi's marine waters and adjacent federal waters. Since the establishment of the Artificial Reef Program, 67 inshore reefs, 15 offshore reefs, and 8 Rigs-to-reef sites have been created to enhance and support important marine species. The DMR, Mineral Management Service (MMS), and petroleum companies are working together to utilize decommissioned oil and gas platforms for offshore AR development. The program commonly known as "Rigs to Reef" uses these abandoned structures for enhancing fish and invertebrate habitat, together with the advertisement of recreational fishery (http://www.dmr.ms.gov/index.php/recreational-fishing/reef-locations).

Regarding recreational fishery on NRs, a list of best practices related to fishing activity have been produced by the Australian Government to safeguard the Australian Great Barrier Reef (Table 3; http://www.gbrmpa.gov.au/access-and-use/responsible-reef-practices/fishing). These practices help to protect the natural environment, maintain the ecological balance of the Reef and

contribute to improve its general health, especially at a time when the Reef is under increasing pressure.

BEST PRACTICE FISHING GUIDELINES FROM THE AUSTRALIAN GREAT BARRIER REEF	
• Actively attend your fishing gear at all times while fishing. • Take only what you need – do not necessarily fish to the bag limit. • Do not use pest or non-native fish for bait. Never release introduced species into the water. • Do not fish where fish feeding takes place, for example as part of a tourist program. • Do not fish near a commercial dive site or pontoon. • Do not fish at known or suspected fish spawning aggregation sites. • Fish a safe distance from marine animals (such as dolphins, whales, turtles, and dugongs) and bird roosting or nesting areas.	• If you're unsure of the fish identity or size, release the fish immediately. • Return all undersized and unwanted fish quickly to minimize injury. • If you're keeping the fish, remove it from the hook or net immediately and kill it humanely. • Do not litter – clean up all fishing gear (such as discarded tackle and line, and bait bags) and take it back to shore to dispose of it properly. • After filleting fish, avoid disposing of the frames at boat ramps and popular areas. • Participate in fish monitoring and research programs where available.

Table 3. Example of Best practice fishing guidelines of the Australian great barrier reef. (from: http://www.gbrmpa.gov.au/access-and-use/responsible-reef-practices/fishing)

By following these simple guidelines, the users are helping to ensure that the Great Barrier Reef continues to be one of the best spots on Earth to fish (http://www.gbrmpa.gov.au).

2.2.5 Mussels farming

It is well known that hard substrata in coastal areas provide variable surfaces and microhabitats for settlement and growth of benthic organisms (Petersen & Malm, 2006). In case of AR construction, the biomass and species composition of these communities will depend on the material of the AR, depth, slope, and wave exposure, but also on the oceanographic features and the unique biodiversity of the area.

In the central and northern Adriatic Sea the vertical walls are mainly colonized by hard-bottom, filter-feeders such as bivalves (e.g. *Mytilus galloprovincialis, Ostrea edulis, Crassostrea gigas*), hydroids, and barnacles (Spagnolo *et al*., 2004). In particular, the highest settlement density of mussels (*M. galloprovincialis*) represents a good opportunity for professional fishermen. Indeed, small-scale fishermen can partially shift, from spring to fall, from fishing activity to the collection of mussels on the artificial substrates (Fabi *et al*., 1989). In order to facilitate mussel harvesting by professional scuba divers a few ARs were placed close to the coast and in shallow waters (approximately 10 m depth).

In this context, an example of a good and sustainable practice can be found in the Portonovo bay (Conero promontory, Italy) were an AR was deployed within the coastal area by the local small-scale fishermen association to improve their activity by creating suitable habitats for reef-dwelling fish and macroinvertebrates and favouring the development of wild mussel populations. The reef sets were composed by two types of mixed modules: a) protection and production; b) production and aquaculture (Fabi *et al*., 2015). The cooperative carries out limited harvesting to ensure natural reproduction and safeguard the survival of mussel populations on the AR and, in parallel, harvest mussels on the nearby NRs (e.g., Trave rock). This wild product is recognized with the establishment of the brand "Mosciolo di Portonovo". The trend mark implies the indication of the date and place of fishing, while the sale in sealed bags ensures strict compliance with the supply chain from the production to the consumer.

The culture of seaweed on reef flats is also proposed as an ecologically and commercially viable alternative that could divert destructive fishing activities to an environmentally friendly endeavour. Seaweed culture in reef flat areas has been practiced since 1971 in the Philippines. For over 25 years, reef flats have continuously produced tons of seaweed, while coral, other invertebrates, wild algae, sea grasses, and fish lived and flourished there. Seaweed cultures can absorb the excess of nutrients produced by terrestrial farming and local villages or from tourist development, thereby preventing the growth of opportunistic plants that often kill corals. As a sustainable livelihood, seaweed farming prevented migration to urban areas and helps development in the province (Zertuche-Gonzalez, 1998).

3. DEFINITION OF THE LIST OF REEFS TO BE CONSIDERED IN THE CASE STUDY IDENTIFICATION

3.1 Introduction

A series of meetings were held between January and May 2019 to discuss on the Activities of WP3 and especially on the choice of the sites to be used as Case Studies within the ADRIREEF project. They were web meetings to save time and funds.

In this chapter, the minutes of all meetings related with the CSs selection have been reported in order to describe the process that led to their final identification.

3.2 Description of the identification process

Virtual KoM (4th December 2018)

This Skype meeting was organized by the Project Leader (PL; Municipality of Ravenna) to inform all the PPs on the technical and financial managements of the project and provided a clear explanation of them.

PL also illustrated the KoM program and communicated which documents/presentations each PPs had to prepare for that meeting. Among other duties, all PPs were asked to propose possible CSs to be carry out inside the project.

Skype Meeting on WPs 3-4 (8th January 2019)

The Skype call was organized by PL with the participation of CNR-IRBIM and ARPAE, WP3LP and WP4LP, respectively. The aim of the meeting was to discuss about the mapping of the natural and artificial reefs existing along the Adriatic coasts (Act. 3.3) and how to organize the work.

A focal point on natural reefs was to identify the different typologies of reefs to make possible their classification. This activity was considered very priority and propaedeutic for the CS identification as the CSs should have been as much as possible representative of the reef typologies occurring in the Adriatic Sea basing on available literature and/or the PPS' experience.

Skype Meeting on KoM and WPs 3-4 (11th of January 2019)

Basing on the previous meeting held on the 8th January, a further Skype meeting involving all the PPs was organized by LP to discuss on KoM and WPs 3-4. Only PP7 (OGS) did not attend the meeting. With regard to Act. 3.3 "Identification of relevant case studies" a preliminary consultation among the PPs on possible CSs was done during the Skype call. PP8 (RERA) described some possible Croatian sites to be taken into account being very important for tourism. PP6 (ARPA PUGLIA) also proposed possible CSs in its Region.

Skype Meeting on Activity 3.3 - possible Italian CSs (14th January 2019)

The aim of this Skype meeting organized by CNR-IRBIM (WP3 Leader) was to start a deeper discussion on the selection of the Italian CSs. All the Italian PPs were involved: LP (Municipality of Ravenna), PP1 (ARPAE Emilia Romagna), PP6 (ARPA Puglia), and PP7 (OGS).

WP Leader (WPR) gave an introduction on the on the possible aspects which had to take into account to select the CSs. Particular emphasis should be given to replicability, economic aspects and the possibility of applying innovative and low impact technologies in the monitoring phase.

All PPs proposed their own CS describing the relevant aspects of each area from the ecological and economical point of view, also pointing out the possible exploitation of the site in order to strengthen the Blue Economy.

ARPAE Emilia Romagna and CNR-IRBIM proposed as CSs artificial habitats: the first one is an offshore rig sunk in 1960s in the northern Adriatic Sea that become a Biological Protected Area in 1995 (Paguro platform), a Site of Community Importance in 2012 and finally a Special Area of Conservation in 2019. The second CS, proposed by CNR-IRBIM, is an AR located in the central Adriatic Sea made of concrete structures (pyramids and poles) purposely deployed for finfish repopulation and to protect the coastal area from illegal trawling. Both ARPA Puglia and OGS proposed as possible CSs either an artificial reef or a natural reef. Taking into account that two already identified artificial habitat CSs could be considered as fully representative for the Italian Adriatic coast, it was agreed to select the two natural reefs: an MPA with coralligenous reefs in the South Adriatic (Torre Guaceto) and a natural reef made of biogenic concretions (Tegnue) in the northern Adriatic, respectively.

The WPL informed the PPs that a template for the CSs description (e.g., location, available data, current and possible exploitation) would have been produced and distributed to all PPs.

This template was prepared and then distributed to the PPs (Ref. to Annex 1).

Skype Meeting on Activity 3.3 - possible Italian CSs (2nd of April 2019)

The scope of the Skype Meeting organized by WP3L was to finalize the selection of the Italian CSs and to start discussing a common strategy on the monitoring plan and dissemination of results. All the Italian PPs involved in the Activity 3.3 attended the meeting: PP1 (ARPAE Emilia Romagna); PP6 (ARPA Puglia), and PP7 (OGS).

The “Porto Recanati - Porto Potenza Picena” AR and the “Paguro” platform were confirmed by CNR-IRBIM and ARPAE Emilia Romagna, respectively, as CSs representative for the artificial habitats along the Italian Adriatic coast.

A “low profile” natural reef made of coralligenous within the Marine Protected Area “Torre Guaceto”, was announced as Apulian CS.

Finally, OGS described its CS representing the typical NRs of the northern Adriatic Sea so called “Tegnue”. These reefs are rocky outcrops extending from a few to several hundred meters and characterized by different substrata (clastic sedimentary, sedimentary sediments, organogenic).

All CSs are representative of different relevant contexts occurring in the Adriatic Sea and in line with the scope of the ADRIREEF project, hence approved.

WPL announced that a new template for the description of all CSs, to be used for Deliverable 3.3.2, would have been distributed in order to get a similar format (Ref. to Annex 2).

Skype Meeting on Activity 3.3 – Croatian CSs (12th March 2019)

The Skype call involved all the Croatian PPs, WP3L, and PL.

The Croatian PPs proposed 7 possible sites of natural reefs to be considered as CSs:

- Plićinia Konjsko, close to the island Krk, a low profile reef and ledges in the northern Adriatic Sea (PP10, University of Rijeka);
- Sika od Kormata, close to the island Krk, a high profile reef in the northern Adriatic Sea (PP10, University of Rijeka);
- Rt Letavica, close to Simuni od in the south-western side of Pag island, a patch reef and a nearby amphora site in the northern Adriatic Sea (PP3, SUNCE and PP4, University of Zadar);
- Plič Lagnjići, close to Dugi Otok island, a low profile reef with a ship wreck in the central Adriatic Sea (PP4, University of Zadar);
- plić Seget, close to the Vis island, a high profile reef in the central Adriatic Sea (PP8, RERA);
- Sika od Stupišta, close to the Vis island, a high profile/low profile reef with wrecks in the central Adriatic Sea (PP8, RERA);
- Pokrivena sika, close to the Vis island, in the central Adriatic Sea (PP8, RERA).

In order to collect the available information about the proposed CSs and to have a comprehensive background knowledge to support the selection of maximum 3 CSs on the Croatian sites the PPs decide to carry out a preliminary study, by an external expert appointed by SUNCE PP3, in agreement with the budget allocation. The study will include an in depth analysis of the sites, as part of deliverable D.3.3.2.

Following the SM the following agreed information were shared by the WPL with the PPs:

- Basical criteria to select case studies
- monitoring protocol for CSs

- draft list of some equipment identified up to date for theirpossible application in the Italian CSs.

Basic criteria to select the case studies, agreed and shared by the Project Partners are the following:

1) The Case Studies should be as much as possible representative of all the natural reef typologies listed in the "Reefs definitions and categories" (refer to Deliverable 3.1.1) as well as of different artificial reefs typologies.
2) Geographical position of the CSs in order to have at least one CS in the northern Adriatic, one in the central and another one in the southern part of the basin either along the Croatian and the Italian side.
3) Scope of the CS in terms of activities that could be developed/implemented there taking also into account eventual already existing human activities and related land activities.
4) Monitoring activities that can be implemented in the CS paying attention to innovative and low impacting methodologies.

Skype Meeting on Activity 3.3 – Croatian CSs (7th May 2019)

A further meeting with the Croatian PPs was held on May 7, to get an update on the process of CSs identification and to discuss their decision of performing a methodological study to select the most suitable sites whose end had been forecasted at the end of June. All Croatian PPs, LP and WP3L attended the meeting.

SUNCE explained that the main objectives of the case study analysis committed to the external expert are the following:

• collect and analyze all existing data on specified areas;
• Identify the ecosystem services of each of these areas using the definition and categorization within the Millennium Ecosystem Assessment (MA);
• analyze the "blue economy" postulates and examples of good practice in the world that include marine reefs;
• analyze the application of the "blue economy" postulate in selected areas in terms of identifying new economic activities and their potential.
In order to fulfill the deadlines it was then agreed with SUNCE to share the first two parts of the study by end of May, so that Croatian PPs could finalize the selection of their CSs.

Following this three Croatian CSs were definitely proposed in June by Croatian PPs. One of them is located in the northern Adriatic Sea (Plićina Konjsko; PP10, University of Rijeka), while the other two are placed in the central Adriatic Sea (Plić Seget; PP8, RERA and Plič Lagnjići; PP4, University of Zadar).

The sites are representative of the different reef typologies occurring along the Adriatic Croatian coast and thus considered significative within the project.

In the overall the 7 CSs, listed in Table 4, were selected for the implementation of monitoring programmes to be conducted within WP4 (Activities 4.1 and 4.2) with the aim of investigating their suitability for developing sustainable activities according to the principles of the Blue Economy (Table 4 and Figure 10).

Indeed, they are representative of different reef typologies occurring in the Adriatic Sea therefore the results obtained during the project could be expanded to a wide range of Adriatic reefs.

A detailed description of each CS is provided in Chapter 4.

CASE STUDY NAME	PP RESPONSIBLE	TYPE OF REEF	REEF CATEGORY
Paguro wreck	ARPAE Emilia Romagna – PP01	Artificial Reef	Sunken jackup drilling rig + additional iron structures
Plić Lagnjići	University of Zadar – PP04	Natural reef with a ship wreck	Sand bottom with reef structures protruding from the sediment
Porto Recanati-Porto Potenza Picena	CNR-IRBIM Ancona – PP05	Artificial Reef	Specifically designed concrete modules geometrically assembled to form structures and concrete poles
Torre Guaceto Marine Protected Area	ARPARP - PP06	Natural Reef	Low profile reef and Patch reef
Trezza San Pietro	OGS – PP07	Natural Reef	Patch reef (sand bottom with small reef structures protruding from the sediment)
Plić Seget	Institut Ruđer Bošković – PP09	Natural Reef	Patch reef (sand bottom with small reef structures protruding from the sediment)
Plićina Konjsko	University of Rijeka, Faculty of Maritime Studies – PP10	Natural Reef	Low profile reef (the reef protrudes less than 20 meters from the base substratum)

Table 4. list of the Case Studies.

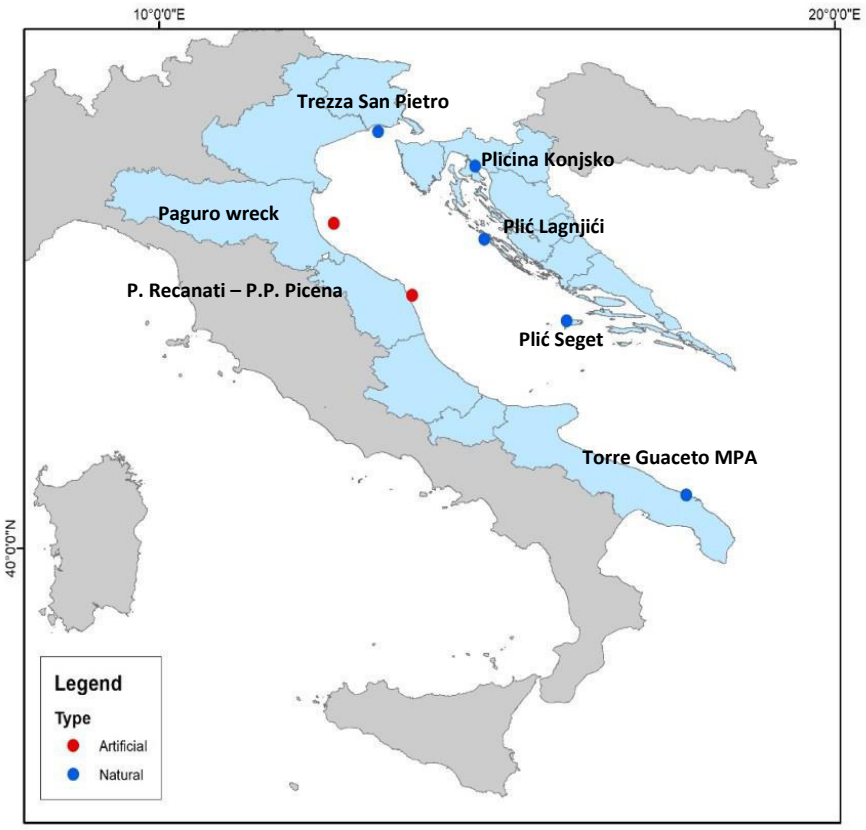

Figure 10. Map of the Case Studies in the project area.

4. CASE STUDY PRESENTATION

4.1. Paguro wreck

4.1.1 General Data

CASE STUDY NAME	Paguro wreck
PP RESPONSIBLE	ARPAE Emilia-Romagna – PP01
TYPE OF REEF	Artificial Reef
REEF CATEGORY	Sunken jackup drilling rig + additional iron structures

4.1.2 Geographical location, physical and ecological features

The “Paguro” drilling platform, owned by AGIP Mineraria, was built by the company "Nuova Pignone" of Porto Corsini in 1962 and for three years was used in numerous perforations in the Adriatic Sea. It was a self-elevating platform, with a drilling tower consisting of a floating triangular-shaped pontoon with three legs placed at the vertices. The pontoon housed powerful engines, pumps and machinery, while its surface was equipped with a lodging module consisting of 5 decks. The heliport was placed at the top of the bow leg, while the drilling tower of about 40 m was located at the stern, between the other two legs. On the 29th September 1965, the platform was located 12 nm offshore Ravenna and sank as a result of a fire caused by methane leaking from the well. Currently it leans on the seabed with the starboard side buried several metres deep in the sediment. The main identifiable structures are the pontoon, the lodging module, including the five decks, and the leg of prow connecting the cylindrical base to the remains of the heliport (Fig. 11). The bottom consists of sandy silt and has an average depth of 24 m, but the gas eruption excavated a crater to a depth of about 34 m. The wreck extends over a depth range between 10 and 34 m.

In the years 1990-1991 and 1999-2000 additional iron structures, once used for off-shore activities, were sunk at the same site and now dominate several parts of the original wreck (Fig. 12).

Water temperatures in the area vary between 26 °C and 28 °C in summer and 8 °C and 10 °C in winter. Vertical profiles show a sharp seasonal thermocline that reaches an average depth of 16 m in August. Below the thermocline, the temperature never exceeds 14-16 °C. In spring and autumn, turbid plumes from Po river floods dilute surface waters, reducing the salinity and raising nutrient concentrations. These phenomena contribute to dystrophic conditions that occasionally cause hypoxic crises in the area of the wreck. Prevailing currents around the wreck flow to South-East direction.

The flora colonizing the wreck consists essentially of 3 species of macroalgae: *Bryopsis hypnoides* (Chlorophyceae), *Ceramium diaphanum* (Rhodophyceae) and *Aglaothamnion tenuissimum* (Rhodophyceae). Their presence can be observed in the upper part of the structure which is more exposed to light.

Sponges tend to be more abundant in the upper part of the wreck and they are mostly represented by *Haliclona mediterranea*. The sessile Cnidarians can be detected on the entire wreck even if they are most common in the upper part. These include *Epizoanthus arenaceus*, *Aiptasiogeton hyalinus* and *Corynactis viridis*.

Sessile bivalve molluscs such as mussels (*M. galloprovincialis*) and oysters (*Ostrea* spp.) inhabit the upper part of the wreck although oysters can be observed also in deeper waters. Comb pen shells (*Atrina pectinata*) are found both in the surrounding muddy bottoms and in the fine sediments deposited in the cavities of the wreck itself. Scallops of the genus *Chlamys* prefer deeper waters and are more abundant during the spring season. Gastropods are mainly represented by Nudibranchs. The most common are *Jorunna tomentosa*, *Facelina bostoniensis*, *Flabellina lineata* and *Polycera quadrilineata*.

Among the Echinoderms, the genus *Ophiothryx* shows a clear dominance, followed by some Holothurians with the species *Holothuria poli*, *Holothuria tubulosa* and *Ocnus planci*.

Polychaete annelids are present on the metallic infrastructures of the wreck and on the shells of bivalves; those belonging to the genus *Serpula* and *Pomatoceros* are generally abundant.

Crustaceans are mainly represented by barnacles with the species *Balanus perforatus* and *Balanus amphitrite*. Shrimps of the genus *Lysmata* are also quite common. Crabs are represented by the species *Dromia personata*, *Eriphia verrucosa* and the genus *Maja*. The lobster *Homarus gammarus* can also be observed. Tunicates (*Ascidia mentua* and *Pjura microcosmus*) can be found in the shaded areas of the wreck (Ponti *et al.,* 1998).

Fishes are those typical of rocky bottoms and difficult to find in other parts of the north-western Adriatic: brown meagre (*Sciaena umbra*), saddled seabream (*Oblada melanura*), striped seabream (*Lithognathus mormyrus*), black scorpionfish (*Scorpaena porcus*), seabass (*Dicentrarchus labrax*) and conger eel (*Conger conger*).

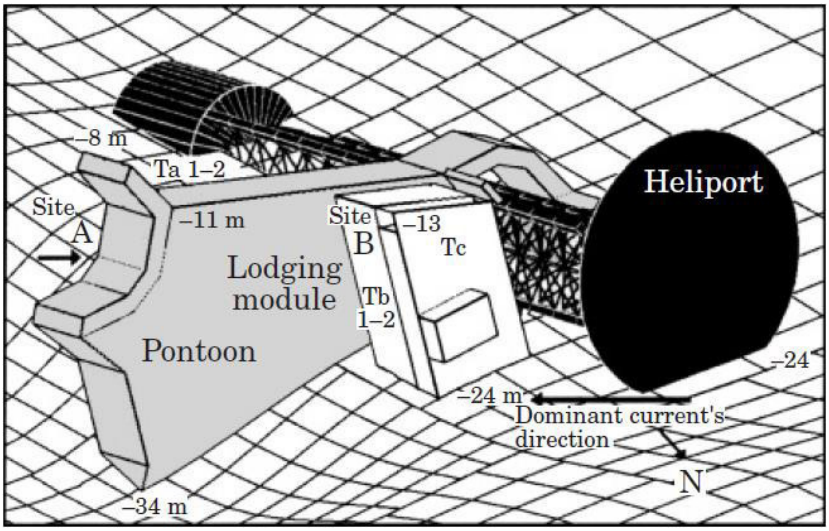

Figure 11. Three-dimensional reconstruction of the wreck showing relevant structures and their orientation. (From: Ponti et al., 2002)

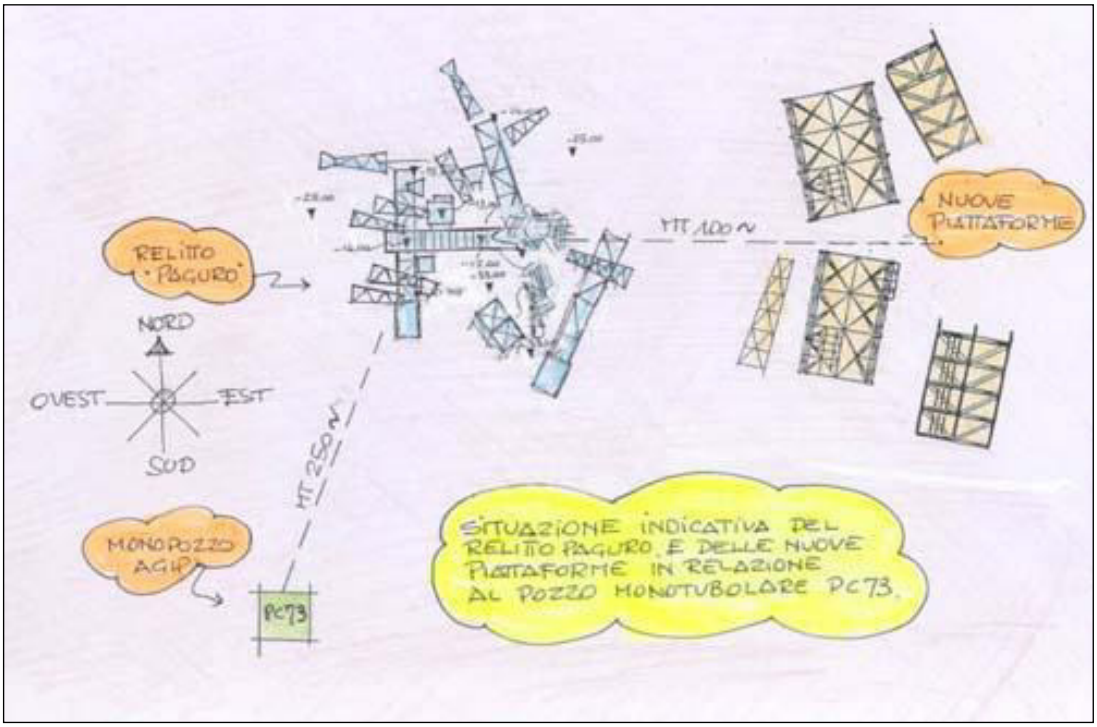

Figure 12. Approximate map of the AR including the original wreck and the additional iron structures. (Drawing by F. Rambelli)

4.1.3 Assessment of *status quo*

Emilia-Romagna is a top European tourism destination, welcoming more than 11.5 million visitors annually and generating 50 million overnight stays. The “Paguro” wreck is located 12 nautical miles offshore Ravenna, a province that covers the southern part of Romagna and extends from the sea to the gently rolling foothills of the Apennines.

Ravenna, the city of mosaics, has been recognized as a world heritage by UNESCO and eight historic buildings are on the World Heritage List. It is a treasure chest of art, history and culture of the highest order with ancient origins and a glorious past; it was a capital three times: of the Western Roman Empire, of Theodoric King of the Goths, and of the emperor of Byzantium. It houses the mortal remains of Dante Alighieri and keeps his memory alive with important events.

The countryside offers many different landscapes with beaches, pinewoods, lagoons and farmland plains. Just 10 km from Ravenna, at Sant'Alberto, there is NatuRa, a Natural Science Museum which is also the point of departure for guided tours in the Po Delta Natural Park. The historic salt-pans of Cervia are located at a distance of only about 20 km.

The "Paguro" wreck, after its sinking, saw an explosion of marine flora and fauna, thus becoming a destination for divers and enriching the tourist offer of the territory.

In July 1995 it was declared "Biological Protection Zone" by the Ministry of Agricultural Resources. This recognition, together with the establishment of the Paguro Association in 1996, contributed to the safeguard of marine life in the protected area. With Commission Decision 2012/14/EU, the "Paguro" wreck was also designated as Site of Community Importance (SCI code: IT4070026) and a management plan was redacted, delineating further conservation constraints (Fig. 13). Finally, in 2019, the site was confirmed as Special Area of Conservation (SAC) by Ministry Decree 3 April 2019, thus ensuring the conservation measures of the natural habitat. The primary objective is therefore the conservation and protection of the wreck area, where all sporting and professional fishing activities are prohibited, whilst recreational and educational dives are authorized, as well as those dedicated to scientific research. The Paguro Association, among its tasks, has the duty to manage all underwater visits in the wreck area, as defined by the Port Authority of Ravenna in 1997.

The current state of conservation of the "Paguro" wreck shows elements of satisfactory quality mainly due to the regulated access to the site. Restrictions are generally respected and dissemination activities have catalyzed a different positive attitude towards the sea and its resources. However, the wreck is endangered by climatic phenomena acting at regional scale such as the water eutrophication caused by freshwater inputs (i.e. Po river delta), by the dispersion of allochthonous species and, at local scale, by illegal fishing activities (i.e. ghost nets).

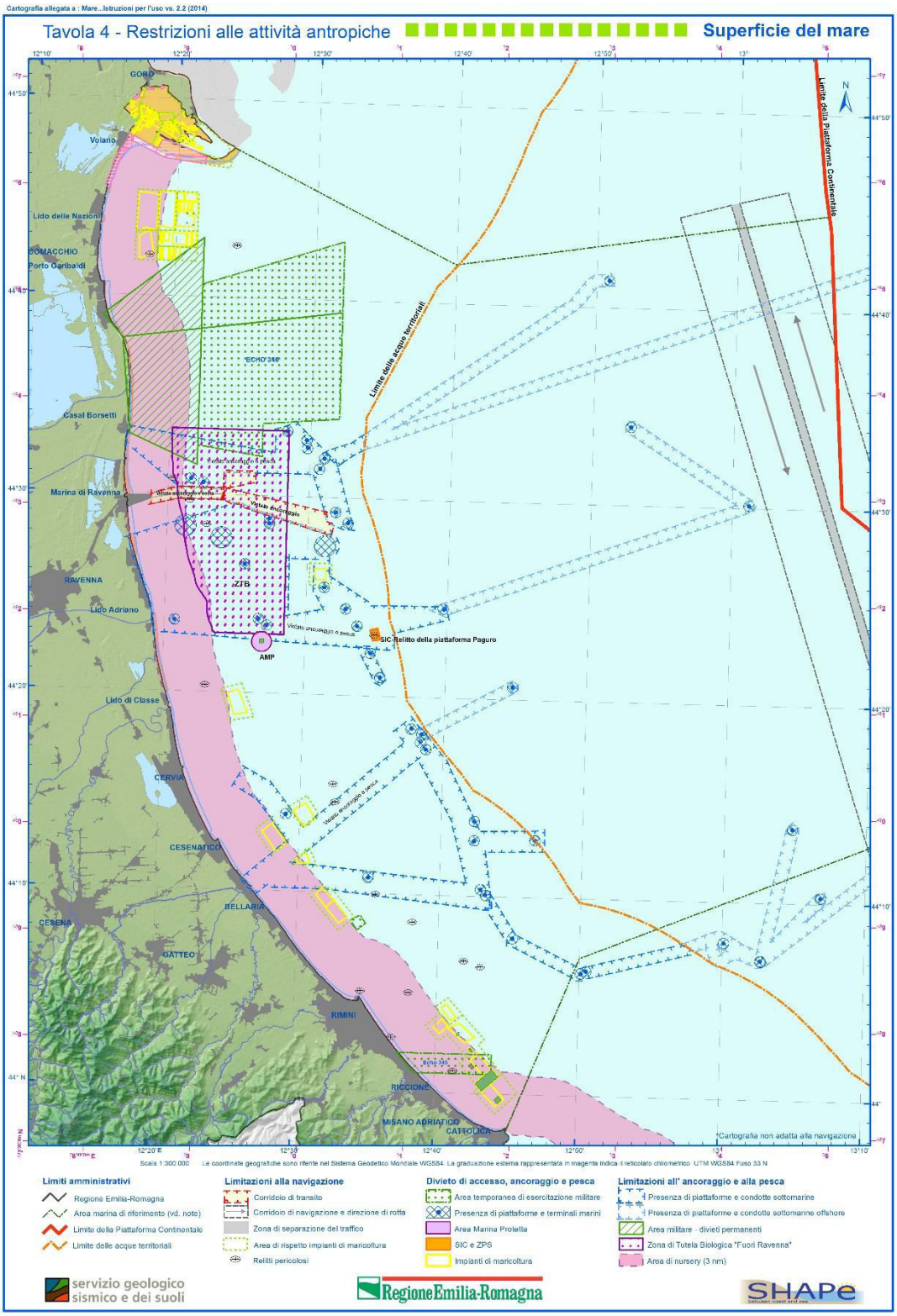

Figure 13. Map of sea-uses along the Emilia-Romagna coast. Areas with restrictions to anthropic activities are indicated, including the "Paguro" wreck protected area (SIC - Paguro platform wreck). (Source: http://ambiente.regione.emilia-romagna.it/en/geologia/pubblicazioni/cartografia-geo-tematica/mare...-istruzioni-per-l2019uso-versione-2.0?set_language=en)

4.1.4 Description of the potential activities

Taking into account that conservation and protection are primary objectives of the wreck area, future potential envisaged activities could be aimed to implement recreational and educational dives, as well as scientific research.

Specific security and surveillance measures are also envisaged by the Management Plan (AAVV, 2018).

4.1.5 Relevant stakeholders

Since the CS in Emilia-Romagna is a Site of Community Importance, where a Management Plan (AAVV, 2018) has been redacted specifying the activities allowed in the area, two main groups of stakeholders can be identified.

The first group comprises public institutions, research institutes and associations that are responsible for the correct implementation of the Management Plan and that are involved in the environmental conservation of the site: Emilia-Romagna regional office “Protected Areas, Forests and Mountain Development Service”, ARPAE Emilia-Romagna – “Daphne” Oceanographic Unit, the Marine Research Centre in Cesenatico, Association “Paguro” in Marina di Ravenna, the local Coast Guard in Porto Corsini (Ravenna).

A second group of stakeholders includes scuba diving associations/clubs and SMEs (boat rentals, scuba diving equipment stores, dive centers), that will be engaged during the dissemination of data and will benefit from an enlarged tourist offer. SMEs may also receive indirect benefits from the achievement of project results. In this perspective, the involvement of other public institutions, such as the Emilia-Romagna regional office “Tourism and trade service” and similar offices at local level, represent a key point to develop valid proposals for an increased tourist attraction potential.

4.2. Plić Lagnjići

4.2.1 General Data

CASE STUDY NAME	Plić Lagnjići
PP RESPONSIBLE	University of Zadar – PP04
TYPE OF REEF	Natural reef with a ship wreck
REEF CATEGORY	Low profile reef (the reef protrudes less than 20 m from the base substratum)

4.2.2 Geographical location, physical and ecological features

Plič Lagnići is located northwest of the Dugi Otok island, covering a large area from the Suhi Rt cape on Dugi Otok, in the direction of northwest, and all around the uninhabited islets of Mali (surface 1 ha) and Veli Lagan (2 hectares), around 1.5 km away from the cape mentioned above (Fig. 14). At a distance of about 400 m from the Veliki Lagan islet, on the western side, there is the shallowest part of Plič, 4 m deep, and nearby is the shipwreck of the Italian cargo ship Michelle, stranded in 1983, whose hull parts are still visible on the surface.

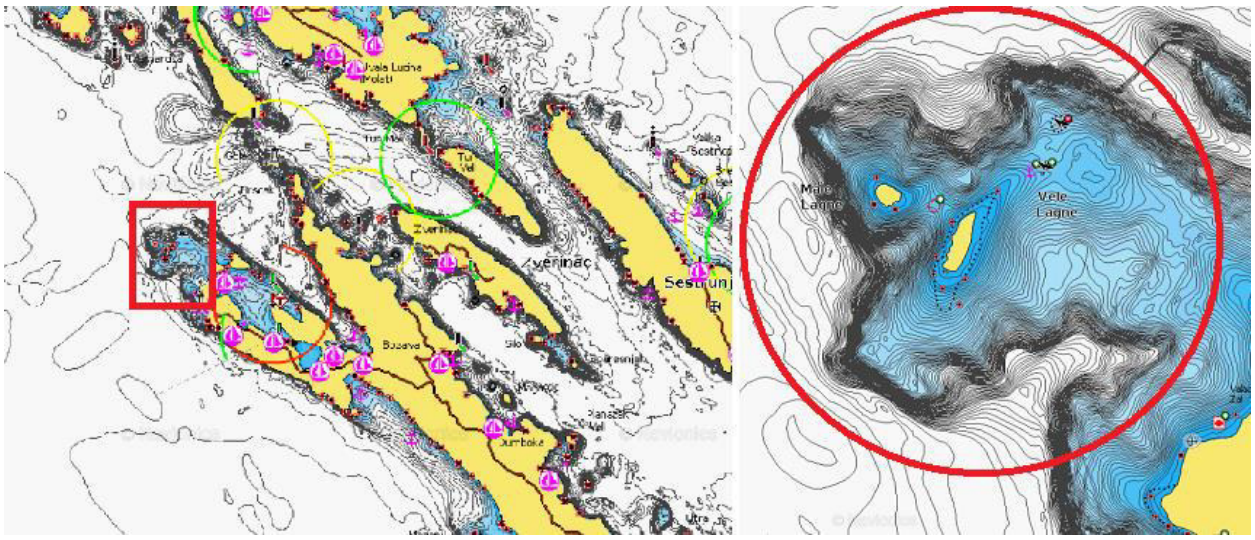

Figure 14.Location of the "Lagnjići" reef.

From its shallowest part Plič spreads irregularly towards the open sea, and at different distances, but on average at a depth of about 15 m, it begins to descend abruptly, with smaller or larger slopes, to the bottom up to 30 m depth. Towards East the reef gradually descends to a greater depth, and towards Molat it reaches a depth of 67 m. This gentle transition is also shown by the alteration of characteristic habitats, ranging from the infralittoral algae community, through the *Posidonia* meadows to the coastal detritus.

In 2009, the Sunce Association (Udruga Sunce, Morska bioraznolikosti akvatorija uz značajni krajobraz na sjeverozapadnom djelu Dugog otoka, 2009) carried out a detailed exploration of underwater habitats in the western part of Pliči, the results of which are shown below (Fig. 15).

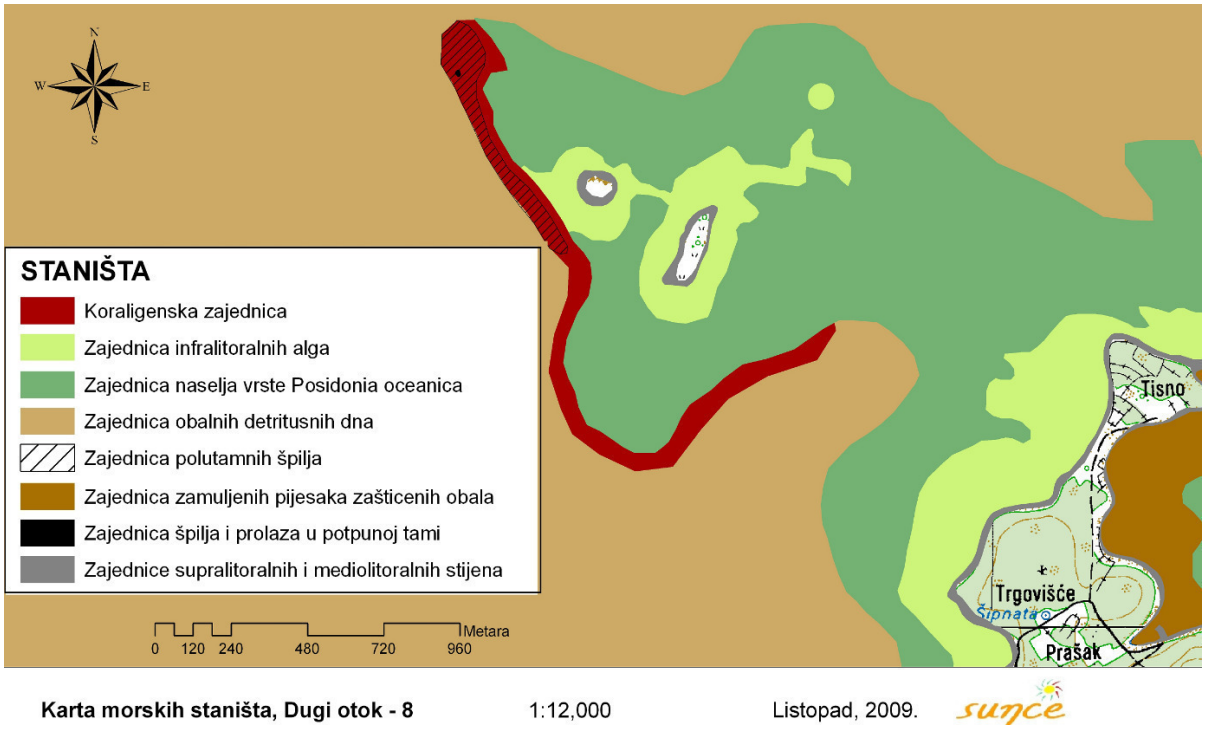

Figure 15.Marine habitats in the Lagnići area.

The bottom near the island is rocky with a developed community of infralittoral algae. With the increase of the depth between the rocks, the proportion of the sedimentary bottom increases inhabited by *Posidonia oceanica*, which gradually develops with depth increase from the crumpled community, intersected with rocks, in a thick, continuous meadow having an average density of 321.38 shoots per square meter. The meadows extend from 3 m to a maximum depth of 27 m.

On the western side of the island, at about 20 m depth, the seabed drops down in a form of a "wall" that extends up to 45-50 m depth. At the beginning of the "wall" the *Posidonia* meadow ceases, and a community of infralitoral algae dominates up to about 25-30 m, followed by a

coralligenous community characterized by a *Eunicella cavolini* facies. The walls in the wider area, and especially on the islet of Mali Lagan, are rich in large holes where a community of semi-dark caves is well developed. A large number of *Aplysia cavernicola* sponge specimens were recorded there, as well as the crustacean *Maja squinado*. At 20 m depth, which is the beginning of the wall, there is a dense settlement of species similar to *Cladocora caespitosa*. Between 30 m and 40 m depth, several species of *Palinurus elephas* (lobster) were found, and a large number of arborescent bryozoans were recorded on the wall. North of the islet of Mali Lagan, at 40 m depth, there is a cave with a community of caves and passages in total darkness.

On the "wall" and at its base a significant amount of abandoned fishing gear can be found, evidencing the issue of fishing influence on coralligenous "walls" in the open sea. That is the reason why a proposal was made to forbid all forms of fisheries in some small areas.

The area of Plič Lagnići is within the scope of a slightly larger area of the ecological network HR3000067 Luka Soliščica; Dugi Otok, proclaimed to protect habitats of sandbanks which are slightly covered by sea water all time, *Posidonia* beds, large shallow inlets and bays. Also, the islets Mali and Veli Lagan are included in the wider area of the ecological network HR1000034 which covers the northern part of the Zadar archipelago, important for birds and designated for the purpose of protecting 10 species, among which three species of terns, Mediterranean Shag and black-throated loon. It is also close to the protected landscape Northwestern Dugi Otok Island, whose protection derives primarily from the features of the coastline that is exceptionally indented, creating a unique panorama of bays, coves, peninsulas and narrow coves. A particular attraction is one of our most beautiful beaches, Saharun. The Act on Protection (Official Gazette of the Municipal Assembly of Zadar No. 10/67) also highlights indented coastline that continues under the sea, making numerous shallows, reefs, etc., which condition the specific and rich biocenosis (ichthyofauna, shells etc.). The protected areas of nature and the ecological network in the area are managed by the Public Institution of Natura-Jadera of Zadarska County, headquartered in Zadar, which in 2013 developed the Management Plan for the Northwestern Part of Dugi Otok Protected Landscape.

4.2.3 Assessment of *status quo*

Plič Lagnići administratively belongs to the municipality of Veli Rat. The nearest urbanization is located on the inner side of the peninsula which closes the Velar bay, named Pantera in geographic maps. There is a lighthouse on the shore towards the shoal. Built in 1845, it is the highest lighthouse in the Republic of Croatia and serves for long-haul navigation. On the opposite side of the coast, i.e. bay, there is Verunić. The above mentioned Saharun beach is largely part of Verunić urbanization, and is oriented towards the southern part of the island, 6 km of air-distance from Plič Lagnići.

Approximately 4 km northwest of the island, the unpopulated island of Molat is located, which belongs to the City of Zadar. Molat is a small fishing village located on the southwestern part of the island. During the summer season it transforms into tourist village and diving centre of the whole area. On the Bonaster peninsula there are the remains of a military camp with tunnels and bunkers.

Relating to sea traffic, the shoal itself is avoided because of the danger of stranding, but between it and Dugi Otok there is a high traffic route running from Zadar, between the islets Golac and Bršćak, towards the open sea (Fig. 16).

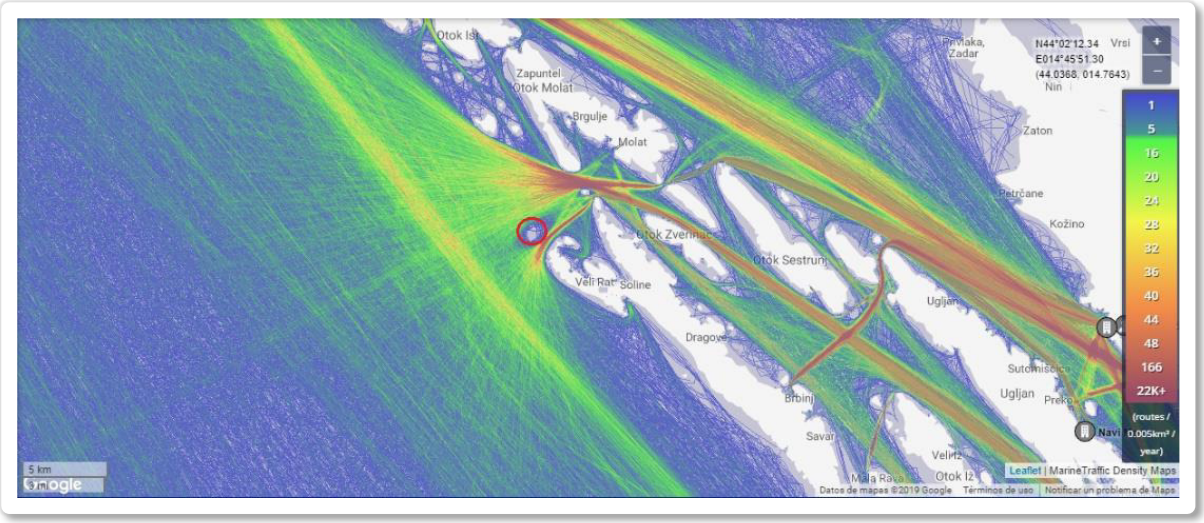

Figure 16. Maritime traffic density map of the wider impact zone on Plič Lagnići (Source: https://www.marinetraffic.com)

The most significant business by income as well by the number of employees is the seafood processing industry which is mostly concentrated on the southeastern side of the island.

Tourism is one of the leading economic industries on the island, and there is a marked polarity in the tourist use of the northwestern and southeastern parts of the island, primarily determined by the position of the Telašćica Nature Park. The municipality of Sali has developed excursions, nautical and sport tourism, and the group of Dugi Otok islands is very attractive as a nautical and diving destination with the necessary amenities and services.

At the western part of the island (settlements of Božava, Dragova, Soline, Veli Rat, Verunić , Zverinac) in 2018 the accommodation capacities were 342 beds (hotel), 770 beds (Private and other accommodation) and nautical marina with a capacity of 199 berths, and 107.097 overnight stays were achieved. Three new tourist settlements with a capacity of 600 beds and 2 camps with a capacity of 200 beds are planned in the villages of Veli Rat and Verunić in the future. The main concern is the majority of arrivals are in the summer months, therefore the highest environmental

pressure is in this short period. Significant constraint on tourism development represents the lack of water being Dugi Otok not connected to the regional water supply system.

In the immediate zone of influence of the Plič Lagnići most of the berths are located in the wide Pantera bay, which is connected to the bay of Čuna by a narrow canal (Table 5).

The entire area is appealing to divers, especially due to the vicinity of Telašćica Nature Park and the Kornati National Park. Fig. 17 shows that Plič Lagnići is being promoted as a dive site.

After the activity of seafood processing and preserving and the provisioning of touristic services, the most important activity is fishing. On the eastern side commercial fishing is much better represented than in the west, where on the other hand, the number of licenses for small scale coastal fishing is higher.

No.	City/ Municipality	Location	Type	Name	Capacity
1.	Sali	Pantera bay	Nautical anchorage	NS Pantera	61 buoys
2.	Sali	Pantera bay	Nautical anchorage	NS Lučina 1	9 buoys
3.	Sali	Čuna bay	Nautical anchorage	NS Čuna	19 buoys
4.	Sali	Sakarun bay	Nautical anchorage	NS Sakarun	15 buoys
5.	Sali	Pantera bay	Nautical marina	Marina Nautika Veli Rat	199 berths

Table 5. Number of buoys and berths in the immediate zone of the Plič Lagnići (Source: Nautical Information Service-nIS; Ministry of Maritime Affairs, Transport and Infrastructure)

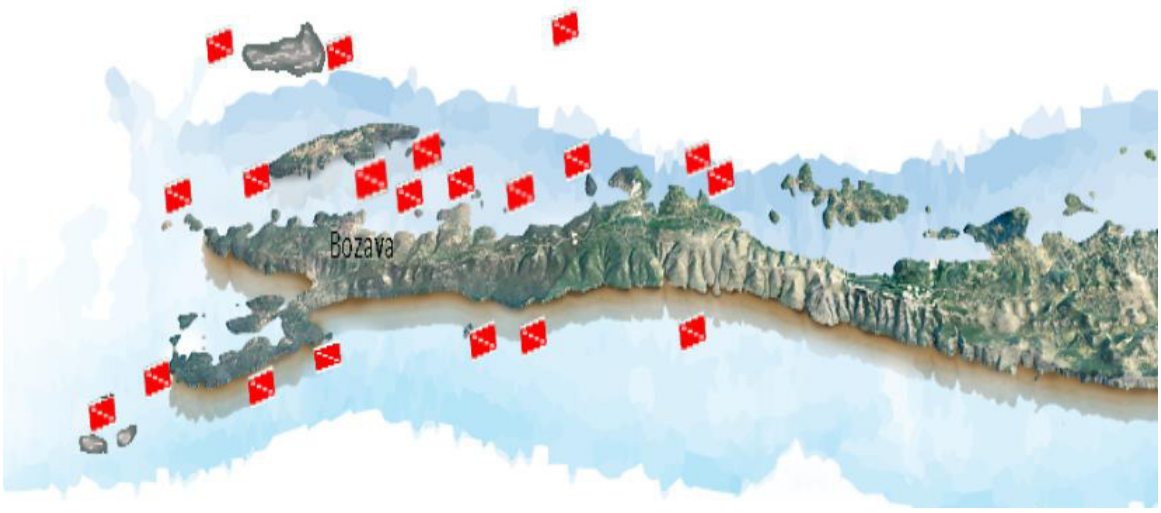

Figure 17. Diving locations of one of the diving centres from Dugi Otok island

Fishing with a traditional technique called “Tramata” is allowed in several locations, including around the islet of Lagnići. “Tramata” is a common name for fishing with special gears “ludra“, “fružata“ and “zagonica“. It is a technique based on frightening the fish. A sea area is surrounded (fenced) with ordinary or decorated rope (with colored strips that fright the fish), which is drawn towards the part of the coast or the bay where the fish is to be cornered. “Tramata” is a sophisticated fishing method specialized for fishing sparids: common dentex, gilthead sea bream, sharop snout seabream, common two banded seabream, salema, etc.. It is considered one of the most selective fishing methods in the Adriatic Sea because it hunts the smallest percentage of inadequate size or sexually immature fish (Cetinić and Pallaoro, 1993). Also, on the Plič Lagnići location from November 1st to March 31st it is possible to fish with a traditional shore seine “migavica“, used to catch picarels (*Spicara smaris*).

The tuna farming is carried out at the location in the North-East of Zverinac island, which is more than 7 km away of the location of Plič Lagnići.

4.2.4 Description of the potential activities

In general, the reef is not explored so it offers many potential opportunities for developing sustainable commercial activities in line with the principles of the Blue Economy. One of these could be the “fish watching”. Being the reef shallow with a ship wreck on the top, it could be ideal for this activity. There are a lot of species that can be seen on the site like *Chromis chromis*, *Epinephelus marginatus*, *Serranus scriba*, *Sparus aurata*, *Phycic phycis*, *C. conger*, *Muraena helena* and others. It could be even possible to implement scuba diving schools which could use the site like a “polygon” for advanced diving inside the wreck. Other activities could include cliff diving because on the southwestern side of the reef there is a cliff characterized by a coralligenous biocenosis with many gorgonians and cryptic fish like *Scorpaena scrofa*.

Other activities that could be implemented are fishing tours for tourists and some sport fishing. Indeed, in all villages on the islands of Dugo otok and Molat the tourist offer does not include any fishing activity at present. Boats that could be rented for this activity can only be found in county capital of Zadar and in Biograd na Moru city which are around 20nm far from this site and these islands. If the tourist offices would encourage the local inhabitants to implement this activity it would be a bonus for the resident community besides beaches and clean sea.

Furthermore, archeology students and students from underwater science in Department of Agronomy, Ecology and Aquaculture, University of Zadar, could learn activities on the ship wreck and could also perform teaching activities.

4.2.5 Relevant stakeholders

Currently the activities related to the reef are mainly managed by the local fishermen, while safety around the reef as well as safety of navigation is controlled by the Harbor master office. Considering that potentially, in the future, fishing tourism, scuba-diving and research activities could be developed, the stakeholders which could be involved are research organizations, universities, and local tourism agencies.

4.3. Porto Recanati-Porto Potenza Picena

4.3.1 General Data

CASE STUDY NAME	Porto Recanati-Porto Potenza Picena
PP RESPONSIBLE	CNR-IRBIM, Ancona – PP05
TYPE OF REEF	Artificial reef
REEF CATEGORY	Specifically designed concrete modules geometrically assembled to form structures and concrete poles

4.3.2 Geographical location, physical and ecological features

The artificial reef is located 5.6 km offshore between Porto Recanati and Porto Potenza Picena (central Adriatic Sea), facing the coastal plain shaped by the Potenza river (Figure 18). The site is approximately 10 km at South of the Conero Promontory, and lies in the first portion of a flat and sandy coastline that continues uninterruptedly southwards until Pedaso (Figure 18). The area is mainly exposed to SE and NE winds and receives nutrient-rich fresh water input from the Potenza and the Musone rivers. The AR, deployed in spring 2001, lies at 12.5 m depth. It covers an area of about 54.5 ha and consists of 222 pyramids positioned at a distance of 80 m from each other and of 444 concrete poles. Each pyramid is made of five cubic concrete blocks (2x2x2 m), four at the bottom and one at the top (height: 4 m), having rough surfaces to promote the settlement of sessile organisms and holes of different dimensions to provide shelter and habitat for various marine organisms. The concrete poles have a height of 4 m and are placed at regular intervals of 20 m from each other, between the pyramids and along the reef perimeter (Figure 18).

Fine sediments with the presence of coarser fractions characterize the sea bottom, which lacks of any natural rocky outcrops or seagrasses. Indeed, before the posing of the AR, soft-bottom species (mainly molluscs and polychaetes) dominated the benthic assemblage of the seabed, while low occurrences of crustaceans and echinoderms were registered.

Results obtained within the monitoring carried out over five years after the reef deployment have shown qualitative and quantitative changes in benthic and fish communities. In particular, an assemblage dominated by the mussel *M. galloprovincialis* and with presence of barnacles (*Balanus ssp.)* and anemones (*Actinia equina*) soon colonized the walls of the blocks, and the occurrence of hard bottom species, such as *Athanas nitescens*, *Alpheus dentipes*, *and Eualus cranchii*, has been observed few years after the deployment. This community represents a valuable food source for reef-dwelling fishes, and might justify the increased amount in terms of both number of individuals and biomass of benthic and nekton-benthic carnivorous species such as brown meagre *S. umbra*, annular seabream *Diplodus annularis,* and striped seabream *L. mormyrus*.

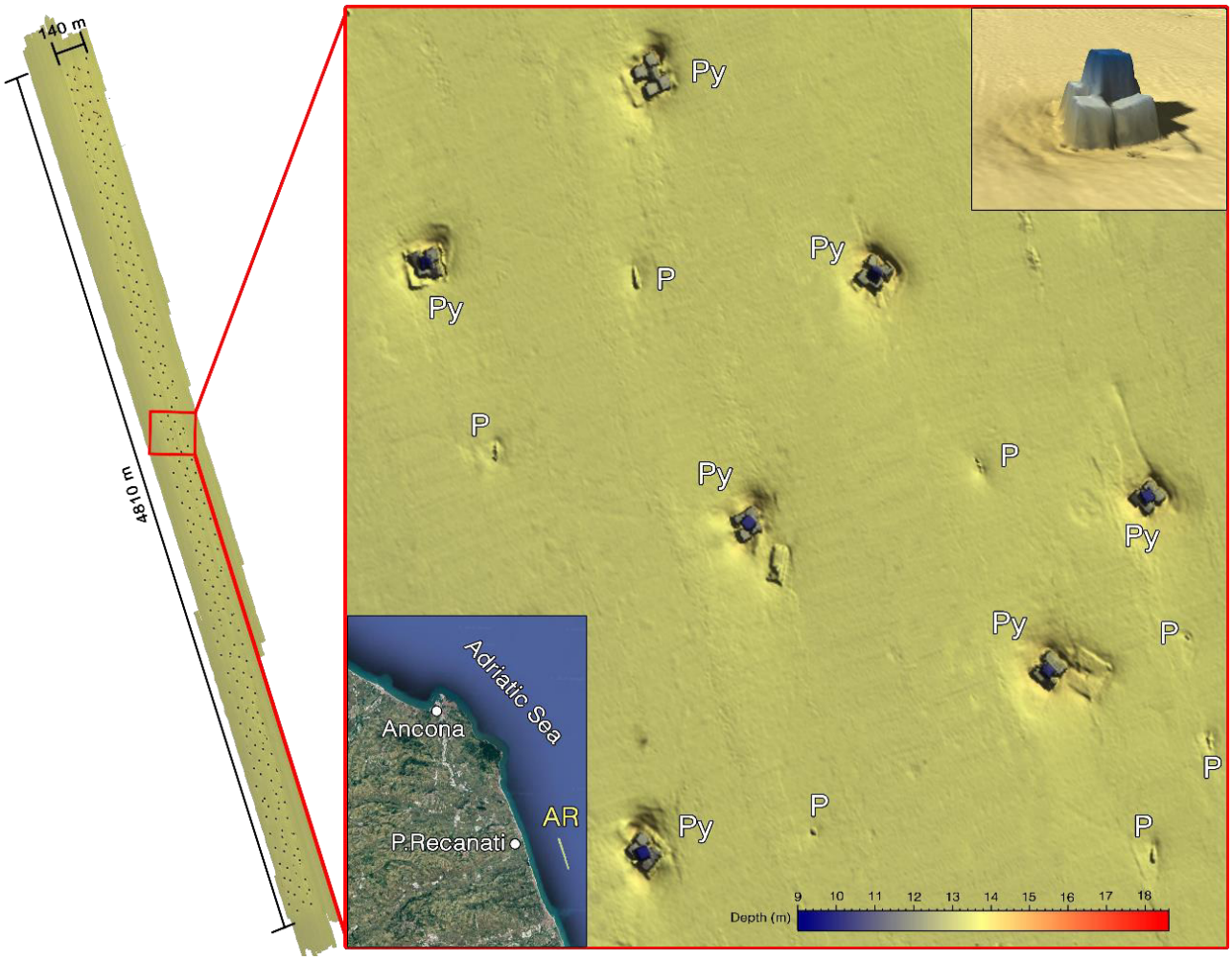

Figure 18. Location and map of the AR obtained with multibeam echo sounder. A view of a pyramid is also reported. Py: concrete pyramid; P: Pole

These observations rely on studies conducted when the AR was still a "young" reef, where all the biological and ecological processes were likely to be ongoing. It is well-known that on artificial reefs, like any hard substrata, a series of progressive modifications in the structure of benthic and ephibenthic communities might occur, leading to sequences of colonization, the presence of

steady-states, and even possible “regression phases” characterized by a reduced amount of species.

From an ecological point of view, this consideration underlines the importance of assuming the Porto Recanati AR as a Case Study, as this would imply a renewed interest in the monitoring of the *biocoenosis* inhabiting the area. Thus, specific studies on the ecological state after 20 years of deployment could be useful either to gain a better understanding of the ecological role of the AR and to obtain useful information for maximizing the effectiveness of future installations. In addition, updating information on the ecological status would be useful to better identify the possible optimal utilization of the reef.

4.3.3 Assessment of *status quo*

The Marche region offers a diversified natural environment, combined with a remarkable artistic and architectural heritage, reminiscent of its historical and cultural past. In particular, the countryside of Porto Recanati contains a rich heritage of fascinating medieval villages, archaeological sites and towns awarded with orange flags, surrounded by protected areas (such as the Conero regional park) and Natura 2000 sites (Fig. 19). In addition, the area offers a wide range of accommodation, sea-related facilities (divings, beach resorts) and equipped marinas from which it is possible to book boat trips, fishing tourism trips or to rent recreational crafts. The economic dynamism coupled with the outstanding surrounding environment acts as a pooling factor for tourism. However, at present some touristic activities such as recreational fishing and diving are mostly concentrated on the natural rocky bottoms of the Conero Promontory and, with specific regard to diving, on the ship wreck Nicole which sunk in 2003 in the coastal area in front of Numana beach. Instead, it seems that tourism scarcely interacts directly with the AR environment by reason of scarce information and promotion of the AR as a diving or fishing site. Other commercial maritime activities that generate larger interactions with the AR are aquaculture and fishing (recreational and professional) carried out in the area by the resident people. In fact, within the range of 3 nm from the AR there are aquaculture facilities involved in mussels farming (*M. galloprovincialis*), and the area is regularly interested by fishing activities carried out by artisanal fishermen (who mostly use set nets, pots and traps) and local recreational anglers.

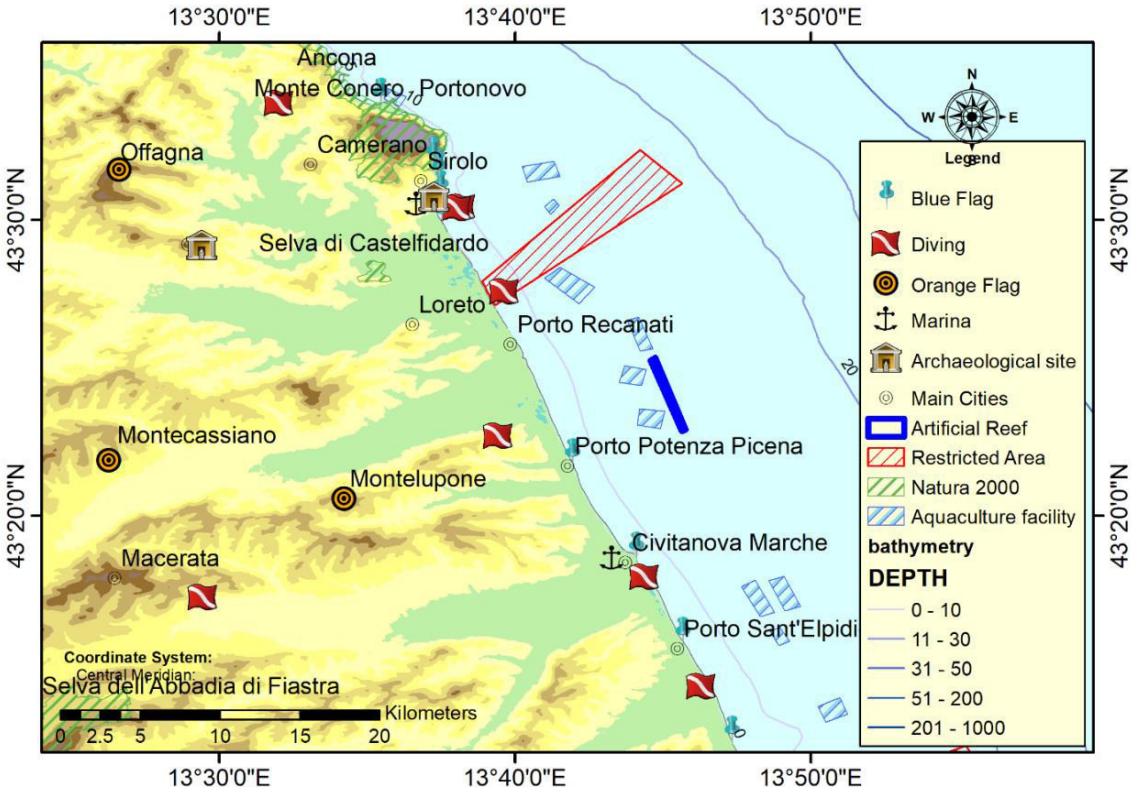

Figure 19. Map of the countryside showing points of interest for tourism.

Regarding the administrative point of view, the AR was realised by the Marche Regional Authority and funded by the Financial Instrument for Fisheries Guidance, CR (EC) n. 1263/1999. The monitoring programme carried out during the first 5 years from deployment was aimed to observe the environmental effects of the reef, in concordance with the requirements of the CE Re. 94/3346 of the 6th December 1994 and C (94) 3760/6 of the 22nd December 1994. Then, the Marche Regional Authority started in 2004 to consider the role of ARs in the context of Fisheries and Aquaculture management within the Regional law n. 11 of the 13th May 2004, which centres on the use of ARs as anti-trawling device. In the following years, ARs were concerned in several regional laws and resolutions falling within the context of dumping, European funding, and activities affecting state-owned maritime properties. However, these laws mostly aim to define the presence of ARs in the maritime legal framework, rather than protect or trying to take advantages from them. The regional body neither promoted laws for a regulated use of the reef, nor established any vigilance programme, just limiting itself to not authorize any activity within the reef area. However, despite the reef should be a closed area, the lack of a specific security and surveillance programme makes the site virtually unregulated.

Actually, the major threatens for the reef are the fishing pressure occurring within its perimeter and in the surrounding area, and the deterioration of the concrete modules that may cause a reduction of the reef bulk volume. The fishing pressure, if unregulated and unreported, causes

resource reduction while preventing managers from capturing the ecosystem status. The deterioration of the AR, in turn, may play an important role in the decrease of fish abundance. Indeed, the absence of detailed information on the biotic communities inhabiting the reef may hampers the sustainable and ecologically responsible management of future fishery systems in the area.

Considering that the information on the structural and ecological status of the Porto Recanati AR have been lacking for 15 years, it is crucial to re-establish a monitoring plan for assessing the current status in the optic of an increased sustainable use of the AR within the contexts outlined above.

4.3.4 Description of the potential activities

Basing on the available data regarding the AR, on the economic activities occurring in the area as well as on the CNR-IRBIM experience in the AR field the reef, if appropriately monitored and managed, could have a great potential for several activities in line with the Blue Economy.

From the touristic point of view it could be seat of recreational fishing and diving, allowing to diversify the local offer and to decrease the current pressure on the natural rocky bottoms of the Conero Promontory.

On the other side, the occurrence of reef-dwelling fish species which are uncommon in the natural soft-bottom environment of the western Adriatic sea and of a great biomass of mussels settled on the artificial substrates could also represent a valuable opportunity for the local small-scale fishermen as it occurs in other AR sites of the northern and central Adriatic sea. Although fishery does not represent a strategic area in the Blue Economy, the EU policies tend to support the development of small-scale fisheries as considered less impacting and more sustainable in respect to other fishing activities. With regard to the AR, allowing the small-scale fishermen to operate within the reef under specific management measures would mean to shift part of the fishing effort from the usually exploited resources of the natural soft seabed to alternative species and/or mussel harvesting.

4.3.5 Relevant stakeholders

Implementable activities in the CS fall into different legal contexts but have like common ground the involvement of a number of stakeholders linked to the use of state-owned maritime properties and to maritime safety. Such bodies are the Port Authority of the Central Adriatic Sea, the local Coastguard offices and the Marche Region office “Servizio Tutela, Assetto e Gestione del Territorio”.

In addition, it is possible to identify two groups of stakeholders related to the possible activities which might be implemented at the reef site. The first group comprises stakeholders linked to tourism (diving and recreational fishing). In this case, the Marche Region - Tourism department, Municipality of Numana - Tourism Office, Municipality of Porto Recanati - Tourism Office, Municipality of Potenza Picena - Tourism Office and Associazione Riviera del Conero e Colli dell'Infinito will play an important role for direct the tourist flow. In addition, diving associations and companies involved in craft rental will be engaged for the dissemination of data and will collaborate with above-mentioned public bodies for creating an integrated touristic offer.

The second group regards the professional fishing activities (small-scale fisheries and mussel harvesting). In this context, the Marche Region - Fishery department, CISP-FLAG Marche Centro, FLAG GAC Marche Sud, and fishermen associations will be engaged to create a common framework for the sustainable exploitation of the reef resources. Considering that, in case the reef would be suitable for the implementation of such activities, it would be necessary to establish a management exploitation plan, the collaboration among stakeholders is crucial to maximize their compliance, assure an optimal distribution of fishing permissions, and minimize the possibilities of illegal catches.

4.4. Torre Guaceto Marine Protected Area

4.4.1 General Data

CASE STUDY NAME	Torre Guaceto Marine Protected Area
PP RESPONSIBLE	ARPA Puglia - PP06
TYPE OF REEF	Natural Reef
REEF CATEGORY	Low profile reef and Patch reef

4.4.2 Geographical location, physical and ecological features

The Case Study selected from the Regional Agency for the Environmental Prevention and Protection of Puglia (ARPA Puglia) is the Marine Protected Area (MPA) of Torre Guaceto (SE Italy, Puglia Region, province of Brindisi) in the southern Adriatic Sea. The Torre Guaceto MPA was formally established in 1991, but entered into force in 2001.

The total surface of the MPA is around 2,227 ha. It is divided into two no-take/no-access zones, called A zones according to the Italian law and covering 179 ha. Within A zones all the fishing activities are banned and access is forbidden, except for the MPA's staff, scientists and police forces (e.g. coast guard). The general reserve zone (B zone) covers 163 ha, access (i.e. swimming) is allowed, but fishing banned. The partial reserve zone (C zone, hereafter called 'buffer zone', as it is the real buffer towards the exterior of the MPA), covers 1,885 ha, access and regulated navigation are permitted (Figure 20).

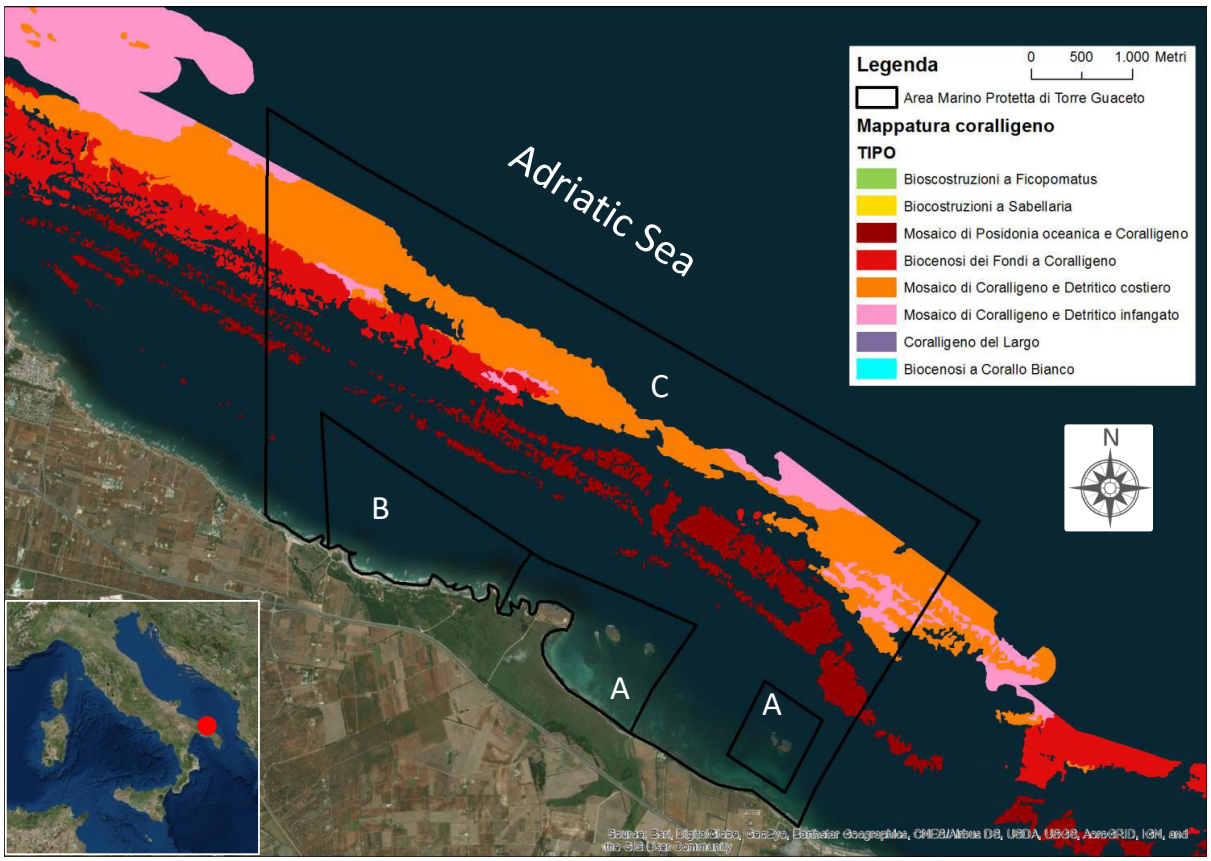

Figure 20. Marine Protected Area of Torre Guaceto. Boundaries of protection regime and Coralligenous reefs classification. (from BIOMAP Project)

The coast, mainly rocky with pocket beach, is characterized by a sloped rocky plateau, declining from the water surface to ~10–12 m depth over coarse sand. Rocky bottoms alternate with sand and *P. oceanica* seagrass beds. From around 25 m to 35–40 m depth, coralligenous formations alternate with sand, and sandy–mud bottoms widely dominate at deeper stands (Guidetti *et al*., 2010). The coralligenous reefs are among the richest and most characteristic marine habitats of the Mediterranean Sea, ranging from about 10 to 120 m depth (UNEP-MAP-RAC/SPA, 2003; Longo *et al*., 2017). They are among the most important biogenic structures in the basin, usually characterized by a well-defined community. However, due to their peculiarities and great structural, biological and geographical heterogeneity, it seems more appropriate to consider them as a puzzle of communities rather than a single community. The main bioconstructors of the coralligenous substrate are coralline algae growing at low light levels; the shallower coralligenous habitats are dominated by erect and foliaceous forms which, as the water deepens, are progressively replaced by encrusting species. Regarding the associated fauna, the abundance of suspension feeders depends on the average current intensity and availability of food. Gorgonians dominate the community in areas rich in suspended organic matter, while sponges, bryozoans and scleractinian corals are the dominant suspension feeders in more oligotrophic waters. With respect to their position, role and ecological functioning, distinguishes four different categories of

invertebrates in the coralligenous habitats, all of them contributing to the turnover of the calcareous concretion: fauna contributing to build up, cryptofauna, epifauna and endofauna, and eroding species (Ballesteros, 2006; Longo *et al*., 2017). Most of the coralligenous reefs of Apulia region were mapped and classified by the BIOMAP Project (BIOcostruzioni MArine in Puglia), promoted by the Puglia Regional Authority as a part of the program "PO FESR 2007/2013 – AXIS IV – line 4.4: intervention for the ecological network". In particular, for the specific area of the Case Study, the BIOMAP project identifies four subtypes of coralligenous habitat, namely Mosaic of Coralligenous and *P. oceanica,* Coralligenous, Mosaic of Coralligenous and coastal detritic, Mosaic of Coralligenous and muddy detritic.

From the ADRIREEF project point of view the selected Case Study, being a natural reef under a high level of protection regime (Marine Protected Area), could be used both as a reference point but also as an example of how potentially implement some activities in an environmentally sustainable way.

4.4.3 Assessment of *status quo*

The Torre Guaceto MPA protects the coastal waters in a wider contest, the regional terrestrial park (Torre Guaceto State Natural Reserve, Fig. 21) protects the adjacent territory. The MPA integrates the management responsibilities of both the terrestrial park and the marine protected area. The management structure for the park and marine protected area lies with a consortium of the City of Carovigno (principal management responsibility), the City of Brindisi and the World Wildlife Fund. The MPA manager works for both the park and the marine protected area, as well as for the Ministry of Environment in Rome who directs the overall MPA program for Italy. The pilot project area includes both terrestrial and marine zones designated as protected for the conservation of species, habitats and biodiversity:

- Wetland of International Importance (Ramsar Convention) "Torre Guaceto" instituted by the Italian National Government in the year 1981;
- "Torre Guaceto" Marine Protected Area (MPA, 2 227 ha), instituted by the Italian National Government in 1991;
- "Torre Guaceto" State Natural Reserve (SNR, 1 120 ha), instituted by the Italian National Government in 2000;
- ZPS "Torre Guaceto" (545 has), Natura 2000 code IT9140008;
- SIC "Torre Guaceto e Macchia S. Giovanni" (318 ha), Natura 2000 code IT9140005.

All the protected areas have been instituted according to the HABITAT EC Directive, BIRD EC Directive as well as the NATURA 2000 project, the Berna Convention and the Barcelona Convention.

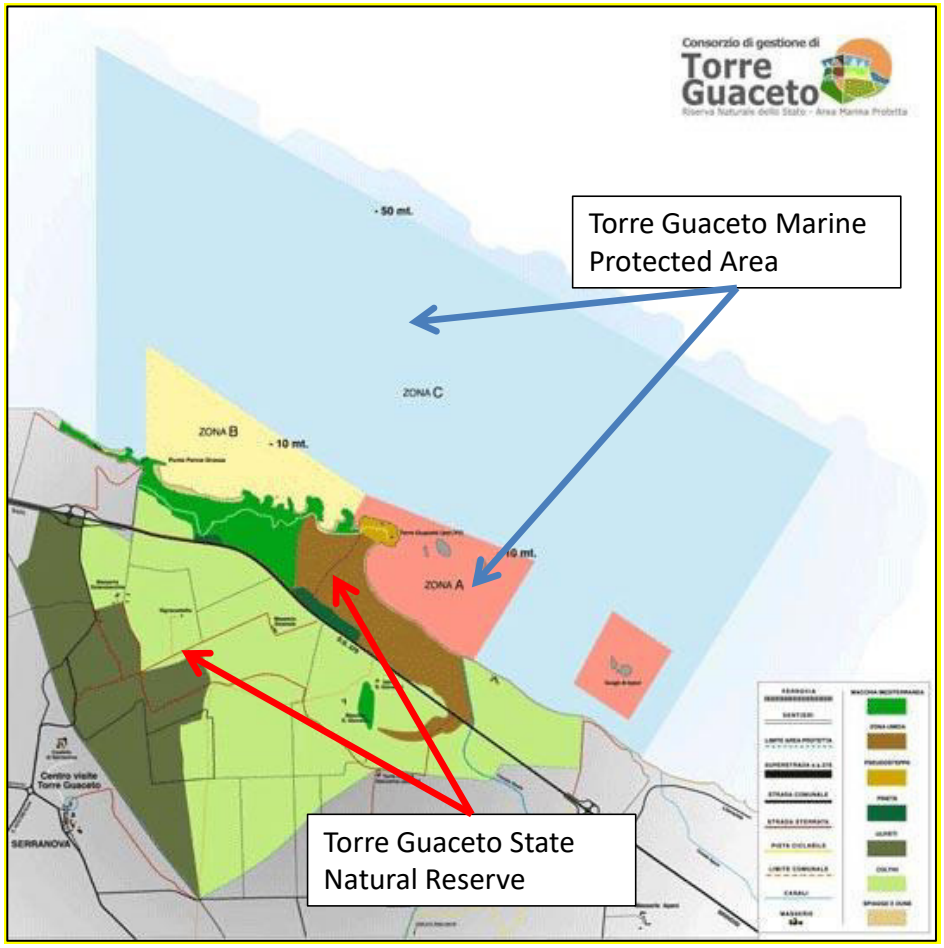

Figure 21. Marine Protected Area of Torre Guaceto and Torre Guaceto State Natural Reserve.

The major threatens for the Case Study area are linked to human activities like illegal fishing, tourism, water discharges, etc. In zone C of the MPA, the small-scale fishermen living in the Municipalities of Brindisi and Carovigno practice their activity. The latter, in collaboration with the Park Authority, have drawn up sustainable fishing specifications in order to avoid negative impacts on the fish population. These specifications enabled to obtain greater fishing results with respect to those got in the marine areas outside the MPA, still preserving the richness of the fish fauna.

The use of maritime national properties and adjacent areas may induce impacts on natural resources such as: impact on aquatic populations deriving from the collection of coastal benthic organisms by visitors of the Reserve; impact on the abiotic compartment of the aquatic environment, etc. Non controlled discharges of undetermined organic and inorganic pollutants have impact on the soil compartment of the coastal zone. Marine pollution due to the stranding of solid inorganic reject and to the organic charge that are transported along the littoral from the northern Adriatic Sea and Albania due to winds and currents, causing their accumulation near the Promontory in the no-take zone.

Fig. 22 shows the results of the Interreg Project SHAPE (Shaping an Holistic Approach to Protect the Adriatic Environment between coast and sea), where the results of a multivariate and cumulative analysis of Driver and Pressure like population density, soil used for agriculture, population density, fishing fleet, presence of allochthonous species, etc., were analysed. Among all considered areas, the case study site is one of those with the lowest Driver/Pressure cumulative values.

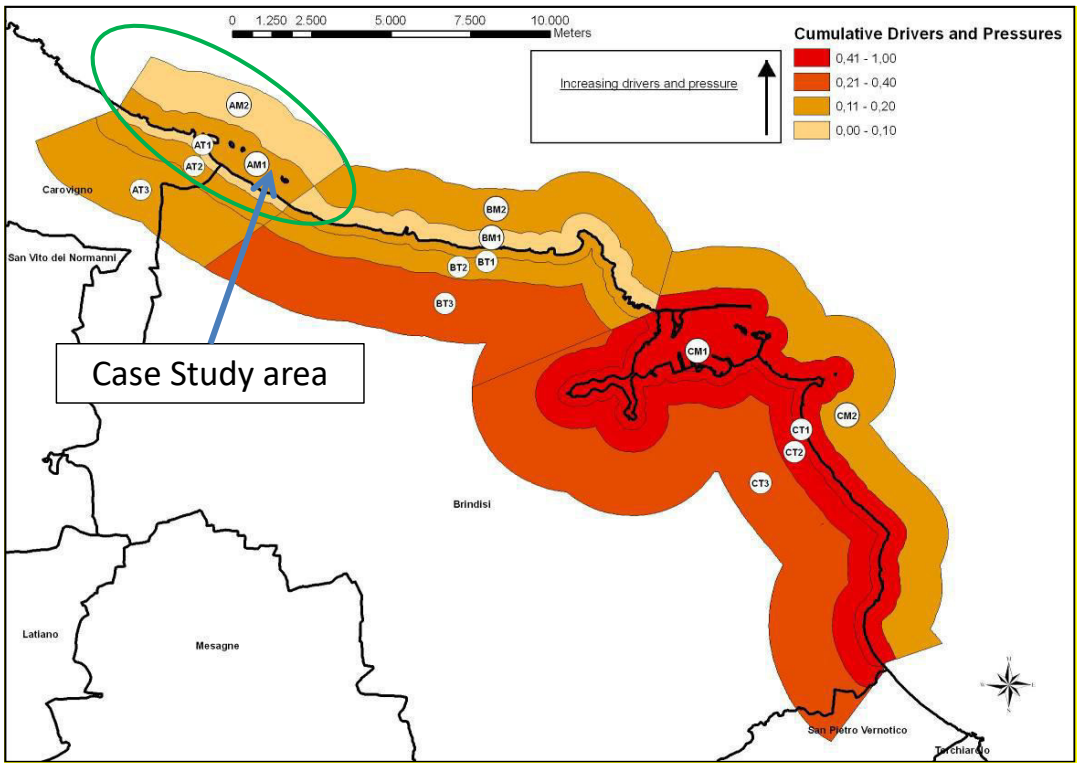

Figure 22. Map of the Driver-Pressure cumulative values in the 15 sectors of the study area. In the green oval the Case Study Area, the Marine Protected Area of Torre Guaceto.

Among the specific aquatic pressure, Figure 23 and Figure 24 show respectively the pressure due to small-scale fishery and the spatial distribution of vessels in the study area during the year 2012 (data source: Marine Traffic.com).

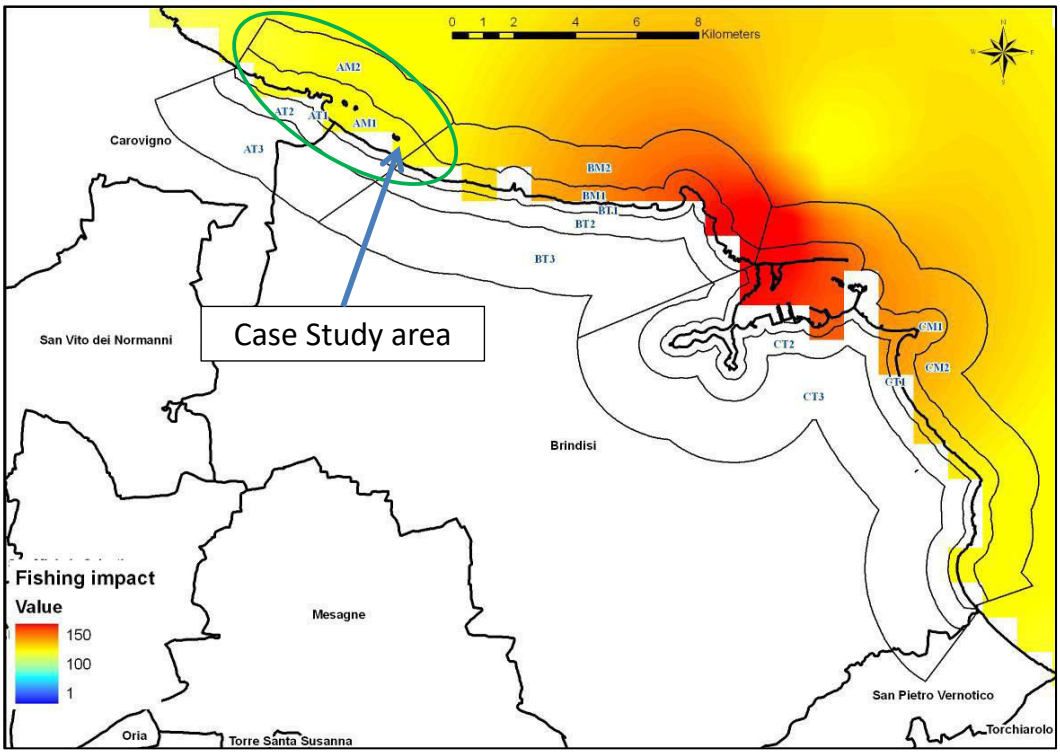

Figure 23. Distribution probability of the small scale fishery pressure in the study area.

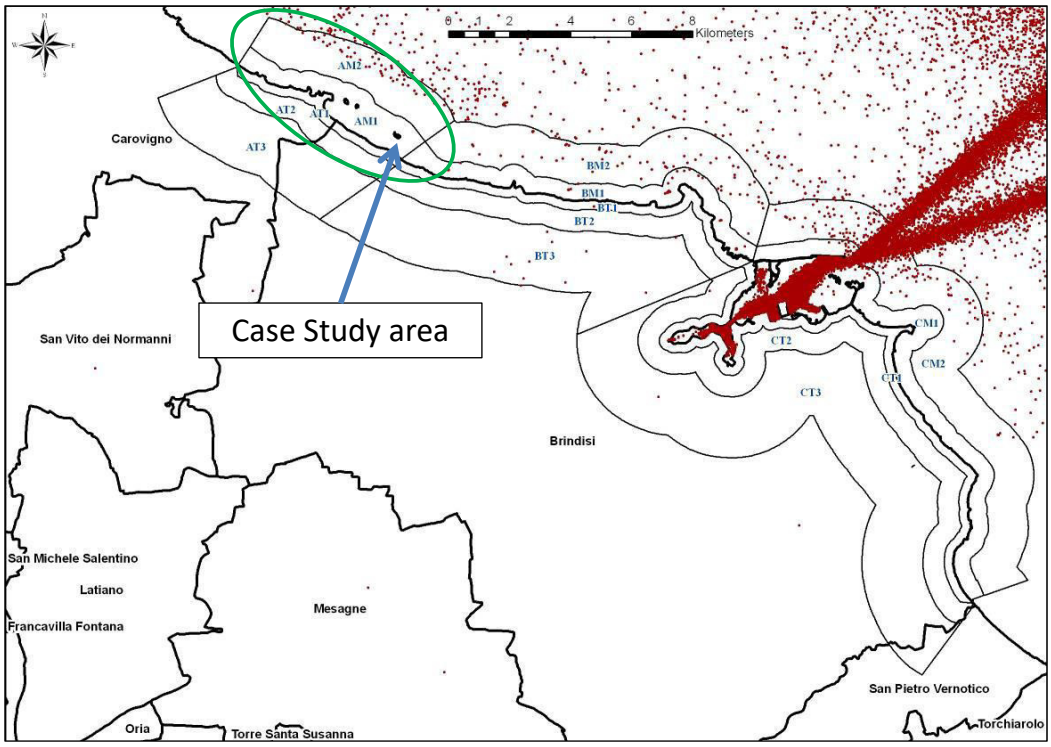

Figure 24. Distribution of vessels in the study area during the year 2012. (data source: Marine Traffic.com)

4.4.4 Description of the potential activities

In the Case Study area, based on the previous available information as well as on the results of the environmental monitoring which will implemented within the ADRIREEF project and could highlight the naturalistic peculiarities of the area, activities aimed to the sustainable exploitation of the natural reef might be implanted, according to the rules of the MPA. The potential activities to be implemented are:

1. Create underwater paths for divers. Currently, no underwater recreational activities take place in the MPA, however these activities can represent an accelerator for the local economy, given the high number of tourists who frequent the site. Being the MPA a biodiversity hotspot, the possibility of perform recreational diving could increase the number of tourists.

2. Create activities of citizen sciences, in order to involve divers in the collection of sensitive data on the species of interest. In this way an increase in scientific information would be obtained through the involvement of the large public.

3. Implementation of an underwater laboratory for Universities and Research Centre where they can conduct experiments, environmental monitoring practices (University of Bari - Biology Department, University of Salento - Department of Biological and Environmental Science), and test new opportunities for eco-sustainable tourism (University of Salento, Department of Economic Science).

4.4.5 Relevant stakeholders

The relevant stakeholders performing and/or managing current and future activities in the area belong to different categories. First of all there are the Public authorities, since the Case Study area is a Marine Protected Area aimed to the environmental protection of the marine habitats. Among these, the Regional Department of Tourism will play an important role for directing the tourist flow, while the Regional Department of Environment can provide useful directions and develop administrative measures for the sustainable use of natural resources. The Universities and the Research Centre (University of Bari - Biology Department, University of Salento - Department of Biological and Environmental Science; University of Salento, Department of Economic Science) could be involved in the new activities. Among the Small-Medium Enterprises (SMEs), diving associations and craft rental companies will be involved to collaborate with the above-mentioned public bodies for creating an integrated tourist offer.

4.5. Trezza San Pietro

4.5.1 General Data

CASE STUDY NAME	Trezza San Pietro
PP RESPONSIBLE	OGS, Trieste – PP07
TYPE OF REEF	Natural Reef
REEF CATEGORY	Patch reef (sand bottom with small reef structures protruding from the sediment)

4.5.2 Geographical location, physical and ecological features

The Natural reef (NR) is located 8.7 km from the coast, offshore Grado harbour (northern Adriatic Sea), facing the coastal plain shaped by the Isonzo river at East and the Grado and Marano Lagoons at the West (Fig. 25). The area is mainly exposed to SE and NE winds and receives nutrient-rich fresh water input from the Isonzo and Tagliamento rivers. The NR is located at a bottom depth between 15 m and 16 m, with a reef edge of 0.2-0.9 m.

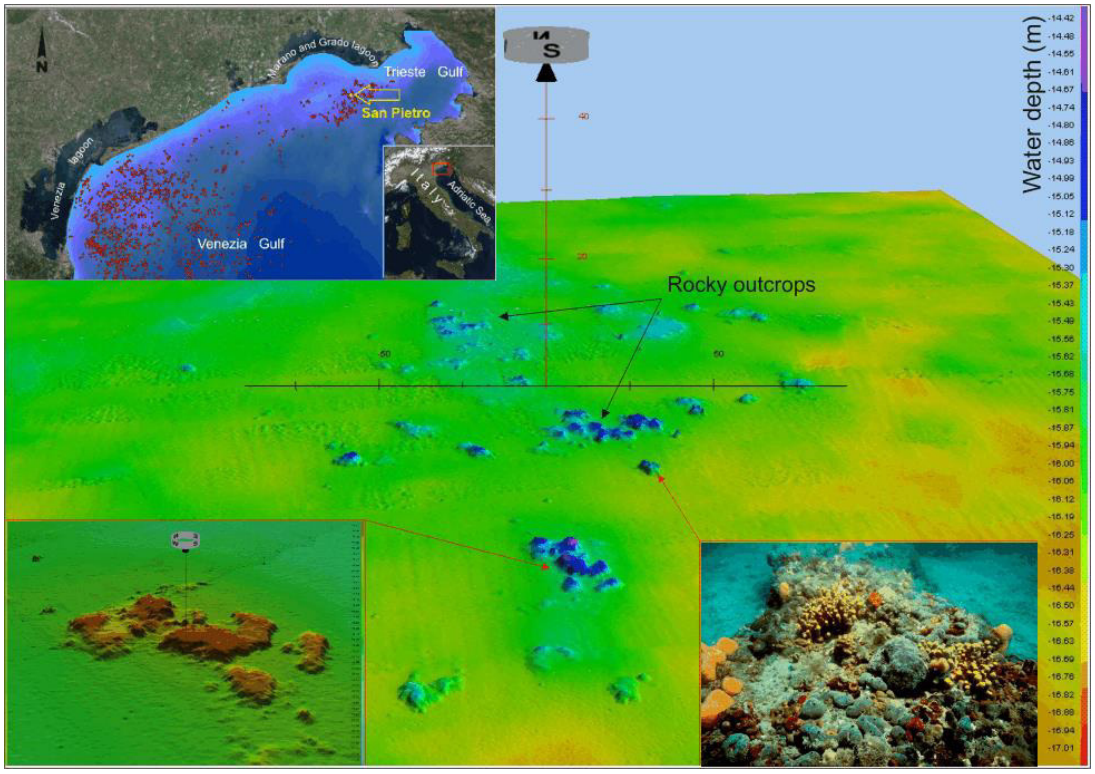

Figure 25. Map of the natural reef and 3D representation of the Multibeam relief realized at the rocky outcrop called "trezza di San Pietro". (from: Gordini, 2010)

It covers an area of about 9,850 m^2, comprising small reef structures protruding from the sediment (patch reef). The surrounding sediments are mainly detritic and sandy.

The site that has been chosen as representative of a vast series of rocky outcrops extending all over the northern Adriatic, approximately from offshore Grado to the offshore area of the Po river delta. Similar structures have also been documented offshore the western coast of Istrian peninsula. From recent investigations about 250 outcrops have been identified only in the Gulf of Trieste, between Punta Sdobba and Punta Tagliamento; the most widespread range of these outcrops is on the seabed in front of the lagoons of Grado and Marano at a distance from the coastline between 2 km and 17 km, and a depth varying between 8.3 and 21.5 m. These rocky outcrops are locally known as *trezze* in Friuli Venezia Giulia, *tegnùe* in Veneto and *bromboli* in the Istrian region. They extend from a few to several hundred meters and are characterized by different substrata (clastic sedimentary, sedimentary sediments, organogenic). Their origin has not yet been completely clarified, since not all of them can be assimilated to bioconstructions, and in some cases they are constituted by slabs deriving from the cementation of sand or rocks by methane gas. The calcareous concretions are attributable to Corallinageous algae and secondly to Briozoans, Molluscs (especially *Arca noae* and *Chama gryphoides*), Anthozoans (*C. caespitosa*) and Serpulid polychaeths.

The rocky outcrops called *trezze* represent authentic natural reserves for the reproduction and settlement both of sessile organisms, which live firmly anchored to the substrate, and of organisms that need shelter. They are also favorable environments for the reproduction and development of juvenile stages of many fish species. Thanks to the cavities and interstices present, these sites enhance a significant increase in marine environmental biodiversity. Taken together, these environments host benthic populations recognized as *coralligenous platform*, but the large variability of conditions and ecological gradients that are observed makes it difficult to adopt a unique classification.

The *trezze* environment, of high environmental, ecological and productive value, gained the attention of the scientific world as well as of numerous categories of stakeholders, since these are sites much sought by divers and fishermen. Nevertheless, this kind of environment is extremely delicate and vulnerable: the same hard substrate is fragile due to its calcareous and porous nature. Indiscriminate anchoring, unsuitable trawl fishing gears and even the passage of unruly divers can cause serious damage both to the sessile species and to the substratum itself. The anchoring bans, fishing with selective and non-impacting tools, the creation of underwater routes and the spread of a greater culture of respect are the tools to be adopted to protect these areas, a great reservoir of biodiversity in order to respond to the threat of environmental degradation and reduction of common natural ecosystems. The protection and conservation measures must also take into account the strong anthropic pressures attributable to some types of fishing (in particular hydraulic dredging for the harvesting of edible bivalve molluscs) and to the quality of the water column, which is affected by the waters coming from the Isonzo and Tagliamento rivers and from the neighboring lagoons of Grado and Marano.

4.5.3 Assessment of *status quo*

Friuli Venezia Giulia is a region in the extreme North-East of Italy, extending on a surface of 7,845 km², that overlooks the Adriatic Sea and borders with Austria and Slovenia. The region has a special statute and hosts 1,230,000 inhabitants.

The region offers a widely diversified natural environment, ranging from Dolomites and Carnic Alps to the Grado and Marano Lagoons. To the West of Isonzo river the coast is low and sandy with large lagoons (where Grado and Lignano Sabbiadoro represent famous seaside resorts), while to the East of the river the coast is rocky up to the border with Slovenia. The provinces of Gorizia and Trieste include a portion of the Karst, characterized by significant geological phenomena such as sinkholes, numerous caves and underground rivers such as the Timavo.

This region is a border land, where at least four different languages are traditionally spoken (Italian, Friulian, German and Slovenian) and where even more cultural traditions can be found. This is due to the fact that the region was a place of passage where different ethnic groups met

between the Alps and the sea, between Eastern Europe and the West, creating an unparalleled cultural panorama. The remarkable historical events have left a great wealth of remains, which range from pre-roman fortifications, to the roman harbor of Aquileia, to the over three hundred medieval fortifications scattered throughout the territory, to the remains of the First World War. Friuli Venezia Giulia counts 2 National Reserves, 2 Regional Parks, 12 Regional Reserves, 1 Marine Protected Area and more than 16 protected biotopes.

Both the surrounding natural and the cultural environment act as a unique pooling factor for tourism. The seaside tourism is very well developed, with an ancient tradition, offering a wide range of accommodations, sea-related facilities (diving, beach resorts) and equipped marinas from which it is possible to book boat trips or to rent recreational crafts. However, at the moment it seems that the tourism scarcely interacts directly with the NR environment by reason of scarce information and promotion of the reefs as diving sites. Other commercial maritime activities largely interacting with the NR are recreational and professional fishing carried out in the area by the resident people. The main professional fishing activities include harvesting the smooth clam *Callista chione* with hydraulic dredges and artisanal fishing with a wide variety of set nets.

From the administrative point of view, in 2012 the NR site was proposed by the Council Resolution 1623, pursuant to Regional Law 7/2008, art. 7, as the new site of community importance it3330009 "Trezze San Pietro e Bardelli" (Figure 26).

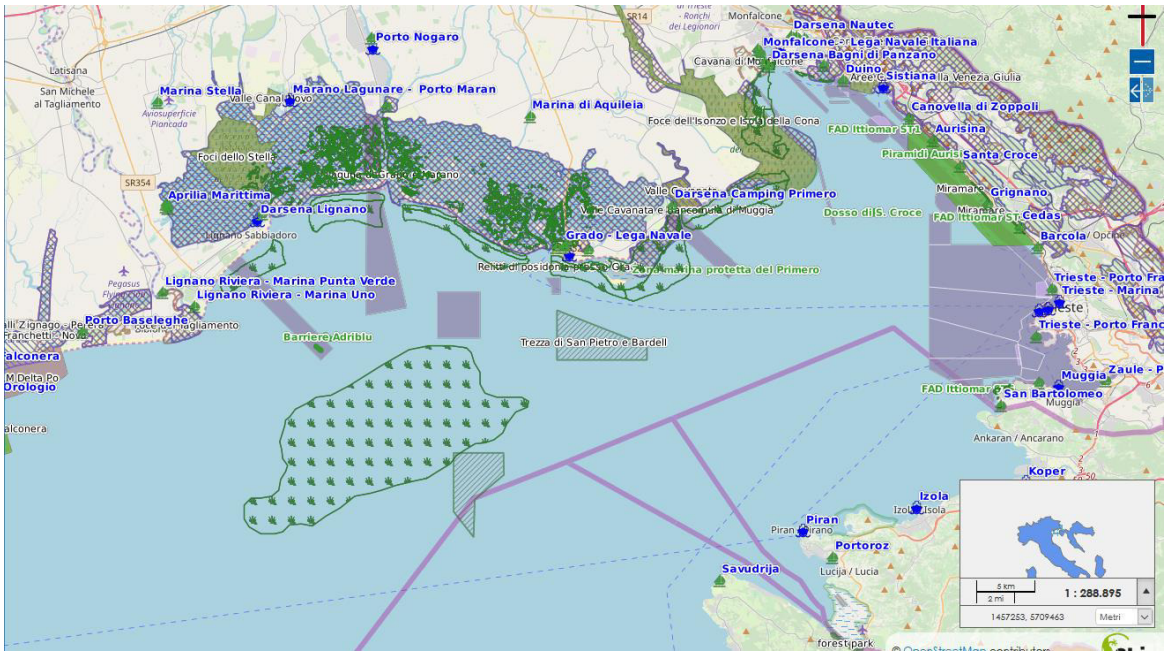

Figure 26. Map of the natural reef "Trezza di San Pietro" showing socio-economic features of the countryside: harbours, seagrass meadows, restocking zone (written with green characters), protected areas (areas indicated with green lines at sea and purple squares at lagoons and on the continent), regulated areas (grey areas, mainly regulated for maritime traffic). (from: http://lizmap.arpa.fvg.it/index.php/view/map/?repository=europrojects&project=ecosea)

Nevertheless, it was necessary to await the European Commission Decision 2015/69/EU of 03.12.2014 which ratified the inclusion of the site in the list of SCI of the continental biogeographical region. The process that has been virtuously since 2015, however, has not come to an end and the SIC is part of the Natura 2000 Network but is not currently equipped with specific measures.

Actually, the major threaten for the reef is the fishing pressure exerted by trawling gears which could heavily deteriorate the reef and its sensitive habitat. The deterioration of the NR, in turn, may play an important role in the decrease of fish and other resource abundances.

Considering the discontinuity of information on the structural and ecological status of the "Trezza San Pietro", it is crucial to establish a monitoring plan for assessing the current status in the optic of an increased sustainable usage of this kind of reefs within the contexts outlined above.

4.5.4 Description of the potential activities

The efforts for a correct and updated description of the site are justified by the potential to develop underwater tourism. The considered site is only an example of the numerous sites of similar nature found in the waters of the northern Adriatic Sea. This means that the tourist package for divers designed for the "San Pietro" site could be replicated on other sites. The underwater tourism can act as a driving force for the development of related activities such as boating, hotel offers, centers for sales and rental of diving equipment. Nevertheless, any kind of economic development and use of the natural reefs should take account of the fishing activities occurring on the same sites. The different economic activities should be managed in order not to compete but, rather, to reinforce each other. As example, fishermen could be involved to craft the divers on the sites or to offer a "double package": diving and fishing touring. The direct involvement of the fishing sector would make it possible to lighten the fishing effort on these natural sites without damaging the fishermen' income. Another positive aspect could be the increase of fishermen' conscience and sense of responsibility inducing them to become a sort of guardians of the sites. In this framework the natural reefs could become a virtuous example of Blue Economy.

4.5.5 Relevant stakeholders

Implementable activities in the CS fall into different legal contexts but have like common ground the involvement of a number of stakeholders linked to the use of state-owned maritime properties and to maritime safety. Such bodies are the Port Authority of the Northern Adriatic Sea, the local Coastguard offices and the Friuli Venezia Giulia Regional office "Direzione centrale risorse agroalimentari, forestali e ittiche. Servizio biodiversità".

In addition, it is possible to individuate two groups of stakeholders. The first group is linked with tourism (diving and recreational fishing). In this case, Friuli Venezia Giulia Region - Direzione

centrale attivita' produttive - Servizio Turismo, Municipality of Grado - Tourism Office, Municipality of Marano Lagunare - Tourism Office, Municipality of Lignano Sabbiadoro - Tourism Office, and the non-profit association “Progetto-Trezza-Lignano-Sabbiadoro” can play an important role to direct the tourist flow. In addition, diving associations and companies involved in craft rental can be engaged for the dissemination of data and can collaborate with above-mentioned public bodies for creating an integrated touristic offer.

The second group regards the professional fishing activities (artisanal fishing and mollusc harvesting). In this context, Friuli Venezia Giulia Region - Direzione centrale risorse agroalimentari, forestali e ittiche. Servizio caccia e risorse ittiche, and fishermen associations will be engaged to create a common framework for the reef resources exploitation. Considering that, the establishment of a management exploitation plan would be needed in case the area would result suitable for implementing such activities, the collaboration among stakeholders is crucial to maximize their compliance, assure an optimal distribution of fishing permissions and minimize the possibilities of illegal catches or fishing attitudes which are dangerous for the environment.

4.6. Plić Seget

4.6.1 General Data

CASE STUDY NAME	Plić Seget
PP RESPONSIBLE	Institut Ruđer Bošković – PP09
TYPE OF REEF	Natural reef
REEF CATEGORY	Patch reef

4.6.2 Geographical location, physical and ecological features

"Plić" in Croatian language means "shallow" and refers to an underwater isolated structure, which extends up to shallow water, surrounded by deeper sea.

Plić Seget is a natural reef located 1.5 nm from the coast of Vis island, in the central Adriatic Sea, at 10.8 m depth (Figs. 27-28). The closest urban centre is the city of Komiža, 3.5 nm away. The nearest continental land (Vinišće near Trogir) is 24.4 nm far; for this reason, according to local standards, Vis is classified as outer or pelagic island (together with islands Biševo, Sveti Andrija, Brusnik, Jabuka, Ravnik, Budikovac, Galiola, Palagruža etc.). The area is only exposed to N-NW-W winds.

Figure 27. Vis island and the Location of the reef.

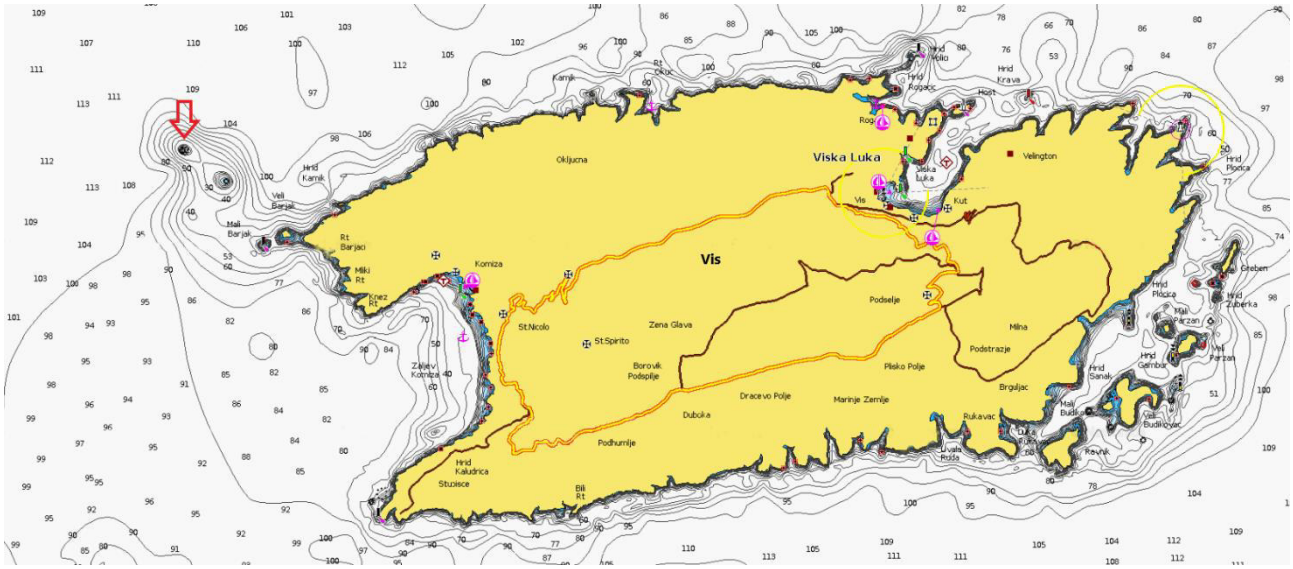

Figure 28. Case study location.

Plić Seget belongs to the Geopark Vis archipelago, a member of UNESCO's Global Geoparks Network. This area is geologically between the most attractive of the basin being composed of old and young rock formations, including volcanic rocks, which are unique in the Adriatic sea. Plić Seget is one of those submarine volcanoes. It represents a series of interconnected reefs built from eruptive rock that goes down from 10.8 m, with a great slope, reaching a first flatbed placed at about 30 m, and going down again up to over 100 m depth.

The flora and fauna of the reef have been not officially studied, but 181 macroalgae families, 2 seagrass species, 269 invertebrate's species, 347 of phytoplankton and 100 zooplankton families have been recorded in the waters of nearby Vis islands and Biševo. In the wider area of the Vis archipelago 114 fish species have been recorded, and 1,017 is the total of the registered families. On the seabed of Vis archipelago, where there are limited visibility and strong currents (such as Plić Seget), a heterogenous coralligenous biocenosis has developed, with gorgonians, stony corals, bryozoans, lobsters, starfish and other numerous organisms (https://issuu.com/undphr/docs/morska_bioraznolikost).

In this part of the Adriatic sea many megafauna species are even recorded: fin whale (*Balaenoptera physalus*), Cuvier's beaked whale (*Ziphius cavirostris*), Risso's dolphin (*Grampus griseus*), striped dolphin (*Stenella coeruleoalba*), common dolphin (*Delphinus delphis*), sperm whale (*Physeter macrocephalus;* rare visitor). Other megafauna recorded in the area includes giant devil ray (*Mobula mobular*), blue-fin tuna (*Thunnus thynnus*), swordfish (*Xiphias gladius*), monk seal (*Monachus monachus*) and the great white shark (*Carcharodon carcharias*) (https://www.blue-world.org/what-we-do/where-we-operate/vis-archipelago/). One of the most characteristic marine mammal species inhabiting the archipelago is the bottlenose dolphin. The bottlenose dolphin population size estimates report a minimum of 250 mature adults, and due to newborns

and calves frequently seen, the Vis archipelago is considered to be their breeding area (http://www.blue-world.org/conservation/species/cetaceans/).

The archipelago of Vis is also recognized as an important bird area, especially for marine birds like yelkouan shearwater (*Puffinus yelkouan*), Scopoli's shearwater (*Calonectris diomedea*), and European shag (*Phalacrocorax aristotelis*), which use these waters as feeding ground.

Natural structures like the Blue cave and the Monk Seal cave on Biševo island, the Green cave and the Stiniva beach (which was voted for the most beautiful European beach in 2016, on web portal "European Best Destinations") on Vis island contribute to enhance the area as a very attractive and unique destination.

Vis is considered to be the oldest city both in Croatia and in the eastern Adriatic coast. Ancient Vis, named "Polis Issa", is considered to be founded in 397 B.C. by Syracuse Greeks under the leadership of Dionysius. A lot of different successive cultures occurred along history: Illyrians, Greeks, Romans, Venetians, French (Napoleon) and Austro-Hungarians. This cultural heritage and the contemporary history after World War II are particularly fascinating for tourists.

Komiža city has a long sailing and fishing tradition and is famous for its "gajeta falkuša". This is a a traditional Dalmatian fishing sailboat made of wood; it is the symbol of a thousand-year fishermen tradition not only in Komiža, but of the Croatian maritime heritage. In fact, the Ministry of Culture of the Republic of Croatia has protected the "gajeta falkuša" as an Intangible heritage of national cultural property. Its design was adapted to specific needs of Komiža fishermen, who went to long fishing expeditions in the open seas, providing them sailing speed and practical characteristics for fish transport. It was designed also for sailing to the distant island of Palagruža, known as the oldest off-shore regatta in Mediterranean (https://alternatura.hr/activities/sailing-gajeta-falkusa).

Komiža had a rising fishing industry in early 16th century and was known to export large quantities of salted fish to Venice. After the foundation of the first Adriatic canning factory in 1870 (39 years before the beginning of industrial fish processing in the United States), this fishing town became, in a short while, the centre of fishing industry in Dalmatia. Komiža's fishermen also spread their businesses beyond the Adriatic Sea – they started fish processing facilities on the Atlantic coast, near Cape Finisterre in Galicia (Spain).

There are around twenty locations with sunken sailing ships, warships, submarines and planes, which make the area the most attractive in this part of the Adriatic Sea for diving tourism.

4.6.3 Assessment of *status quo*

Plić Seget is included in the area HR3000469 Vis archipelago of the ecological network Natura 2000, which is important for preserving common bottlenose dolphin (*Tursiops truncatus*). At the

distance of 1.5 nm there is the island Vis, whose underwater area is designated as a part of the NATURA 2000 ecological network (Fig. 29), under the code HR3000097. The ecological network is managed by the Public Institution Sea and Karst of the Split-Dalmatia County with headquarters in Split. The wider marine area of the island Vis, including the Plić Seget reef, is covered by the scope of the Vis Archipelago Geopark which belongs to the UNESCO Global Geoparks Network.

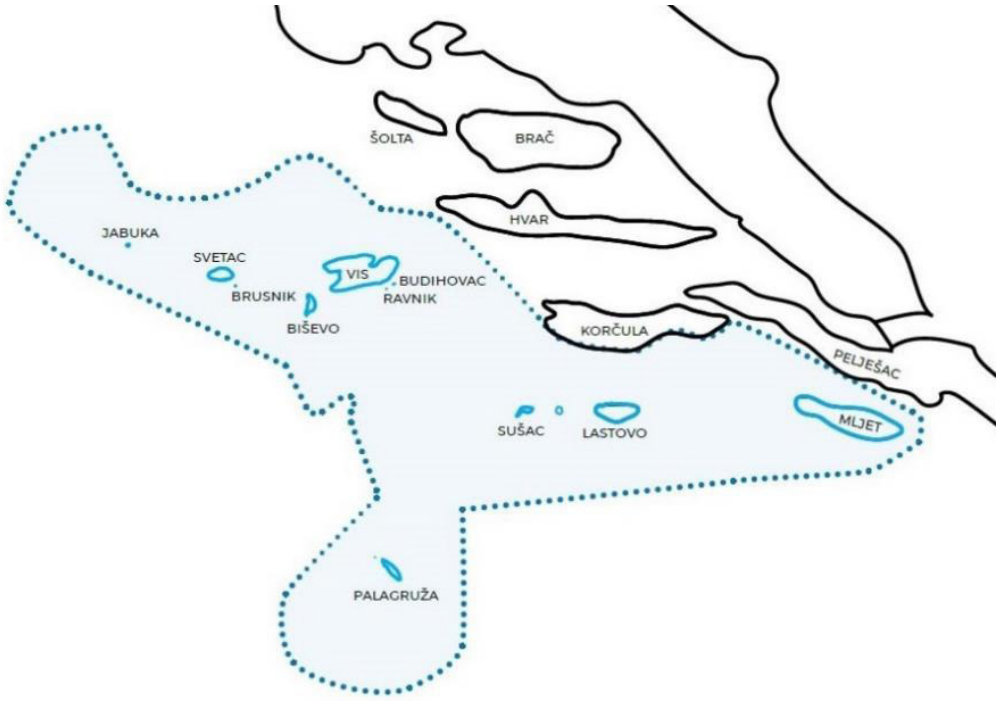

Figure 29. Natura 2000 network (Source: https://geopark-vis.com/en/heritage/naturale-heritage/natura-2000)

In 2003 the international ecological organization World Wildlife Fund (WWF) has declared Vis archipelago as "one of the 10 last paradise oases of the Mediterranean", including it, together with the islands Mljet and Lastovo, in the "Adriatic Blue Corridor", based on scientific research which revealed that this maritime zone has the largest biodiversity in the Mediterranean basin.

In the Tourism Development Master Plan of Split-Dalmatia County the island of Vis is recognized as an area of top quality natural, cultural and historical resource-attractiveness. The primary tourist products of the island are identified as the sun and sea, yachting, scuba diving and hiking.

Plić Seget is known as a rich fishing spot, where fishing occurs through the whole year around (recreational and professional, with various fishing techniques). in 2018 3 activities with 60 employees were registered in fishing industry in the area of Komiža and, according to the craft register, there were 6 crafts with fishing as a predominant activity. The number of licenses issued on the island of Vis is constant. Regarding the use of fishing gears, it should be noted that the reef Plić Seget is located along the edge of the coastal zone where the Spatial plan restricts the use of the gill-nets "psara" (for cartilaginous fishes) and "prostica" (for bottom and pelagic species). Two

fishermen are also registered for fishing tourism in Komiža, and one more in Vis, all equipped with a registered small-scale fishing gear.

According to the Register for the Cultivation of Fish and Other Marine Organisms, in the wider area of influence there are no issued aquaculture concessions nor locations for farming are planned by the Spatial plan.

There are 5 dive centres on the Island Vis: 3 in Komiža and 2 in the town Vis. Plić Seget is being promoted as an attractive scuba dive location on the websites of three dive centres. It is mainly visited during June, July and August, however, sporadically (approx. once per month), as it is considered "*extremely demanding for diving due to strong currents, constant sea traffic and rapid weather changes, which is why it is recommended only to well-trained and prepared dive teams*" (https://diving-croatia.hr/diving-locations-komiza-vis/seget-reef + pers. com.). In general, the area surrounding Vis island is one of the frequently listed among "top locations" for diving in Europe. It is especially famous for its walls, caves and numerous wrecks, interesting for different levels – from beginners to experienced divers. Due to numerous attractive dive sites in closer proximity to the island, also available to mid- and beginner levels, Plić Seget is not frequently visited. Also, experienced divers usually come to dive on wrecks and are taken to the walls and caves closer to the island.

The island Vis is connected to Split by boat and catamaran lines. According to the marinetraffic.com webpage, average shipping traffic in the area is of moderate intensity.

In the immediate impact zone of Plić Seget reef, berth facilities for nautical tourism refer mostly to the city of Komiža, while only one smaller anchorage is located in the city of Vis (Table 6), and all other capacities are placed within the port open for public transport.

No.	City/ Municipality	Location	Type	Name	Capacity
1.	Komiža	Zaliv Komiža	Nautical anchorage	NS Komiža, Lučica	20 buoys
2.	Komiža	Zaliv Komiža	Nautical anchorage	NS Komiža, Jastožera	8 buoys
3.	Komiža	Zaliv Komiža	Nautical anchorage	NS Komiža, Pol Guspu	40 buoys
4.	Komiža	Mezuporat Biševo	Nautical anchorage	NS Uvala Mezuporat	20 buoys
5.	Vis	Uvala Stončica	Nautical anchorage	NS Uvala Stončica	6 buoys

Table 6. Number of buoys and berths in the immediate zone of impact on reefs Plić Seget

According to the data of the Komiža Tourist Board, since 2016 tourist arrivals have constantly increased, while the trend of overnight stays is variable. At the same time the city of Vis has seen a continuous increase in both arrivals and overnight stays.

Threats, pressures and activities with possible impacts on the site are: disposal of household/recreational facility waste, fishing, illegal taking/removal of marine fauna, scuba diving, garbage and solid waste, invasive non-native species, temperature changes (i.e. rise of temperature & extremes), noise pollution.

There is no specific monitoring programme of the Plić Seget reef in place.

4.6.4 Description of the potential activities

Regarding potential commercial activities and following the Blue Economy principles and project objectives, the reef may be exploited in many different ways and undoubtedly can contribute to the development of economic activities in the area. As for the majority of coral reefs the potential activities are connected to tourism, specifically diving activities, and possible recreational fishing. Tourist activities could be also linked with boat excursion and history spots description.

It could also be a location of an interest for geological and biological studies, as it is one of rare volcanic formations in the Adriatic.

Implementation of touristic activities can act as a driving force for the development of related activities such as boating, hotel offers, centers for sales and rental of diving and fishing equipment.

However, an increased tourism could lead to a higher environmental impact, hence it is crucial to establish a monitoring plan for assessing the current status of the site in the optic of an increased sustainable usage of the reef within the context outlined above.

4.6.5 Relevant stakeholders

Currently the activities related to the reef are mainly managed by the local diving centres. However, other stakeholders could be interested such as: Javna ustanova za upravljanje zaštićenim dijelovima prirode na području Splitsko-dalmatinske županije More i krš; Turistička zajednica Grada Komiže; Turistička zajednica Grada Visa; Turistička zajednica SDŽ; Hrvatski ronilački savez; Split Dalmatia County -department for Tourism and Maritime affairs; Ministry of Tourism RH; Ministry of environmental protection and energy; Grad Vis.

The most important for sure are: Grad Vis and Komiža and the Turistička zajednica Grada Komiže; Turistička zajednica Grada Visa for the development of the touristic activities. The Harbor Master's Office is responsible for the safety around the reef as well as the safety of navigation. Research activities would be realized in cooperation with different Institutes and Universities.

4.7. Plićina Konjsko

4.7.1 General Data

CASE STUDY NAME	Plićina Konjsko
PP RESPONSIBLE	University of Rijeka, Faculty Of Maritime Studies - PP10
TYPE OF REEF	Natural reef
REEF CATEGORY	Low profile reef (the reef protrudes less than 20 meters from the base substratum)

4.7.2 Geographical location, physical and ecological features

The Natural reef (NR) Plićina Konjsko is located in the northern part of the Adriatic Sea close to the north-eastern shore of Krk island on the western side of Vinodolski Kanal, 2.4 km offshore from Crikvenica and about 150 m from the shoreline (Fig. 30). Reef Konjsko, with a depth of 5.8 m, lies between Rt Konjska and Rt Šilo, about 8 km SE of the Rt Šilo (Fig. 31). This point is the termination of a narrow and low tongue of land which projects from the eastern side of Otok Krk, area exposed only to North winds.

Plićina Konjsko is a shoal that drops with a vertical wall to the bottom from the depth of 7 to 18 m, 200 m from the mainland (Rt Šilo). The area is extremely shallow, and in the wider area it does not exceed 18 m. The wall is solidly covered with typical coralligenous communities. Further from the reef, a sedimentary bottom is spread, with a typical detritus biocenosis. There is no flow and the visibility is really clear.

Figure 30. Location of the "Konjska" reef. (Source: http://www.bioportal.hr/gis/)

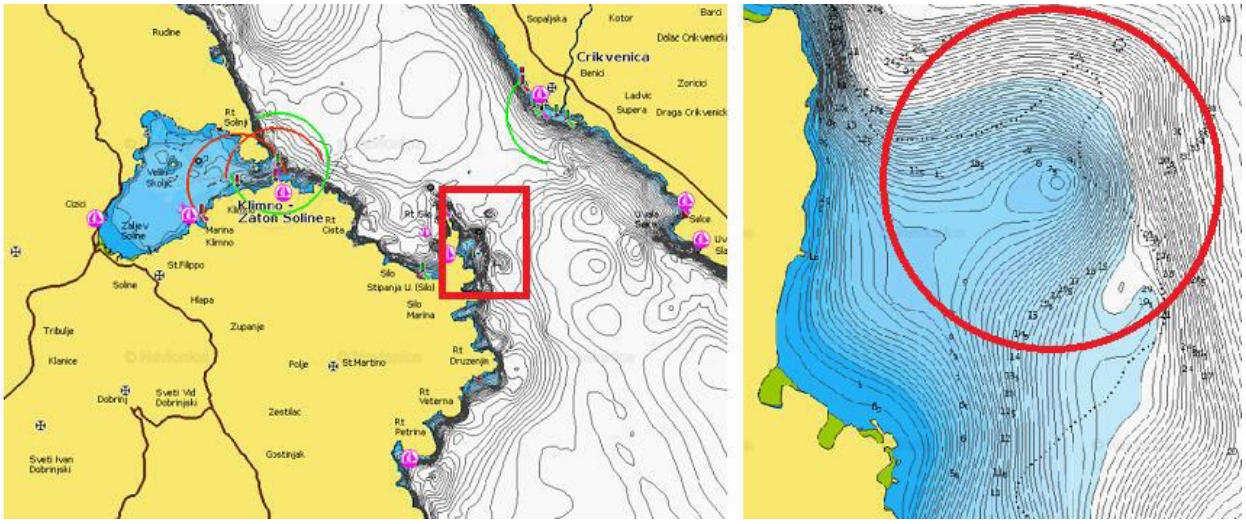

Figure 31. Location and bathymetry of the "Konjska" reef. (Source: https://webapp.navionics.com)

4.7.3 Assessment of *status quo*

Near the Plićina Konjsko there are three areas of the Natura 2000 ecological network. The area is significant for the preservation of habitats and species HR2001357 Otok Krk, which covers almost the entire island of Krk (mainland), and HR3000029 Obala između rta Šilo i Vodotoč (the eastern end of the area ends in the Dobrinj municipality), whose aim is to protect the sandy bottoms permanently covered by sea and reefs. Also, Plićina is partially included in the area of importance

for bird conservation HR1000033 Kvarnerski otoci, whose aim is to preserve 40 species of birds, among which griffon vulture and Mediterranean shag. In this area, it is planned to set up a monitoring of the populations of griffon vulture. The mentioned ecological network areas are managed by the public institution Nature of the Primorsko-goranska County, based in Rijeka.

The nearest place to the location of the reef is Šilo. Šilo is dominantly a small tourist town located on the north-eastern part of Krk island, in front of the Crikvenica Riviera (26 km from the Krk bridge). Although Šilo is today the tourist center of the area Dobrinj on island of Krk, it used to be a fishermen' and seamen' village. Except for the fact that it boasts the longest tradition in tourism in this region, the tourist center of Dobrinj area is significant on a wider historical scale as well. Crikvenica is a town with a hundred-year-old tourist tradition. It is located in the Kvarner bay, the most beautiful part of the Croatian littoral. The entire town is actually a Riviera with a series of almost connected urban places.

The impact zone refers mainly to the coastal area of the Vinodolski canal, within a radius of about 15 km, which includes the cities of Crikvenica, Novi Vinodolski, Omišalj, Vrbnik and Dobrinj. The entire area of the Vinodolski kanal, and in particular the Crikvenica-Vinodol Riviera, is clearly intended for the intensive development of high-standard tourist facilities (Figure 32).

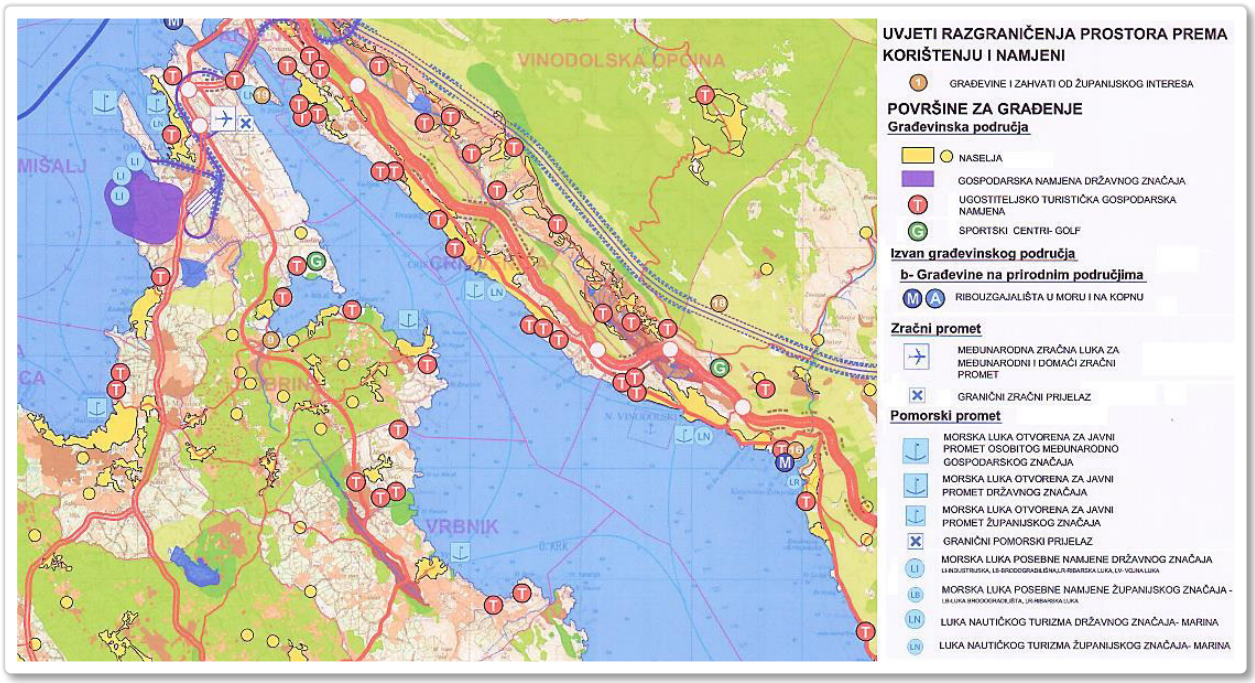

Figure 32. Layout of tourist zones and other purposes in relation to the Plićina Konjsko (Source: clips from CR 1. Land use of SP PGC and SP of Dobrinj municipality).

The site of the reef is located outside commercial waterway areas and marine traffic is of low density (Figure 33).

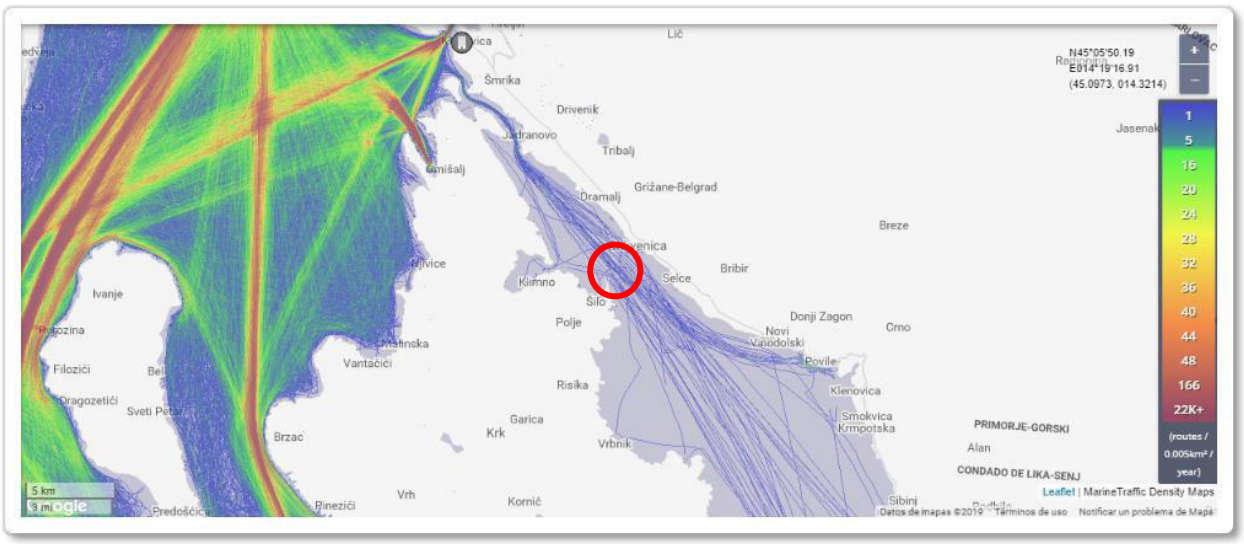

Figure 33. Maritime traffic density map of the wider impact zone on Plićina Konjsko (source: https://www.marinetraffic.com).

The reef is already subject to exploitation by SMEs offering recreational diving (Figure 34) and local tourism, however those activities are not intensive and are limited to the summer season. Actually, the major threatens for the reef are recreational diving and local tourism pressure occurring within the reef perimeter and in the surrounding area. Eight diving centers are located within 20 Km from Plićina Konjsko: two in Šilo, two in Crikvenica, and one each in Vrbnik, Selce, Novi Vinodolski and Kostrena.

Figure 34. Diving locations of diving centers at Crikvenica (Source: http://www.divecity.net/html/eng/dive_sites.htm)

In Figure 34 it is visible that cape Šilo, where Plićina Konjsko is located, is being promoted as a dive site. The coastal area of the Municipality of Dobrinj abounds in underwater caves, which are

recognized by the Spatial plan as a significant resource in the sense of natural monuments and the underwater caves in the coastal part of the municipality are marked for detailed systematic research and classification. In order to assure a lasting protection of caves, in addition to other protection measures, it is necessary to forbid any construction activity in the area of underwater caves, and to allow divers to enter only in limited numbers and under expert supervision.

In the observed zone of influence in the Vinodolski kanal, 35 licenses were issued for commercial fishing in 2018 and the number is decreasing. The number of licenses issued for small scale coastal fishing was small in 2018, 8 licenses were issued and the number is slowly rising. In the entire area of influence, there has been no license issued for fishing tourism.

Those activities represent significant recreational load especially because they happen close to the important tourist centre (Crikvenica and Šilo). For that reason, monitoring implementation of the reef would significantly contribute to the appropriate exploitation of the reef and to its protection.

4.7.4 Description of the potential activities

Generally, the reef has been not explored hence it offers potential development for different commercial activities, as long as these are in line with the Blue Economy and project objectives, contributing to the development of the whole area.

The major potential activities are connected with the tourism developed in the coastal area close to the reef, namely diving activities and recreational fishing. Tourist activities could be also linked to boat excursion that could offer reef itself as one of the best spots. The CS location is also recommended for underwater photo exhibitions exposure, competitions and other activities allowing to diversify the local tourist offer.

In order to promote potential commercial activities linked to the exploitation of the reef, dissemination of information should be locally and regionally performed, it could be carried out by installing interactive video screens on the relevant tourists' "hotspots": on Krka island and in the Crikvenica riviera area. Additionally, promotion will be done using adequate social networks (Facebook, twitter, etc.) and via official web pages of the local tourist's panel.

4.7.5 Relevant stakeholders

Currently the activities related to the reef are mainly managed by the local diving centres. For the development of fishing tourism around the reefs (diving and recreational fishing), and the implementation of other events, it could be necessary to involve the Dobrinj Municipality Tourist Board, which would represent a key point to develop valid proposals for an increasing potential touristic attraction and its promotion. In addition, diving associations and companies involved in

rental, as well as local tourist agencies, could be engaged for the dissemination and could collaborate with above-mentioned public body, in order to create an integrated touristic offer.

Looking at the potential development of research activities around the reef, stakeholders which could be involved are research organizations and universities. The Harbor Master's Office is responsible for the safety around the reef as well as the safety of navigation.

5. ANNEX 1: Template “Case Study Proposal”

CASE STUDY PROPOSAL

PP……..

- ✓ **Where?** Description of the site and map
- ✓ **What is?** natural reef, artificial reef (in this case explain which kind of AR, e.g. concrete, wreck, sunk platform....)
- ✓ **Current uses/activities of the site:** (e.g: diving, mariculture, fishing, tourism,.....)
- ✓ **Which are the main economic activities in the area (land and sea)?**
- ✓ **Why?** (please, explain why the site should be chosen as a Case Study, which is the potential of the area, etc.)
- ✓ **Which are the activities that you want to develop/implement within the project?**
- ✓ **Which useful data could be collected to develop/implement/?**
- ✓ **Are there available data?:** (environmental - *water column, sediment features, geomorphological maps..*) - and biological - *benthic communities, finfish population..* – dataset and literature). Please list the available data
- ✓ **Are monitoring programs already in place? If yes, which?**
- ✓ **Do fixed stations exist for monitoring?** (if not, is it possible to install them?)
- ✓ **Can you propose for this CS an innovative monitoring system/technology to be tested during the project?**
- ✓ **And a testing technology with low environmental impact?**

6. ANNEX 2: Case Study Form

CASE STUDY……. (name)

PP RESPONSIBLE:

MAP OF THE CASE STUDY (.tif or .jpg)

TYPE OF REEF: Specify if it is natural or artificial reef

REEF CATEGORY: indicate the category of the reef on the base of the document “Reef definition” circulated by Damir Zec

1. DESCRIPTION OF THE CS

1.1 Geographical location, physical and ecological features

(max 4000 characters)

1.2 Assessment of status quo (activities, legislation, management, threatens, human pressure)

(max 4000 characters)

1.3 Description of the potential activities that could be implemented in the CS

(max 4000 characters)

1.4 Monitoring programme (describe eventual already existing information and/or monitoring programmes in place and the low environmental impact monitoring methodologies that will be employed to verify the suitability of the CS to implement the activities indicated at point 1.3)

(max 4000 characters)

1.5 Who are the relevant stakeholders having major powers to influence the use of the CS? (Identify the main stakeholders – e.g. companies, authorities, NGOs, etc. performing and/or managing the current and future activities in the area and explain their role)

(max 2000 characters)

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